Chapter 2: The National Emissions Inventory and Emission Inventory Tools

LESSON GOAL

Demonstrate, through successful completion of the chapter review exercises, a general understanding of the National Emissions Inventory and the process by which it was developed. Also, the student should be able to describe the emission inventory preparation tools that are available as well as those that are under development.

STUDENT OBJECTIVES

When you have mastered the material in this chapter, you should be able to:

1. Describe the purpose of the National Emission Inventory (NEI).
2. Describe some of the data contained in the NEI.
3. Identify inventory preparation tools that currently exist.
4. Explain the purpose of process based emission models.
5. Identify source categories where better data for estimating emissions is needed.

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2.1 THE NATIONAL EMISSIONS INVENTORY

The information contained in the NEI includes data on 52,000-point sources by latitude/longitude with over 4,500 types of processes represented. There are about 400 categories of highway and nonroad mobile sources and 300 categories of area sources in the NEI. Emissions for area and mobile sources are allocated by county. The NEI includes annual emissions, the dates that sources started or stopped operations, and stack parameters. There are also HAPs emissions for over 6,000 types of processes.

Figure 2-1. Evolution of the NEI

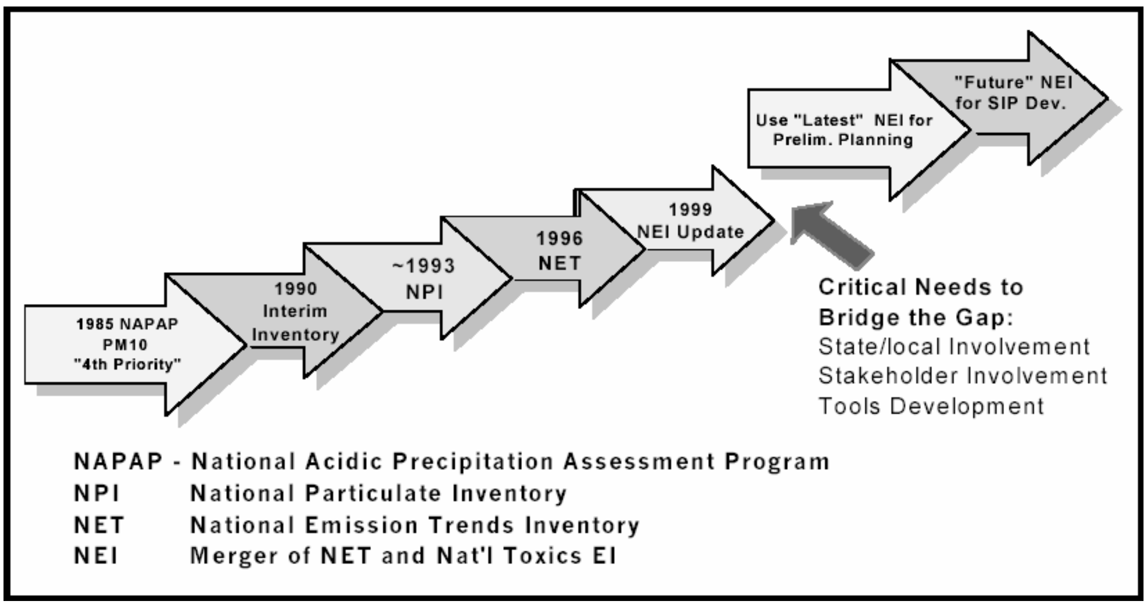

Figure 2-1 presents a timeline showing the evolution of the National Emissions Inventory (NEI). The first PM inventory in the NEI was in the 1985 National Acidic Precipitation Assessment Program (NAPAP). This inventory was for PM_{10} and it was developed without any input from the states. It has only been recently that the states have become involved in the development of the NEI for PM.

During the early 1990s there was minimal activity on developing PM inventories, although a National Particle Inventory was prepared in 1993. In 1996 it was called the

National Emissions Trends Inventory (NET). The NET was updated in 1999 and was renamed the NEI. Integration of the National Air Toxics Assessment Inventory was begun with the 1999 NEI and was completed with the 2002 NEI. Improving and updating the NEI is a continuing process.

In the 2002 NEI, some areas of the US began to include large fires as point sources. Data on when they started, when they ended, and where they were located are essential to accurately model their impact on air quality. Smaller fires may continue to be treated as area sources. These are allocated to counties using data on forested land area and emissions are assigned to months of the year using temporal allocation factors. Treating fires as point sources is important, for example, where a fire may have a major impact on a Class 1 area it could relate to the 20% worst days at that area. When fires are treated as area sources, it is impossible to know where the fire occurred or when. As a result, it is impossible to determine if the particulate matter emissions in the Class 1 area are attributable to the fire.

The process of developing the NEI begins with data on emission factors and models, various databases for source activity levels, default values for emissions related variables, existing point source data, and growth factors for source categories. This data is combined to form what is called the preliminary NEI. The preliminary NEI is provided to State and local air agencies for their refinements and improvements. Working with stakeholders and using factor and model improvements, and local activity levels and variables provided by State and local agencies, the preliminary NEI is transformed into the improved NEI. This process is repeated yearly, but emphasized every three years.

2.2 INVENTORY PREPARATION TOOLS

2.2.1 Introduction

One of the tools used to prepare the NEI is the Factor Information and Retrieval database (FIRE), which is available at www.epa.gov/ttn/chief. There are about 20,000 emission factors in this database that are used in developing the NEI. However, since industrial processes vary over time and from facility to facility, there are representativeness issues with many of these factors.

Another inventory preparation tool is process-based emission models. TANKS is an example of a model that is used for estimating storage tank emissions of VOCs. The NONROAD model is used to estimate emissions from non-road vehicles and BEIS is used to estimate biogenic emissions.

Other tools include special characterization and locator aids such as GIS (Geographic Information Systems) and global positioning systems (GPS). Satellites are beginning to be used to locate fires, especially in Mexico and Canada. It should be noted that there are some severe limitations in using satellites to locate certain fires, such as those that are below a certain size or through cloud cover, for instance.

2.2.2 Emissions Processors

The purpose of an emissions processor is to provide an efficient tool for converting emissions inventory data into the formatted emission files required by an air quality dispersion model.

After the NEI emissions data is developed it goes into an emissions processor such as SMOKE (Sparse Matrix Operator Kernel Emissions) modeling system. Speciation factors are applied to the emissions data by the SMOKE emissions processor. These steps happen to the inventory after the NEI, and it is something that is generally performed when the inventory is to be used by air quality dispersion modelers. It is important to recognize that emissions modeling depends on speciation factors, temporalization factors, and species allocation factors. The data flow is from the NEI to the emissions processor and then into the air quality model. The output of the emissions processor is a gridded, hourly emissions file speciated into elemental carbon, organics, primary sulfates, and primary nitrates. It should be noted that the speciated inventory data is especially useful in modeling for regional haze. For example, carbon particles absorb and scatter light with a different efficiency than other particles, such as sulfate particles. As a result, it is necessary to consider different types of particles separately when doing regional haze work.

Area source data is input to the emissions processor as an annual county level inventory and point source data is input as annual data, located by latitude and longitude. CEM data feeds into the emission processor separately through a CEM database. The emissions processor contains default factors and profiles, including county to grid allocation factors, temporal allocation profiles, and speciation profiles. Using this data, the emissions processor turns the annual, (sometimes) county level inventory into a gridded, hourly emission file speciated into EC, POA, Primary SO4, Primary Nitrate and Other, which contains crustal materials/fugitive dust and unidentified species. It is then ready to be used as input to a dispersion model.

The emissions processor assigns all of the $PM_{2.5}$ sources to one of several dozen speciation profiles. Note that elemental carbon and the primary organic aerosols are derived within the emission processor from $PM_{2.5}$ data using speciation profiles. As such, they are not part of the NEI inventory.

There are some issues with compiling a carbon inventory. The split between elemental carbon and primary organic aerosols is subject to some analytical uncertainties and there are a lot of questions about how to do that type of analysis. It is an operational definition of what to call elemental carbon and what to call organic carbon when doing those analyses. Also these analyses provide data for organic carbon, not the organic carbonaceous matter that accounts for all the oxygens and hydrogens. As mentioned in Section 1, it is necessary to use a multiplier or a compound adjustment to go from organic carbon to primary organic aerosols.

2.2.3 Processed-based Emission Models

There is another set of tools becoming available called process-based emission models. Process-based models consider spatially and temporally available activity parameters as a part of the emissions estimation in an effort to reflect real world conditions like wind, temperature, relative humidity, vegetation type, soil type, moisture, etc. For example, these models will eventually include algorithms to develop a wind-blown dust inventory by examining the wind fields for the whole modeling domain and deciding when the wind is going to blow fast enough to create dust emissions. Other examples are a model under development to estimate fire emissions by taking into account such factors as relative humidity, moisture, and wind speed and a fugitive dust, model.

These models would have to links to various databases such as MM5, the meteorological data processor. They would also be linked to GIS coverages of soil and vegetation types, and would contain emission algorithms responsive to these variables. Currently there are several models containing some aspects of process-based emission models. These include the MOBILE 6 model and the BEIS 3 model because they take temperature into account. Consideration of temperature is critical for estimating biogenic emissions.

There are a number of other needs for process-based emission models. Some examples include estimating emissions of ammonia and residential wood burning. In the future, some of these process-based models will be integrated with the emissions processor and some will be stand-alone. Currently, the biogenics model (BEIS) is always integrated with the emissions processor. The onroad model MOBILE 6 can optionally be integrated with the emissions processor. The development of process-based emissions models for ammonia, fugitive dust and wildland fires are currently underway.

2.2.3.1 Wildland Fires Model

The inputs for the wildland fire model include fire locations, duration, and size. This model will access meteorological data for wind speed and moisture and uses fuel-loading defaults from a one-kilometer resolved national map of fuel loadings. Although a fuel map currently exists (e.g., NFDRS) there is a project currently being funded to develop a map that will provide better fuel-loading data. Fuel moistures are calculated using the MM5 data. Fuel consumption will be done using CONSUME or the First Order Fire Effects Model (FOFEM) for fuel consumption. The emissions projection model, together with the Briggs' Plume Rise equation modified for fires calculates emissions, heat release, and plume rise. When it is completed, this emissions module will provide gridded, hourly emissions and plume characteristics that will take into account the real world meteorological conditions that would effect fire behavior and emissions.

2.2.3.2 Fugitive Dust Model

Another model that is currently under development is a fugitive dust model. The approach for developing a fugitive dust model is to establish a consistent database of resource information such as soil, land use, vegetation, moisture, precipitation, and wind speed that can be used to estimate emissions for use with grid models. Currently, a proof of concept of this emission model is being demonstrated for wind-erosion, unpaved roads, construction, and other dust sources.

2.2.4 Receptor Models

Receptor modeling is an important toolset that can be used in the development of an emissions inventory. An estimate of the amount of fossil versus contemporary carbon can be obtained by using radiocarbon analysis. Some receptor models can use specific tracers for gas versus diesel particles by looking at the specific organic compounds that make up those particles and identifying whether those carbon particles are emitted from gas or diesel engines and also whether they are emitted from cold starts or smokers. Other tracers (or groups of tracers, called source profiles) are available for a variety of source types. One model commonly used is the Chemical Mass Balance, a dedicated weighted least squares model to infer source contribution estimates from ambient speciated data and source profiles. Multivariate models are the Positive Matrix Factorization (PMF) model and UNMIX, which is somewhat similar to PMF.

2.3 OTHER NEEDS

There are a number of specific $PM_{2.5}$ categories that generally need better emissions models and emissions data. Some of these categories include wildland, forest and rangeland burning, particularly private and state and tribal burners. For these categories, data on acreage burned, fuel loadings for the largest fires, and the timing of those fires is needed.

Other source categories that need better emissions data include:

- Residential open burning, household waste, and yard waste. For these categories, data on the volumes, burning practices, regulations and their effectiveness, and local surveys of burn activities are needed.
- Construction debris and logging slash. Data on the regulations and their effectiveness, including local surveys of burn activities, is needed.
- Agricultural field burning is another source category and data on acreages, fuel loadings, and timing of the burn events is needed.
- Residential wood combustion, fireplaces and wood stoves. Data from local surveys of fuel burn is needed. This includes data on whether the wood is being burned in a fireplace or a wood stoves.
- Area-specific industrial process sources are another category for which better data are needed. However, since these source constitute a small percentage of the industrial process sources, it is important to pick those sources that have the biggest errors associated with them.

Finally, data on local conditions contributing to fugitive dust are needed in some cases.

Review Exercises

1. Which of the following was the first particulate matter inventory in the NEI?
   a. National Acidic Precipitation Assessment Program
   b. National Particle Inventory
   c. National Emissions Trends Inventory
   d. None of the above

2. Which of the following best describes how large fires are **currently** handled in the NEI?
   a. Large fires are treated as point sources.
   b. Large fires are treated as area sources.
   c. Large fires are not currently included in the NEI.
   d. Large fire emissions are allocated seasonally across the entire state.

3. Which of the following is **not** an example of an existing emissions inventory preparation tool?
   a. FIRE
   b. TANKS
   c. BIES3
   d. NET

4. _______ models apply space and time sensitivities to emissions.
   a. Receptor
   b. Grid
   c. Process-based emission
   d. Photochemical dispersion

5. Which of the following best describes the emissions data that is the output of an emissions processor?
   a. Unspeciated annual averages
   b. Speciated hourly averages
   c. Speciated annual averages
   d. Unspeciated hourly averages

6. Process-based emission models are needed for estimating emissions from _______.
   a. ammonia sources
   b. fugitive dust
   c. wildland fires
   d. All of the above

7. Which of the following is **not** an input that would be needed for a process-based emissions model for wildland fires?
   a. Fire location
   b. Fire temperature
   c. Size of the fire
   d. Fuel loading

8. _______ models can identify the source of an emission.
   a. Receptor
   b. Grid
   c. Process-based emission
   d. Photochemical

9. Efforts to develop data for _______ sources should be limited to those sources that have the biggest errors associated with them.
   a. mobile
   b. open burning
   c. specific industrial processes
   d. fugitive dust

Review Answers

1. a. National Acidic Precipitation Assessment Program

2. b. Large fires are treated as area sources.

3. d. NET (National Emissions Trends Inventory)

4. c. Process-based emission

5. b. Speciated hourly averages

6. d. All of the above

7. b. Fire temperature

8. a. Receptor

9. c. specific industrial processes

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