



**Asia-Pacific  
Economic Cooperation**

**Best Practices in Environmental Monitoring  
for Coal-Fired Power Plants: Lessons for  
Developing Asian APEC Economies**

**APEC Energy Working Group  
Expert Group on Clean Fossil Energy**

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## **Chapter 1. OVERVIEW**

### **1.1 Introduction**

The objective of this study is to assess best practices for environmental monitoring of air emissions, water, and solid waste from coal-fired power plants in developed economies and based on this provide recommendations for how developing Asian economies could strengthen their environmental monitoring frameworks.

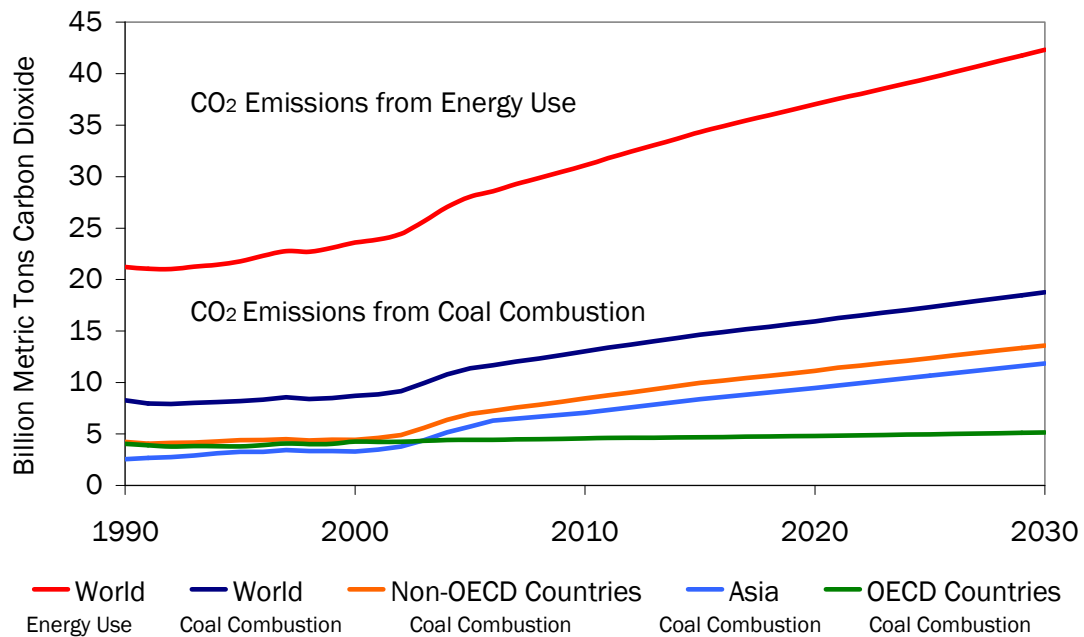
Developing Asian economies continue to introduce and strengthen environmental regulations and monitoring for coal-fired power, focusing on efforts to limit conventional air pollutants, water effluents, and coal waste. These regulations rely mostly on emission limits and effluent standards to control pollution from existing and new coal-fired power plants, but some economies such as China augment their regulations with specific plant size, combustion technology, and environmental control standards.

The standards imposed in developing Asia Pacific Economic Cooperation (APEC) economies are beginning to influence the use of environmental controls at new and existing capacity, but, except for China, they have not led to significant improvement in the use of more efficient combustion technology. China is now deploying supercritical technology at most of its new power plants and is in the process of building ultra-supercritical power plants. The switch has been initiated out of concern for energy security, in addition to the concern for the environment.

Even though the use of environmental controls has increased, local air pollution and carbon dioxide emissions are growing. Many of developing Asia's cities are still among the world's most polluted and according to the U.S. Energy Information Administration (EIA), non-OECD Asian economies emitted just over half of the total 12 billion metric tons of global carbon dioxide (CO<sub>2</sub>) emissions from coal combustion in 2006 (Figure 1).<sup>1</sup> EIA projects that this proportion will increase to approximately 63% by 2030, with non-OECD Asian economies emitting over 11.8 billion metric tons of CO<sub>2</sub> from coal-fired power plants.<sup>2,3</sup> A large share of the growing emissions will come from coal-fired power plants that are still in the planning stages.

Some of the reason for the continued growth in air pollution stems from the weak monitoring and enforcement frameworks in the region. Asian APEC economies such as Japan and Thailand are on a par with developed nations with respect to regulating and monitoring emissions while other Asian economies, such as China, Indonesia, the Philippines, and Viet Nam have significant room for improvement. In the latter economies, technical monitoring standards are weak, maintenance requirements are not sufficient, the market for continuous emissions monitoring equipment is not standardized, and data is not yet tracked in public inventories that facilitate review and analysis of reported data.

**Figure 1.1 World CO<sub>2</sub> Emissions from Energy Use and Coal Combustion**



Source: EIA International Energy Outlook 2008

Moreover, even though national governments have continued to improve their regulatory and monitoring guidelines, the implementation is sometimes lacking. In many of Asian economies, economic growth is creating immense pressure to expand energy supplies. Demand for electricity continues to be greater than supply creating fierce competition for scarce financial resources and often requiring that existing units are kept on-line and that environmental objectives are overlooked. Although some plants may install monitoring and control systems, they will find them costly and relatively cumbersome to maintain and this will drain both manpower and costs leaving compliant sources at a disadvantage compared to non-compliant sources. For example, many facilities in China have adopted continuous emissions monitoring technology, but the data is not always used or the results may be overlooked because local officials do not always incorporate CEMS monitored data into the calculation of pollutant fees. Other economies lack inspectors to ensure that the monitored data is reported accurately.

Effective monitoring and compliance mechanisms are necessary to ensure that environmental regulations have their intended impact on emissions and discharges. If monitoring is weak, it is harder to determine which plants should be rehabilitated or retrofitted with new technology. Lack of good data also makes it difficult to determine whether current standards are sufficient or whether they should be strengthened specifically for coal-fired power plants versus other industrial sources. A move towards increased measurement and monitoring in developing Asian economies would make it easier for national and local governments to evaluate environmental areas of concern and produce more effective national and regional policies. Better monitoring equipment and procedures at plants would also be beneficial for plant operators, particularly for identify improvements to operating procedures and thermal efficiency. Such improvements could lead to significant energy cost savings. Finally, the absence of good data may further erode public confidence that plants are getting cleaner thus making it even harder to site new coal-fired power plants in the region.

To provide developing Asian APEC economies with a practical tool to use while they work improve their environmental monitoring frameworks, the APEC Expert Group on Clean Fossil Energy conceived this report. It provides best practice examples on how to design and implement monitoring guidance for air emissions, water effluents, and waste based on how monitoring is implemented in developed economies which use a lot of coal. This includes an overview of monitoring guidance in Australia, Canada, the European Union (EU), and the United States (US). We also discuss the emerging monitoring frameworks in China, Indonesia, the Philippines, Thailand, and Viet Nam in order to develop recommendations for how to best strengthen these.

The report details the actual types of monitoring practices employed in Australia, Canada, the EU, and the US, as well as the regulations and objectives they are intended to support. We used this approach because, in many cases, the technologies to monitor emissions are somewhat uniform across economies, while the methods/practices to characterize, quantify, and report the emissions can vary quite a bit based on what the regulations were designed to achieve. As a result, developing Asian economies should consider not just the monitoring practices and regulations in developed economies, but also the structure which connects the two, (i.e., the entire monitoring framework), as they work to establish and/or improve their monitoring efforts.

Monitoring practices and regulations in Australia, Canada, the EU, and the US are covered in three chapters. They are:

- *Chapter 2 - Air Emissions*: Sulfur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), and Particulate matter (PM);<sup>4</sup> mercury (Hg); and carbon dioxide (CO<sub>2</sub>)
- *Chapter 3 - Water*: Effluents of biological and/or chemical substances; the effluent of heat (thermal pollution); and consumption (including issues of impingement and entrainment)
- *Chapter 4 - Solid Waste*: Chemical effluents; storage; landfill leachate; and recycling.

Environmental regulations in developing Asian economies are covered in the next two chapters. They are:

- *Chapter 5 - China*: Environmental regulations and monitoring practices for local air pollutants (SO<sub>2</sub>, NO<sub>x</sub>, and PM) water effluents, and coal waste.
- *Chapter 6 – Other Developing Asian Economies*: Environmental regulations and monitoring practices for local air pollutants, water effluents, and coal waste in Indonesia, the Philippines, Thailand, and Viet Nam.

Chapters 2, 3 and 4 give an overview of the relationship between monitoring and regulation and provide detailed information on many of the practices in place in Australia, Canada, the EU and the US. However, due to the extensive regulations in each economy/region, the chapters do not comprehensively cover all issues pertaining to monitoring of air, water and solid waste emissions.



For air emissions, where there are a significant number of detailed regulations and corresponding monitoring guidance,<sup>5</sup> we summarize practices in Australia, Canada, the EU and the US. For the EU and the US, we look exclusively at actions at the EU-wide and federal level, respectively. In a number of instances, we explain the general relationship between these practices and monitoring activities in EU Member States/US States. Where applicable and useful, we also highlight specific practices in the Australian State of New South Wales (NSW) and the Canadian Province of Alberta.

For water and waste monitoring, we focus exclusively on US federal level and EU-wide efforts. This approach was devised for three reasons:

1. Generally, both the EU and the US have stricter and/or more detailed regulations than those in Canada and Australia;
2. Comparing the US and the EU practices directly tends to more clearly highlight the different approaches toward monitoring than can be readily derived from a comparison including Australian and Canadian efforts; and
3. A number of developing Asian APEC economies have used EU and US approaches as a basis for establishing their own standards and monitoring practices.

In general, for all the developing APEC economies examined, the monitoring rules for air emissions are much further developed than those for water and waste management, and all the economies continue to struggle with enforcement. Because of such weaknesses in the monitoring framework of Asian economies, the effectiveness of existing and new environmental regulations for coal-fired power is compromised and is likely to delay the introduction of new clean coal technologies.

Finally, we note that while we have tried to include as much relevant information as possible in this report, the information presented does not comprehensively cover all regulations and monitoring practices in the selected economies. In developing Asian economies, for example, there was limited information available in English, particularly in the case of monitoring practices for water and coal waste. Moreover, although a lot of monitoring guidance is developed and implemented at the local level, a complete analysis of state and local monitoring plans in the US and other economies is beyond the scope of this report. Finally, we only focus on emissions that are due to normal operation of coal-fired power plants, as opposed to accidental releases. While many of the monitoring options described are generally applicable to these situations as well, issues of monitoring frequency and follow-up monitoring activities may/will vary based on the nature of the unintended release.

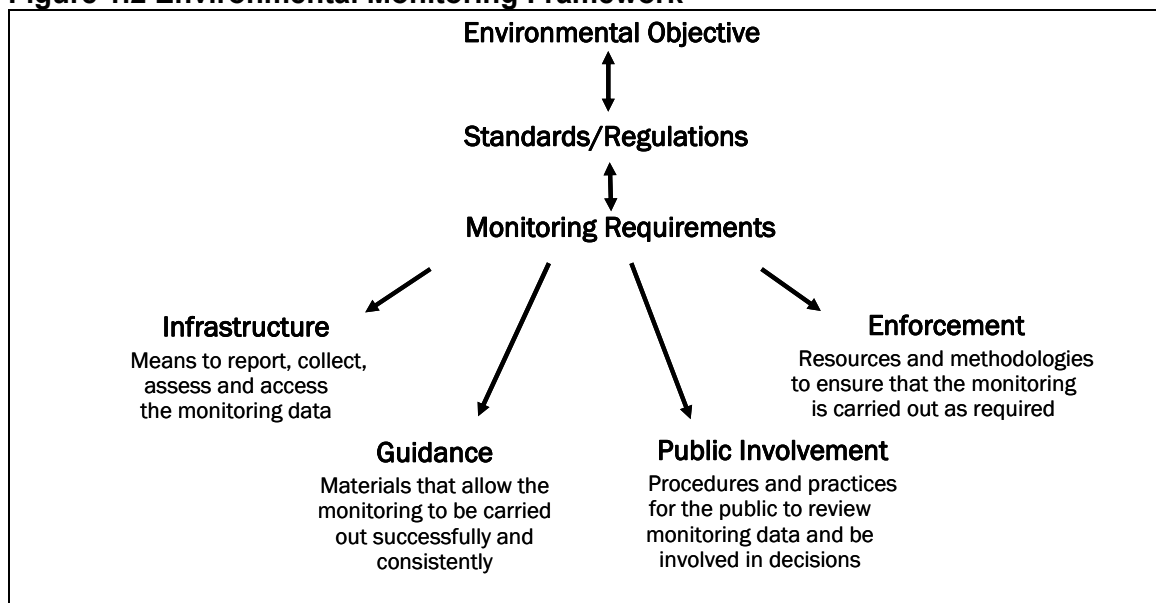
## **1.2 Monitoring Overview**

Monitoring is the systematic collection of physical, chemical and/or biological data,<sup>6</sup> while a monitoring framework is the network of regulations and technical methodologies that assist economies in meeting their environmental objectives. This includes meeting the environmental objectives as a whole and for specific sources, such as coal-fired power plants. For the latter case, the monitoring framework ideally serves to ensure that source-specific requirements are properly set up and

implemented in such a way that allows them to meet broader environmental objectives.

Figure 1.2 illustrates the relationship between environmental objectives, regulations, and monitoring. Economies typically tailor the specific monitoring steps to specific environmental objectives and regulations. For example, US regulators determined that continuous emissions monitoring would be necessary in order to effectively support emissions trading for SO<sub>2</sub> and NO<sub>x</sub>. Other economies, which instead rely on technology and emission limits to regulate those pollutants, offer more flexibility in the monitoring methods used.

**Figure 1.2 Environmental Monitoring Framework**



An effective monitoring regime can also be used to measure progress towards meeting stated regulations and objectives. For example, if monitored data is collected at the regional and national level and published in a pollutant inventory, the data can be used for determining whether existing standards are sufficient or need to be modified and strengthened. Without adequate monitoring data, development of effective standards can sometimes be difficult. For example, the EU did not have an inventory of greenhouse gas (GHG) emissions from major facilities when it completed the allowance allocation for the Pilot Phase of the EU Emissions Trading Scheme (EU ETS). As a result, once the program had started, it became clear that the EU had over-allocated allowances and the allowance price quickly fell below one Euro.

The types of monitoring utilized are generally most clearly related to the nature of the standard/regulation. Possible legislative formats that directly apply to pollutant sources and influence the resulting monitoring requirements include:

- *Emission Standards/Limits/Caps*: Simple fixed limit values for a source or source type.
- *Emissions Performance Standards*: Regulations that incorporate output-based controls linked to electricity production.

- *Efficiency Standards*: Based on the efficiency of the coal-combustion process (i.e., the boiler and turbine). The standard could be set in terms of the power plant's thermal efficiency or heat rate.
- *Technology Standards*: Ensures that emissions are continually reduced as new and improved control technologies come onto the market. Best Available Technology (BAT) is the EU term, while in the US it's called Maximum Achievable Control Technology (MACT).
- *Fines, Taxes and Levies*: A common way of penalizing sources for non-compliance and/or incentivizing adoption of costly control technologies.
- *Emissions Trading*: An administrative approach used to control pollution by providing economic incentives for achieving reductions in the emissions of pollutants. It is based on the principle that any increase in emissions must be offset by a decrease of an equivalent, or sometimes greater, quantity of emissions. Cap and trade, rate-based trading and project-based trading are three forms of emissions trading.
- *Inventories*: Mandated, public reporting from a source that exceeds defined thresholds for specified substances.

In a prior study, APEC reviewed all of the possible formats for environmental regulations and provided recommendations for how to strengthen these in developing Asian economies. For additional information on the recommended standards and regulations, please see the APEC 2007 report titled *How Can Environmental Regulations Promote Clean Coal Technology Adoption in APEC Developing Economies?*<sup>7</sup>

#### *Components of a Monitoring Framework*

As illustrated in Figure 1.2, the specific monitoring requirements are generally products of the overall monitoring framework used in a economy/region. Therefore, when establishing monitoring requirements legislators will likely consider a number of broad issues. The typical elements include:

- *The Environmental Objective*: The ultimate goal that the standards/regulations and monitoring activities are intended to achieve.
- *The Standards/Regulations*: Prescribed mandatory or voluntary restrictions designed to meet the environmental objective.
- *Characterizing Intent*: The expected relationship between the standards/regulations, monitoring activity and environmental objective.

Once regulators have determined the overall goals of the monitoring process, they can begin drafting the specific requirements of the monitoring framework. An integral component of a successful monitoring framework is the supporting infrastructure for implementing it. This includes procedures for reporting monitored data, detailed guidance for carrying out monitoring activities, resources for enforcement, and a mechanism for public participation and evaluation. A successful framework must be based on the following elements:

- *Establishing Monitoring Requirements*: Specifications for systematically collecting and analyzing data, including the types of equipment to be used, as well as certification, calculation, QA/QC, sampling, and analytical procedures.

- *Building Infrastructure*: Means to report, collect, assess and access the monitoring data.
- *Drafting Guidance*: Relevant materials, including methodologies and other information, that allow the monitoring activity to be carried out successfully and consistently.
- *Ensuring Enforcement*: Resources and methodologies to ensure monitoring is carried out correctly, consistently, and as required.
- *Securing Public Involvement*: Procedures and practices for the public to review monitoring data and be involved in regulation and/or monitoring-related decisions.

A comprehensive monitoring framework requires activities that verify that all monitoring is being performed as required. In this report, we classify these types of monitoring efforts, and their corresponding regulations, using four specific terms:

- *Indirect Actions*: Activities aimed at achieving specific objectives for areas, such as a city, locality, state or nation, that have consequences for coal-fired power plants, but do not prescribe regulations and monitoring requirements that apply to individual plants. This normally involves monitoring to assess compliance with national ambient air quality standards.
- *Direct Actions*: Practices that involve regulations and monitoring of emissions from individual sources, which for this report are coal-fired power plants. Examples include direct sampling or continuous monitoring at the stack.
- *Semi-Direct Actions*: Measures taken in the vicinity of coal-fired power plants in order to assess how individual plants are affecting the achievement of specific environmental objectives for areas.
- *Oversight Actions*: Means to ensure that direct and/or indirect activities are being effectively carried out.

When implemented correctly, these four activities collectively allow economies to comprehensively monitor coal-fired power plants. For example, in the US standards for emissions of air pollutants, such as SO<sub>2</sub>, NO<sub>x</sub> and PM that directly apply to coal-fired power plants were set up to meet National Ambient Air Quality Standards (NAAQS). Therefore, the limits for coal-fired power plants are as strict as they need to be to meet the overall goal, but can vary by State based on whether the NAAQS is being met or not. This setup requires both ambient and plant-specific monitoring data, as well as methods to assess compliance with data collection and reporting requirements. While air emissions from sources are not a direct indicator of ambient air quality, the ambient data provides general, indirect oversight of power plant emissions and the plant-specific data helps to determine how these sources are contributing to ambient concentrations.

Indirect legislative formats that affect sources typically take the form of emission standards/limit/caps that apply to a defined boundary that contains both a given power plant and other emissions sources. In terms of air emissions, they are generally referred to as ambient air quality standards. For water emissions, they usually refer to

conditions for specific bodies of water, such as overall limit values for chemical and biological substances.

In many cases, these tools are used in combination to meet desired environmental objectives. As an example of how regulations and monitoring practices are linked, we take the case of emissions cap and trade programs, such as for SO<sub>2</sub> trading under the US Acid Rain Program (ARP). Since emission allowances are based on the total mass of pollutant emitted over a certain period of time, emissions must be monitored continuously in order for the program to achieve its goal of delivering actual, measurable emissions reductions in a cost-effective manner.<sup>8</sup> A more detailed explanation of the types of monitoring practices used to monitor air, water and waste emissions is described in the section below.

### **1.3 Summary of Regulations and Monitoring Best Practices**

In this section, we summarize overall trends in regulations and their corresponding monitoring best practices for air emissions in Australia, Canada, the EU and the US. As applicable, we also summarize this information for the Australian State of New South Wales (NSW) and the Canadian Province of Alberta. We then cover water and, finally, waste emissions, where, in both cases, we focus exclusively on regulations and corresponding monitoring practices in the US and the EU.

Based on the information we were able to gather from developed Asian economies, we have also summarized their progress towards developing monitoring guidance in these three areas.

#### **1.3.1 Air Emissions**

In this report, we focus on five major substances emitted to the air from coal fired power plants. First we will examine monitoring practices for the criteria air pollutants: SO<sub>2</sub>, NO<sub>x</sub> and PM. Then we investigate methods for monitoring Hg and CO<sub>2</sub>.

##### **1.3.1.1 Sulfur Dioxide (SO<sub>2</sub>), Nitrogen Oxides (NO<sub>x</sub>), and Particulate Matter (PM)**

SO<sub>2</sub> and NO<sub>x</sub> are pollutants that adversely affect air quality, the environment and public health. Furthermore, they are the principal pollutants that cause acid rain. When released into the air, they react with water vapor and other chemicals to form acids that fall back to earth, leading to damage to lakes and streams.<sup>9</sup> Over 65% of SO<sub>2</sub> released to the air, or more than 13 million tons per year, comes from electric utilities, especially those that burn coal.<sup>10</sup> Electric utilities are a substantial source of NO<sub>x</sub>, accounting for 22% of total manmade NO<sub>x</sub> in 2003.<sup>11</sup>

PM, also known as particle pollution, is a complex mixture of extremely small particles and liquid droplets.<sup>12</sup> PM is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles. Inhalable particulates, often referred to as PM<sub>10</sub>, are particulate matter less than 10 micrometres (µm) in diameter that can be inhaled into the nose and throat.<sup>13</sup> Respirable particulates, or PM<sub>2.5</sub>, are particulate matter less than 2.5 micrometres in diameter, a size small enough to penetrate into the lungs. Both PM<sub>10</sub> and PM<sub>2.5</sub> arise from industrial processes such as electricity generation from combustion plants.

## Indirect Activities

Indirect monitoring for air pollutants typically involves monitoring to meet ambient air quality standards.

### *Ambient Air Quality*<sup>14</sup>

Australia, the EU and the US have all set ambient air quality standards for SO<sub>2</sub>, nitrogen dioxide (NO<sub>2</sub>)<sup>15</sup> and PM<sub>10</sub> through regulation. Canada has set national goals for ambient air quality. In Australia, the EU and the US, relatively similar requirements exist for monitoring ambient air quality. The requirements include designating responsibility for monitoring at the economy and state levels (as applicable), establishing acceptable monitoring and reporting methods, and setting requirements for the location and number of monitoring stations. Table 1.1 summarizes the monitoring parameters for national ambient air quality used in Australia, Canada, the EU, and the US.

**Table 1.1 National Ambient Air Quality Standards in the Australia, Canada, the EU and the US**

Pollutant	Country	Standard/ Goal	Averaging Period	Maximum Concentration
Nitrogen dioxide	Australia	Standard	1 hour 1 year	0.12 ppm 0.03 ppm
Nitrogen dioxide	Canada	Goal <sup>a</sup>	annual 24 hours 1 hour	53 ppb 106 ppb 213 ppb
Nitrogen dioxide	EU	Standard <sup>b</sup>	1 hour 1 year	200 µg/m <sup>3</sup> 40 µg/m <sup>3</sup>
Nitrogen dioxide	US	Standard	annual (arithmetic mean)	0.053 ppm <sup>c</sup> (100 µg/m <sup>3</sup> ) <sup>c</sup>
Sulfur dioxide	Australia	Standard	1 hour 1 day 1 year	0.20 ppm 0.08 ppm 0.02 ppm
Sulfur dioxide	Canada	Goal <sup>d</sup>	annual 24 hours 1 hour	23 ppb 115 ppb 334 ppb
Sulfur dioxide	EU	Standard <sup>e</sup>	1 hour 24 hours	350 µg/m <sup>3</sup> 125 µg/m <sup>3</sup>
Sulfur dioxide	US	Standard	annual (arithmetic mean) 24-hour <sup>f</sup> 3-hour <sup>f</sup>	0.03 ppm <sup>c</sup> 0.14 ppm <sup>c</sup> 0.5 ppm <sup>g</sup> (1300 µg/m <sup>3</sup> ) <sup>g</sup>
PM <sub>10</sub>	Australia	Standard	1 day	50 µg/m <sup>3</sup>
Total Suspended Particulate	Canada	Goal <sup>h</sup>	annual 24 hours	70 µg/m <sup>3</sup> 120 µg/m <sup>3</sup>
PM <sub>10</sub>	EU	Standard <sup>i</sup>	24 hours 1 year	50 µg/m <sup>3</sup> 40 µg/m <sup>3</sup>
PM <sub>10</sub>	US	Standard	24-hour <sup>j</sup>	150 µg/m <sup>3</sup> <sup>c</sup>
PM <sub>2.5</sub>	Australia	Advisory Reporting Standard <sup>k</sup>	1 day 1 year	25 µg/m <sup>3</sup> 8 µg/m <sup>3</sup>
PM <sub>2.5</sub>	EU	Standard	1 year	25 µg/m <sup>3</sup>
PM <sub>2.5</sub>	US	Standard	annual (arithmetic mean) <sup>l</sup> 24-hour <sup>m</sup>	15.0 µg/m <sup>3</sup> <sup>c</sup> 35 µg/m <sup>3</sup> <sup>c</sup>

Australia, Canada, the EU and the US are at different stages with respect to setting and implementing PM<sub>2.5</sub> standards. The US was the first to set standards in 1997 and the EU set a standard in 2007. Australia has set an advisory reporting standard and Canada has announced a target. Monitoring is underway to different degrees throughout Australia and the U.S., with the latter requiring areas that are not meeting the standard (called nonattainment areas) to demonstrate that they are adopting all reasonably achievable control measures (RACM) to meet the standard as expeditiously as possible. No monitoring requirements have been established for the EU standard or the Canadian target.

The developed Asian economies examined in this report all have national ambient air quality standards in place for SO<sub>2</sub>, NO<sub>2</sub> and PM<sub>10</sub>, but do not track PM<sub>2.5</sub>. They have also established requirements for monitoring progress towards these, including designating responsibility for monitoring at the national and local levels and establishing acceptable monitoring and reporting methods.

However, in some economies, the air quality monitoring frameworks could be improved to provide more accurate information on the contribution of individual sources. The Chinese air quality monitoring system, for example, is at a relatively early development stage. At the present time, many of its local and regional monitoring systems cannot separate the impact of different sources of pollution. In particular, it cannot separate urban pollution from the pollution contributed by transboundary or major industrial sources, such coal-fired power plants.<sup>16</sup> This is because ambient air quality monitoring stations are typically designed to measure only one of the following sources of pollution:

- Urban pollution (i.e., households, commercial buildings, automobiles, small industry);
- Transboundary pollution (i.e., background pollution); and
- Pollution from major sources (i.e., large industrial facilities and power plants).

In developed economies, this is usually not a problem because most of the large industrial sources and power plants are located outside urban centers. However, in China, power plants are often located in the middle of urban areas. Because monitoring stations can only track one type of pollutant at a time, stations located in urban areas in China cannot always provide an accurate measurement of the contribution from an individual power plant versus that of other urban sources.

As a result, local and provincial authorities do not have sufficient information to determine whether targeted pollution reduction measures are effective at meeting their objectives. This became an issue when authorities wanted to reduce air pollution prior to the 2008 Beijing Olympics. Because the authorities did not know the specific contribution of individual industrial, power generation, and transportation sources, they did not know to what extent they needed to shut down plants and/or reduce traffic. Instead, operations were shut down based on estimates of their expected impact, and it was not until right before the opening of the Olympics that it became clear whether the selected strategies were sufficient and whether adjustments should be made.

## Semi-Direct Activities

In a few cases, including in Alberta, Canada, New South Wales, Australia and under a specific US Clean Air Act (CAA) program,<sup>17</sup> an assessment of the air quality in the vicinity of a power plant may be (or is) required. This may involve monitoring and/or dispersion modeling to estimate the impact of the plant prior to and after it enters into operation. This is done to distinguish the contribution of the power plant from other urban and transboundary pollution and determine whether it would lead to exceeding the local air quality standards. Each source typically requires at least 3 monitoring stations to determine changes upwind and downwind of the prevailing wind direction.

In the Canadian province of Alberta, ambient air monitoring in the vicinity of a power plant may be required by Regional Approvals staff.<sup>18</sup> This may involve monitoring along the perimeter of the power plant boundary for specified periods or continuously at a permanent station. In New South Wales, Australia, in order to demonstrate acceptable impacts of the sensitive receptors surrounding the premises of the plant under the POEO 2002 Regulation, an air quality impact assessment, as specified in the *Approved Methods for the Modeling and Assessment of Air Pollutants in New South Wales*,<sup>19</sup> is required. Finally, in the US the New Source Review (NSR) Prevention of Significant Deterioration (PSD) permits<sup>20</sup> require an air quality analysis, which generally include an assessment of existing air quality (possibly including ambient monitoring data and air quality dispersion modeling results); and predictions, using dispersion modeling, of ambient concentrations that will result from project.

Thailand also requires air quality monitoring in the vicinity of major plants. In the case of the Mae Moh power plant this is done to determine if there is an immediate danger of exceeding local air quality standards. None of the other developing Asian economies examined had similar requirements for monitoring in the vicinity of plants.

## Direct Activities

Direct monitoring involves activities to show that emissions regulations are met. In general, a number of monitoring options are available for generating data on air emissions (and water and waste emissions, as applicable). They are:<sup>21,22</sup>

- *Continuous Emissions Monitoring Systems (CEMS)*: Devices that record emissions over an extended, uninterrupted period.<sup>23</sup>
- *Predictive Emissions Monitoring Systems (PEMS)*: A setup that predicts emissions from process parameters (e.g. fuel usage, steam production, etc.) and ambient conditions. It consists of an emissions model and a measurement device that ensures the accuracy of the predicted data. The predictive monitoring technique may be considered a hybrid of continuous monitoring, emissions factors and stack tests.
- *Stack/Source Tests*: Collecting samples of the emissions and then determining the concentration(s) of the substance(s).
- *Mass Balance (MB)*: Applies the law of conservation of mass to a facility, process or piece of equipment. Emissions can be calculated as the difference between the input and output of each substance listed.



- *Fuel Analysis Data*: Fuel analysis can be used to predict SO<sub>2</sub> (and metals and metal compounds) based on the application of mass conservation laws.
- *Engineering Calculations/Estimates (ECs)*: Releases can be estimated by using physical and chemical properties in addition to other features of the source. Their advantage over generic emission factors (described below) is that they require facility-specific information.
- *Emission Factors (EFs)*: Generally relate the quantity of a substance emitted from a source to some common activity associated with those emissions. Emissions factors may be:
  - Published: Government agencies and industry associations publish emission factors.
  - Site Specific: Industrial facilities may develop their own emission factors.
- *Emission Models*: Known as emission estimation tools, they generally require detailed input such as equipment specifications, process and environmental conditions and other factors. Usually, these models also have default input parameters, which can be used when site-specific information is not available.

### *Data Reporting and Inventories*

Australia,<sup>24</sup> Canada<sup>25</sup> and the EU<sup>26</sup> each require sources that exceed defined thresholds of certain substances to report these emissions to national inventory programs in order to provide free, public information about substance emissions. The information is also used to evaluate progress towards meeting environmental objectives and for identifying areas that need improvement. Over the years, these national inventories have become important indicators of environmental management in each individual economy.

In Australia and Canada, SO<sub>2</sub>, NO<sub>x</sub>, PM<sub>10</sub> and PM<sub>2.5</sub> are reported annually, while in the EU only SO<sub>2</sub>, NO<sub>x</sub> and PM<sub>10</sub> are reported triennially. In the US, inventories for all four substances are compiled annually by the US EPA by means of information attained from state and local air agencies, tribes, and industry.<sup>27</sup> All economies and the EU make their inventory data public. The monitoring requirements of these economies are described further in Table 1.2.

Variations exist in the monitoring requirements for substances reported to inventories in Canada, Australia and the EU. In Australia, you can use any of the approved techniques (or mix of techniques) in order to have the data displayed with the notation of “acceptable reliability.” In Canada, you may base your data on an approved method and must describe the method used in the inventory report. In the EU, monitoring must be done by the methodology that is known/expected to result in the “best available information.” In the US, the inventory is not compiled through data submitted by the source, but rather by the US EPA from information it obtains via other regulations that require monitoring and reporting.

**Table 1.2 Monitoring for Inventories of SO<sub>2</sub>, NO<sub>x</sub> and PM**

	Australia	Canada	EU	US
<b>Inventory</b>	National Pollutant Inventory	National Pollutant Release Inventory	European Pollutant and Transfer Register	National Emissions Inventory
<b>Pollutants</b>	SO <sub>2</sub> , NO <sub>x</sub> , PM <sub>10</sub> and PM <sub>2.5</sub>	SO <sub>2</sub> , NO <sub>2</sub> , TPM, PM <sub>10</sub> and PM <sub>2.5</sub>	SO <sub>x</sub> /SO <sub>2</sub> , NO <sub>x</sub> /NO <sub>2</sub> , and PM <sub>10</sub>	SO <sub>2</sub> , NO <sub>x</sub> , PM, PM <sub>10</sub> and PM <sub>2.5</sub>
<b>Threshold</b>	Burning = 400 tonnes fuel/year; or Burning = 1 tonne or more of fuel/hour	<i>Reporting:</i> SO <sub>2</sub> , NO <sub>2</sub> and TPM – 20 tonnes, PM <sub>10</sub> – 0.5 tonnes, PM <sub>2.5</sub> – 0.3 tonnes <i>Stack Specific:</i> SO <sub>2</sub> , NO <sub>2</sub> and TPM – 5 tonnes PM <sub>10</sub> – 0.25 tonnes PM <sub>2.5</sub> – 0.15 tonnes	SO <sub>x</sub> /SO <sub>2</sub> -150,000 kg/year; NO <sub>x</sub> /NO <sub>2</sub> - 100,000 kg/year; PM <sub>10</sub> – 50,000 kg/year.	-
<b>Monitoring</b>	CEMS, Stack/Source Tests, MB, Fuel Analysis Data, ECs or EFs	CEMS, PEMS, Stack/Source Tests, MB, Engineering Estimates, EFs or Emission Models.	Direct measurements, i.e., CEMS or source/stack testing.	Info from: Surveys compiled by US DOE; US EPA's Emission Tracking System/CEMS programs; and others
<b>Frequency</b>	Annually	Annually	Triennially	Annually

China, Indonesia, the Philippines, and Viet Nam do not have public inventories for tracking local air pollutants. However, Indonesia is close to adopting a new Air Quality Act (2008) which would include the establishment of such an inventory.

#### *Source Emissions Covered by Regulations*

Australia, Canada, the EU and the US have, to different degrees and at different levels, adopted one or more standards and regulations for limiting emissions of SO<sub>2</sub>, NO<sub>x</sub>, PM, PM<sub>10</sub> and/or PM<sub>2.5</sub> directly from coal-fired power plants. The methods for monitoring compliance with these are outlined in Tables 1.3 and 1.4.

Australia has no federal emission standards for individual coal-fired power plants, but the State of New South Wales has set electricity generation standards<sup>28</sup> for total solid particles (TSP) and NO<sub>2</sub> and limits on pollutant loads<sup>29</sup> for SO<sub>x</sub>, NO<sub>x</sub>, PM<sub>10</sub>, and PM<sub>2.5</sub>. Canada provides advice on emission performance standards for SO<sub>2</sub>, NO<sub>x</sub>, and PM<sub>10</sub>,<sup>30</sup> while the Province of Alberta has standards for SO<sub>2</sub>, NO<sub>x</sub>, and primary PM.<sup>31</sup> The EU has set emission limits based on the thermal output of the fuel source for SO<sub>2</sub>, NO<sub>x</sub> and dust (PM)<sup>32</sup> and has used the integrated prevention and pollution control (IPPC) approach to set emission limits based on best available techniques.<sup>33</sup>

**Table 1.3. SO<sub>2</sub>, NO<sub>x</sub> and PM Monitoring Requirements in Australia, Canada, and the EU**

	<b>Regulations</b>	<b>Monitoring</b>
<b>Australia</b>	<ul style="list-style-type: none"> <li>• No federal standards for individual plants.</li> <li>• Standards set by each jurisdiction.</li> </ul>	<b>N/A</b>
<b>NSW, Australia</b>	<ul style="list-style-type: none"> <li>• Clean Air Regulation: Electricity Generation Standards for TSP and NO<sub>2</sub></li> </ul>	<b>CEMS</b>
	<ul style="list-style-type: none"> <li>• Load-Based Licensing Scheme: PM<sub>10</sub>, PM<sub>2.5</sub>, SO<sub>2</sub> and NO<sub>x</sub></li> </ul>	<b>CEMS/Periodic Monitoring; EFs; or MB. To monitor PM<sub>10</sub> and PM<sub>2.5</sub> with EFs requires PEMS.</b>
<b>Canada</b>	<ul style="list-style-type: none"> <li>• New Source Emission Guidelines for Thermal Electricity Generation</li> <li>• Advice on emission performance standards for SO<sub>2</sub>, NO<sub>x</sub> and PM<sub>10</sub>, as well as stack opacity limits.</li> <li>• Provinces and territories implement regulations.</li> </ul>	<b>Recommends CEMS for measuring SO<sub>2</sub>, NO<sub>x</sub> and opacity on each new coal-fired unit.</b>
<b>Alberta, Canada</b>	<ul style="list-style-type: none"> <li>• Emission performance standards for SO<sub>2</sub>, NO<sub>x</sub> and primary PM.</li> </ul>	<b>CEMS required on the stack for SO<sub>2</sub>, NO<sub>x</sub>, in-stack opacity and other parameters necessary to determine mass emissions.</b>
<b>EU</b>	<ul style="list-style-type: none"> <li>• LCP Directive</li> <li>• Limits for SO<sub>2</sub>, NO<sub>x</sub> and dust (PM) based on thermal output of the fuel source.</li> </ul>	<b>For plants with a rated thermal input of &gt; 100 MW, CEMS is required for SO<sub>2</sub>, NO<sub>x</sub> and dust (since Nov. 2002).</b>
	<ul style="list-style-type: none"> <li>• IPPC Directive</li> <li>• Permits conditions, including limits for SO<sub>2</sub>, NO<sub>x</sub> and dust, based on BAT.</li> </ul>	<b>Specific in permit.</b>

**Table 1.4 SO<sub>2</sub>, NO<sub>x</sub> and PM Monitoring Requirements of the US Clean Air Act**

<b>Regulation</b>	<b>Regulation Requirements</b>	<b>Monitoring Requirements</b>
<b>New Source Performance Standards</b>	<ul style="list-style-type: none"> <li>• Technology based standards covering SO<sub>2</sub>, NO<sub>x</sub>, as NO<sub>2</sub>, TSP, PM<sub>10</sub> and opacity for new, modified and reconstructed affected facilities.</li> </ul>	<b>Requires CEMS for SO<sub>2</sub>, NO<sub>x</sub> and opacity.</b>
<b>New Source Review</b>	<ul style="list-style-type: none"> <li>• Facilities must get a permit before they begin construction.</li> <li>• Specifies emissions limits for SO<sub>2</sub>, NO<sub>x</sub> as NO<sub>2</sub>, TSP, PM<sub>10</sub> and opacity.</li> </ul>	<b>Specified in permit.</b>
<b>Operating Permits</b>	<ul style="list-style-type: none"> <li>• All major sources must obtain an operating permit, which includes emissions limits.</li> </ul>	<b>Monitoring, record keeping, and reporting requirements specified in permit.</b>
<b>Acid Rain Program</b>	<ul style="list-style-type: none"> <li>• First cap and trade program; Covers SO<sub>2</sub> and includes NO<sub>x</sub>.</li> <li>• Affected plants must have a permit specifying the SO<sub>2</sub> allowance allocation and the NO<sub>x</sub> limitation.</li> </ul>	<b>Requires, in general, the use of CEMS.</b>
<b>NO<sub>x</sub> Budget Trading Program</b>	<ul style="list-style-type: none"> <li>• Market-based cap and trade program to reduce emissions of NO<sub>x</sub> from power plants in the eastern US.</li> <li>• Applies mainly to large EGUs and boilers through state regulations.</li> </ul>	<b>CEMS monitoring for NO<sub>x</sub>, unless prior written approval has been obtained.</b>

US regulations established under CAA, which covers SO<sub>2</sub>, NO<sub>2</sub>/NO<sub>x</sub>, TSP, and PM<sub>10</sub> (but not PM<sub>2.5</sub><sup>34</sup>), are the most complex and site-specific, incorporating a range of emission limits, caps under emission trading systems, performance standards and technology-based standards.

Despite their differences in regulatory approach, NSW, Australia, Canada, the EU and the US each have at least some requirements for a specific subset of plants to use CEMS. The protocols for CEMS are mainly the same across the economies and

include specified installation, certification, data substitution, quality assurance and quality control (QA/QC), record maintenance, and data reporting procedures.

### **Oversight Monitoring**

In addition to the monitoring coal-fired power plants are required to perform in order to demonstrate that they are meeting the requirements of relevant regulations, environmental protection agencies and other authorities monitor the plants in order to ensure that they are correctly collecting and reporting emissions data. For example, under the New Source Performance Standards (NSPS) in the US, sources that meet the CAA definition of a “major source,” such as power plants, receive a full compliance evaluation at least once every two years.<sup>35</sup> The evaluation includes, but is not limited to, reviewing required reports, an assessment of air pollution control devices, observing visible emissions, an assessment of process parameters, and, as necessary, stack tests.

#### **1.3.1.2 Mercury (Hg)**

Mercury is a toxic, persistent, bioaccumulative substance. It converts in water to the highly toxic form, methylmercury, which accumulates in fish and other species, damaging the central nervous system and causing reproductive failure among loons and river otters. Human exposure to mercury, primarily by eating contaminated fish, may cause neurological and developmental damage.<sup>36</sup> Mercury may be emitted substantially in the gas phase from the combustion of coal.<sup>37</sup> The heavy metal content is normally several orders of magnitude higher in coal than in oil or natural gas.<sup>38</sup>

Most economies have Hg emission standards in place for industrial sources that coal-fired power plants can easily meet. However, there is increasing concern over the mercury emitted from coal-fired power plants because of their large contribution to their emissions. So far, only Canada has established standards for mercury from power plants. The EU has considered some type of regulatory program, and the US developed a cap-and-trade program that was recently rescinded by the courts.

No developed Asian economy has indicated an interest in regulating mercury from coal-fired power. For developing economies, an important immediate step would be to develop an inventory for the reporting of mercury emissions from power generation and other large industrial sources. This would help governments determine the extent to which coal-fired power plants contribute to this type of emissions and whether regulation would be required. For example, Chinese power plants are reported to release large amounts of mercury, but there is still uncertainty regarding how much and how significant the problem is.

### **Indirect Activities**

#### **Ambient Air Quality**

The EU’s Fourth Daughter Directive of 2004<sup>39</sup> to the Air Quality Framework Directive of 1996<sup>40</sup> includes mercury, but does not establish a value for its ambient concentration. Methods and criteria for assessing concentrations and depositions of mercury are specified in the 2004 Directive.

## Direct Activities

### *Inventories*

Australia, Canada, the EU and the US all require reporting of mercury to an established inventory when it exceeds a pre-specified threshold. For Australia, Canada and the EU, the inventories are the same ones used for reporting SO<sub>2</sub>, NO<sub>x</sub>, and PM emissions. For the US, unlike for SO<sub>2</sub>, NO<sub>x</sub>, and PM, which are compiled from data obtained from State and local air agencies, tribes and industry, power plants must calculate and report these emissions to an inventory when they exceed a specified threshold. Table 1.5 describes monitoring of mercury emissions for inclusion in inventories in these four economies.

In general, a number of monitoring options are available for generating data on mercury emissions for national pollutant inventories. In Australia, you can use any of the approved techniques (or mix of techniques) in order to have the data displayed with the notation of “acceptable reliability.” In Canada, you may base your data on an approved method and must include the method used in the report. In the EU, as for the other substances, monitoring must be done by the methodology that is known/expected to result in the “best available information.” In the US, reporters are required to use their best readily available information to report using monitoring data or direct measurement, MB, EFs, and/or ECs. The primary method used must also be noted.

**Table 1.5 Monitoring of Hg Emissions for Inventories in Australia, Canada, the EU and the US**

	<b>Australia</b>	<b>Canada</b>	<b>EU</b>	<b>US</b>
<b>Inventory</b>	National Pollutant Inventory	National Pollutant Release Inventory	European Pollutant and Transfer Register	Toxics Release Inventory
<b>Pollutant</b>	Hg	Hg and its compounds	Hg	Hg
<b>Threshold</b>	<ul style="list-style-type: none"> <li>• Burning of ≥ 2,000 tonnes/year of fuel; or</li> <li>• Consuming ≥ 60,000 MW hours/year of electrical energy for other than lighting or motive purposes</li> </ul>	Manufactured, processed or otherwise used in a quantity of ≥ 5 kg and employees worked ≥ 20,000 hours at the facility.	Combustion plants with a heat input of > 50 MW if they emit > 10 kg/year.	Facilities that have ≥ 10 full-time employees and generate > 10 lbs/year
<b>Monitoring</b>	CEMS, Stack/Source Tests, MB, Fuel Analysis Data, ECs, EFs or an alternative technique.	CEMS, PEMS, Stack/Source Tests, MB, Engineering Estimates, EFs or Emission Models.	Measurement, calculation or estimation method that will result in the “best available information.”	Direct measurement, MB, EFs, and ECs
<b>Frequency</b>	Annually	Annually	Triennially	Annually

### *Source Emissions Covered by Regulations*

Mercury emitted by coal-fired power plants is not regulated either at the federal level in Australia or by the Australian State of New South Wales. In Canada, all provincial

and territorial governments, with the exception of Québec, have approved caps on mercury emissions (Canada-Wide Standards<sup>41</sup>) in 2010 for existing coal-fired power plants and capture rates for new plants based on best available control technology that is already in effect.

The Protocol to the 1979 Convention on Long-range Transboundary Air Pollution on Heavy Metals,<sup>42</sup> which the EU approved in 2001 and applies to combustion installations with a net rated thermal input of greater than 50 MW,<sup>43</sup> stipulates the use of best available technologies to all existing and due to be created Hg sources. Under the currently suspended Clean Air Mercury Rule (CAMR),<sup>44,45,46</sup> which would have made the US the first economy to regulate Hg emissions from utilities, “standards of performance” and a market-based cap and trade program were established for new and existing power plants that produce electricity for sale and serve a generator with a nameplate capacity of greater than 25 MW.<sup>47,48</sup>

Under the Canadian standards, monitoring for total annual Hg emissions for new and existing units commissioned before 1 January 2012 must be generated by either source testing stack surveys, CEMS, MB methods, established data, the sorbent trap method, or other approaches of equal or better accuracy. For new units commissioned after 1 January 2012, CEMS must be used and must be capable of measuring both total and elemental Hg. In the EU, monitoring of Hg may occur either discontinuously or continuously, with the latter required if the emitted mass flow of particulates is >10 kg/hour.

For the currently suspended CAMR, Part 75-compliant monitoring systems<sup>49</sup> for Hg mass emissions (which are summed and reported annually) and, if required, heat input would had to have been installed and certified by 1 January 2009.<sup>50</sup> For any affected unit under the CAMR rule, a sorbent trap monitoring system (an alternative type of continuous Hg monitoring system) may have been used instead of an Hg CEMS.<sup>51</sup> Even though the US would have required the use of CEMS for the implementation of its regulations, there are still some concerns related to the accuracy of CEMS for the monitoring of Hg. However, regulators in the US determined that continuous monitoring would be required because this would be the only way to effectively support the proposed trading system.

Table 1.6 provides a summary of the different ways that mercury would be monitored under existing and proposed regulations for coal-fired power plants.

**Table 1.6 Examples of Regulatory Monitoring of Mercury**

	<b>Regulations</b>	<b>Monitoring</b>
<b>Australia</b>	<ul style="list-style-type: none"> <li>• No federal regulation for plants.</li> </ul>	N/A
<b>Canada</b>	<p>Canada-wide Standard Agreement</p> <ul style="list-style-type: none"> <li>• Provincial cap on emissions from existing plants in 2010</li> <li>• Capture rates or emission limits based on BAT effective Oct. 2005</li> <li>• COC, and all provinces and territories except Québec</li> </ul>	<p>Source testing stack surveys, CEMS, MB, Sorbent Trap Method (STM) and other approaches of equal or better accuracy.</p> <ul style="list-style-type: none"> <li>• New and existing units: Total annual Hg.</li> <li>• New units on or after 2012: CEMS to measure total and elemental Hg</li> </ul>
<b>EU</b>	<p>Protocol on Heavy Metals</p> <ul style="list-style-type: none"> <li>• Limit values for annual emissions of Hg (as well as PM).</li> <li>• Stipulates signatories require BAT for all new and existing sources</li> <li>• Covers combustion installations with a net thermal input of &gt; 50 MW</li> </ul>	<p>May occur either discontinuously or continuously.</p> <ul style="list-style-type: none"> <li>• Continuous if the emitted mass flow of particulates is &gt; 10 kg/h</li> </ul>
<b>US</b>	<p>Clean Air Mercury Rule</p> <p><i>Suspended Feb. 2006</i></p>	<p>Would have required the same emission monitoring and reporting provisions as the Acid Rain Program</p> <ul style="list-style-type: none"> <li>• Hg mass emissions and, where required, heat input by Jan. 09</li> <li>• 1 kg CEMS or Sorbent Trap Monitoring System</li> </ul>

### 1.3.1.3 Carbon Dioxide (CO<sub>2</sub>)

Power generation accounts for about one-quarter of total emissions of CO<sub>2</sub>, the main GHG responsible for global warming.<sup>52</sup> Globally, power generation emits nearly 10 billion tons of CO<sub>2</sub> per year.

There are no national regulatory requirements controlling CO<sub>2</sub> emissions in Australia, Canada and the US. However, the EU has implemented a CO<sub>2</sub> emission cap and trade system<sup>53</sup> and efforts are underway to establish an Australian emissions trading scheme, which is planned to commence in 2010.<sup>54</sup> In addition, a mandatory GHG emissions trading scheme involving electricity retailers and certain other parties is in effect in the Australian State of New South Wales<sup>55</sup> and ten US Northeastern and Mid-Atlantic states have formed the Regional Greenhouse Gas Initiative (RGGI), the first mandatory cap-and-trade program for CO<sub>2</sub> emissions from power plants in the US.<sup>56</sup> The first RGGI auction took place 25 September 2008. Other state and regional systems are emerging involving western US states and several Canadian Provinces.

No developed Asian economy has established GHG regulations.

#### **Direct Activities**

##### *Required Reporting*<sup>57</sup>

Australia, Canada, and the US require reporting of GHG emissions from power plants. These requirements are summarized in Table 1.7.

**Table 1.7 Monitoring of GHG Emissions without Mandatory Targets**

	Reporting Requirements	Applicability	Monitoring
Australia	National Greenhouse and Energy Reporting Act 2007	Corporations that emit $\geq 25$ kilotonnes of CO <sub>2</sub> e.	Designated EFs; Fuel and raw material analysis (facility level reporting); and CEMS or PEMS.
Canada	Mandatory Reporting of GHG Emissions by Major Emitters	Facilities that emit $\geq 100,000$ tonnes/year of GHGs (CO <sub>2</sub> e).	<ul style="list-style-type: none"> <li>• Facility-level reporting of direct CO<sub>2</sub> emissions.</li> <li>• Monitoring or direct measurement; MB; EFs; and Engineering Estimates.</li> </ul>
US	Clean Air Act: Acid Rain Program	<ul style="list-style-type: none"> <li>• All units <math>&gt; 25</math> MW; and</li> <li>• New units <math>&lt; 25</math> MW that use fuel with a sulfur content of <math>&gt; 0.05\%</math> by weight.</li> </ul>	Options: <ol style="list-style-type: none"> <li>1. CO<sub>2</sub> CEMS and a flow monitoring system with an automated data acquisition and handling system (DAHS);</li> <li>2. Flow monitoring system and a CO<sub>2</sub> CEMS that uses an O<sub>2</sub> concentration monitor and an automated DAHS; or</li> <li>3. Calculations based on the measured carbon content of the fuel.</li> </ol>

In Australia, as of 1 July 2008, corporations are required to report if they control facilities that emit 25 kilotonnes or more of GHGs (CO<sub>2</sub> equivalent). Mandatory reporting of GHG emissions by major emitters (all facilities that emit the equivalent of 100,000 tonnes or more of GHGs annually, in units of CO<sub>2</sub> equivalents covering the six Kyoto gases)<sup>58</sup> was introduced in Canada in 2004. While there are no federal regulatory requirements in the US for the reduction of CO<sub>2</sub> (or other GHGs), plants covered under the US Acid Rain Program (ARP)<sup>59</sup> must measure and report their CO<sub>2</sub> emissions to the US EPA.

GHG measurements for reporting in Australia may be done by four methods, which are:

1. EFs;
2. Fuel and raw material analysis;
3. Fuel and raw material analysis using Australian or international standards;<sup>60</sup> and
4. Direct monitoring either by CEMS or PEMS.

In Canada, the reporting facility needs to calculate and report its direct emissions of CO<sub>2</sub>.<sup>61</sup> No specific protocols have been published for this task, but the reporter must specify the estimation method(s) used. Such methods include:

1. Monitoring or direct measurements;
2. MB;
3. EFs; and
4. Engineering estimates.

Three options for monitoring CO<sub>2</sub> exist under the US ARP, two of which involve CEMS and a third which uses calculations based on the measured carbon content of the fuel.

Indonesia is about to pass a new Clean Air Act (2008) which would include mandatory reporting of CO<sub>2</sub> by all thermal power plants. The details of the Act are still not publically available but it is expected that new facilities greater than 25MW would be required to use CEMS.



## Mandatory Targets

The GHG monitoring requirements differ slightly when the goal is to support mandatory emission reduction targets. Table 1.8 describes the various targets and monitoring approaches that have been adopted in Australia, Canada, the EU, and the US.

**Table 1.8 Monitoring of GHG Emissions with Mandatory Targets**

	<b>Regulations</b>	<b>Monitoring</b>
NSW, Australia	<b>New South Wales Greenhouse Gas Reduction Scheme (GGAS):</b> NSW electricity retailers and other parties must meet mandatory targets for reducing or offsetting GHG emissions.	On-going and post-improvement greenhouse intensity (GI) performance monitoring by either: <ul style="list-style-type: none"> <li>• Performance Testing,</li> <li>• Efficiency Approach, or</li> <li>• Use of instrumentation and the direct method (use of fuel flow together with fuel analysis and sent out power generation).</li> </ul>
Alberta, Canada	Facilities that emit $\geq 100,000$ tonnes of GHGs annually must reduce emissions intensity by 12%.	Same as under federal Canadian standards. <ul style="list-style-type: none"> <li>• Must identify the type of methods used, though no specific calculation protocols exist</li> <li>• Methods include: Monitoring or direct measurements; MB; EF; and Engineering Estimates</li> </ul>
EU	<b>EU Greenhouse Gas Emission Trading Scheme (EU ETS):</b> <ul style="list-style-type: none"> <li>• Covers 6 industrial sectors, including electricity generation.</li> </ul>	Calculation or measurement-based methodologies (CEMS). <ul style="list-style-type: none"> <li>• Measurement-based only if it can be demonstrated to reliably result in more accurate values while avoiding unreasonable costs.</li> </ul>
Ten US States	<b>Regional Greenhouse Gas Initiative (RGGI):</b> Units $\geq 25$ MW	Almost entirely based on the US Acid Rain Program continuous monitoring rules

In the New South Wales, Australia Greenhouse Gas Reduction Scheme (GGAS), electricity retailers and certain other parties are required to meet mandatory targets for reducing or offsetting GHG emissions from the production of the electricity they supply or use.<sup>62</sup> As of 1 July 2007, facilities in Alberta, Canada that emit more than 100,000 tonnes of GHGs a year must reduce their emissions intensity by 12 percent.<sup>63</sup> In January 2005, the EU Greenhouse Gas Emission Trading Scheme (EU ETS),<sup>64</sup> the first large CO<sub>2</sub> emission cap and trade system, came into effect. It requires six industrial sectors, including electricity generation, to obtain a permit for each of the six Kyoto GHGs they emit. Established in December 2005, the Regional Greenhouse Gas Initiative (RGGI) is the first mandatory US cap and trade program for CO<sub>2</sub> emissions from power plants 25 MW or larger for ten Northeastern and Mid-Atlantic states.<sup>65</sup>

Under the New South Wales, Australia GGAS, ongoing and specific post-improvement greenhouse intensity (GI) performance monitoring is required, which may be carried out by performance testing; the efficiency approach; use of instrumentation and the direct method (use of fuel flow together with fuel analysis and sent out power generation). For the mandatory targets in Alberta, Canada, the monitoring and reporting requirements are the same as under the national Canadian reporting rules for large emitters (see section above). Under the EU ETS, either a calculation-based methodology or a measurement-based methodology (i.e., CEMS) may be used, however, to use the latter, approval must be obtained. The approval is based on being able to demonstrate that the measurement-based methodology reliably results in a more accurate value for annual emissions while avoiding unreasonable

costs. Monitoring under RGGI is almost entirely based on the US ARP requirements (see section above).

### **Oversight Activities**

In addition to the monitoring activities coal-fired power plants must perform in order to meet emissions and other general requirements, authorities may monitor the data collection and reporting process to ensure that the information submitted is complete and accurate. For example, in Australia authorized officers may search the premises; examine any activity, piece of equipment, documentation, etc.; collect data; collect items that show evidence of unauthorized activities; operate equipment; and question personnel.

Under the EU ETS and the GGAS, installations' reports have to be checked by independent verifiers and auditors, respectively. Operators under the EU ETS with non-satisfactory emissions reports for the previous year are not allowed to sell allowances until a revised report is approved by a verifier.

### **1.3.2 Water Effluents**

In this section, we focus on coal-fired power plant monitoring of water effluents (chemicals, biological substances and thermal pollution) and consumption in the EU and the US. In both entities, the regulations and monitoring practices are mainly focused on effluents.

Two pieces of regulation, the Water Framework Directive<sup>66</sup> in the EU and the Clean Water Act (CWA)<sup>67</sup> in the US, address issues of overall water management. The Water Framework Directive indirectly applies to coal-fired power plants (i.e., it contains water-related goals that are affected by the operation of power plants, but does not include specific requirements for the plants themselves). The requirements that directly address water emissions from coal-fired power plants in the EU are instead covered under the Integrated Pollution Prevention and Control (IPPC) Directive<sup>68</sup> (see below), the same directive that sets common rules for permitting and controlling air and waste emissions from plants. The US CWA, on the other hand, pertains directly and indirectly to power plants. It focuses on federal water management by implementing pollution control programs, such as setting water quality standards for all contaminants in surface waters and wastewater standards for industry (including electricity production from coal-fired power plants).<sup>69</sup> Under the CWA, all point source pollutant discharges require permits, which are covered under Section 404 and the National Pollutant Discharge Elimination System (NPDES).

Under the EU Water Framework Directive, Member States must establish programs for monitoring surface waters (including the ecological and chemical status and ecological potential, in addition to the volume and level or rate of flow, as relevant), groundwaters (chemical and quantitative status) and protected waters. Monitoring of general water quality under the US CWA rests with many different federal, state and local agencies, while industry monitoring requirements for pollutant discharges are specified in the individual permits.

Table 1.9 provides a summary of the monitoring requirements for chemical and biological substances under these two programs.

**Table 1.9 EU and US Monitoring Requirements for Chemical and Biological Substances in the Water**

	Legislation	Details	Monitoring
EU	IPPC Directive	<ul style="list-style-type: none"> <li>• Limit values based on best available techniques</li> </ul>	<p>Permits must contain suitable release monitoring requirements, including:</p> <ul style="list-style-type: none"> <li>• Measurement Methodology</li> <li>• Frequency and Evaluation Procedures</li> </ul>
US	Clean Water Act: National Pollutant Discharge Elimination System (NPDES)	<ul style="list-style-type: none"> <li>• Limits and standards must consider technology-based or water quality-based standards</li> </ul>	<p>Each state establishes appropriate frequencies, procedures, and locations for monitoring. All states must require:</p> <ul style="list-style-type: none"> <li>• At least annual reporting</li> <li>• That the monitoring is performed at the location where the limits are calculated and applied</li> </ul>

### Indirect Activities

These regulations are related to electric power generation because they result in wastewater streams that contain detectable levels of elements or compounds that have established standards.

#### *Surface Waters/Aquatic Environment*

In the EU, a number of regulations deal with the discharge of substances that affect surface waters/the aquatic environment. The Directives are: Other Dangerous Substances: Protection of the Aquatic Environment;<sup>70</sup> Water Suitable for Fish-Breeding;<sup>71</sup> and Quality of Shellfish Water.<sup>72</sup> The European Community is also working to set quality standards and emissions controls for the list of substances outlined in the Decision on the Priority Substances in the Field of Water Policy,<sup>73</sup> in addition to eight other substances. In the US, the Total Maximum Daily Load (TMDL)<sup>74,75</sup> regulations address these types of waters.

For the EU regulations, the Directives lay out either general guidance or specific requirements for monitoring by Member States. For example, under the Quality of Shellfish Water Directive, mandatory and/or selected limits are provided for each parameter, along with a reference method and a minimum sampling and measuring frequency. In the US program, states establish TMDLs. They are then either deemed acceptable and approved by the US EPA or deemed inadequate and established by the US EPA itself.<sup>76</sup>

### *Groundwaters*

EU regulations that deal with groundwater are the Protection of Groundwater against Pollution Directive;<sup>77,78</sup> and Other Dangerous Substances: Protection of Groundwater.<sup>79</sup>

Under the Protection of Groundwater against Pollution Directive, Member States must establish a monitoring program that uses international quality control principles and assessment based on statistical methods, and meets specific monitoring specifications laid out in the Directive. The Other Dangerous Substances: Protection of Groundwater Directive requires prior authorization for all discharges, which may include, as necessary, measures for monitoring.

### *Surface and Groundwaters*

For the US National Water Quality Inventory,<sup>80</sup> each state must develop a program to monitor the quality of its surface and groundwaters and prepare a report every two years. Since many states have taken different approaches toward this task, national guidance was issued on the variety of activities involved in an attempt to standardize these different programs.

### *Drinking Water*

The EU and US regulations pertaining to drinking water include the Directive on the Quality of Drinking Water<sup>81</sup> and the Safe Drinking Water Act,<sup>82</sup> respectively.

Under the EU Directive, Member States must take all necessary measures to ensure regular monitoring of drinking water for all substances that have parametric values, in addition to case-by-case monitoring for substances and microorganisms that have no set parametric values. While the types of monitoring are specified (check and audit), monitoring frequencies and other related requirements are laid out by the Member States. Under the US SDWA, detailed federal monitoring requirements (including the number of sampling points, frequency, etc.) for coliform; turbidity; inorganic, volatile organic and synthetic organic contaminants; and radionuclides are specified.

### *Consumption*

Under the EU Water Framework Directive, management plans are supposed to ensure a balance between groundwater abstraction and replenishment. The programs to monitor water status under this Directive involve measuring surface water level and volume,<sup>83</sup> and the use of a sufficient number of representative monitoring points to estimate groundwater levels.

### **Oversight Activities**

In the EU, compliance monitoring is generally a responsibility designated to the individual Member States. However, some oversight is done by the European Commission. Under the SDWA, states or the US EPA, acting as a primacy agent, make sure water systems test for contaminants, review plans for water system

improvements, conduct on-site inspections and sanitary surveys, provide training and technical assistance, and take action against water systems not meeting standards.<sup>84</sup>

## **Direct Activities**

### *Inventories*

Releases to water of substances that exceed certain thresholds from coal-fired power plants in the EU (generally 12 substances) are reported to the European Pollutant and Transfer Register.<sup>85,86</sup> In the US, electric generating facilities<sup>87</sup> must perform a determination for each chemical listed in the Toxics Release Inventory.<sup>88</sup> If the chemicals exceed a certain threshold, the amount of emissions must be reported. The US inventory is compiled annually, while the EU report is prepared triennially. For both inventories, the data is made public.

In the EU, monitoring must be done by the methodology that is known/expected to result in the “best available information,” while in the US, reporters are required to use their best readily available information.<sup>89</sup> Inventory methods for the EU and US may include monitoring data/direct measurement; EFs; MB; and engineering judgments. Indirect monitoring, other calculations or other methods may be used in the EU. The type of methodology (measurement, calculation and/or estimation) must be reported in the EU, while only the primary method used must be reported in the US.

### *Source Emissions Covered by Regulations*

Chemical and biological substances emitted to water from coal-fired power plants are covered by permits issued under the IPPC Directive in the EU and the CWA National Pollutant Discharge Elimination System (NPDES) in the US. Emissions limit values in the EU are based on best available techniques. Limits and standards in the US (which cover conventional, priority and non-conventional pollutants) must consider technology-based standards or water quality-based standards, the latter implemented when the technology-based standards cannot ensure that the water quality standards will be met. Based on industry-specific control technologies, the technology-based standards may represent:

- Best conventional pollutant control technology (BCT);
- Best practicable control technology currently available (BPT);
- Best available technology economically achievable (BAT); or
- New Source Performance Standards (NSPS).

Water-quality standards vary significantly by application, industry and location. The CWA Stormwater permit program also includes water discharge requirements for power plants.

EU IPPC permits must contain suitable release monitoring requirements, specifying measurement methodology and frequency and evaluation procedures. For US CWA NPDES permits, requirements vary by state, but all must require at least annual monitoring and that the monitoring is performed at the location where the limits are

calculated and applied. Under the US CWA Stormwater program, general permits requires 1 to 2 years of monitoring and reporting and include recommended best practices for power plants, while individual permits vary based on the permit writer's judgment.

### **Oversight Monitoring**

For the EU IPPC's Directive, compliance monitoring is the responsibility of the Member States and permits require an obligation for plants to supply the competent authority with the data required to verify compliance. Under the NPDES permit program,<sup>90</sup> self-monitoring or monitoring by the US EPA or the state is conducted under regulations to assess compliance.

#### *Thermal Pollution*

Thermal pollution is not directly addressed under the EU's IPPC Directive, but is, to some degree, implied since the regulation requires permits to account for the environmental performance of the plant as a whole. In the US, the CWA regulates heated discharges into waters based on the body's ability to dissipate heat and preserve a "balanced and indigenous" wildlife population.<sup>91,92</sup> Thermal effluent limitations are noted in a plant's NPDES permit.

EU IPPC permits must include suitable release monitoring requirements, which could potentially address thermal pollution. If a power plant in the US feels that the thermal effluent limitations assigned in an NPDES permit are too strict, they may request alternate ones. In this case, the discharger must present a variety of data to support the claim, including physical monitoring data.

#### *Consumption*

Consumption, like the issue of thermal pollution, is not directly addressed under the EU's IPPC Directive, but is, to some degree, implied since the regulation requires permits to account for the environmental performance of the plant as a whole. US coal-fired power plants with effluent or national performance standards set under the CWA NPDES program must use BAT for the location, design, construction and capacity of their cooling water intake structures (CWIS).<sup>93,94</sup> The rule originally covered impingement and entrainment,<sup>95</sup> for both new plants and existing plants that met certain specifications. Currently, the rule is only in effect for new plants.

EU IPPC permits must include suitable release monitoring requirements and could potentially address thermal pollution. Under the CWA CWIS regulations, new plants need to perform biological monitoring; impingement sampling; entrainment sampling; velocity monitoring,<sup>96</sup> and visual or remote inspections at/for specified frequencies/durations. Under the suspended rule for existing plants, a verification monitoring plan was established and additional monitoring may have been required.

### **1.3.3 Waste**

The burning of coal creates solid waste, called ash, which is composed primarily of metal oxides and alkali.<sup>97</sup> In some cases, ash may be disposed in landfills. In other

cases, this waste may contain toxic and hazardous elements and materials that require special handling, treatment and disposal. In this section, we focus on coal-fired power plant monitoring of solid waste in the EU and the US.

Table 1.10 provides a summary of the relevant monitoring and reporting requirements for coal waste in the EU and the US. These are described further in the following subsections.

**Table 1.10 Reporting Requirements for Coal Waste in the EU and the US**

	Cross-cutting activities	Landfill leachate	Inventories
EU	<p><b>Framework Directive on Waste Disposal:</b> Must record the quantity, nature, origin, destination, frequency of collection, mode of transport and treatment method of the waste.</p> <p><b>IPPC Directive:</b> Combustion activities with a rated thermal input &gt; 50 MW and landfills with given specifications. The permits must include:</p> <ul style="list-style-type: none"> <li>• Sources of the emissions and the nature and quantities of expected emissions</li> <li>• Technologies/techniques for reducing pollution</li> <li>• Measures to prevent and recover waste</li> <li>• Plans to monitor emissions</li> </ul>	<p><b>Landfill of Waste Directive</b></p> <ul style="list-style-type: none"> <li>• Standard waste acceptance procedures</li> <li>• Permits must contain an operation, control and monitoring plan</li> </ul>	<p><b>European Pollutant and Transfer Register</b></p> <ul style="list-style-type: none"> <li>• Same as for water</li> </ul>
US	<p><b>The RCRA Solid Waste Program:</b> Coal Combustion Wastes (CCWs) fall under Subtitle D (CCWs used to fill mines may also be subject to the Surface Mining Control and Reclamation Act). Specifications exist for:</p> <ul style="list-style-type: none"> <li>• Groundwater monitoring</li> <li>• MSWLFs since they may receive CCWs. Must meet various location, environmental, operating and other requirements.</li> </ul>	<p><b>RCRA Solid Waste Program</b></p> <ul style="list-style-type: none"> <li>• Composite liner requirements</li> <li>• Provisions for leachate collection and removal systems</li> </ul>	<p><b>Toxics Release Inventory</b></p> <ul style="list-style-type: none"> <li>• Same as for water</li> </ul>

## Direct Activities

### *Cross-Cutting Activities*

Two EU regulations, the Framework Directive on Waste Disposal<sup>98</sup> and the Integrated Pollution Prevention and Control (IPPC) Directive,<sup>99</sup> address a number of activities related to the disposal of solid waste generated by coal-fired power plants. The former regulation, which covers residues from industrial processes, pollution abatement processes, etc., requires Member States to prohibit the abandonment, dumping or uncontrolled disposal of waste and promote waste prevention, recycling and processing for re-use. Third parties, who handle waste on behalf of others, recovery centers and undertakings disposing of their own waste require permits. Permits are also required under the IPPC Directive, where<sup>100</sup> emission limit values and waste protection measures must be based on BAT.<sup>101</sup>

In the US, the US EPA has determined that coal combustion wastes (CCWs) that are disposed in landfills and surface impoundments should be regulated under the subtitle of the Resource Conservation and Recovery Act (RCRA)<sup>102</sup> that deals with solid waste regulations (Subtitle D).<sup>103</sup> CCWs used to fill surface or underground mines (minefill) should be regulated under authority of Subtitle D of RCRA and/or the Surface Mining Control and Reclamation Act (SMCRA).<sup>104</sup>

Under the EU Waste Disposal Framework Directive, permit holders must record and make public (the latter as requested) the quantity, nature and origin of the waste. Where relevant, the destination, frequency of collection, mode of transport and treatment method must also be included. Under the EU IPPC Directive, permit applications must include information on the sources of emissions and the nature and quantities of expected emissions into each medium; the proposed technologies and other techniques for reducing pollution; measures for the prevention and recovery of waste; and measures planned to monitor emissions, including the methodology, frequency and evaluation procedure.

For US Solid Waste Disposal Facilities and Municipal Solid Waste Landfills (MSWLFs), which receive CCWs under Subtitle D of RCRA, specifications are provided for groundwater monitoring, including the criteria for the systems used and the sampling and analysis requirements, detection monitoring, assessment monitoring, methods for assessment of corrective measures and recordkeeping requirements. Additional specifications for monitoring of explosive gases and post-closure conditions are also provided for MSWLFs.

### *Landfill Leachate*

The EU Landfill of Waste Directive,<sup>105</sup> which applies to all landfills, sets a standard waste acceptance procedure, requires waste to be treated before being landfilled and requires operating permits for landfill sites. Permit applications must contain, among other things, the proposed operation, monitoring and control plan.<sup>106</sup> At minimum for the operational and after-care phases, monitoring must ensure that the waste has been accepted in accordance with the criteria for the specific landfill, the processes within the landfill proceed as desired, environmental protection systems are functioning fully and that the permit conditions for the landfill are fulfilled. This should include information on the collection of meteorological data and must include emission data for water, leachate and gas control, groundwater sampling and means for assessing if trigger levels have been exceeded.

### *Inventories*

Releases to land (or to water via leachate) for substances that exceed certain thresholds from coal-fired power plants in the EU (generally 12 substances) are reported to the European Pollutant and Transfer Register.<sup>107,108</sup> In the US, electric generating facilities<sup>109</sup> must perform a determination for each chemical listed in the Toxics Release Inventory.<sup>110</sup> If the chemicals exceed a certain threshold, the amount of emissions must be reported. The US inventory is compiled annually while the EU report is prepared triennially. For both inventories, the data is made public. Furthermore, the EU and US inventories require inclusion of offsite transfers for disposal, recovery and recycling. The US thresholds for these categories are the same as for releases to land, while in the EU the thresholds are 2 tonnes and 2,000 tonnes for hazardous and non-hazardous waste, respectively.

For releases to land in the EU, monitoring must be done by the methodology that is known/expected to result in the “best available information,” while in the US reporters are required to use their best readily available information.<sup>111</sup> Inventory methods for the EU and US may include monitoring data/direct measurement; EFs;



MB; and engineering judgments. Indirect monitoring, other calculations or other methods may be used in the EU. The type of methodology (measurement, calculation, or estimation) must be reported in the EU, while the primary method only must be reported in the US. For hazardous waste transferred off-site for recycling in the EU, the contact information of the person responsible for recovering the waste and the recovery site must also be reported.

### Oversight Monitoring

Under the Framework Directive on Waste Disposal,<sup>112</sup> the Member States designate authorities to draw up management plans, which include: the type, quantity and origin of waste to be recovered or disposed of; general technical requirements; special arrangements; and suitable disposal sites or installations. For IPPC permits,<sup>113</sup> the permit application must also include an obligation to supply monitoring information to Member States, who are responsible for inspecting the installations and ensuring compliance. In order to ensure compliance under the US RCRA Solid Waste Program,<sup>114,115</sup> a state has the authority to obtain any and all information necessary; conduct monitoring or testing; and enter any site or premise subject to the permit program or in which relevant records are kept.<sup>116</sup>

#### 1.3.4 Continuous Emissions Monitoring

For most developed economies it is becoming more and more common to measure air pollutants (PM, SO<sub>2</sub> and NO<sub>x</sub>) on a continuous basis using CEMS. The US CEMS protocol for monitoring local air pollutants is the most comprehensive and is typically referenced by other economies. As illustrated in Table 1.11, CEMS are also being used in some economies for monitoring and reporting of CO<sub>2</sub> emissions.

**Table 1.11 Examples of CEMS Use in Australia, Canada, US, and the EU**

	Compounds	Example of CEMS use
NSW, Australia	NO <sub>2</sub> , SO <sub>2</sub> and PM	<i>Clean Air Regulation 2002</i> : CEMS based on US EPA methods, or as specified in the relevant statutory instruments.
Canada	Hg	<i>Canada-Wide Standards</i> : New units commissioned after Jan. 2012 must use CEMS to measure both total and elemental Hg.
Alberta, Canada	SO <sub>2</sub> , NO <sub>x</sub> in-stack opacity	CEMS is required on the stack to determine mass emissions.
EU	SO <sub>2</sub> , NO <sub>x</sub> and dust	<i>LCP Directive</i> : Plants with a rated thermal input of >100 MW, continuous measurements of the concentrations are required (since Nov. 2002).
	Hg	<i>Protocol on Heavy Metals</i> : Continuous monitoring if mass flow of particulates is > 1.0 kg/h
US	SO <sub>2</sub> , NO <sub>x</sub> and opacity; CO <sub>2</sub> or O <sub>2</sub>	<i>New Source Performance Standards</i> : CEMS for monitoring, as well as to measure the O <sub>2</sub> or CO <sub>2</sub> content of the flue gases.
	SO <sub>2</sub> , NO <sub>x</sub> and opacity; CO <sub>2</sub>	<i>Acid Rain Program</i> : Requires, in general, the use of CEMS. - For SO <sub>2</sub> and NO <sub>x</sub> , a pollutant concentration monitor and a volumetric flow monitor are required. - For NO <sub>x</sub> , a diluent gas (O <sub>2</sub> or CO <sub>2</sub> ) monitor is also required. - Three options for monitoring CO <sub>2</sub> exist, two of which involve CEMS.
	Hg	<i>Clean Air Mercury Rule – Suspended</i> : Would have required CEMS or a Sorbent Trap Monitoring System
	CO <sub>2</sub>	<i>Regional Greenhouse Gas Initiative</i> : CEMS required; Almost entirely based on the Acid Rain Program rules.

Variations do exist in the methods used for each CEMS procedure based on the stringency of the regulations in place. For example, frequent (daily), highly accurate sampling of emissions is a critical component of cap-and-trade programs such as the US Acid Rain Program which requires continuous monitoring of SO<sub>2</sub>, volumetric flow, NO<sub>x</sub>, diluent gas, and opacity for units regulated under the program.<sup>117</sup> This level of detail is required to ensure that the awarded allowances accurately, transparently and consistently reflect a plant's true emissions and that the regulated facilities are on track to meet their target. In the case where CEMS are used for tracking compliance with emissions standards only, such as in New South Wales, Australia, the program typically provides more flexibility in the allowable sampling procedures.

CEMS technologies have continued to evolve as economies have strengthened their emissions standards. Power companies are taking advantage of technological developments, which have made CEMS more accurate and reliable, and are using them as an important part of the plant's operating system. In the US, companies put a lot of money into the right CEMS technology because they cannot afford to shut down the plant if emissions exceed the specified threshold. They also use the system to better control the use of consumables such as lime, limestone, or ammonia thereby reducing costs.<sup>118</sup>

In the future, new pollutants of concern, such as mercury and fine particulates (PM<sub>2.5</sub>), would likely result in the requirement for additional CEMS on plants. The Canadian mercury rule requires CEMS monitoring at new plants starting in 2010. The proposed but rescinded US Clean Air Mercury rule would have required installation of either CEMS or a Sorbent Trap Monitoring System. However, there is some concern, especially in Europe, that the current CEMS technology is not accurate enough to effectively monitor mercury emissions. More research and development will be required to address these issues.

Ideally all plants should be fitted with CEMS to measure emission concentrations and totals at all times. When CEMS are not available, manual monitoring can be performed, although this provides only a 'snap-shot' of emissions and cannot truly represent total emissions over time. Once installed, the CEMS should be combined with online, real-time reporting of the collected data to local, and perhaps national, authorities. This approach is used by economies such as Germany, Thailand, and the US. In addition to monitoring of compliance, these systems have proven valuable for tracking data for emission inventories, and also for emission trading schemes. Accurate monitoring systems can also provide valuable information on the performance of a plant to highlight any existing or predict impending problems that can be addressed through preventative maintenance. In Thailand, real-time reporting of emissions to local health authorities is helping to alleviate public concern with the environmental impacts of coal-fired plants. This is particularly the case with the large Mae Moh plant in the northern part of the economy, which experienced two serious pollution incidents in the late 1990s.

Except for Thailand, most developing Asian economies have been slower to adopt CEMS. In China, driven by a variety of government mandates, most new coal-fired plants are installing these systems. However, it is unclear how much they are being used in practice since the reported emission values have not always been incorporated

into local compliance reporting processes. The Philippines requires installation of CEMS at its major sources, but due to their high cost few have been installed. The government-run utility is having a particularly hard time raising adequate funds. Viet Nam and Indonesia do not require the use of CEMS, although Indonesia is about to pass a new Air Quality Act that would require their near-term use at new facilities and a phased in adoption rate at existing plants.

### *Cost of CEMS*

The biggest barrier to the installation of CEMS is cost. CEM systems can be expensive and often require trained staff for maintenance to ensure accurate and reliable performance of the system. Regular calibration, quality control, and assurance checks can add hundreds of thousands of dollars more in annual running costs. Most plants in Europe either have in-house staff to deal with pollution monitoring or use third party stack-testing crews to ensure compliance. In the US, most power companies have dedicated staff to maintain and calibrate their CEMS. This all adds cost.

Initial capital costs are a substantial portion of the overall costs, but in the long-run operational and maintenance costs including preventive and corrective maintenance, calibration, record-keeping, data QA/QC, and data reporting also require significant effort and resources. One report estimates that 50-70% of the manpower required to maintain CEMS at a plant in the US relates to recording daily system readings such as dilution air pressure, sample flow rates, and analyzer lamp voltages.<sup>119</sup> In addition pumps need frequent repair, filters must be replaced, and probes need to be maintained to keep the system in good working condition. These tasks are in addition to the daily calibration. Finally, in some cases, calibration of monitors and test equipment can require specific plant conditions which can interfere with the smooth running of the plant.

### *Operation of CEMS*

It is not enough to just require the installation of CEMS for continuous monitoring. When establishing a monitoring framework for their use, developing Asian economies must be careful to also specify the infrastructure, technical requirements, and operating procedures for the CEMS.

In the case of China, a large number of plants now include CEMS. However, surveys indicate that many of these do not operate probably or simply are not able to function. As discussed in Section 5.2.4 there are several reasons for this including:

- Lack of guidance on the technologies that can be used for continuous monitoring, leading to unsatisfied post-sale service;
- Lack of quality control and verification during procurement;
- Insufficient technical guidance on the certification calibration, maintenance, and operation of the CEMS;
- Inadequate training by staff operating the CEMS;

- Lack of management infrastructure (i.e., networking facilities) and staff trading at the Environmental Protection Department which collects the data; and
- Insufficient standards, management, and oversight of the certification, inspection, verification, networking, and data use of CEMS at the national and local level.

The national government is working to develop better guidance for the use of CEMS, but this is an area that will require particular attention in the near future.

The technical guidance for the use of CEMS should also include standards for how to calibrate these systems. In China, usually a third party calibrates the CEMS on a weekly basis and more comprehensive calibration is performed every six months.<sup>120</sup> Ideally, CEMS calibrations should be performed more frequently. Daily calibrations would be preferable to be consistent with practices in the US and Europe.

### *Predictive Emissions Monitoring (PEMS)*

The traditional approach to enhanced monitoring is to install a continuous emissions monitoring system made up of analytical instrumentation which directly measures the concentration of various pollutants in the stack. However, as outlined earlier in this section this “hardware” system can be expensive to purchase and maintain.

A potentially attractive alternative is the use of a predictive emissions monitoring system (PEMS) which calculates the emissions from a plant’s process variables. The PEMS predicts a unit’s emissions indirectly using process parameters that have a known relationship to pollutant concentration. Their principle of operation can range from a relatively simple relationship based on combustion principles to the more complex computer models that are trained to predict emissions using neural networks technology.<sup>121</sup>

PEMS offers the advantages of lower cost, lower maintenance, and higher reliability than more traditional hardware. As a result, PEMS may be of particular interest to developing economies with scarce resources.

The use of PEMS is still new and guidance for their use is emerging. In the US, PEMS have been used on a case-by-case basis for monitoring purposes under the US Clean Air Act at industrial, commercial, and institutional steam-generating units, gas turbines, internal combustion engines, and other combustion processes where process parameters have a predictable relationship to emissions.

The EPA is studying the applicability of PEMS for NO<sub>x</sub> compliance determinations for various sources, including thermal power plants. A draft protocol for assessing the accuracy and precision of PEMS have been developed and is expected to be proposed sometime in the near future.<sup>122</sup> Once this protocol has been completed, developing Asian economies may consider adopting similar procedures for using PEMS as a low-cost alternative to CEMS.

## 1.4 Comments

This chapter outlines best practices for environmental monitoring for coal-fired power plants, and discusses some of the areas where developing Asian economies may be able to strengthen their monitoring frameworks. Key areas that could be improved include the overall air quality monitoring network, establishment of public pollutant inventories, and improved technical guidelines for the certification, operation, and management of equipment used for tracking emissions and pollutants. However, these monitoring measures will only be completely effective if they are combined with good compliance incentives, regular oversight, and consistent enforcement measures by local and national authorities.

Our review of monitoring practices in China, Indonesia, Thailand, the Philippines, and Viet Nam indicate that many developing economies face challenges in this area. Oftentimes, monitored data collected by power plants have shown excess emissions or faulty pollution prevention practices, but authorities still chose to overlook this data in preference to other economic or social priorities. In other cases, the penalties for non-compliance have been insufficient for driving environmental clean-up. For example, the Chinese SO<sub>2</sub> and NO<sub>x</sub> levies are often lower than the cost of installing and operating enhanced controls or using low-sulfur coal. Thus, even though the government has developed fairly extensive regulations and monitoring guidelines for reducing emissions, plant managers often choose to pay the emission fee and continue to pollute rather than employ more expensive controls. The result is non-compliance with the government's overall environmental objective of reducing local air pollution in major urban and industrial areas.

The above example illustrates the importance of developing an overall environmental framework that, as a whole, ensures that environmental objectives are being met. Good monitoring practices are an important subset of this, because they provide a means to track performance of regulated entities and evaluate progress towards overall regulatory goals.

## **Chapter 2. AIR EMISSIONS**

The following chapter provides an overview of air emissions monitoring frameworks in Australia, Canada, the European Union, and the US. It begins with a discussion of the relevant emission sources to be examined in this report and then moves on to summarize economy-specific monitoring activities.

### **2.1 Sulfur Dioxide (SO<sub>2</sub>), Nitrogen Oxides (NO<sub>x</sub>) and Particulate Matter (PM)**

Sulfur dioxide (SO<sub>2</sub>) and nitrogen oxides (NO<sub>x</sub>) are pollutants that adversely affect air quality, the environment, and public health. Furthermore, they are principal pollutants that cause acid rain precipitation. When released into the air, they react with water vapor and other chemicals to form acids that fall back to earth, leading to damage lakes and streams.<sup>123</sup>

Sulfur dioxide (SO<sub>2</sub>) belongs to the family of sulfur oxide gases (SO<sub>x</sub>). These gases dissolve easily in water.<sup>124</sup> Sulfur is prevalent in all raw materials, including crude oil, coal, and ore that contains common metals like aluminum, copper, zinc, lead, and iron. SO<sub>x</sub> gases are formed when fuel containing sulfur, such as coal and oil, is burned, and when gasoline is extracted from oil, or metals are extracted from ore. SO<sub>2</sub> dissolves in water vapor to form acid, and interacts with other gases and particles in the air to form sulfates and other products that can be harmful to people and their environment. Over 65% of SO<sub>2</sub> released to the air, or more than 13 million tons per year, comes from electric utilities, especially those that burn coal.

NO<sub>x</sub> is the generic term for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying amounts. Many of the nitrogen oxides are colorless and odorless.<sup>125</sup> However, one common pollutant, nitrogen dioxide (NO<sub>2</sub>) along with particles in the air can often be seen as a reddish-brown layer over many urban areas. Nitrogen oxides form when fuel is burned at high temperatures, as in a combustion process. The primary manmade sources of NO<sub>x</sub> are motor vehicles, electric utilities, and other industrial, commercial, and residential sources that burn fuels. NO<sub>x</sub> can also form naturally.

Particulate matter (PM), also known as particle pollution, is a complex mixture of extremely small particles and liquid droplets.<sup>126</sup> Particle pollution is made up of a number of components, including acids (such as nitrates and sulfates), organic chemicals, metals, and soil or dust particles. Inhalable particulates, often referred to as PM<sub>10</sub>, are particulate matter less than 10 micrometers (µm) in diameter that can be inhaled into the nose and throat.<sup>127</sup> Respirable particulates, or PM<sub>2.5</sub>, are particulate matter less than 2.5 µm in diameter, and they are small enough to penetrate into the lungs. Both PM<sub>10</sub> and PM<sub>2.5</sub> arise from industrial processes such as electricity generation from combustion plants.

#### **2.1.1 Australia**

Over 85% of electricity generated during 1999-2000 was based on fossil fuel combustion.<sup>128</sup> Currently black coal is the largest source of fuel for electricity generation (used in New South Wales, Queensland, and Western Australia) followed

by brown coal, also known as lignite (South Australia, Victoria, and Western Australia) natural gas and petroleum oils.<sup>129</sup> The characteristics and composition of coal vary more than those for other fuels commonly used in electricity production. Due to the variation in coal properties, it is difficult to characterize emission factors that apply to the range of coals used in Australia.

### 2.1.1.1 Federal Level

The National Environment Protection Council (NEPC) of Australia, through the enactment of the National Environmental Protection Measures (NEPMs) develops federal regulations that pertain to coal-fired power plants and other industrial sources. Australia does not have national air quality *emissions* standards. Environment protection authorities in individual States and Territories set such standards.<sup>130</sup>

Two national NEPMs are relevant for coal plants: the Ambient Air Quality NEPM and the National Pollutant Inventory.

#### National Environment Protection Measure for Ambient Air Quality

In June 1998, the National Environment Protection Council (NEPC) made Australia's first national ambient air quality standards as part of the National Environment Protection Measure for Ambient Air Quality (the 'Air NEPM').<sup>131</sup>

The Air NEPM sets national standards for the six key air pollutants to which most Australians are exposed: carbon monoxide (CO), ozone (O<sub>3</sub>), sulfur dioxide (SO<sub>2</sub>), nitrogen dioxide (NO<sub>2</sub>), lead (Pb) and particulate matter (PM). The standards for SO<sub>2</sub>, NO<sub>x</sub> and PM<sub>10</sub> (see Table 2.1a), are legally binding on each level of government, and must be met by the year 2008. In May 2003, the NEPM was varied to add an advisory PM<sub>2.5</sub> standard (Table 2.1b).<sup>132</sup>

**Table 2.1a. Australian Standards and Goal for Ambient Air Quality: SO<sub>2</sub>, NO<sub>x</sub> and PM<sub>10</sub>**

Pollutant	Averaging period	Maximum concentration	Goal within 10 years Maximum allowable exceedences
Nitrogen dioxide	1 hour 1 year	0.12 ppm 0.03 ppm	1 day a year none
Sulfur dioxide	1 hour 1 day 1 year	0.20 ppm 0.08 ppm 0.02 ppm	1 day a year 1 day a year none
Particles as PM <sub>10</sub>	1 day	50 µg/m <sup>3</sup>	5 days a year

**Table 2.1b. Australian Advisory Standard and Goal for Ambient Air Quality: PM<sub>2.5</sub>**

Pollutant	Averaging period	Maximum concentration	Goal
Particles as PM <sub>2.5</sub>	1 day 1 year	25 µg/m <sup>3</sup> 8 µg/m <sup>3</sup>	Goal is to gather sufficient data nationally to facilitate a review of the standard as part of the review of this Measure scheduled to commence in 2005.

### Monitoring

The Air NEPM requires the jurisdictions to monitor air quality and this helps to identify potential air quality problems.<sup>133</sup> All jurisdictions commenced formal reporting against the Air NEPM standards in 2002.

Specifically, the National Environment Protection (Ambient Air Quality) Measure<sup>134</sup> specifies a number of monitoring requirements:

- Concentration of pollutants in the air: To be measured either at performance monitoring stations or by other means that provide information equivalent to measurements that would otherwise occur at a performance monitoring station (these can include the use of emissions inventories, windfield and dispersion modeling and comparisons with other regions).
- Accreditation: The operator of the monitoring station must be accredited as required in the Air NEPM.
- Siting of Monitoring Stations: To the extent practicable, performance monitoring stations should be sited in accordance with the requirements for Australian Standard AS2922-1987 (Ambient Air-Guide for Siting of Sampling Units). They must be located in a manner such that they contribute to obtaining a representative measure of the air quality likely to be experienced by the general population in the region or subregion and they should be operated in the same location for at least 5 years unless the integrity of the measurements is affected by unforeseen circumstances.
- Number of performance monitoring stations: For a region with a population of 25,000 people or more must be the next whole number above the number calculated in accordance with the formula:  $1.5P + 0.5$ , where  $P$  is the population of the region (in millions). Additional performance monitoring stations may be needed where pollutant levels are influenced by local characteristics such as topography, weather or emission sources. Fewer performance monitoring stations may be needed where it can be demonstrated that pollutant levels are reasonably expected to be consistently lower than the standards mentioned in the Measure.
- Trend Stations: A number of performance monitoring stations in each participating state and territory must be nominated as trend stations. The number of performance monitoring stations to be nominated as trend stations must be



sufficient to monitor and assess long term changes in ambient air quality in different parts of the jurisdiction. A trend station must be operated in the same location for one or more decades.

- The Australian Standard Methods should be used for monitoring pollutants in the air (other standards may be used if they are at least as stringent as these methods). They are:
  - NO<sub>2</sub>: *Determination of Oxides of Nitrogen- Chemiluminescence Method AS3580.5.1-1993*
  - SO<sub>2</sub>: *Determination of Sulfur Dioxide-Direct Reading Instrumental Method AS3580.4.1-1990*
  - PM<sub>10</sub>: *Determination of Suspended Particulate Matter-PM<sub>10</sub> High Volume Sampler with Size Selective Inlet-Gravimetric Method AS3580.9.6-1990 or Determination of Suspended Particulate Matter-PM<sub>10</sub> Dichotomous Sampler- Gravimetric Method AS3580.9.7-1990*

#### *PM<sub>2.5</sub>*

PM<sub>2.5</sub> is to be undertaken at existing or planned performance monitoring stations specified for monitoring PM<sub>10</sub>. Seven jurisdictions (5 states and 2 territories) began monitoring as of July 2004.<sup>135</sup> The reference methods for monitoring particles as PM<sub>2.5</sub> are Class 1 and Class 2 equivalent manual gravimetric methods designated in the US EPA Federal Reference Method (US EPA reference method; *US Code of Federal Regulations Title 40 Part 50 Appendix L Reference Method for the Determination of Fine Particulate Matter as PM<sub>2.5</sub> in the Atmosphere*).<sup>136</sup> Continuous direct mass methods using a tapered element oscillating microbalance may also be used in addition to the reference method.

### **National Pollutant Inventory**

The National Pollutant Inventory (NPI) is a public internet database that displays information about the emissions from industrial facilities and diffuse sources of 93 different substances to air, land and water.<sup>137</sup> Every year Australian industrial facilities that use certain amounts of the 90 NPI substances must estimate and report their emissions directly to their state or territory environment agency. The state and territory environment agencies review all NPI reports for accuracy and forward the data to the Australian Government. The reports are then displayed on the NPI public website: [www.npi.gov.au](http://www.npi.gov.au).

NPI reportable emissions from fossil fuel power stations are largely emissions from stacks.<sup>138</sup> Under the NPI, NO<sub>x</sub>, SO<sub>x</sub> and PM<sub>10</sub> and PM<sub>2.5</sub> are Category 2 substances, and each substance is contained in both of the Category 2 subcategories (2a and 2b). If a facility trips any of the Category 2 thresholds the substances emitted must be reported to the NPI. With the exception of PM<sub>2.5</sub>, which only requires combustion sources to be reported, emissions from all sources, not just combustion sources, need to be estimated.

Category 2a consists of a group of substances that are common products of combustion or other thermal processes.<sup>139</sup> The NPI reporting thresholds for this category are:

- burning of 400 tonnes or more fuel or waste in a year; or
- burning 1 tonne or more of fuel or waste in an hour at any time during the reporting year.

Category 2b also contains substances that are common products of combustion or other thermal processes and includes all Category 2a substances. The NPI thresholds for this category are:

- burning 2,000 tonnes or more of fuel or waste in the reporting year;
- consuming 60,000 megawatt hours or more of electrical energy for other than lighting or motive purposes in the reporting year; or
- a facility that has maximum potential power consumption of 20 megawatts or more for other than lighting or motive purposes in the reporting year.

## Monitoring

*National Pollutant Inventory Guide: General Guidelines for All Emissions Sources*<sup>140</sup>

There are four types of emission estimation techniques (EET) available to assist in calculations of NPI emissions.

1. **Mass balance:** Identifies the quantity of a substance going in or going out of an entire facility, process or piece of equipment. Emissions can be calculated as the difference between the input and output of each listed substance.
2. **Fuel analysis or engineering calculations:** Utilizes the physical/chemical properties, e.g. vapor pressure of the substance and mathematical relationships, e.g. ideal gas law. Theoretical models for specific processes can also be used although reporters should note that these could be complex.
3. **Sampling or direct measurement:** Covers both periodic sampling and continuous monitoring and is based on measured concentrations of the substance in a waste stream and volume/flow rate of that stream. If your local state or territory environment agency already requires monitoring of certain substance emission streams, the reporter can use this data for NPI estimations.
4. **Emission factors:** Based on the average measured emissions from processes and facilities similar to those of the reporter. Emission factors are usually equations that relate emissions to process or equipment throughput.

An alternative approach may also be used. It is reliant on the robustness of and the ability to review and verify the alternative technique. Written approval of the environment agency in a state or territory may provide, only prior to submission of an

emissions report, permission to use techniques that are not specified in the EET manual.

*National Pollutant Inventory Emission Estimation Technique Manual for Fossil Fuel Electric Power Generation: Industry Specific Guidance*<sup>141</sup>

The manual provides specific guidance relevant to fossil fuel electric power generation on the effective EETs listed in the *National Pollutant Inventory Guide*. In general, direct measurement may be the most accurate method for characterizing emissions. However, when reporting to the NPI, power plants may select the EET or mix of EET's that is most appropriate for its purposes, including:

1. **Direct measurement:** Stack sampling test reports often provide emissions data in terms of kg/hr or grams/m<sup>3</sup><sub>STP,dry</sub> (dry standard cubic meter). Annual emissions for NPI reporting can be calculated from this data.
  - Stack tests for NPI reporting should be performed under representative (i.e. normal) operating conditions, and in accordance with the methods, or standards, approved by the relevant environmental authority.
  - Tests conducted specifically for the NPI may differ from stack tests undertaken for a state or territory license condition, which may require the test be taken under maximum emissions rating conditions (i.e. where emissions are likely to be higher than when operating under normal operating conditions).
2. **Using Continuous Emission Monitoring Systems (CEMS) Data:** Applicable to power stations with suitable equipment installed, or for facilities that undertake medium term monitoring that is representative of the power station operations over a year.
  - To monitor SO<sub>2</sub> and NO<sub>x</sub>, emissions using a CEMS, use a pollutant concentration monitor that measures concentration in parts per million by volume dry air (ppmvd).
  - Flow rates should be measured using a volumetric flow rate monitor. Emission rates (kg/hr) are then calculated by multiplying the stack gas concentrations by the stack gas flow rates.
  - While it is possible to determine from this data the total emissions of an individual pollutant over a given time period (assuming the CEM operates properly all year long), an accurate emission estimate can be derived by adding the hourly emission estimates if the CEMS data is representative of typical operating conditions.
  - Although CEMS can report real-time hourly emissions automatically, it may be necessary to manually estimate annual emissions from hourly concentration data.
  - To calculate emissions for the NPI from CEMS concentration data, the selected CEMS data should be representative of operating conditions. When possible, data collected over longer periods should be used.
  - Prior to using CEMS to estimate emissions, reporters should develop a protocol for collecting and averaging the data in order to verify that the

method satisfies the requirements for NPI emission estimations by the environment authority in the facility's state or territory.

3. **Using Fuel Analysis Data:** Fuel analysis can be used to predict SO<sub>2</sub>, metals and metal compounds, and other emissions based on application of mass conservation laws.
  - If using fuel analysis data, it is important to ensure that data are collected and reported in an approved and consistent manner from representative fuel samples. Standards Australia AS 1038 Coal and Coke – Analysis and Testing (Reference: Standards Australia 2002) provides a useful guide to sampling and analyzing coal and coke.
4. **Emission Factors:** Emission factors usually relate the quantity of substances emitted from a source to some common activity associated with those emissions.
  - Emission factors are obtained from US, European and Australian sources, and are usually expressed as the weight of a substance emitted for a unit mass, volume, distance, or duration of the activity emitting the substance (e.g. kilograms of sulfur dioxide emitted per tonne of coal fired). When available, it is preferable to use facility-specific information (e.g. monitoring data) for emission estimation.
  - The emission factor must be approved by state or territory environmental authorities prior to its use for NPI estimations.
  - Emission factors are commonly available for emissions to air, but currently are rarely available for emissions to water or land.
5. **Using a mass balance approach – Trace element behavior during combustion:** Trace elements have been classified into three general, overlapping classes according to their behavior during combustion.
  - Class I: Elements concentrated in the coarse residues (bottom ash) or partitioned equally between coarse residues and flyash, which are generally trapped by the particulate control systems.
  - Class II: Elements concentrated more in the flyash compared with coarse residues. Also enriched in fine-grained particles that may escape the particle control systems.
  - Class III: Elements which volatilize most readily.
6. **Using Engineering Calculations:** There are engineering equations available to enable emissions of a number of trace metals and metal compounds, from black and brown coal combustion, to be estimated with a high degree of confidence.
  - The advantage of these emission equations over simple generic emission factors is that they require the input of facility-specific information relating to fuel type and operating conditions.

## 7. Approved Alternative Method

The EETs presented in the *National Pollutant Inventory Guide* relate principally to average process emissions. Emissions resulting from non-routine events are rarely

discussed in the literature, and there is a general lack of EETs for such events. However, it is important to recognize that emissions resulting from significant operating excursions and/or accidental situations (e.g. spills) will also need to be estimated.

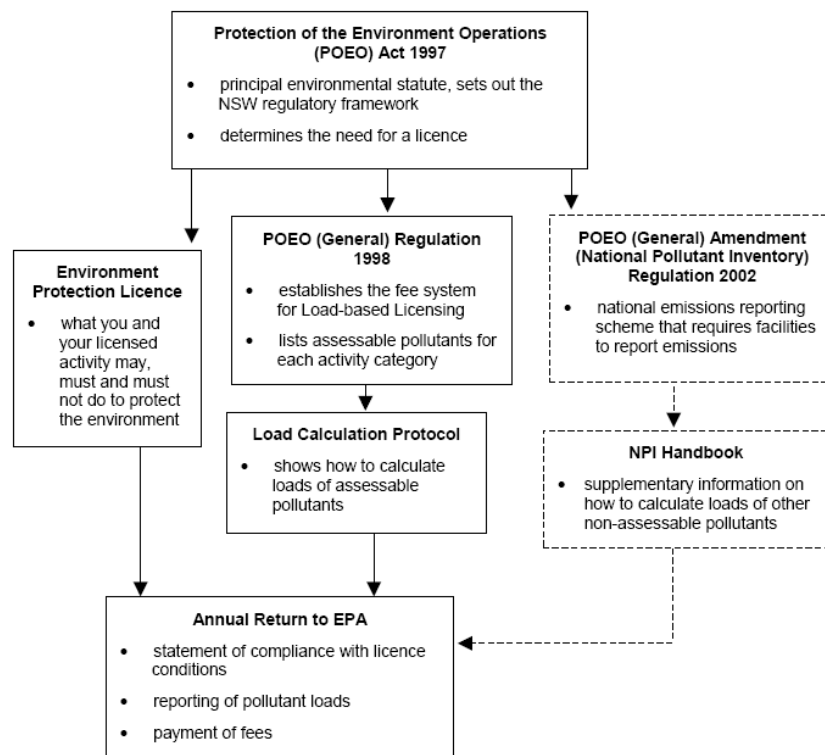
## State Level

While the NEPC, through its Air NEPM, set federal regulations that pertain to coal-fired power plants, it has not set federal emission standards for individual coal-fired power plants. Instead, emission standards for power stations are a matter of the environmental protection agencies in each jurisdiction. These would normally be part of the licensing provisions associated with each facility, based on local conditions, and determined in the context of data available from the NEPMs described above. In the following section, we describe how one state in Australia, New South Wales, regulates and monitors coal-fired power plants.

### 2.1.1.2 New South Wales

An overview of the New South Wales (NSW) regulatory framework is given in Figure 2.1.

**Figure 2.1. Overview of Regulatory Framework Affecting Coal-Fired Power Plants in New South Wales, Australia**



### Protection of the Environment Operations Act

The *Protection of the Environment Operations (POEO) Act 1997* is the key piece of environment protection legislation administered by the New South Wales (NSW)

Environment Protection Authority (EPA), which is part of the Department of Environment and Conservation (DEC).<sup>142</sup> The POEO Act establishes a system of environmental protection licensing for 'scheduled' activities with the potential to have a significant impact on the environment. Electricity generation works (including associated water storage, ash and waste management facilities) that supply or are capable of supplying more than 30 megawatts of electrical generating power from energy sources, including coal, are covered under the Act and are considered Schedule 1 activities.<sup>143</sup>

## POEO (Clean Air) Regulation 2002

The POEO (Clean Air) Regulation 2002, Part 4 deals with 'Emission of air impurities from activities and plant.'<sup>144</sup> On September 1, 2005, significant amendments to the 2002 regulation in relation to activities and the operation of plant and equipment came into effect.<sup>145</sup>

The regulation sets electricity generation standards (in Schedule 3).<sup>146</sup> SO<sub>2</sub> is not regulated because of the low-sulfur content of Australia's coal. The standards are in-stack emission limits and are the maximum emissions permissible. They are based on levels that are achievable through the application of reasonably available technology and good environmental practices. In addition, they reflect proper and efficient operation of the plant and equipment (as a result, these levels can be lower than those prescribed by the regulation). Furthermore, even where the regulation does not prescribe standards for a particular air impurity (such as for SO<sub>2</sub>), emitters must still undertake all practicable means to prevent or minimize air pollution. The emission standards for electricity generation in NSW are shown in Table 2.2.

**Table 2.2. Emission Standards for Coal-Fired Electricity Generation in New South Wales**<sup>147</sup>

Electricity generation			
Air impurity	Activity or plant	Standard of concentration	
Solid particles (Total)	Any activity or plant using a liquid or solid standard fuel <sup>a</sup> or a non-standard fuel <sup>b</sup>	Group 1 <sup>c</sup>	400 mg/m <sup>3</sup>
		Group 2, 3 or 4	250 mg/m <sup>3</sup>
		Group 5	100 mg/m <sup>3</sup>
		Group 6	50 mg/m <sup>3</sup>
	Any crushing, grinding, separating or materials handling activity	Group 1	400 mg/m <sup>3</sup>
		Group 2, 3 or 4	250 mg/m <sup>3</sup>
		Group 5	100 mg/m <sup>3</sup>
		Group 6	20 mg/m <sup>3</sup>
Nitrogen dioxide (NO <sub>2</sub> ) or nitric oxide (NO) or both, as NO <sub>2</sub> equivalent	Any boiler operating on a fuel other than gas, including a boiler used in connection with an electricity generator that forms part of an electricity generating system with a capacity of 30 MW or more	Group 1, 2, 3 or 4	2,500 mg/m <sup>3</sup>
		Group 5	800 mg/m <sup>3</sup>
		Group 6	500 mg/m <sup>3</sup>
	Any turbine operating on a fuel other than gas, being a turbine used in connection	Group 1, 2, 3 or 4	2,500 mg/m <sup>3</sup>
		Group 5	150 mg/m <sup>3</sup>

	with an electricity generating system with a capacity of 30 MW or more	Group 6	90 mg/m <sup>3</sup>
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<sup>a</sup> *Standard fuel* includes coal or coal-derived fuels (other than any tar or tar residues).

<sup>b</sup> *Non-standard fuel* means any fuel other than a standard fuel and does not include coal or coal-derived fuels.

<sup>c</sup> There are six different groups of emission standards that apply to scheduled premises and cover activities or equipment.<sup>148</sup> They are:

**Group 1:** Before January 1, 1972

**Group 2:** After January 1, 1972 and before July 1, 1979

**Group 3:** After July 1, 1979 and before July 1, 1986

**Group 4:** After July 1, 1986 and before August 1, 1997

**Group 5:** After August 1, 1997, as a result of:

- An application for a pollution control approval made on or after August 1, 1997 and before July 1, 1999
- An application for an environment protection license made on or after July 1, 1999 and before September 1, 2005.

**Group 6:** After September 1, 2005, as a result of an application for an environment protection license made on or after September 1, 2005.

## Monitoring

### *Direct Monitoring of Stationary Sources*

All relevant standards in the POEO Part 4 Regulation must be complied with, but the regulation itself does not specify monitoring or sampling frequency. Requirements governing monitoring or sampling emissions of air impurities, including frequency (such as annual, monthly, continuous, etc.), may instead be specified in individual licenses.<sup>149</sup>

The POEO (Clean Air) Regulation 2002 notes selected averaging periods and reference conditions for monitoring air pollutants, which are listed in Tables 2.3 and 2.4, respectively.<sup>150</sup>

**Table 2.3. Selected List of Averaging periods for Air Pollutants**

Air impurity	Averaging period
Nitrogen dioxide (NO <sub>2</sub> ) or nitric oxide (NO) or both, as NO <sub>2</sub> equivalent Sulfur dioxide (SO <sub>2</sub> )	1 hour block
Smoke (if determining whether a specified standard of concentration of opacity has been exceeded)	6 minutes rolling

**Table 2.4. Selected List of Reference Conditions for Monitoring Air Pollutants**

<b>Groups 1, 2, 3 or 4<sup>a</sup></b>		
<b>Air impurity</b>	<b>Activity or plant</b>	<b>Reference conditions</b>
All air impurities (except as listed below)	Any activity or plant	Dry, 273 K, 101.3 kPa
Smoke (if determining whether a specified standard of concentration of opacity has been exceeded)	Any activity or plant	Gas stream temperature above dew point. Path length corrected to stack exit diameter as per CEM-1
Solid particles (total)	Boilers or incinerators	Dry, 273 K, 101.3 kPa, 12% CO <sub>2</sub>
<b>Reference conditions relating to Group 5 or 6<sup>a</sup></b>		
<b>Air impurity</b>	<b>Activity or plant</b>	<b>Reference conditions</b>
All air impurities (except as listed below)	Any activity or plant (except as listed below)	Dry, 273 K, 101.3 kPa
	Any fuel burning equipment using solid fuel	Dry, 273 K, 101.3 kPa, 7% O <sub>2</sub>
Smoke (if determining whether a specified standard of concentration of opacity has been exceeded)	Any activity or plant	Gas stream temperature above dew point. Path length corrected to stack exit diameter as per CEM-1 <sup>a</sup>

<sup>a</sup> There are six different groups of emission standards that apply to scheduled premises and cover activities or equipment.<sup>151</sup> They are:

**Group 1:** Before January 1, 1972

**Group 2:** After January 1, 1972 and before July 1, 1979

**Group 3:** After July 1, 1979 and before July 1, 1986

**Group 4:** After July 1, 1986 and before August 1, 1997

**Group 5:** After August 1, 1997, as a result of:

- An application for a pollution control approval made on or after August 1, 1997 and before July 1, 1999
- An application for an environment protection licence made on or after July 1, 1999 and before September 1, 2005.

**Group 6:** After September 1, 2005, as a result of an application for an environment protection licence made on or after September 1, 2005.

### *Compliance Monitoring*

All monitoring to show compliance must be done in one of three ways:<sup>152</sup>

1. In accordance with the methods specified in the document: *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales*,<sup>153</sup>
2. In accordance with the methods specified in the relevant statutory instrument; or
3. If no method is specified in either this document or the statutory instrument, in a manner approved by the EPA in writing before any tests are conducted.



A licensee may choose to monitor and/or sample air impurities beyond what is required by their license in order to demonstrate that the regulation standards are being met.

The *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales*:<sup>154</sup>

- Covers pollutants from stationary sources and ambient air;
- References a range of previously established test methods (TM), continuous emissions monitoring methods (CEM), other approved methods (OM) and ambient air modeling methods (AM) methods, each of which were dominantly established by the US EPA and/or the Standards Association of Australia.

The approved methods for monitoring air pollutants in NSW, established by the US EPA (US Code of Federal Regulations Title 40, Part 60), are listed in Table 2.5.

**Table 2.5. Selected List of Approved Monitoring Methods for Air Pollutants**

<b>Air impurity</b>	<b>Monitoring method</b>
Smoke (if determining whether a specified standard of concentration of opacity has been exceeded)	CEM-1 <sup>a</sup>
Nitrogen dioxide (NO <sub>2</sub> ) or nitric oxide (NO) or both, as NO <sub>2</sub> equivalent	CEM-2 <sup>b</sup>
Sulfur dioxide (SO <sub>2</sub> )	CEM-2 <sup>b</sup>

<sup>a</sup> US EPA 2000, Code of Federal Regulations, Title 40, Part 60, Appendix B, Performance Specification 1 – Specifications and test procedures for opacity continuous emission monitoring systems in stationary sources, Washington, DC.

<sup>b</sup> US EPA 2000, Code of Federal Regulations, Title 40, Part 60, Appendix B, Performance Specification 2 – Specifications and test procedures for SO<sub>2</sub> and NO<sub>x</sub> continuous emission monitoring systems in stationary sources, Washington, DC.

### *Modeling and Assessment of Air Pollutants*

The emission limits in Part 4 of the Regulation do not take into account site-specific features such as meteorology and background air quality, and therefore do not necessarily protect against adverse air quality impacts in the areas surrounding the premises. These site-specific features are accounted for in a required air quality impact assessment. The purpose of an air quality impact assessment is to demonstrate acceptable impacts at the sensitive receptors surrounding the premises.

The *Approved Methods for the Modeling and Assessment of Air Pollutants in New South Wales*<sup>155</sup> specifies the methods required by statute to be used to model and assess emissions of air pollutants from stationary sources in NSW. It is referred to in Part 4: Emission of Air Impurities from Activities and Plant in the Protection of the Environment Operations (Clean Air) Regulation 2002 (the ‘Regulation’). Industry has an obligation to ensure compliance with the requirements specified in the Regulation.

The document covers:

- Preparation of emissions inventory data
- Preparation of meteorological data
- Methods for accounting for background concentrations and dealing with elevated background concentrations
- Dispersion modeling methodology
- Interpretation of dispersion modeling results
- Impact assessment criteria for – sulfur dioxide (SO<sub>2</sub>), nitrogen dioxide (NO<sub>2</sub>), ozone (O<sub>3</sub>), lead (Pb), PM<sub>10</sub>, total suspended particulates (TSP), deposited dust, carbon monoxide (CO) and hydrogen fluoride (HF)
- Modeling of chemical transformation
- Procedures for developing site-specific emission limits

The emissions inventory is the foundation of the air quality impact assessment. It is obtained by identifying all sources of air pollution at a site by:

- Release type
- Location (in meters relative to fixed origin, elevation and discharge geometry)
- Potential air pollutants emitted.

For estimating emission rates for the inventory, a number of methods can be used to estimate the emission rate from each source.<sup>156</sup> The EPA's preferred methods are direct measurement for existing sources (must be in accordance with the *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales*) and manufacturers' design specifications for proposed sources. Emission factors are generally used when there is no other information available or when emissions can reasonably be demonstrated to be negligible.

Variability in emission rates should be taken into account in the air quality impact assessment. How this is actually included generally depends on the size of the source. For large sources, like power plants, the frequency distribution of emission rates should be compiled and used in conjunction with the frequency distribution of meteorological conditions to predict the overall frequency distribution of predicted ground level concentrations. Where practicable, emission rate data should be constructed using an averaging period that is less than one hour or the sampling time used in the concentration calculations

Emission concentrations for point sources must also be established from the:

- Concentration of the pollutant emitted from a source (mg/m<sup>3</sup>)
- Rate the pollutant is emitted from the source (mg/s)
- Rate of the gaseous volumetric flow (m<sup>3</sup>/s)

The inventory should contain two emission concentrations:

1. Actual concentration of a pollutant emitted from a source in milligrams per actual cubic meter -the volume of gas that occupies a volume of 1 m<sup>3</sup> at stack discharge conditions- (mg/Am<sup>3</sup>), calculated using the actual gaseous volumetric flow rate (Am<sup>3</sup>/s) and measured emission rate.
2. Concentration of a pollutant emitted from a source corrected to the reference conditions as specified in the Regulation (mg/Nm<sup>3</sup>@ O<sub>2</sub>%). This is calculated using the gaseous volumetric flow rate corrected to normal conditions (dry, 273K, 101.3 kPa) and the measured emission rate

The inventory must be used to demonstrate compliance with the Regulation. All sources of air emissions must comply with the requirements of the Regulation. If a source does not comply, the emissions inventory must be revised to reflect the implementation of new technology and/or pollution control equipment such that the source will comply with the Regulation.

### **Load-based Licensing under the POEO Act 1997**

The load-based licensing (LBL) scheme, established under the POEO (General) Regulation 1998 and commenced on 1 July 1999, sets limits on the pollutant loads emitted by holders of environment protection licenses, and links license fees to pollutant emissions. PM (coarse and fine), NO<sub>x</sub> and SO<sub>x</sub> are all subject to fees, which include an administrative fee and a load-based fee. Failure to comply with these requirements is an offense and can involve significant penalties.<sup>157</sup>

LBL is a tool for controlling, reducing and preventing air and water pollution in NSW. The LBL scheme sets clear minimum standards for environmental performance and enables the long-term tracking of emissions reductions.<sup>158</sup> Under LBL there are four categories of pollutant loads:

1. **Assessable:** *Lowest* of the actual, weighted or agreed load. Fees are calculated using the assessable load.
2. **Actual:** Mass in kilograms of the pollutant released into the environment from defined LBL potential emission sources, including electricity generation.
3. **Weighted:** Actual load adjusted using one of the load-weighting methods described in the Protocol.
4. **Agreed:** Load that will be achieved through future improvements as part of the Load Reduction Agreement, or an amount permitted to be reported as part of the 'bubble' license with the EPA.

The POEO (General) Regulation 1998 establishes the fee system for LBL and lists the assessable pollutants for each activity category.<sup>159</sup> In general, the LBL scheme has a relatively high threshold and emissions below this do not incur a fee. NSW increased the fees in July 2004 because the Department of Environment and Conservation found that the fees did not have an impact on the bottom line of the regulated companies.<sup>160</sup>

The Load Calculation Protocol, published in February 2005, shows how to calculate load of assessable pollutants.<sup>161</sup> The Protocol has two parts:

- Part A provides generic information applicable to all license-holders who are required by the Regulation to calculate pollutant loads.
- Part B sets out additional specific requirements that relate to particular fee-based activity classifications of licensed activities listed in Schedule 1 of the Regulation. It includes a worksheet to use for the calculations required by the Protocol.

## Monitoring

There are three general methods for calculating actual pollutant loads:

1. **Source Monitoring (SM):** Direct measurement or representative sampling at the facility. The two monitoring methods generally applicable for air pollutants are continuous emission monitoring (CEMS) and periodic emissions monitoring (PM).
2. **Emission Factors (EF):** Formula that relate known emission characteristics to other variables that are easier or more economical to monitor than the pollutants themselves. Two classes of factors are available: generic and site-specific. In some cases, a Predictive Emission Monitoring Systems (PEMS) may be used.
3. **Mass Balance Calculations (MB):** Generally involves the calculation of a pollutant load from a particular activity by quantifying the materials going into and out of the process.

The general requirements for SM are:

1. Sampling points and monitoring procedures must be established to provide data representative of the actual loads generated at the facility.
2. Monitoring loads of assessable air pollutants discharged to the environment must be conducted strictly in accordance with:
  - The requirements of the EPA license
  - *Approved Methods for the Sampling and Analysis of Air Pollutants in NSW*
3. All records used to calculate license fees must be kept, including
  - A description of the intended monitoring program for LBL purposes;
  - A site map showing all discharge points and monitoring locations;
  - The actual monitoring undertaken and, if applicable, any reasons why it varied from the intended monitoring program; and
  - The sample handling procedures used to ensure the integrity of the sample
4. Where there is a discrepancy between the sampling frequency required by a specific license and those set out in the Load Calculation Protocol, the more frequent sampling method is to be used.

To use EFs:

1. Select the emission factors for each relevant component of the activity for each pollutant (found in Part B of the Load Calculation Protocol for *Electricity Generation*). The factor selected should be the one that is most appropriate to the control technology in place (if none applies, use the default EF).
2. Calculate the load for each component of the activity. Multiply the EF from Step 1 by the quantity of activity.
3. Sum the load for each activity to calculate the total load.

As shown in Table 2.6 below, acceptable monitoring of coarse and fine particulates with EFs requires predictive emissions monitoring systems (PEMS) to develop site specific (SS) EFs. Site specific EFs other than PEMS require EPA approval, which generally follows an assessment by the LBL Technical Review Panel. Licensees must demonstrate that the SS EF will reflect the full range of operating conditions and emissions likely to occur during the license fee period. Acceptable monitoring of SO<sub>x</sub> and NO<sub>x</sub> with EFs also requires site specific SS EFs, though the method required for their generation is not specified.

#### *Predictive Emissions Monitoring System*

With a predictive emissions monitoring system (PEMS), licensees use a representative monitoring campaign to establish consistent relationships between pollutant discharge rates and other operational parameters that are simpler to monitor than the pollutant. These may include the quantity of steam produced, unit loading, rate of fuel consumption and stack or furnace temperature. Results from monitoring these operational parameters can be used to calculate emissions at lower cost than by either CEMS or periodic emission monitoring. PEMS must be used in a suitable program of lower-intensity validation monitoring to ensure that the calculated relationships remain accurate over time. PEMS can be used to estimate most pollutants from fuel-burning activities.

To use PEMS to calculate actual loads, the following steps must be completed:

1. Develop a PEMS that will reflect the full range of operating conditions and emissions likely to be experienced during the license period.
2. Lodge a copy of the PEMS certification (including a description of the monitoring program undertaken and copies of the data obtained) with the EPA during the license fee period.
3. Submit, with the copy of the PEMS specification, a declaration signed by the licensee, which must include a statement of the assessable pollutants, the components of the activity and the maximum error ranges of the PEMS.
4. Where the declared error range of the PEMS is greater than 10%, the amount equal to the part of the error range in excess of 10% (i.e. error range minus 10%) must be added to load values calculated using the PEMS.

Specific PEMS guidance can be from the US EPA in documents titled, *Example Specifications and Test Procedures for Predictive Emission Monitoring Systems*<sup>162</sup> and *Alternative Monitoring Protocol - PEMS for NOX and CO from Industrial Furnaces*.<sup>163</sup>

To use the MB approach:

1. Develop a mass balance that will reflect the full range of operating conditions and emissions likely to be experienced during the license fee period.
2. Lodge a copy of the mass balance with the EPA during the license fee period.
3. Lodge a signed declaration with the copy of the mass balance that includes a statement of assessable pollutants, the components of activity and the maximum error ranges of the mass balance.
4. When the declared error range of the mass balance is greater than 10%, the amount equal to part of the error range in excess of 10% (i.e. error range minus 10%) must be added to load values calculated using the mass balance.

Table 2.6 shows the specific methods required for calculating actual loads (found in Part B of the Load Calculation Protocol for *Electricity Generation*). Where more than one method is shown as acceptable, licensees may use any of the acceptable methods.

**Table 2.6. Specific Load Calculation Methods and Emission Factors, where applicable, for Electricity Generation in New South Wales, Australia**

(Except where otherwise stated—kg/GWh generated)

(a) Electricity generation	Assessable pollutants—AIR					
	Benzo(a) pyrene (eq.)	Coarse particulates	Fine particulates	Fluorides	NO <sub>x</sub>	SO <sub>x</sub>
1. Combustion						
—Coal	SM—PM EF—PEMS, SS, G	SM—PM EF—PEMS, SS	SM—PM EF—PEMS, SS	SM—PM EF—PEMS, SS	SM—PM <sup>a</sup> , CEMS <sup>b</sup> EF—SS	SM—PM, CEMS <sup>b</sup> EF—SS MB
—Gas	-	-	-	-	SM—PM <sup>a</sup> , CEMS <sup>b</sup> EF—SS	-
—Other	-	-	-	-	-	-
<b>TOTAL actual load (kg)</b>						

SM—source monitoring (PM—periodic monitoring; CEMS—continuous emission monitoring system); EF—emission factor (SS—site specific; PEMS—predictive emission monitoring system); MB—mass balance

<sup>a</sup> Only if generating capacity at premises is < 100 MW.

<sup>b</sup> Where more than one identical unit is installed at premises and CEMS is in operation on one unit, PEMS can be used to estimate emissions from second and subsequent units. CEMS or PEMS may be rotated between units.

## 2.1.2 Canada

### 2.1.2.1 Federal Level

#### Canadian Environmental Protection Act

The *Canadian Environmental Protection Act, 1999* (CEPA 1999) came into force on 31 March 2000 following a Parliamentary review of the first CEPA.<sup>164</sup> The focus of CEPA 1999 is pollution prevention and the protection of the environment and human health in order to contribute to sustainable development.<sup>165</sup> Under CEPA 1999, the federal government can assess air pollutants and control their impact through the setting of National Ambient Air Quality Objectives (NAAQOs) and Canada-Wide Standards (CWS).

#### National Ambient Air Quality Objective

The National Ambient Air Quality Objective (NAAQOs) is Canada's national goal for outdoor air quality. For the NAAQOs for SO<sub>2</sub>, total suspended particulate (TSP) and NO<sub>2</sub>, see Table 2.7.<sup>166</sup>

**Table 2.7. National Ambient Air Quality Objectives & Guidelines in Canada**

Pollutant	Averaging Time	Maximum Desirable Level	Maximum Acceptable Level	Maximum Tolerable Level
Sulfur dioxide (SO <sub>2</sub> )	annual	11 ppb	23 ppb	---
	24 hours	57 ppb	115 ppb	306 ppb
	1 hour	172 ppb	334 ppb	---
Total Suspended Particulate (TSP)	annual	60 µg/m <sup>3</sup>	70 µg/m <sup>3</sup>	---
	24 hours	---	120 µg/m <sup>3</sup>	400 µg/m <sup>3</sup>
Nitrogen Dioxide (NO <sub>2</sub> )	annual	32 ppb	53 ppb	---
	24 hours	---	106 ppb	160 ppb
	1 hour	---	213 ppb	532 ppb

#### Monitoring

Monitoring stations continuously measure the concentrations of specific pollutants in the outside air through the National Air Pollution Surveillance (NAPS) Network, a cooperative program of the federal, provincial, territorial and some regional governments.<sup>167</sup> In 2003, the NAPS Network and associated provincial/territorial/regional monitoring networks reporting data to the Canada-wide air quality database consisted of approximately 290 monitoring stations in over 175 communities in Canada, equipped with approximately 600 continuous monitors measuring sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone, and particulate matter, and over 160 air samplers measuring components of particulate matter, volatile organic compounds and other toxic substances.

#### Canada- Wide Acid Rain Strategy for Post 2000

In addition to CEPA 1999, in October 1998, federal, provincial and territorial Energy and Environment Ministers signed the Canada-Wide Acid Rain Strategy for Post 2000.<sup>168</sup> The strategy laid the framework for how Canada would manage acid rain in

the future. As part of this plan, the eastern provinces of Ontario, Quebec, New Brunswick and Nova Scotia were required to develop targets and timelines for achieving critical loads for wet sulfate deposition. At the time of the agreement, modeling suggested that, in order to reach this goal, SO<sub>2</sub> emissions in Ontario and Quebec would need to be reduced by 75 percent from their existing caps and by 30 to 50 percent from the existing caps in New Brunswick and Nova Scotia. Targets and schedules for these SO<sub>2</sub> emission reductions were established by each jurisdiction.

### **Canada-Wide Standards (CWS)**

In January 1998, Canadian Environment Ministers (with the exception of Quebec) signed the Canada-Wide Accord on Environmental Harmonization and its sub-agreement on Canada-Wide Standards (CWS).<sup>169</sup> The CWS provide an alternative regulatory tool for the management of environmental issues of national interest and are intended to be achievable targets that will reduce health and environmental risks within a specific timeframe. Departments have integrated the NAAQOs (National Ambient Air Quality Objectives) and CWS processes. Air pollutants that have been identified by governments as needing to be managed will be targeted for either CWS or NAAQOs development, not both. CWS are considered Environmental Quality Objectives under CEPA 1999.

PM has been identified as priority substances for the development of CWS under the Harmonization agreement and a target of 30 µg/m<sup>3</sup> for PM<sub>2.5</sub> by 2010 (averaging time 24 hours) was announced in June 2000.

### **National Pollutant Release Inventory**

The National Pollutant Release Inventory (NPRI) is a legislated, nation-wide, publicly-accessible inventory of pollutants released, disposed of and recycled by facilities in Canada.<sup>170</sup> Facilities which meet reporting thresholds are required to report annually to the NPRI under the CEPA 1999. The NPRI is managed by Environment Canada and currently tracks 341 substances. The NPRI substances are grouped into five parts based on their reporting criteria.<sup>171</sup> Part 4 deals with Criteria Air Contaminants (CACs).

All facilities are required to consider CACs released from stationary combustion equipment, in the quantities listed in this paragraph, regardless of the number of employees. Facilities with greater than 20,000 employee hours (including contractors) must consider all sources of carbon monoxide (CO), oxides of nitrogen (expressed as NO<sub>2</sub>), sulfur dioxide (SO<sub>2</sub>), total particulate matter with a diameter less than 100 microns (TPM), PM<sub>10</sub>, and PM<sub>2.5</sub>. Reporting of NO<sub>2</sub>, SO<sub>2</sub> and PM with diameter less than 100 µm, may be necessary if these substances were released to the air from a facility in a quantity of 20 tonnes or more. Reporting of PM<sub>10</sub> and PM<sub>2.5</sub> may be required if it was released in quantities of 0.5 and 0.3 tonnes, respectively.

If the stack-specific quantitative threshold is met for CACs (see Table 2.8), additional requirements to break down the releases for each stack greater than or equal to 50 meters above grade may take effect.



**Table 2.8. Stack-Specific Reporting Thresholds for Stacks  $\geq$  50 M above Grade**

Substance Name	Stack Reporting Threshold
Oxides of nitrogen, NO <sub>x</sub> (expressed as NO <sub>2</sub> )	5 tonnes
Sulphur dioxide, SO <sub>2</sub>	5 tonnes
Carbon monoxide, CO	5 tonnes
Total particulate matter, TPM	5 tonnes
Particulate matter $\leq$ 10 microns, PM <sub>10</sub>	0.25 tonnes
Particulate matter $\leq$ 2.5 microns, PM <sub>2.5</sub>	0.15 tonnes

## Monitoring

Estimates of the quantity of a substance that was manufactured, processed or otherwise used, and the quantity that was released, disposed of or transferred, may be based on one of the following methods:<sup>172</sup>

1. **Continuous Emission Monitoring Systems (CEMS):** Record emissions/releases over an extended and uninterrupted period. Various methods are employed to measure the concentration of contaminants in the effluent or gas stream. Once the contaminant concentration and the flow rate have been determined, release or emission rates can be calculated by multiplying the contaminant concentration by the discharge flow rate or volumetric stack gas flow rate. Annual releases of the contaminant can then be estimated by multiplying the contaminant concentration by the annual flow rate of the discharged effluent or gases in the stack or duct.
2. **Predictive Emission Monitoring (PEM):** Based on developing a correlation between contaminant release/emission rates and process parameters (e.g., fuel usage, steam production, furnace temperature). PEM may be considered a hybrid of continuous monitoring, emission factors and stack tests. A correlation test must first be performed to determine the relationship between contaminant emission rates and process parameters. Releases/emissions can then be calculated or predicted using process parameters to predict release/emission rates based on the results of the initial source test.
3. **Source testing:** Involves collecting a sample of the emission or effluent, then determining the concentration of one or more substances in the sample. The concentration of the substance(s) of interest is then multiplied by the volumetric flow rate to determine the amount of the substance(s) emitted over time. Source testing of air emissions generally involves inserting a sampling probe into the stack or duct to collect a volume of exhaust effluent isokinetically. The contaminants collected in or on various media are subsequently analyzed. For liquid effluents, grab samples or 24-hour composite samples are extracted from the effluent stream. Source testing is often conducted as a regulatory requirement for provincial, territorial or regional authorities.
4. **Mass balance:** Applies the law of conservation of mass to a facility, process or piece of equipment. If there is no accumulation, then all the materials that go into the system must come out. Releases are determined from the difference in the input and output of a unit operation where the accumulation and depletion of a substance are included in the calculations. The reliability of release estimates based on mass balances is dependent on the source type

considered. Pollution-control equipment should be accounted for when mass balance calculations are performed.

5. **Site-specific and published emission factors:** Emission factors are available for many emission-source categories and are generally based on the results of source-sampling tests performed at one or more facilities within a specific industry. Generally, emission factors relate the quantity of substances emitted from a source to some common activity associated with those emissions. Government agencies and industry associations publish emission factors to be applied to emission sources in their particular jurisdiction or industrial sector. Industrial facilities may also develop their own site-specific emission factors using emission-testing data and source-activity information. For a particular piece of equipment, specified emission factors may be available from the manufacturer or sales center.
  - The US EPA's Factor Information REtrieval (FIRE) database<sup>173</sup> contains emission factors for a number of NPRI substances including CACs.
6. **Engineering estimates:** In many cases, sound engineering assessment is the most appropriate approach to determining process factors and base quantity values. Releases can be estimated from engineering principles and judgment, by using knowledge of the chemical and physical processes involved, the design features of the source and an understanding of the applicable physical and chemical laws. The reliability of these estimates depends on the complexity of the process and the level of understanding of its physical-chemical properties.
7. **Emission Models:** Emission estimation models, also known as emission estimation tools, are equipment-specific and may be available from process developers and designers, government agencies or others. Emission models generally require detailed input such as equipment specifications, process and environmental conditions and other factors that affect emissions. Generally, these models also have default input parameters, such as meteorological data, which can be used when site-specific information is not available. Review all the default data carefully to ensure that they apply to local conditions. The resulting estimates should also be reviewed to ensure their accuracy.

When you report on-site releases, disposals and off-site transfers, you are required to enter the method of estimation in the NPRI reporting software.

### **New Source Emission Guidelines for Thermal Electricity Generation**

Under CEPA 1999, *New Source Emission Guidelines for Thermal Electricity Generation* have been published.<sup>174</sup> The Guidelines, released in the Canada Gazette in January 2003 after public consultation, are intended to provide advice on emission standards to regulatory authorities for new coal, oil and gas-fired steam-electric power plants. They include emission limits for SO<sub>2</sub>, NO<sub>x</sub> and (PM<sub>10</sub>).

Changes in the CEPA 1999 *New Source Emission Guidelines for Thermal Electricity Generation* with respect to the old version include:

- More stringent emission limits for SO<sub>2</sub>, NO<sub>x</sub> and PM<sub>10</sub>;

- A statement of Environment Canada's intention to continuously update the Guidelines to address advancements in emission control technologies and strategies, and other pollutants of concern; and
- Previous guidelines contained input-based emission limits (i.e. allowable emissions per unit of heat energy input). The new emission limits are expressed in output-based units (i.e. allowable emissions per unit of electricity output). This change is intended to encourage more efficient generation technology and operations by making efficiency count towards meeting emission limits.

The annexed Guidelines include emission limits for NO<sub>x</sub>, PM<sub>10</sub> and SO<sub>2</sub> based on the emissions performance achievable using current best available economically feasible technologies and strategies. The limits are included in Table 2.9. There are no federal guidelines for PM<sub>2.5</sub>.

**Table 2.9. Guidelines for National Emission Standards for New Thermal Electricity Generation**

SO <sub>2</sub>	NO <sub>x</sub>	PM <sub>10</sub>
<b>Kg/MWh per net energy output</b> <b>Based on the hourly mean rate of discharge of SO<sub>2</sub>, NO<sub>x</sub>, or PM<sub>10</sub> emitted over successive 720 hour rolling average periods</b>		
4.24 (and 8% of the uncontrolled emission rate); or 2.65 (and 25% of the uncontrolled emission rate); or 0.53	0.69	0.095

Opacity standards are also given. A new generating unit should not emit visible emissions with opacity greater than 20%. A new generating unit may emit visible emissions with opacity greater than 20% but no more than 40% for a maximum of six (6) minutes in the sixty (60) minute period following any increase in opacity above 20%.

Also under CEPA, any facility (including coal fired power plants) may be required to implement a pollution prevention plan which may then be used to further develop control measures (including environmental regulations) if they are deemed necessary to achieve the desired environmental results.

### **Monitoring**

A continuous emissions monitoring system (CEMS) for measuring SO<sub>2</sub> and NO<sub>x</sub> should be installed on each new generating unit that is fired with coal. The installation and operation of the system should be in accordance with Protocol and Performance Specifications EPS 1/PG/7. CEMS should also be installed for opacity measurement on each new generating unit that is fired with coal.

All CEMS should be installed, calibrated and operating prior to the emission tests required under the Guidelines. During emission tests or within 30 days after the tests have been conducted, and at such other times as may be required, an evaluation of the performance of the CEMS should be conducted in accordance with the requirements and procedures set out in Protocol and Performance Specifications EPS 1/PG/7.<sup>175</sup> A

written report of the results should be prepared and submitted, within sixty (60) days of the evaluation, to the appropriate regulatory authority.

The Guidelines specify that the 720 rolling average emission rate for each pollutant should be sent to the appropriate regulatory authority at least every calendar quarter. Operators of new generating units should keep records of malfunction and breakdowns and should report each occurrence, at least every calendar quarter, to the appropriate regulatory authority.

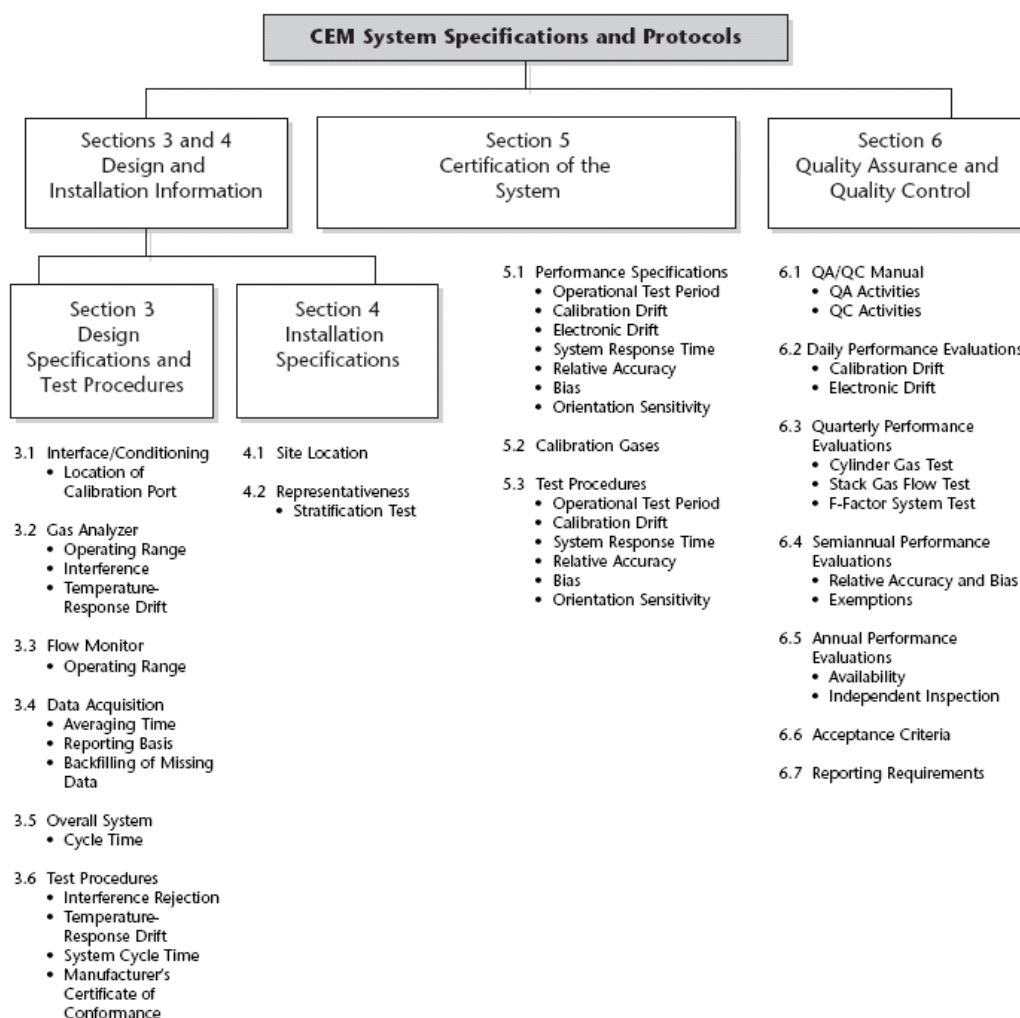
*Protocols and Performance Specifications for Continuous Monitoring of Gaseous Emissions from Thermal Power Generation, Report EPS 1/PG/7 (revised)*<sup>176</sup>

The report was most recently published in November 2005 and outlines specifications for the design, installation, certification, and operation of automated continuous emission monitoring (CEM) systems used to measure gaseous releases of SO<sub>2</sub> and NO<sub>x</sub> from fossil fuel-fired steam electric generating facilities. The procedures used to determine the various CEM system parameters during initial certification testing and subsequent long-term operation of the monitoring system are presented. This report also describes quality assurance and quality control (QA/QC) procedures, including the contents of a site-specific QA/QC manual, which must be developed by the system operator for each installed CEM system. The QA/QC plan must encompass a diverse range of topics, including calibration procedures, maintenance, performance evaluations, and corrective actions.

No specific monitoring system has been designated in this report. Any system that meets initial certification criteria, specified parameters and quality assurance/quality control (QA/QC) requirements is acceptable. In situ or extractive CEM systems based on dynamic dilution technology or direct measurement of the target species may be used. Time-shared CEM systems using a single set of analyzers to determine emission rates for several sources are acceptable.

The specifications that must be met and the procedures that must be followed for the installation, certification, and continued operation of a CEM system are summarized in Figure 2.2.

**Figure 2.2. Summary of Specifications and Protocols for Continuous Emission Monitoring Systems**



## Province Level

Using the Canadian national emissions standards outlined in Table 2.9, the provinces and territories are responsible for implementing regulatory requirements for power generation. This has resulted in significant variation from region to region. Most emission standards for coal-fired power plants in Canada are decided on a case by case basis. Emission limits for existing plants vary according to regional air quality considerations.

### 2.1.2.2 Alberta

In Alberta, natural gas processing plants are responsible for close to half of the SO<sub>2</sub> emissions in the province, but oil sands facilities and power plants are also major SO<sub>2</sub> sources.<sup>177</sup> Transportation (automobiles, locomotives and aircraft) is the major source of NO<sub>x</sub> in Alberta. Other major sources include industrial sources (oil and gas industries) and power plants.

## Ambient Air Quality Objectives

The Alberta *Environmental Protection and Enhancement Act* (EPEA) allows Alberta Environment to develop ambient air quality objectives for all or part of the province to protect Alberta's air quality.<sup>178</sup> Alberta's objectives are equal to or more stringent than existing National Ambient Air Quality Objectives and Canada Wide Standards.

All industrial facilities must be designed to meet Ambient Air Quality Objectives. The objectives for NO<sub>2</sub>, PM and SO<sub>2</sub> are shown in Table 2.10. Objectives are used to establish Approval conditions and can be used to assess compliance and evaluate performance.

**Table 2.10. Alberta's Ambient Air Quality Objectives for NO<sub>2</sub>, PM and SO<sub>2</sub>**

Substance	µg m <sup>-3</sup>	ppbv	Effective
<b>NO<sub>2</sub></b>			1975
1 hour average	400	212	
24 hour average	200	106	
Annual Average	60	32	
<b>PM</b>			
Fine (2.5 µm or less)			2007
1 hour average	80		
24 hour average	30		
Total suspended			1975
24 hour average	100		
Annual Geometric Mean	60		
<b>SO<sub>2</sub></b>			1975, reviewed 1987
1 hour average	450	172	
24 hour average	150	57	
Annual average	30	11	

## Source Emission Standards

To ensure that the quality of the ambient air is maintained within ambient guidelines, emissions are restricted by legislation and management using an approval system.<sup>179</sup> Under the approval system, regulated industries and facilities are allowed to emit limited amounts of various air contaminants.

The determination of air toxics source emission standards for any given facility requesting or applying for an approval is dependent on:

1. The existing air quality;
2. Ambient air quality guidelines or prescribed ambient levels;
3. Source emission standards based on the:
  - nature of the air contaminant, that is, carcinogenic or not,
  - nature of the process industry,
  - air pollution technology that is determined to be the

- best available demonstrated, or
  - best available;
4. The results of air dispersion modeling which takes into account the
- local meteorology and terrain, and
  - surrounding emission sources.

### Alberta Air Emission Standards for Electricity Generation

All new generating units of a power plant for the generation of thermal electric power or new generating units at a cogeneration power plant that produce both thermal energy that is used in an industrial process and to generate thermal electric power are required to install pollution control technologies that shall, at a minimum, achieve the emission limits set out in the *Alberta Air Emission Standards for Electricity Generation*.<sup>180</sup>

The emission standards listed in the Standard represent what is achievable through implementing BATEA (Best Available Technology Economically Achievable). BATEA refers to technology that can achieve superior emissions performance and that has been demonstrated to be economically feasible through successful commercial application across a range of locations and fuel types.

The standards cover SO<sub>2</sub>, NO<sub>x</sub>, and Primary Particulate Matter (PM).

Annual emission intensity limits for new generating units of a coal fired power plant (effective January 1, 2006) can be found in Table 2.11.

**Table 2.11. Annual Emission Intensity Limits for New Coal Fired Power Plants**

Substance	Limit
Sulfur Dioxide (SO <sub>2</sub> )	0.80 kg/MWh <sub>output</sub> for each new generating unit
Nitrogen Oxides (NO <sub>x</sub> )	0.69 kg/MWh <sub>output</sub> for each new generating unit
Primary Particulate Matter (PM)	0.095 kg/MWh <sub>output</sub> for each new generating unit

For newly installed units or equipment, the emission limits for PM shall be based on a one-hour average or as otherwise specified in the EPEA approval. Emission limits for SO<sub>2</sub> and NO<sub>x</sub> (expressed as NO<sub>2</sub>) shall be set as tonnes per hour based on a 720- hour rolling average and also as annual emission intensity limits.

For generating units that have reached the end of their design life of a coal fired power plant (effective January 1, 2006) annual emission limits are specified in Table 2.12. Hourly emission limits will be set within the approval.

**Table 2.12. Generating Units of a Coal Fired Power Plant Post Design Life Annual Emission Intensity Limits**

<b>Substance</b>	<b>Limit</b>
Sulfur Dioxide (SO <sub>2</sub> )	0.80 kg/MWh <sub>output</sub> for each generating unit
Nitrogen Oxides (NO <sub>x</sub> )	0.69 kg/MWh <sub>output</sub> for each generating unit

For any transitional generating unit of a coal fired power plants (effective January 1, 2016) releases into the atmosphere shall not exceed the limits in Table 2.13.

**Table 2.13. Transitional Generating Units of a Coal Fired Power Plant Annual Emission Intensity Limits**

<b>Substance</b>	<b>Limit</b>
Sulfur Dioxide (SO <sub>2</sub> )	0.80 kg/MWh <sub>output</sub> for each generating unit
Nitrogen Oxides (NO <sub>x</sub> )	0.69 kg/MWh <sub>output</sub> for each generating unit

Alberta Environment, industry and other stakeholders have created an emissions management framework, based on recommendations of the Clean Air Strategic Alliance.<sup>181</sup> The framework provides industry with flexibility, which may involve emissions trading, to meet the new NO<sub>x</sub> and SO<sub>2</sub> emission standards and encourages early emissions reductions and early shutdown of older units.

## **Monitoring**

### *Source Emission Monitoring*

For generating units of a coal fired power plant, continuous emission monitoring (CEMS) shall be required on the stack for SO<sub>2</sub>, NO<sub>x</sub>, stack effluent velocity or flow rate, and in-stack opacity in the effluent stream along with any other parameters necessary to determine mass emissions.<sup>182</sup> These technical requirements, along with performance specifications and use of equivalent methodologies such as predictive emission monitoring systems are outlined in the *Alberta Continuous Emission Monitoring System (CEMS) Code*,<sup>183</sup> which is largely based on methodology developed and used by both the US Environmental Protection Agency and Environment Canada. Any additional CEMS or contaminants or manual stack surveys will be determined during the approval issuance phase and in consultation with Alberta Environment's Regional Approvals staff.

All data generated by a CEMS (where the use of that CEMS is linked to the EPEA approval for its associated facility) can be used as a basis for enforcement.<sup>184</sup> Within the thermal electric power generating industry, in-stack opacity limits for start-up and shutdown have been established and CEMS generated data for this industry can be



used as a basis for compliance. For opacity, the "visible emissions reader" will continue to be the only official compliance method for determining opacity levels.

Under the *Alberta CEMS Code*, for new installations, the following information regarding the CEM system must be submitted at least sixty (60) days prior to system installation.<sup>185</sup>

1. Describe in general terms the process(es) and pollution control equipment, along with all factors that may affect the operation of the monitoring system.
2. Describe the location of the monitoring system/sample acquisition point(s) or path(s) in relation to flow disturbances (fans, elbows, inlets, outlets), pollution control equipment, flue walls, and emission point of the monitored effluent streams to the atmosphere. Explain any deviations from the location criteria.
3. List the following system information:
  - Pollutant(s) or parameters to be monitored;
  - Operating principles of the analyzer(s);
  - Number of analyzers, and the number of acquisition point(s) or path(s) for an analyzer, or bank of analyzers sharing multiple ducts (time sharing systems),
  - Equipment manufacturer and model number(s)
  - Copy of the checklist to be used by the instrument technician for periodic checking of the analyzer(s), and the expected normal and maximum analyzer or flow rate readings.
4. Describe the process and pollution control equipment operating parameters that affect the levels of the pollutants being monitored or the parameters being monitored, and also explain the method to be used to record these parameters.
5. Describe calibration, operational and maintenance procedures, along with recommended schedules.
6. Explain procedures to be used to satisfy the requirements for record keeping.

Each facility shall maintain "raw" data for a period of at least 3 years and "summary" data for a period of at least 10 years. "Raw" data should provide for "satisfactory demonstration" of quality control activities as defined in the CEMS Code and the facility Quality Assurance Plan (QAP). Raw data shall be made available for inspection if requested by Alberta Environmental Protection.

#### *Ambient Air Monitoring*

Ambient air monitoring in the vicinity of the power plant *may* additionally be required. These requirements would be determined in consultation with Regional Approvals staff.<sup>186</sup> The number of monitoring stations, frequency and duration of monitoring or sampling, measuring or sampling techniques, and analytical methods, if necessary, are dependent upon the substance to be monitored and its emission rate.

Ambient monitoring for air pollutants takes various forms:<sup>187</sup>

- **Perimeter monitoring** consists of taking discrete samples of substances at various locations along the property boundary of the plant for specified

periods. The substances are considered to be of significance either from a quantity or a health and environmental effects standpoint.

- **Continuous monitoring** is another form of ambient monitoring in which a continuous monitor is installed in a permanent station located at the point of predicted maximum ground level concentration, maximum frequency of exposure direction, or for other considerations. NO<sub>x</sub>, SO<sub>2</sub>, PM<sub>10</sub> and PM<sub>2.5</sub> are collected by continuous (hourly) methods by Alberta Environmental Protection.

### *Plume Dispersion Modeling*

Plume dispersion models are tools that link stack emissions to ambient concentrations.<sup>188</sup>

Once an emission limit for a particular source has been set, the models are used to determine the required stack height to properly disperse any residual air contaminants, thus ensuring that the prescribed ambient levels are met. These models use information on emission characteristics such as pollutant mass emission rate, gas temperature and flow rate to predict the maximum ground level concentrations that can occur over a wide range of possible meteorological conditions, including the worst case atmospheric conditions. Modeling is also used in the siting of air monitoring stations in the vicinity of industrial facilities and takes into account all other sources of similar air contaminants being emitted in the area, i.e. cumulative impacts.

### **2.1.3 European Union**

#### **National Emission Ceilings**

The European Parliament and the Council on National Emission Ceilings for certain pollutants (NEC Directive) sets upper limits for each Member State for the total emissions in 2010 of the four pollutants responsible for acidification, eutrophication and ground-level ozone pollution (SO<sub>2</sub>, NO<sub>x</sub>, volatile organic compounds (VOCs) and ammonia (NH<sub>3</sub>)), but leaves it largely to the Member States to decide which measures – on top of Community legislation for specific source categories - to take in order to comply.<sup>189</sup>

The national ceilings for the EU27 are given in Table 2.14.

**Table 2.14. National Emission Ceiling for the EU27 for SO<sub>2</sub>, NO<sub>x</sub>, VOCs and NH<sub>3</sub> to be obtained by 2010<sup>190</sup>**

Country	SO <sub>2</sub>	NO <sub>x</sub>	VOC	NH <sub>3</sub>
	Kilotonnes	Kilotonnes	Kilotonnes	Kilotonnes
<i>Austria</i>	39	103	159	66
<i>Belgium</i>	99	176	139	74
<i>Bulgaria (3)</i>	836	247	175	108
<i>Cyprus (2)</i>	39	23	14	9
<i>Czech Republic (2)</i>	265	286	220	80
<i>Denmark</i>	55	127	85	69
<i>Estonia (2)</i>	100	60	49	29
<i>Finland</i>	110	170	130	31
<i>France</i>	375	810	1050	780
<i>Germany</i>	520	1051	995	550
<i>Greece</i>	523	344	261	73
<i>Hungary (2)</i>	500	198	137	90
<i>Ireland</i>	42	65	55	116
<i>Italy</i>	475	990	1159	419
<i>Latvia (2)</i>	101	61	136	44
<i>Lithuania (2)</i>	145	110	92	84
<i>Luxembourg</i>	4	11	9	7
<i>Malta (2)</i>	9	8	12	3
<i>Netherlands</i>	50	260	185	128
<i>Poland (2)</i>	1397	879	800	468
<i>Portugal</i>	160	250	180	90
<i>Romania (3)</i>	918	437	523	210
<i>Slovakia (2)</i>	110	130	140	39
<i>Slovenia (2)</i>	27	45	40	20
<i>Spain</i>	746	847	662	353
<i>Sweden</i>	67	148	241	57
<i>United Kingdom</i>	585	1167	1200	297
<b>EC27</b>	<b>8297</b>	<b>9003</b>	<b>8848</b>	<b>4294</b>

(1) These national emission ceilings are designed with the aim of broadly meeting the interim environmental objectives set out in Article 5. Meeting those objectives is expected to result in a reduction of soil eutrophication to such an extent that the Community area with depositions of nutrient nitrogen in excess of the critical loads will be reduced by about 30% compared with the situation in 1990.

(2) These national emission ceilings are temporary and are without prejudice to the review according to Article 10 of this Directive, which is to be completed in 2004."

(3) provisional information based on accession treaty

## Convention on Long-Range Transboundary Air Pollution

Parallel to the development of the EU NEC Directive, the EU Member States together with Central and Eastern European economies, the United States and Canada have negotiated the "multi-pollutant" protocol under the Convention on Long-Range Transboundary Air Pollution (the so-called Gothenburg protocol, agreed in November 1999). The emission ceilings in the protocol are equal or less ambitious than those in the NEC Directive.<sup>191</sup>

## Air Quality Framework Directive

The *Air Quality Framework Directive* of 1996 deals with ambient air quality assessment and management. It describes the basic principles as to how air quality should be assessed and managed in the Member States.<sup>192</sup> The limit values for the specific pollutants are set through a series of Daughter Directives. The *First Daughter Directive* of 1999 sets limit values for sulfur dioxide (SO<sub>2</sub>), nitrogen dioxide (NO<sub>2</sub>), and particulate matter (PM) in ambient air.<sup>193</sup> The limits are listed in Table 2.15. Under EU law, a limit value is legally binding from the date it enters into force subject to any exceedences permitted by the legislation.

**Table 2.15. Ambient Air Quality Limits for SO<sub>2</sub>, NO<sub>2</sub> and PM<sub>10</sub>**

<i>Pollutant</i>	<i>Concentration</i>	<i>Averaging period</i>	<i>Legal nature- Date Enters into force</i>	<i>Permitted exceedences each year</i>
Sulfur dioxide (SO <sub>2</sub> )	350 µg/m <sup>3</sup>	1 hour	1/1/05	24
	125 µg/m <sup>3</sup>	24 hours	1/1/05	3
Nitrogen dioxide (NO <sub>2</sub> )	200 µg/m <sup>3</sup>	1 hour	1/1/10	18
	40 µg/m <sup>3</sup>	1 year	1/1/10	n/a
PM <sub>10</sub>	50 µg/m <sup>3</sup>	24 hours	1/1/05	35
	40 µg/m <sup>3</sup>	1 year	1/1/05	n/a

### *New Air Quality Directive*

*A Proposal for a Directive of the European Parliament and of the Council on ambient air quality and cleaner air for Europe* is currently under review.<sup>194</sup> It is subject to the co-decision procedure and will only enter into force once adopted by both the Council of Ministers and the European Parliament. It retains the same limits as listed above and does not include a limit for PM<sub>2.5</sub>.

### **Monitoring**

European legislation on air quality is built on certain principles. The first of these is that the Member States divide their territory into a number of zones and agglomerations. In these zones and agglomerations, the Member States should undertake assessments of air pollution levels using measurements and modeling and other empirical techniques. Where levels are elevated, the Member States should prepare an air quality plan or program to ensure compliance with the limit value before the date when the limit value formally enters into force. In addition, information on air quality should be disseminated to the public.

The First Daughter Directive lays out details for the number of sampling points to be used, data quality objectives, and other monitoring objectives. It also lays out reference methods from the International Standards Organization (ISO)/ European Standards (EN) to be used to assess air pollutants concentrations for:<sup>195</sup>

- **SO<sub>2</sub>**: ISO/FDIS 10498 (Standard in draft) - Ambient air - determination of sulfur dioxide – ultraviolet fluorescence method.
- **NO<sub>2</sub> and NO<sub>x</sub>**: ISO 7996: 1985 Ambient air - determination of the mass concentrations of nitrogen oxides - chemiluminescence method.
- **PM<sub>10</sub>**: EN 12341: Air Quality - Field Test Procedure to Demonstrate Reference Equivalence of Sampling Methods for the PM<sub>10</sub> fraction of particulate matter'.
  - The measurement principle is based on the collection on a filter of the PM<sub>10</sub> fraction of ambient particulate matter and the gravimetric mass determination.

A Member State may use any other method which it can demonstrate gives results equivalent to the above method.

The *First Daughter Directive* addresses both PM<sub>10</sub> and PM<sub>2.5</sub> but only establishes monitoring requirements and references methods for fine particles (PM<sub>10</sub>).

The proposed new air quality directive includes additional information for acquiring PM<sub>2.5</sub> data. It also and suggest the following reference method:<sup>196</sup>

- **PM<sub>2.5</sub>**: EN 14907:2005: Standard gravimetric measurement method for the determination of the PM<sub>2.5</sub> mass fraction of suspended particulate matter in Ambient air.

### *PM<sub>2.5</sub> Standards Setting*

On 11 December 2007, the European Parliament set, for the first time, binding standards for fine particles PM<sub>2.5</sub> from the transportation and energy industries.<sup>197</sup> The new Directive was approved on 14 April 2008.<sup>198</sup>

Under the standard, Member States will be required to reduce exposure levels in urban areas to PM<sub>2.5</sub> by an average of 20% by 2020 based on 2010 exposure levels.<sup>199</sup> The final agreement introduces an additional condition which obliges Member states to bring exposure levels below 20 µg/m<sup>3</sup> by 2015 in these areas. Throughout their territory Member States will need to respect the PM<sub>2.5</sub> limit value set at 25 µg/m<sup>3</sup>, (averaging time calendar year). This value must be achieved by 2015 or, where possible already, by 2010.

Under the agreed text the deadlines for complying with these standards can be postponed by up to the three years after the directive's entry into force (mid-2011), provided that the relevant EU legislation such as industrial pollution prevention and control (IPPC) is fully implemented, and that all appropriate abatement measures are being taken. The directive provides a list of measures that need to be considered.

### *Monitoring under PM<sub>2.5</sub> Standard Setting*

According to the new Air Quality Directive,<sup>200</sup> in all zones and agglomerations where PM<sub>2.5</sub>:

- Exceeds the upper assessment threshold - 70 % of limit value (17 µg/m<sup>3</sup>) - fixed measurements shall be used to assess the ambient air quality. The measurements may be supplemented by modeling techniques and/or indicative measurements to provide adequate information on the spatial distribution of the ambient air quality.
- Below the upper assessment threshold - 50 % of limit value (12 µg/m<sup>3</sup>) - a combination of fixed measurements and modeling techniques and/or indicative measurements may be used to assess the ambient air quality.
- Below the lower assessment threshold established for those pollutants, modeling techniques or objective-estimation techniques or both shall be sufficient for the assessment of the ambient air quality.

In addition, measurements shall be made, at rural background locations away from significant sources of air pollution, for the purposes of providing, as a minimum, information on the total mass concentration and the chemical speciation concentrations of PM<sub>2.5</sub> on an annual average basis. Measurements shall be conducted using the following criteria:

- One sampling point shall be installed every 100 000 km<sup>2</sup>;
- Each Member State shall set up at least one measuring station or may, by agreement with adjoining Member States, set up one or several common measuring stations, covering the relevant neighboring zones, to achieve the necessary spatial resolution;
- Where appropriate, monitoring shall be coordinated with the monitoring strategy and measurement program of the Cooperative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe (EMEP);
- Sections A (Data quality objectives for ambient air quality assessment) and C (Quality assurance for ambient air quality assessment: data validation) of Annex I of the Directive shall apply in relation to data quality objectives for mass concentration measurements of particulate matter and Annex IV (Measurements at Rural Background Locations Irrespective of Concentration) of the Directive shall apply in its entirety.

Member States shall inform the Commission of the measurement methods used in the measurement of the chemical composition.

The location of sampling points for the measurement shall be determined using the criteria listed in Annex III of the Directive.

The reference method for the sampling and measurement of PM<sub>2.5</sub> is the European Standard (EN) reference method 14907:2005 titled, *Standard gravimetric measurement method for the determination of the PM<sub>2.5</sub> mass fraction of suspended particulate matter*.

### **European Pollutant Emission Register/European Pollutant Release and Transfer Register**

The European Pollutant Emission Register (EPER), established July 17, 2000, was the first European-wide register of industrial emissions into air and water.<sup>201</sup> According to the EPER Decision, Member States have to produce a triennial report, which covers the emissions of 50 pollutants to be included if the threshold values indicated in the EPER Decision are exceeded.

The European Pollutant Release and Transfer Register (E-PRTR), which will succeed the EPER, is intended to fully implement the obligations of the United Nations Economic Commission for Europe (UN-ECE) Pollutant Release and Transfer Register (PRTR) Protocol, which was signed in May 2003 by 36 economies and the European Community.<sup>202</sup> The obligations under the E-PRTR Regulation extend beyond the scope of EPER mainly in terms of more facilities included, more

substances to report, additional coverage of releases to land, off-site transfers of waste and releases from diffuse sources, public participation and annual instead of triennial reporting.

The first reporting year under the E-PRTR was 2007 and respective information will have to be reported by Member States in June 2009. The Commission will publish the data in autumn 2009.

Thermal power stations and other combustion installations with a heat input of greater than 50 megawatts (MW) – the same requirements covered by the Large Combustion Plants (LCP) Directive and the Integrated Pollution Prevention and Control (IPPC) Directive - are required to report emissions under the E-PRTR for SO<sub>2</sub>, NO<sub>x</sub>, and PM<sub>10</sub>. The reporting thresholds are: SO<sub>x</sub>/SO<sub>2</sub> - 150,000 kg/year; NO<sub>x</sub>/NO<sub>2</sub> - 100,000 kg/year; PM<sub>10</sub> – 50,000 kg/year.<sup>203</sup>

### **Monitoring**

Reporting is carried out based on measurement, calculation or estimation of releases and off-site transfers.<sup>204</sup> The operator of the facility has to decide before collecting the data which determination methodology for a certain pollutant results in "best available information" for the reporting. Where data are measured or calculated, the method of measurement and/or the method for calculation must also be indicated.

Operators should prepare their data collection in accordance with internationally approved methodologies, where such methodologies are available. The operator may use "equivalent" methodologies other than internationally approved methodologies, even when available, if one or more of the following conditions are fulfilled:

1. The operator uses one or more measurement, calculation or estimation methodologies already prescribed by the competent authority in a license or an operating permit for that facility.
2. A national or regional binding measurement, calculation or estimation methodology is prescribed by legal act for the pollutant and facility concerned.
3. The operator has shown that the alternative measurement methodology used is equivalent to existing European Committee for Standardization (CEN)/ International Standard Organization (ISO) measurement.

The approved standards for Nitrogen oxides (NO<sub>x</sub>/NO<sub>2</sub>) are:

- European Standard (EN)14792:2005: *Stationary source emissions – Determination of mass concentration of nitrogen oxides (NO<sub>2</sub>) – Reference method: chemiluminescence*
- International Standard (ISO) 11564:1998: *Stationary source emissions - Determination of the mass concentration of nitrogen oxides - Naphthylethylenediamine photometric method*
- ISO 10849:1996: *Stationary source emissions - Determination of the mass concentration of nitrogen oxides – Performance characteristics of automated measuring systems*

The approved standards for Sulfur oxides (SO<sub>x</sub>/SO<sub>2</sub>) are:

- EN 14791:2005: *Stationary source emissions - Determination of mass concentration of sulphur dioxide - Reference method*
- ISO 7934:1989: *Stationary source emissions - Determination of the mass concentration of sulfur dioxide, hydrogen peroxide/bariumperchlorate/Thorin method*
- ISO 7935:1992: *Stationary source emissions; determination of the mass concentration of sulfur dioxide; performance characteristics of automated measuring methods*
- ISO 11632:1998: *Stationary source emissions - Determination of mass concentration of sulfur dioxide – Ion chromatography method*

For PM<sub>10</sub>, the standard is available as a committee draft (CD):

- ISO/CD 23210:2005: *Stationary source emissions — Determination of low PM<sub>10</sub>/PM<sub>2.5</sub> mass concentration in flue gas by use of impactors*

### **Large Combustion Plants Directive**

The overall aim of Large Combustion Plants (LCP) Directive, which entered into force on November 27, 2001, is to reduce emissions of acidifying pollutants, particles, and ozone precursors.<sup>205</sup> LCPs are defined as plants whose thermal input is greater than 50 megawatts (MW), irrespective of the fuel type used. Member States may adopt emission limit values and compliance deadlines which are stricter than those provided for in the Directive, include other pollutants and lay down additional requirements.

The Commission considers that it is possible to adopt a "combined approach" for the implementation of the LCP Directive for existing plants, which may consist of:

1. Applying a national emission reduction plan for some plants and an emission limit value approach for others for all the compliance periods (2008-2015, 2016-2017, and 2018 onwards), or
2. Adopting a national emission reduction plan for a/some compliance period(s) and complying with emission limit values for the rest of the compliance periods, or
3. Mixing options 1 and 2.

A national emission reduction plan (which had to be submitted by 27 November 2003), whether used alone or as part of a combined approach, must address all the three pollutants covered by the Directive for all the plants covered by the plan.

SO<sub>2</sub> emission limit values for solid fuels expressed in mg/Nm<sup>3</sup> (O<sub>2</sub> content 6 %) to be applied by new plants (pursuant to LCP Directive, Article 4(2)<sup>206</sup>) with the exception of gas turbines are listed in Table 2.16.



**Table 2.16. SO<sub>2</sub> Emission Limit Values for Solid Fuels**

Type of fuel	50 to 100 MWth <sup>a</sup>	100 to 300 MWth	> 300 MWth
General case <sup>b</sup>	850	200 <sup>c</sup>	200

<sup>a</sup> MWth is megawatts thermal

<sup>b</sup> Coal and other solid fuels, but not including gas or biomass

<sup>c</sup> Except in the case of the ‘Outermost Regions’ where 850 to 200 mg/Nm<sup>3</sup> (linear decrease) shall apply.

‘Outermost Regions’ are the French Overseas Departments with regard to France, the Azores and Madeira with regard to Portugal and the Canary Islands with regard to Spain.

NO<sub>x</sub> emission limit values expressed in mg/Nm<sup>3</sup> (O<sub>2</sub> content 6 % for solid fuels, 3 % for liquid and gaseous fuels) to be applied by new and existing plants (pursuant to LCP Directive, Articles 4(1)<sup>207</sup> and 4(3),<sup>208</sup> respectively) are listed in Table 2.17.

**Table 2.17. Emission Limit Values for NO<sub>x</sub> (measured as NO<sub>2</sub>)**

Type of fuel	Limit values <sup>a</sup> (mg/Nm <sup>3</sup> )
Solid <sup>b,c</sup>	
50 to 500 MWth <sup>d</sup>	600
>500 MWth	500
From January 1, 2016	
50 to 500 MWth	600
>500 MWth	200

<sup>a</sup> Except in the case of the ‘Outermost Regions’ where the following values shall apply: Solid in general: 650; Solid with < 10 % vol comps: 1,300. ‘Outermost Regions’ are the French Overseas Departments with regard to France, the Azores and Madeira with regard to Portugal and the Canary Islands with regard to Spain.

<sup>b</sup> Until December 31, 2015 plants of a rated thermal input greater than 500 MW, which from 2008 onwards do not operate more than 2,000 hours a year (rolling average over a period of five years), shall:

- In the case of plant licensed in accordance with Article 4(3)(a), be subject to a limit value for nitrogen oxide emissions (measured as NO<sub>2</sub>) of 600 mg/Nm<sup>3</sup>;
- In the case of plant subject to a national plan under Article 4(6), have their contribution to the national plan assessed on the basis of a limit value of 600 mg/Nm<sup>3</sup>.

From January 1, 2016 such plants, which do not operate more than 1,500 hours a year (rolling average over a period of five years), shall be subject to a limit value for nitrogen oxide emissions (measured as NO<sub>2</sub>) of 450 mg/Nm<sup>3</sup>.

<sup>c</sup> Until 1 January 2018 in the case of plants that in the 12 month period ending on January 1, 2001 operated on, and continue to operate on, solid fuels whose volatile content is less than 10 %, 1,200 mg/Nm<sup>3</sup> shall apply.

<sup>d</sup> MWth is megawatts thermal

Dust emission limit values expressed in mg/Nm<sup>3</sup> (O<sub>2</sub> content 6 % for solid fuels) to be applied by new and existing plants (pursuant to LCP Directive, Articles 4(1) and 4(3), respectively) and new plants (pursuant to LCP Directive, Article 4(2) with exception of gas turbines) are listed in Table 2.18.

**Table 2.18. Emission Limit Values for Dust**

Type of fuel	Rated Thermal Input <sup>a</sup> (MW)	Emission limit values (mg/Nm <sup>3</sup> )
Solid New and existing plants: Articles 4(1) and 4(3)	≥ 500	50 <sup>a</sup>
	< 500	100
Solid: New plants Article 4(2)	50 to 100 MWth <sup>b</sup>	50
	> 100 MWth	30

<sup>a</sup> A limit value of 100 mg/Nm<sup>3</sup> may be applied to plants licensed (pursuant to LCP Directive Article 4(3)) with a rated thermal input greater than or equal to 500 MWth burning solid fuel with a heat content of less than 5 800 kJ/kg (net calorific value), a moisture content greater than 45% by weight, a combined moisture and ash content greater than 60% by weight and a calciumoxide content greater than 10%.

<sup>b</sup> MWth is megawatts thermal

### Monitoring

The national emission reduction plans need to contain objectives, measures and timetables in addition to a monitoring mechanism. The methods of measurement of emissions are defined in Annex VIII. Member States must take the necessary measures to ensure that emissions from the plants covered by the Directive are monitored. They may require such monitoring to be carried out at the operator's expense.<sup>209</sup>

*ANNEX VIII of the LCP Directive:*<sup>210</sup>

The methods of measurement of emissions are:

1. **Until 27 November 2004:**
  - Concentrations of SO<sub>2</sub>, NO<sub>x</sub>, and dust shall be measured continuously in the case of new plants for which a licence is granted with a rated thermal input of more than 300 MW.
  - Monitoring of SO<sub>2</sub> and dust may be confined to discontinuous measurements or other appropriate determination procedures in cases where such measurements or procedures, which must be verified and approved by the competent authorities, may be used to obtain concentration.
  - In the case of new plants for which a licence is not covered by the first subparagraph, the competent authorities may require continuous measurements of those three pollutants to be carried out where considered necessary.
  - Where continuous measurements are not required, discontinuous measurements or appropriate determination procedures as approved by the competent authorities shall be used regularly to evaluate the quantity of SO<sub>2</sub>, NO<sub>x</sub> and dust.
2. **From 27 November 2002:**
  - Competent authorities shall require continuous measurements of concentrations of SO<sub>2</sub>, NO<sub>x</sub>, and dust from waste gases from each combustion plant with a rated thermal input of 100 MW or more.

- For combustion plants burning coal, continuous measurements may not be required for plants with a life span of less than 10,000 operational hours.
  - Where continuous measurements are not required, discontinuous measurements shall be required at least every six months.
  - As an alternative, appropriate determination procedures, which must be verified and approved by the competent authorities, may be used to evaluate the quantities of SO<sub>2</sub>, NO<sub>x</sub> and dust. Such procedures shall use relevant European Committee for Standardization (CEN) standards as soon as they are available. If CEN standards are not available International Standards Organization (ISO) standards, national or international standards which will ensure the provision of data of an equivalent scientific quality shall apply.
3. In the case of plants which must comply with the desulfurization rates, the requirements concerning SO<sub>2</sub> emission measurements established under paragraph 2 of this point apply. Moreover, the sulfur content of the fuel which is introduced into the combustion plant facilities must be regularly monitored.
  4. The competent authorities shall be informed of substantial changes in the type of fuel used or in the mode of operation of the plant. They shall decide whether the monitoring requirements laid down in paragraph 2 are still adequate or require adaptation.
  5. The continuous measurements carried out in compliance with paragraph 2 shall include the relevant process operation parameters of oxygen content, temperature, pressure and water vapour content. The continuous measurement of the water vapour content of the exhaust gases shall not be necessary, provided that the sampled exhaust gas is dried before the emissions are analyzed.
    - Representative measurements, i.e. sampling and analysis, of relevant pollutants and process parameters as well as reference measurement methods to calibrate automated measurement systems shall be carried out in accordance with CEN standards as soon as they are available. If CEN standards are not available ISO standards, national or international standards which will ensure the provision of data of an equivalent scientific quality shall apply. Continuous measuring systems shall be subject to control by means of parallel measurements with the reference methods at least every year.
    - The values of the 95 % confidence intervals of a single measured result shall not exceed the following percentages of the emission limit values:
      - SO<sub>2</sub>: 20 %
      - NO<sub>x</sub>: 20 %
      - Dust: 30 %
    - The validated hourly and daily average values shall be determined from the measured valid hourly average values after having subtracted the value of the confidence interval specified above.
    - Any day in which more than three hourly average values are invalid due to malfunction or maintenance of the continuous measurement system shall be invalidated.
    - If more than ten days over a year are invalidated for such situations the competent authority shall require the operator to take adequate

measures to improve the reliability of the continuous monitoring system.

For determination of total annual emissions of combustion plants until and including 2003:

- The competent authorities shall obtain determination of the total annual emissions of SO<sub>2</sub> and NO<sub>x</sub> from new combustion plants.
- When continuous monitoring is used, the operator of the combustion plant shall add up separately for each pollutant the mass of pollutant emitted each day, on the basis of the volumetric flow rates of waste gases.
- Where continuous monitoring is not in use, estimates of the total annual emissions shall be determined by the operator.
- Member States shall communicate to the Commission the total annual SO<sub>2</sub> and NO<sub>x</sub> emissions of new combustion plants at the same time as the communication of the total annual emissions of existing plants.
- Member States shall establish, starting in 2004 and for each subsequent year, an inventory of SO<sub>2</sub>, NO<sub>x</sub> and dust emissions from all combustion plants with a rated thermal input of 50 MW or more.
- The competent authority shall obtain for each plant operated under the control of one operator at a given location the following data:
  - Total annual emissions of SO<sub>2</sub>, NO<sub>x</sub> and dust (as total suspended particles).
  - Total annual amount of energy input, related to the net calorific value, broken down by fuel category.
  - A summary of the results of this inventory that shows the emissions from refineries separately shall be communicated to the Commission every three years within twelve months from the end of the three-year period considered.
- The yearly plant-by-plant data shall be made available to the Commission upon request.
- The Commission shall make available to the Member States a summary of the comparison and evaluation of the national inventories within twelve months of receipt of the national inventories.
- Commencing on 1 January 2008 Member States shall report annually to the Commission on those existing plants declared for eligibility under Article 4(4)<sup>211</sup> along with the record of the used and unused time allowed for the plants' remaining operational life.

For determination of the total annual emissions of existing plants until and including 2003:

1. Member States shall establish, starting in 1990 and for each subsequent year until and including 2003, a complete emission inventory for existing plants covering SO<sub>2</sub> and NO<sub>x</sub>:
  - On a plant by plant basis for plants above 300 MWth and for refineries;

- On an overall basis for other combustion plants to which this Directive applies.
2. The methodology used for these inventories shall be consistent with that used to determine SO<sub>2</sub> and NO<sub>x</sub> emissions from combustion plants in 1980.
  3. The results of this inventory shall be communicated to the Commission in a conveniently aggregated form within nine months from the end of the year considered.
  4. The methodology used for establishing such emission inventories and the detailed base information shall be made available to the Commission at its request.
  5. The Commission shall organize a systematic comparison of such national inventories and, if appropriate, shall submit proposals to the Council aiming at harmonizing emission inventory methodologies, for the needs of an effective implementation of this Directive.

### **Integrated Pollution Prevention and Control Directive**

The Integrated Pollution Prevention and Control Directive (IPPC) of 1996, set common EU rules for permitting and controlling industrial installations.<sup>212</sup> Operators of industrial installations covered by Annex I of the IPPC Directive, which includes combustion installations with a rated thermal input exceeding 50 MW, are required to obtain an authorization (environmental permit) from the authorities in the EU economies. About 50,000 installations are covered by the IPPC Directive. New installations, and existing installations which are subject to "substantial changes", have been required to meet the requirements of the IPPC Directive since 30 October 1999. Other existing installations had to be brought into compliance by the deadline of 30 October 2007.

The IPPC Directive is based on several principles:

1. **Integrated Approach:** Permits must take into account the whole environmental performance of the plant, covering e.g. emissions to air, water and land, generation of waste, use of raw materials, energy efficiency, noise, prevention of accidents, and restoration of the site upon closure.
2. **Best Available Techniques (BAT):** The methods upon which the permit conditions, including emission limit values (ELVs), must be based on.
3. **Flexibility:** Allows the licensing authorities, in determining permit conditions, to take into account the installation's technical characteristics, geographical location and local environmental conditions.
4. **Public right to participate:** The public has access to permit application, permits, results of the monitoring releases and the European Pollutant Emission Register, where emissions are reported by Member States.

The permit shall include emission limit values for pollutants, including SO<sub>2</sub>, NO<sub>x</sub> and dust, likely to be emitted from the installation concerned in significant quantities, having regard to their nature and their potential to transfer pollution from one medium to another (water, air and land).

## **Monitoring**

Permit shall contain suitable release monitoring requirements, specifying measurement methodology and frequency, evaluation procedure and an obligation to supply the competent authority with data required for checking compliance with the permit. The results of monitoring of releases as required under the permit conditions and held by the competent authority must be made available to the public.

Member States shall take the necessary measures to ensure that the conditions of the permit are complied with and that the operator regularly informs the competent authority of the results of the monitoring of releases and without delay of any incident or accident significantly affecting the environment.

### **2.1.4 United States**

In the United States, roughly 67% of all SO<sub>2</sub> and 25% of all NO<sub>x</sub> come from electric power generation that relies on burning fossil fuels, like coal.<sup>213</sup>

#### **The Clean Air Act**

The federal regulation that controls air pollution in the United States is the Clean Air Act (CAA). The US Environmental Protection Agency (US EPA) is primarily responsible for carrying out the law. The Clean Air Act of 1970 set National Ambient Air Quality Standards (NAAQS). Since many States failed to meet the NAAQS set in 1970, amendments to the act were adopted in 1977 and 1990, the latter of which established the US EPA Acid Rain Program.

#### **National Ambient Air Quality Standards (NAAQS)**

##### *Background*

The CAA, which was last amended in 1990, requires the US EPA to set National Ambient Air Quality Standards (40 CFR part 50) for pollutants considered harmful to public health and the environment.<sup>214</sup> The Clean Air Act established two types of national air quality standards. *Primary standards* set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly. *Secondary standards* set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings.

The US EPA Office of Air Quality Planning and Standards (OAQPS) has set NAAQS for six principal pollutants, which are called "criteria" pollutants. They are carbon monoxide (CO), lead (Pb), nitrogen dioxide (NO<sub>2</sub>), Particulate Matter (PM), ozone (O<sub>3</sub>), and sulfur dioxide (SO<sub>2</sub>). The standards for SO<sub>2</sub>, NO<sub>2</sub> and PM<sub>10</sub> and PM<sub>2.5</sub> can be found in Table 2.19.

**Table 2.19. US National Ambient Air Quality Standards<sup>215</sup>**

Pollutant	Primary Standards		Secondary Standards	
	Level	Averaging Time	Level	Averaging Time
Nitrogen Dioxide	0.053 ppm (100 µg/m <sup>3</sup> )	Annual (Arithmetic Mean)	Same as Primary	
PM <sub>10</sub>	150 µg/m <sup>3</sup>	24-hour <sup>a</sup>	Same as Primary	
PM <sub>2.5</sub>	15.0 µg/m <sup>3</sup>	Annual <sup>b</sup> (Arithmetic Mean)	Same as Primary	
	35 µg/m <sup>3</sup>	24-hour <sup>c</sup>	Same as Primary	
Sulfur Dioxide	0.03 ppm	Annual (Arithmetic Mean)	0.5 ppm (1300 µg/m <sup>3</sup> )	3-hour <sup>d</sup>
	0.14 ppm	24-hour <sup>d</sup>		

<sup>a</sup> Not to be exceeded more than once per year on average over 3 years.

<sup>b</sup> To attain this standard, the 3-year average of the weighted annual mean PM<sub>2.5</sub> concentrations from single or multiple community-oriented monitors must not exceed 15.0 µg/m<sup>3</sup>.

<sup>c</sup> To attain this standard, the 3-year average of the 98<sup>th</sup> percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m<sup>3</sup> (effective December 17, 2006).

<sup>d</sup> Not to be exceeded more than once per year.

### *State Implementation Plans*

The NAAQS are achieved by each state through the implementation of State Implementation Plan (SIPs) that impose emission limits on individual sources, such as coal-fired power plants. Federal requirements for SIPs can be found in 40 CFR Part 51.<sup>216</sup> Once an SIP is fully approved by the US EPA, it is legally binding under both state and federal law, and may be enforced by either government. Complete analysis of state and county regulatory plans is beyond the scope of this report.

A geographic area that meets or does better than the NAAQS primary standard for a criteria pollutant is called an attainment area; areas that don't meet the primary standards are called nonattainment areas.

### *Status of Standards for PM<sub>2.5</sub> - Clean Air Fine Particle Implementation Rule*

The US EPA first established air quality standards for fine particles (PM<sub>2.5</sub>) in 1997. After sufficient monitoring data was collected by state, local and tribal governments, US EPA designated areas as “attainment” or “nonattainment” for the PM<sub>2.5</sub> standards.<sup>217</sup> These designations became effective in April 2005. For “nonattainment” areas, the CAA requires the state to submit an implementation plan within three years, making them due in April 2008.

On 29 March 2007, the US EPA issued a rule defining requirements for SIPs to clean the air in “nonattainment” areas. An implementation plan includes rules and programs to reduce air pollutant emissions, and a demonstration that the area will meet the air quality standard within the time provided in the statute. States must meet the PM<sub>2.5</sub> standard by 2010. However, in their 2008 implementation plans, states may propose an attainment date extension for up to five years. Those areas for which EPA

approves an extension must achieve clean air as soon as possible, but no later than 2015.

## **Monitoring**

### *NAAQS*

For each of these pollutants, the US EPA tracks two kinds of air pollution trends:<sup>218</sup>

1. Air concentrations based on actual measurements of pollutant concentrations in the ambient (outside) air at selected monitoring sites throughout the economy
2. Emissions based on engineering estimates of the total tons of pollutants released into the air each year.<sup>219</sup>

OAQPS monitors the states' progress in meeting air quality standards by measuring concentrations of criteria pollutants.<sup>220</sup> State and local government monitoring stations across the nation collect direct measurements of pollutants in the air and submit this data to EPA's Aerometric Information Retrieval System (AIRS). The vast majority of these measurements represent the economy's heavily populated urban areas.

The Clean Air Act requires every state to establish a network of air monitoring stations for criteria pollutants, using criteria set by OAQPS for their location and operation.<sup>221</sup> The monitoring stations in this network are called the State and Local Air Monitoring Stations (SLAMS). The states must provide OAQPS with an annual summary of monitoring results at each SLAMS monitor, and detailed results must be available to OAQPS upon request.

To obtain more timely and detailed information about air quality in strategic locations across the nation, OAQPS established an additional network of monitors: the National Air Monitoring Stations (NAMS). NAMS sites, which are part of the SLAMS network, must meet more stringent monitor siting, equipment type, and quality assurance criteria. NAMS monitors also must submit detailed quarterly and annual monitoring results to OAQPS.

A third type of monitor, the Special Purpose Monitor (SPMS), is used by State and local agencies to fulfill very specific or short-term monitoring goals.<sup>222</sup>

### *Status of Monitoring for PM<sub>2.5</sub> - Clean Air Fine Particle Implementation Rule*

For each nonattainment area, the Clean Air Act requires the state to demonstrate that it has adopted all reasonably available control measures (RACM), considering economic and technical feasibility and other factors, that are needed to show that the area will attain the fine particle standards as expeditiously as practicable. This rule sets forth guidelines for making RACM and reasonably available control technology (RACT) determinations. The rule includes a presumption that for power plants subject to the Clean Air Interstate Rule (CAIR), which was struck down by a court panel on 11 July 2008,<sup>223</sup> compliance with the CAIR would have satisfied these requirements



for SO<sub>2</sub> and NO<sub>x</sub> with certain conditions (see below in this section for additional information on the how CAIR would have worked).

This final rule provides guidance on the required elements of an attainment demonstration, the recommended analytical process to follow to identify the most expeditious attainment date for an area, and guidance on air quality modeling. The final rule does not, however, include New Source Review (NSR) requirements (see text below in this section on Implementing New Source Review Requirements in PM<sub>2.5</sub> Attainment Areas for additional information) for the PM<sub>2.5</sub> standards.<sup>224</sup> These requirements will be addressed in a separate rulemaking.

The *Clean Air Fine Particle Implementation Rule* Final Rule states that improved monitoring is critical to implementing the PM<sub>2.5</sub> direct and precursor emissions reductions programs.<sup>225</sup> Improving monitoring includes both increasing data collection and analysis frequency and measuring the pollutant of interest more directly. The US EPA will continue to evaluate the effects of improved monitoring on emissions reductions in addition to developing and providing additional technical and informational materials

#### *Compliance Monitoring for State Implementation Plans*

SIPs need to definitively state recordkeeping and monitoring requirements for the source(s) it applies to.<sup>226</sup> The recordkeeping and monitoring requirements must be sufficient to enable the State or the US EPA to determine whether the source is complying with the emission limit on a continuous basis. An enforceable regulation must also contain test procedures in order to determine whether sources are in compliance.

Regulations that ensure compliance with an applicable emissions limit must include requirements for both performance testing of emissions and ongoing monitoring of the compliance performance of control measures. SIP regulations must include the following critical elements of regulatory compliance testing:

- Indicator(s) of compliance
- Test method
- Averaging time
- Frequency
- Indicator(s) of performance
- Measurement technique
- Monitoring frequency
- Averaging time

#### **National Emissions Inventory**

In addition to tracking ambient air concentrations, the US EPA also prepares a national database of air emissions information, known as the National Emissions Inventory (NEI), with input from numerous State and local air agencies, from tribes, and from industry.<sup>227</sup> The database contains information on stationary and mobile sources that emit criteria air pollutants and their precursors, as well as hazardous air pollutants (HAPs). The database includes estimates of annual emissions, by source, of

air pollutants in each area of the economy (including all 50 states plus DC, Puerto Rico and the Virgin Islands), on an annual basis.

Data from the NEI are used for air dispersion modeling, regional strategy development, regulation setting, air toxics risk assessment, and tracking trends in emissions over time.

SO<sub>2</sub>, NO<sub>x</sub>, PM, PM<sub>10</sub> and PM<sub>2.5</sub> are included in the NEI database.

## **Monitoring**

Emissions from electric generating units (EGUs) are compiled for the NEI, mainly from surveys compiled by the US Department of Energy's Energy Information Agency (EIA).<sup>228</sup> Additional input data comes from the US EPA's Emission Tracking System/Continuous Emissions Monitoring (ETS/CEM) programs. The US EPA uses this input data to prepare a national database of air emissions information.<sup>229</sup>

## **Permits and Regulations**

To achieve the NAAQS, air emissions from coal-fired power plants are effectively required to comply with two major regulatory programs introduced by the CAA, New Source Performance Standards (NSPS) and New Source Review (NSR). NSPS specifies maximum emission limits on criteria air pollutants, but can be superseded by provisions of NSR that impose emission limits on individual sources, such as a coal-fired power plant. Other regulatory limits are based on Titles I, III and IV of the 1990 Clean Air Act Amendments (CAAA) covering ozone, PM<sub>10</sub>, and PM<sub>2.5</sub> nonattainment, hazardous air pollutant emissions and aggregate emissions of acid rain precursors, respectively. These CAAA titles result in a national cap on SO<sub>2</sub> emissions and regional caps on NO<sub>x</sub> emissions.

Once EPA has delegated its authority for a permitting program to a state or tribe, they can then implement their own version of the permit program as long as it meets the minimum requirements stated in the governing statutes and regulations. EPA has delegated authority to most states for implementing part or all of the major permit programs. Some states have enacted provisions that are more stringent than federal requirements, while other states have adopted the federal requirements without revision.

### *New Source Performance Standards*

New Source Performance Standards (NSPS) for stationary sources are addressed in Section 111 of the CAA, which requires the US EPA to establish federal emission standards for source categories which cause or contribute significantly to air pollution. They are technology based standards that apply to new, modified and reconstructed affected facilities in specific source categories.<sup>230</sup> These standards can be found in the Code of Federal Regulations (CFR) at Title 40 (Protection of Environment), Part 60 (Standards of Performance for New Stationary Sources), Subpart Da.<sup>231</sup>

Subpart Da of 40 CFR 60 sets "Standards of Performance for Electric Utility Steam Generating Units for Which Construction is Commenced After September 18, 1978."

It applies to coal-fired power plants capable of combusting >73 megawatts (MW) heat input of fossil fuel. The NSPS requirements for air pollutants from coal-fired power plants are listed in Table 2.20.

**Table 2.20. NSPS Requirements for Air Pollutants from Coal-Fired Power Plants**

Pollutant	New Source Performance Standard (NSPS)
Sulfur Dioxide, SO <sub>2</sub>	0.6 to 1.2 lb/10 <sup>6</sup> Btu and 70% to 90% Removal
Nitrogen Oxides, NO <sub>x</sub> as NO <sub>2</sub>	1.6 lb/Megawatt-hour and 0.15 lb/10 <sup>6</sup> Btu
Particulates, TSP or PM10	0.03 lb/10 <sup>6</sup> Btu and 99% Removal
Opacity	20% Opacity (6 minute average) <sup>a</sup>

<sup>a</sup> May emit 27% opacity for one 6-minute period per hour

### Monitoring

40 CFR 60, Subpart Da<sup>232</sup> requires CEMS monitoring to ensure compliance with NSPS for coal-fired power plants for SO<sub>2</sub>, NO<sub>x</sub> and opacity. In addition, affected facilities shall use CEMS to measure the O<sub>2</sub> or carbon dioxide (CO<sub>2</sub>) content of the flue gases at each location where SO<sub>2</sub> or NO<sub>x</sub> emissions are monitored. If opacity interference due to water droplets exists in the stack (for example, from the use of a flue gas desulfurization system), the opacity is monitored at the inlet to the flue gas desulfurization system. If opacity interference is experienced at all locations (both at the inlet and outlet of the SO<sub>2</sub> control system), alternate parameters indicative of the PM control system's performance and/or good combustion are monitored (subject to the approval of the Administrator).

Similar, yet somewhat different rules exist between the requirements for CEMS monitoring under 40 CFR 60 and 40 CFR 75 for SO<sub>2</sub> and NO<sub>x</sub>, the latter of which contains the detailed rules for CEMS monitoring under the Acid Rain Program (see text on the Acid Rain Program below in this section for more information). The US EPA is undertaking efforts to harmonize these two rules.<sup>233</sup> Some improvements have been made so far. Specifically, the 40 Part 60 rule states that affected facilities subject to a lb/MMBtu SO<sub>2</sub> emission limit under 40 CFR 60 that have installed and certified a CO<sub>2</sub> or O<sub>2</sub> monitoring system that meets all of the requirements of the 40 CFR 75 rules may use this monitoring systems, along with the SO<sub>2</sub> CEMS required under 40 CFR 60, to determine the SO<sub>2</sub> emission rate in lb/MMBtu for the NSPS. In addition, all of the performance testing and reporting requirement for the 40 CFR 60 rule must be met.<sup>234</sup> For affected facilities using a NO<sub>x</sub> emission rate CEMS to meet the 40 CFR 75 requirements, that CEMS may be used to meet the requirements of this section, except that the owner or operator shall also meet the reporting requirements of 40 CFR 60.

For units that began construction, reconstruction, or modification on or before 28 February 2005, emission data must be obtained for at least 18 hours in at least 22 out of 30 successive boiler operating days. For units that began construction, reconstruction, or modification after 28 February 2005, emission data must be obtained for at least 90 percent of all operating hours for each 30 successive boiler operating days. If the minimum data requirement cannot be met in either scenario

with CEMS, the affected unit shall supplement emission data with other monitoring systems approved by the Administrator or the reference methods and procedures in the rule.

### *Performance Specifications*

40 CFR Part 60, Appendix B<sup>235</sup> outlines the following performance specifications for continuous monitoring of opacity, SO<sub>2</sub>, NO<sub>x</sub> and O<sub>2</sub> or CO<sub>2</sub> at the time of installation or when specified in the regulation.

Performance Specification 1 (PS-1): Specifications and test procedures for continuous opacity monitoring systems in stationary sources.

PS-1 requires:

1. Opacity monitor manufacturers comply with a comprehensive series of design and performance specifications and test procedures to certify opacity monitoring equipment before shipment to the end user,
2. The owner or operator to follow installation guidelines, and
3. The owner or operator to conduct a set of field performance tests that confirm the acceptability of the COMS after it is installed.

ASTM D 6216–98<sup>236</sup> is the reference for design specifications, manufacturer's performance specifications, and test procedures.

PS-1 provides guidance for locating an opacity monitor in vertical and horizontal ducts. It is encouraged to seek approval for the opacity monitor location from the appropriate regulatory authority prior to installation. After the continuous opacity monitoring systems (COMS) is installed and calibrated, the owner or operator must test the COMS for conformance with the field performance specifications in PS-1.

Performance Specification 2 (PS-2): Specifications and Test Procedures for SO<sub>2</sub> and NO<sub>x</sub> Continuous Emission Monitoring Systems in Stationary Sources

The SO<sub>2</sub> and NO<sub>x</sub> CEMS may include, for certain stationary sources, a diluent (O<sub>2</sub> or CO<sub>2</sub>) monitor. The source owner or operator is responsible to calibrate, maintain, and operate the CEMS properly (procedures for measuring CEMS relative accuracy and calibration drift are outlined). CEMS installation and measurement location specifications, equipment specifications, performance specifications, and data reduction procedures are included). The Administrator may require the operator to conduct CEMS performance evaluations at other times besides the initial test to evaluate the CEMS performance.

Performance Specification 3 (PS-3): Specifications and Test Procedures for O<sub>2</sub> and CO<sub>2</sub> Continuous Emission Monitoring Systems in Stationary Sources

This specification applies to O<sub>2</sub> or CO<sub>2</sub> monitors that are not included in PS-2. The procedures are very similar to those included in PS-2 with only a few differences in the performance and equipment specification and the relative accuracy test procedures.

## *Compliance Monitoring*

In addition to performing an initial performance test to demonstrate compliance and using CEMS to demonstrate continuous compliance NSPS sources that meet the CAA definition of “major source,” such as power plants generally receive a full compliance evaluation by the state or regional office at least once every two years. A full compliance evaluation includes:

- A review of all required reports and the underlying records;
- An assessment of air pollution control devices and operating conditions;
- Observing visible emissions; a review of facility records and operating logs;
- An assessment of process parameters, such as feed rates, raw material compositions, and process rates; and
- A stack test if there is no other way to determine compliance with the emission limits.

A full compliance evaluation may be accomplished through a series of Partial Compliance Evaluations, documented compliance assessments focusing on a subset of regulated pollutants, regulatory requirements, or emission units at a given facility.

In order to provide national consistency in developing stationary source air compliance monitoring programs, while at the same time provide States/locals with flexibility to address local air pollution and compliance concerns, the US EPA published a *Clean Air Act Stationary Source Compliance Monitoring Strategy*.<sup>237</sup>

## *New Source Review*

Congress established the New Source Review (NSR) permitting program as part of the 1977 Clean Air Act Amendments.<sup>238</sup> New Source Review (NSR) requires stationary sources of air pollution to get permits before they start construction (40 CFR 52.21).<sup>239</sup> NSR permits are legal documents that the facility owners/operators must abide by. The permit specifies what construction is allowed, what emission limits must be met, and often how the emissions source must be operated.

There are three types of NSR permitting requirements (a source may have to meet one or more):

1. Prevention of Significant Deterioration (PSD) permits (required by the CAA, Title I, Part C<sup>240</sup>) are required for new major sources<sup>241</sup> or a major source making a major modification in an attainment area. PSD permits require:<sup>242</sup>
  - Installation of the "Best Available Control Technology (BACT)";
  - An air quality analysis;
    - Generally, the analysis will involve (1) an assessment of existing air quality, which may include ambient monitoring data and air quality dispersion modeling results, and (2) predictions, using dispersion modeling, of ambient concentrations that will result from the applicant's proposed project and future growth associated with the project.
  - Additional impacts analysis; and
  - Public involvement.

2. Nonattainment NSR permits (required by the CAA, Title I, Part D<sup>243</sup>) are required for new major sources<sup>244</sup> or major sources making a major modification in a nonattainment area.  
Nonattainment NSR programs require:
  - The installation of the lowest achievable emission rate (LAER),<sup>245</sup>
  - Emission offsets;
  - Opportunity for public involvement.
3. Minor source permits (required by Title 1, Part A, Section 110(a)(2)(C)<sup>246</sup>).

The NSR requirements for air pollutants from coal-fired power plants are listed in Table 2.21.

**Table 2.21. NSR Requirements for Air Pollutants from Coal-Fired Power Plants**

POLLUTANT	RECENT NSR BACT/LAER EMISSION LIMIT	RECENT BACT/LAER CONTROL TECHNOLOGY	RECENT BACT/LAER CONTROL EFFICIENCY
Sulfur Dioxide, SO <sub>2</sub>	0.12 to 0.2 lb/10 <sup>6</sup> Btu	Low to Medium Sulfur Coal, FGD	90 to 95%
Nitrogen Oxides, NO <sub>x</sub> as NO <sub>2</sub>	0.05 to 0.1 lb/10 <sup>6</sup> Btu	Selective Catalytic Technology with Low-NO <sub>x</sub> Burners	50 to 90%
Particulates, TSP or PM <sub>10</sub>	0.01 to 0.015 lb/10 <sup>6</sup> Btu	ESP, Fabric Filter	>99.5%
Opacity	10% opacity	ESP, Fabric Filter	99.9% TSP

Comparison of the NSPS and NSR requirements for air pollutants from coal-fired power plants (Tables X and Y, respectively), show that actual permitted emissions levels may be significantly less than required by NSPS based on a requirement to use Best Available Control Technology (BACT) in attainment areas and Lowest Achievable Emissions Reduction (LAER) technology in nonattainment areas.

*Implementing New Source Review Requirements in PM<sub>2.5</sub> Attainment Areas*

The US EPA is now required by the Clean Air Act to determine how much of PM<sub>2.5</sub> can be emitted in areas already meeting the standard, known as attainment areas.<sup>247</sup> These determinations are made under the PSD program, which establishes three thresholds of air quality and emissions to guide states in maintaining clean air: Increments, Significant Impact Levels (SILs), and Significant Monitoring Concentrations (SMC). Recently, the US EPA laid out options three for making determinations on each of these thresholds under the PSD program.

For the increments threshold,<sup>248</sup> the U.S EPA proposed:

- Treat PM<sub>2.5</sub> as a new pollutant, rather than a new indicator of particulate matter.
- The other two options are variations of an approach the US EPA has used to establish increments in the past. It is known as the "equivalent increment" approach and based upon a relationship between emissions to observable environmental impacts.

For developing SILs,<sup>249</sup> the US EPA proposed:

- For Class I: Set the SIL to 4 percent of the Class I PM<sub>2.5</sub> increment. Class I areas have the most stringent levels of protection under the PSD program. For Class II and Class III areas: Establish the SIL values of 1.0 µg/m<sup>3</sup> for the annual averaging period and 5.0 µg/m<sup>3</sup> for the 24-hour averaging period.
- Set the value of the PM<sub>2.5</sub> SILs by adjusting PM<sub>10</sub> SILs as a proportion of the typical point source emissions ratio of PM<sub>2.5</sub> to PM<sub>10</sub>.
- Set the value of the PM<sub>2.5</sub> SILs by adjusting PM<sub>10</sub> SILs as a proportion of the NAAQS ratio of PM<sub>2.5</sub> to PM<sub>10</sub>.

For calculating the SMC,<sup>250</sup> the US EPA proposed:

- The SMC be based on the “Lowest Detection Concentration,” using the approach that was used for establishing the SMC for Total Suspended Particulate (TSP) and PM<sub>10</sub>. i.e., determining the lowest detectable concentration and multiplying this value by five.
- Set the value of the P<sub>M2.5</sub> SMC by adjusting (multiplying) the P<sub>M10</sub> SMC by the proportion of P<sub>M2.5</sub> emissions compared to PM<sub>10</sub> emissions.
- Set the PM<sub>2.5</sub> SMC by adjusting (multiplying) the PM<sub>10</sub> SMC by the proportion of the PM<sub>2.5</sub> NAAQS to the PM<sub>10</sub> NAAQS.

#### *Implementing New Source Review Requirements in PM<sub>2.5</sub> Nonattainment Areas*

Until the US EPA promulgates the PM<sub>2.5</sub> major NSR regulations, States should use a PM<sub>10</sub> nonattainment major NSR program as a surrogate to address the requirements of nonattainment major NSR for the PM<sub>2.5</sub> NAAQS.<sup>251</sup> By applying a PM<sub>10</sub> nonattainment major NSR program in the interim period, States will effectively mitigate increases in PM<sub>2.5</sub> emissions and protect air quality because PM<sub>2.5</sub> is a subset of PM<sub>10</sub> emissions.

#### *Operating Permits*

Title V of the 1990 Clean Air Act Amendments requires all major sources<sup>252</sup> and some minor sources of air pollution to obtain an operating permit.<sup>253</sup> The permit includes all air pollution requirements that apply to the source, including emissions limits and monitoring, record keeping, and reporting requirements. It also requires that the source report its compliance status with respect to permit conditions to the permitting authority. Most permits are issued by State or local agencies (40 CFR 70); a small number are issued by EPA (40 CFR 71).

The monitoring requirements for operating permits are currently undergoing legal challenges because environmentalists say that a December 2006 final rule by the US EPA would overturn a key agency regulation that requires state and federal authorities to issue operating permits with sufficient monitoring to ensure compliance.<sup>254</sup> In a brief, the US EPA argued the agency's decision not to require "case-by-case sufficiency reviews as reasonable." The agency has said the 2006 rule will make monitoring more uniform and manageable nationwide.

## Acid Rain Program

Background: The Clean Air Act Amendments of 1990 (Title IV) introduced a nationwide approach to reducing acid pollution by substantively reducing emissions of SO<sub>2</sub> and NO<sub>x</sub>.<sup>255</sup> Using a market-based cap and trade approach, the program set a permanent, nationwide cap on SO<sub>2</sub> emissions for electric power plants of (annual emissions not to exceed 10 million tons below 1980 levels). Regardless of the number of allowances a source holds, it may not emit at levels that would violate federal or state limits set under Title I of the Clean Air Act to protect public health.<sup>256</sup>

As required by the law, EPA's Acid Rain Program (ARP) was implemented in two phases. Phase I of the ARP, which began in 1995, targeted larger, higher emitting power plants. Phase II, which began in the year 2000, tightened the annual emissions limits imposed on the plants participating in Phase I and set restrictions on smaller, cleaner plants fired by coal, oil, and gas. The program affects existing electric generating units (EGUs) that burn fossil fuel and that serve generators with an output capacity of greater than 25 megawatts and all new utility units. Stiff monetary penalties are imposed on plants that release more pollutants than are covered by their allowances (USD 2,000 per excess ton of SO<sub>2</sub> or NO<sub>x</sub> emissions, adjusted for inflation). As of 2005, SO<sub>2</sub> emission reductions were 41 percent below 1980 levels.<sup>257</sup>

The 1990 amendments also called for a 2 million ton reduction in NO<sub>x</sub> emissions by the year 2000. The ARP focuses on one set of sources that emit NO<sub>x</sub>, coal-fired electric utility boilers. The NO<sub>x</sub> program embodies many of the same principles as the SO<sub>2</sub> cap and trade program, however it is not a cap and trade program (i.e. it does not set a "cap" on NO<sub>x</sub> emissions nor does it utilize allowance trading to fulfill its emission reduction goals).<sup>258</sup>

Permits: Every emissions source affected by the Acid Rain Program must have a permit. Each acid rain permit specifies the Title IV requirements that apply to each affected unit at the affected source.<sup>259</sup> All affected sources must submit acid rain permit applications to an EPA-approved state or local Title IV permitting authority, which in turn issues and administers the permit. Every acid rain permit is a portion of a larger Title V permit.

The acid rain permit specifies each unit's allowance allocation and NO<sub>x</sub> limitation (if applicable), and also specifies compliance plan(s) for the affected source.

## Monitoring

Monitoring is a critical component for accurate, transparent and effective implementation of the Clean Air Act ARP. This is because the APR requires an accounting of each ton of emissions from each regulated unit. Compliance is then determined through a direct comparison of total annual emissions reported by the continuous emissions monitoring (CEM) and allowances held for the unit.<sup>260</sup>

### *Overview*

Title IV, Section 412, of the CAA amendments titled, *Monitoring, Reporting, and Recordkeeping Requirements* requires the owner and operator of any source subject to



this title install and operate CEMS on each affected unit at the source, and to quality assure the data for SO<sub>2</sub>, NO<sub>x</sub>, opacity and volumetric flow at each such unit.<sup>261</sup> 40 CFR Part 75, originally published in January 1993 and periodically updated, contains the rule that established CEM and reporting requirements under Title IV, Section 412. Under the Part 75 rule, in general, if a unit is coal-fired or combusts any type of solid fuel, the basic continuous monitoring provisions require the use of CEMS for all monitored parameters. However, there are a few exceptions. For example coal-fired units with wet scrubbers may be exempted from opacity monitoring requirements if the presence of condensed water in the effluent gas stream interferes with the opacity readings.<sup>262</sup>

Coal-fired power plants covered under the ARP (units serving and generator greater than 25 MW), all new coal units and other sources that opt-in to the program, must continuously monitor, record and report a number of parameters, including:

- SO<sub>2</sub> in pounds per hour (lbs/hr)
- NO<sub>x</sub> in units of pounds per million British thermal units (lbs/mmBtu) and (mm/Btu/hr)
- Opacity in percent (%)
- CO<sub>2</sub> (lbs/hour)

To measure and record SO<sub>2</sub> in the correct units, a pollutant concentration monitor for the gas and a volumetric flow monitor are required. For NO<sub>x</sub> monitoring, in addition the pollutant control and volumetric flow monitor, a diluent gas (O<sub>2</sub> or CO<sub>2</sub>) monitor is also required. Opacity monitoring only requires an opacity monitor. Computer-based data acquisition and handling systems (DAHS) must also be used to report and collect all data. Table 2.22 summarizes necessary CEMS components for these measurements.<sup>263</sup>

**Table 2.22. CEMS Monitoring Components**

Monitoring Requirement (units required)	Required CEM Monitoring Component					
	SO <sub>2</sub>	NO <sub>x</sub>	Flow	Opacity	Diluent Gas	Data Handling
SO <sub>2</sub> (lbs/hr)	Yes		Yes			Yes
NO <sub>x</sub> (lbs/mmBtu) <sup>a</sup>		Yes			Yes	Yes
Opacity (%)				Yes		Yes
CO <sub>2</sub> (lbs/hr) <sup>b</sup>			Yes		Yes	Yes

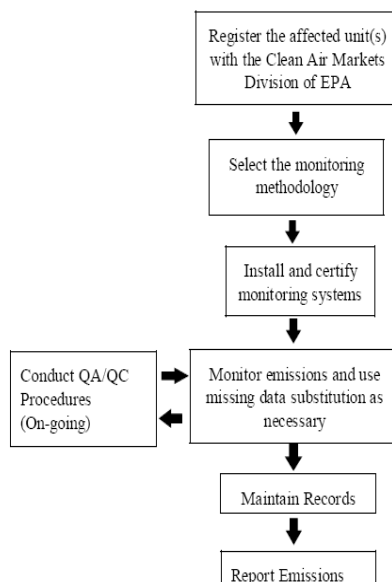
<sup>a</sup>Heat input in mm/Btu/hr is also required

<sup>b</sup>Alternative methods may be used to monitor CO<sub>2</sub>

Part 75 requires an hourly accounting of the emissions from each affected unit. All CEM systems must be in continuous operation and able to sample, analyze and record data at least every 15 minutes. All emissions and flow data will be reduced to 1-hour averages. Part 75 also requires on-going quality assurance and quality control (QA/QC) procedures, to ensure that the data collected by the monitoring systems

continue to be accurate.<sup>264</sup> An overview and general description of the Part 75 monitoring and reporting requirements are shown in Figure 2.3.

**Figure 2.3. Overview and general description of the Part 75 monitoring and reporting requirements\***



\* In the case of coal fired power plants, the “monitoring methodology” is CEMS

### *Detailed Monitoring Provisions from the Part 75 Rule*

#### *General Operating Requirements*

For SO<sub>2</sub> emissions from a coal-fired unit, the owner or operator shall install, certify, operate, and maintain:<sup>265</sup>

- An SO<sub>2</sub> CEMS
- A flow monitoring system with an automated data acquisition and handling system for measuring and recording:
  - SO<sub>2</sub> concentration (in ppm);
  - Volumetric gas flow (in scfh); and
  - SO<sub>2</sub> mass emissions (in lb/hr) discharged to the atmosphere.

For NO<sub>x</sub> emissions, the owner or operator shall install, certify, operate, and maintain:

- A NO<sub>x</sub>-diluent CEMS (consisting of a NO<sub>x</sub> pollutant concentration monitor and an O<sub>2</sub> or CO<sub>2</sub> diluent gas monitor) with an automated data acquisition and handling system for measuring and recording:
  - NO<sub>x</sub> concentration (in ppm);
  - O<sub>2</sub> or CO<sub>2</sub> concentration (in percent O<sub>2</sub> or CO<sub>2</sub>); and
  - NO<sub>x</sub> emission rate (in lb/mmBtu) discharged to the atmosphere

NO<sub>x</sub> emissions, both NO and NO<sub>2</sub>, either by monitoring for both NO and NO<sub>2</sub> or by monitoring for NO only and adjusting the emissions data to account for NO<sub>2</sub> shall be accounted for.

For PM, the owner or operator shall install, certify, operate, and maintain:

- A continuous opacity monitoring system with the automated data acquisition and handling system for measuring and recording the opacity of emissions (in percent opacity) discharged to the atmosphere.

Each CEMS must meet the required equipment, installation, and performance specifications in 40 CFR 47 Appendix A<sup>266</sup> and be maintained according to the quality assurance and quality control procedures in 40 CFR Appendix B.<sup>267</sup>

The heat input rate, in units of mmBtu/hr, must be determined for each affected unit for every hour or part of an hour any fuel is combusted (procedures are provided in 40 CFR 75 Appendix F<sup>268</sup>).

All continuous emission and opacity monitoring systems must be in operation and monitoring at all times that the affected unit combusts any fuel except during periods of calibration, quality assurance, or preventive maintenance, periods of repair, periods of backups of data from the data acquisition and handling system, or recertification performed. The requirements are that each:

- CEMS must be capable of completing a minimum of one cycle of operation (sampling, analyzing, and data recording) for each successive 15-min interval. All SO<sub>2</sub> concentrations, volumetric flow, SO<sub>2</sub> mass emissions, CO<sub>2</sub> concentration, O<sub>2</sub> concentration, CO<sub>2</sub> mass emissions (if applicable), NO<sub>x</sub> concentration, NO<sub>x</sub> emission rate, and Hg concentration data collected will be reduced to hourly averages (computed using at least one data point in each fifteen minute quadrant of an hour, where the unit combusted fuel during that quadrant of an hour).
- Continuous opacity monitoring system is capable of completing a minimum of one cycle of sampling and analyzing for each successive 10-sec period and one cycle of data recording for each successive 6-min period. All opacity data shall be reduced to 6-min averages (procedures provided in 40 CFR 51 Appendix M<sup>269</sup>) of this chapter, except where the applicable State implementation plan or operating permit requires a different averaging period. In that case, the State requirement shall satisfy this APR requirement.

If a valid hour of data is not obtained, the owner or operator shall estimate and record emissions, moisture, or flow data for the missing hour by means of the automated data acquisition and handling system, in accordance with the applicable procedure for missing data substitution (40 CFR 75 Subpart D<sup>270</sup>).

The owner or operator shall, at minimum, record and report the hourly, daily, quarterly, and annual information collected as required.

#### *Specific Provisions for Monitoring SO<sub>2</sub> emissions*

For a moisture correction (i.e. where the SO<sub>2</sub> concentration is measured on a dry basis), the owner or operator shall either:<sup>271</sup>

- Report the appropriate fuel-specific default moisture value for each unit operating hour, selected from among the following: 3.0%, for anthracite coal; 6.0% for bituminous coal; 8.0% for sub-bituminous coal; 11.0% for lignite coal; 13.0% for wood; or
- Install, operate, maintain, and quality assure a CEMS for measuring and recording the moisture content of the flue gases, in order to correct the measured hourly volumetric flow rates for moisture when calculating SO<sub>2</sub> mass emissions (in lb/hr) (procedure in 40 CFR Appendix F<sup>272</sup>). The following continuous moisture monitoring systems are acceptable:
  - A continuous moisture sensor; an oxygen analyzer (or analyzers) capable of measuring O<sub>2</sub> both on a wet basis and on a dry basis; or
  - A stack temperature sensor and a moisture look-up table.

For a unit with no location for a flow monitor meeting siting requirements either:

- A petition shall be made for an alternative method for monitoring volumetric flow; or
- The owner or operator shall construct a new stack or modify existing ductwork to accommodate the installation of a flow monitor, and a petition shall be made for an extension of the required certification date given; or
- The owner or operator shall install a flow monitor in any existing location in the stack or ducts serving the affected unit at which the monitor can achieve the performance specifications of this part.

#### Specific provisions for monitoring NO<sub>x</sub> emission rate

If a correction for the stack gas moisture content is needed to properly calculate the NO<sub>x</sub> emission rate in lb/mmBtu, e.g., if the NO<sub>x</sub> pollutant concentration monitor measures on a different moisture basis from the diluent monitor, the owner or operator shall either:<sup>273</sup>

- Report a fuel-specific default moisture value for each unit operating hour; or
- Shall install, operate, maintain, and quality assure a continuous moisture monitoring system.

To determine the NO<sub>x</sub> emission rate, the owner or operator shall calculate hourly, quarterly, and annual NO<sub>x</sub> emission rates (in lb/mmBtu) by combining the NO<sub>x</sub> concentration (in ppm), diluent concentration (in percent O<sub>2</sub> or CO<sub>2</sub>), and percent moisture (if applicable) measurements (Procedures provided in 40 CFR 75 Appendix F<sup>274</sup>).

#### *Specific Provisions for Monitoring Opacity*

If the owner or operator of units with a wet flue gas pollution control systems, can demonstrate that condensed water is present in the exhaust flue gas stream and would impede the accuracy of opacity measurements, then the owner or operator of an affected unit equipped with a wet flue gas pollution control system for SO<sub>2</sub> emissions or particulates is exempt from the opacity monitoring requirements of this part.<sup>275</sup>

### *Special provisions for monitoring emissions from common, bypass, and multiple stacks*

The 40 CFR Part 75 Continuous Emissions Monitoring rule also include special provisions for monitoring emissions from:

- Common, bypass and multiple stacks for SO<sub>2</sub> emissions and heat input determinations in 40 CFR 75.16<sup>276</sup>
- Common, bypass and multiple stacks for NO<sub>x</sub> emission rate in 40 CFR 75.17<sup>277</sup>
- Common and by-pass stacks for opacity in 40 CFR 75.18<sup>278</sup>

### **NO<sub>x</sub> Budget Trading Program**

In 2003, EPA began to administer the NO<sub>x</sub> Budget Trading Program (NBP) under the “NO<sub>x</sub> SIP Call.”<sup>279</sup> The NO<sub>x</sub> Budget Trading Program is a market-based cap and trade program created to reduce emissions of nitrogen oxides (NO<sub>x</sub>) from power plants and other large combustion sources in the eastern United States. NO<sub>x</sub> is a prime ingredient in the formation of ground-level ozone (smog), a pervasive air pollution problem in many areas of the eastern United States. The NO<sub>x</sub> Budget Trading Program was designed to reduce NO<sub>x</sub> emissions during the warm summer months, referred to as the ozone season (from May 1 to September 30), when ground-level ozone concentrations are highest.

### **Monitoring**

The state regulations for the NBP apply mainly to large EGUs and industrial boilers. The state rules require NO<sub>x</sub> mass emissions and heat input to be monitored and reported according to 40 CFR Part 75, Subpart H.<sup>280</sup>

According to 40 CFR, Part 75, Subpart H, owner or operators of an affected unit are required to use CEMS, unless prior written approval has been obtained. For coal-fired units the rule specifies that operators with approval for alternative monitoring systems must either:

1. Meet the general operating requirements for a NO<sub>x</sub>-diluent CEMS (consisting of a NO<sub>x</sub> pollutant concentration monitor, an O<sub>2</sub> or CO<sub>2</sub> diluent gas monitor, and a data acquisition and handling system) to measure the NO<sub>x</sub> emission rate and for a flow monitoring system and an O<sub>2</sub> or CO<sub>2</sub> diluent gas monitor to measure heat input rate, OR
2. Meet the general operating requirements for a NO<sub>x</sub> CEMS (consisting of a NO<sub>x</sub> pollutant concentration monitor and a data acquisition and handling system) to measure NO<sub>x</sub> concentration and for a flow monitoring system. In addition, if heat input is required to be reported under the applicable State or federal NO<sub>x</sub> mass emission reduction program that adopts the requirements of this subpart, the owner or operator also must meet the general operating requirements for a flow monitoring system and an O<sub>2</sub> or CO<sub>2</sub> diluent gas monitor to measure heat input rate.

Moisture Correction - If a correction for the stack gas moisture is needed to properly calculate the:

- NO<sub>x</sub> emission rate in lb/mmBtu (e.g., if the NO<sub>x</sub> pollutant concentration monitor in a NO<sub>x</sub>-diluent monitoring system measures on a different moisture basis from the diluent monitor), or to calculate the heat input rate, the owner or operator of an affected unit shall account for the moisture content of the flue gas on a continuous basis.
- NO<sub>x</sub> mass emissions in tons, in the case where a NO<sub>x</sub> concentration monitoring system which measures on a dry basis is used with a flow rate monitor to determine NO<sub>x</sub> mass emissions, the owner or operator of an affected unit shall account for the moisture content of the flue gas on a continuous basis.
- NO<sub>x</sub> mass emissions, in the case where a diluent monitor that measures on a dry basis is used with a flow rate monitor to determine heat input rate, which is then multiplied by the NO<sub>x</sub> emission rate, the owner or operator shall install, operate, maintain, and quality assure a CEMS.

Frequency of Monitoring - For an owner or operator of an affected unit subject both to an Acid Rain emission limitation and to a State or federal NO<sub>x</sub> mass reduction program that adopts the provisions of this part, he/she must and report annual emissions on an hourly basis during the entire calendar year. For an owner or operator of an affected unit that is not required to meet the requirements of this subpart on an annual basis, he/she may either meet the requirement of this subpart:

1. On an annual basis; or
2. Meet the requirements of this subpart during the ozone season.

If the owner or operator of an affected unit chooses to meet the requirements of this subpart on less than an annual basis, then the owner or operator of a unit that uses CMES or a fuel flowmeter to meet any of the requirements quality assure the hourly ozone season emission data required. To achieve this, the owner or operator shall operate, maintain and calibrate each required CEMS and shall perform diagnostic testing and quality assurance testing of each required CEMS or fuel flowmeter

### **Clean Air Interstate Rule**

On 10 March 2005, EPA issued the Clean Air Interstate Rule (CAIR). The rule was struck down by a federal appeals court panel on 11 July 2008.<sup>281</sup> This rule had attempted to provide states with a solution to the problem of power plant pollution that drifts from one state to another. The CAIR would have applied to units in 28 eastern states and the District of Columbia that produced electricity for sale and served a generator with a nameplate capacity > 25 megawatts and covers.<sup>282</sup> The rule would have used a cap and trade system to reduce the target pollutants of SO<sub>2</sub> and NO<sub>x</sub>. When it would have been fully implemented, the CAIR was projected to reduce SO<sub>2</sub> emissions in these states by over 70 percent and NO<sub>x</sub> emissions by over 60 percent from 2003 levels.<sup>283</sup>

States would have had to achieve the required emission reductions using one of two compliance options:<sup>284</sup>

1. Meet the state's emission budget by requiring power plants to participate in an EPA-administered interstate cap and trade system that caps emissions in two stages; or
2. Meet an individual state emissions budget through measures of the state's choosing.

US EPA had anticipated that states would have achieved this primarily by reducing emissions from the power sector and by participating in the interstate cap and trade system.

The CAIR rule actually would have consisted of three separate regulations, i.e. one for annual SO<sub>2</sub> mass emissions, one for annual NO<sub>x</sub> emissions and one for ozone season NO<sub>x</sub> mass emissions.<sup>285</sup> The timeline that was established for the CAIR rule is shown in Table 2.23.

**Table 2.23. Timeline for the CAIR Rule (Note: Rule struck down by court panel)**

Promulgate CAIR Rule	2005
State Implementation Plans Due	2006
Phase I Cap in Place for NO <sub>x</sub>	2009
Phase I Cap in Place for SO <sub>2</sub>	2010
Phase II Cap in Place for NO <sub>x</sub> and SO <sub>2</sub>	2015

## Monitoring

40 CFR Part 96,<sup>286</sup> which would have specified the regulations for the CAIR, required monitoring under 40 CFR Part 75, as required for sources affected under the Acid Rain Program and the NO<sub>x</sub> Budget Trading Program. The affected units were electric generating units and opt-in units, most of which are already covered under one and/or the other of the trading programs. Monitoring systems for NO<sub>x</sub> mass emissions and heat input would had to have been installed and certified by 2008, and monitoring systems for SO<sub>2</sub> mass emissions and heat input would had to have been certified by 2009.<sup>287</sup>

## 2.2 Mercury (Hg)

Mercury is a toxic, persistent, bioaccumulative substance. It converts in water to the highly toxic form, methylmercury, which accumulates in fish and other species, damaging the central nervous system and causing reproductive failure among loons and river otters. Human exposure to mercury – primarily by eating contaminated fish – may cause neurological and developmental damage.<sup>288</sup> Mercury may be emitted substantially in the gas phase from combustion of coal.<sup>289</sup> The heavy metal content is normally several orders of magnitude higher in coal than in oil or natural gas.<sup>290</sup>

## 2.2.1 Australia

### 2.2.1.1 Federal Level

Australia does not regulate emissions of mercury (Hg) from coal-fired power plants. In December 2004, the National Environment Council (NEPC) made the National Environment Protection (Air Toxics) Measure (known as the 'Air Toxics NEPM') which establishes 'monitoring investigation levels' for 5 air toxics, but does not include Hg.<sup>291</sup>

#### National Pollutant Inventory

Mercury, when it exceeds a threshold, is a substance that must be reported to the NPI (see the text on the NPI in section 2.1.1.1 for more information).<sup>292</sup> For the purposes of combustion, it is defined as a Category “2b” substance, with NPI thresholds of:<sup>293</sup>

- Burning 2,000 tonnes or more of fuel or waste in the reporting year
- Consuming 60,000 megawatt hours or more of electrical energy for other than lighting or motive purposes in the reporting year
- A facility that has maximum potential power consumption of 20 megawatts or more for other than lighting or motive purposes in the reporting year.

#### Monitoring

The *Estimation Technique Manual for Fossil Fuel Electric Power Generation* from the NPI suggests the following monitoring methods (see the text on NPI monitoring in section 2.1.1.1 for more information).<sup>294</sup>

1. Direct measurements ;
2. Using Continuous Emission Monitoring Systems (CEMS) Data;
3. Using Fuel Analysis Data;
4. Emission Factors;
5. Using a mass balance approach - Trace element behavior during combustion; Trace elements have been classified into 3 general, overlapping classes according to their behavior during combustion.
  - Class I: Elements which are concentrated in the coarse residues (bottom ash) or are partitioned equally between coarse residues and flyash which is generally trapped by the particulate control systems.
  - Class II: Elements concentrated more in the flyash compared with coarse residues. Also enriched in fine-grained particles that may escape the particle control systems.
  - Class III: Elements which volatilize most readily. NPI substances such as mercury & compounds generally fall into Class III or are intermediate between Classes II and III. They may be able to be determined by examining the mercury levels in the coal and ash. The mass balance approach requires the collection of reliable, representative data on element concentrations in coal and ash. It assumes that the difference between the quantity of the element measured in coal and collected in ash is emitted to the atmosphere.<sup>295</sup>
6. Using Engineering Calculations; and



## 7. Approved Alternative Method

### 2.2.1.2 New South Wales

There is no emission standard for mercury under the POEO (Clean Air) Regulation 2002 from coal-fired power plants. A standard for mercury only applies to plants using non-standard fuels, which does not include coal or coal derived fuels.<sup>296</sup> Mercury is also not an assessable air pollutant under the New South Wales Load Based Licensing Scheme.<sup>297</sup>

### 2.2.2 Canada

#### 2.2.2.1 Federal Level

In 2003, the coal-fired electric power generation (EPG) sector emitted an estimated 2,695 kilograms (kg) of mercury from an estimated 3,725 kilograms of mercury in coal burned. The EPG sector is the largest single remaining man-made source of mercury emissions in Canada.<sup>298</sup>

#### National Pollutant Release Inventory

Mercury and its compounds, part 1B substances, must be reported in 2006, if they were manufactured, processed or otherwise used at a facility in a quantity of 5 kilograms or more<sup>299</sup> and employees (including contractors) worked 20,000 hours or more at the facility. Power stations typically report these substances.<sup>300</sup>

#### Monitoring

Estimates of the quantity of a substance that was manufactured, processed or otherwise used, and the quantity that was released, disposed of or transferred, may be based on one of the following methods (each method is explained in more detail in the text on reporting SO<sub>2</sub>, NO<sub>x</sub> and PM emissions under the NPRI in Canada in section 2.1.2.1):<sup>301</sup>

1. Continuous Emission Monitoring Systems (CEMS);
2. Predictive Emission Monitoring (PEM);
3. Source testing;
4. Mass balance;
5. Site-specific and published emission factors;
  - The US EPA's Factor Information REtrieval (FIRE) database<sup>302</sup> contains emission factors for a number of NPRI substances including mercury (and its compounds).
6. Engineering estimates; and
7. Emission Models.

When you report on-site releases, disposals and off-site transfers, you are required to enter the method of estimation in the NPRI reporting software.

## Canada-Wide Standard

Under the Canadian Council of Ministers of the Environment (CCME), the Government of Canada, along with provincial and territorial governments – expect Québec-entered a Canada-wide standard (CWS) agreement concerning mercury emissions from coal-fired power plants.<sup>303</sup> The CWS consists of two sets of targets:

- Provincial caps (see Table 2.24) on mercury emissions from existing coal-fired electric power generation (EPG) plants, with the 2010 provincial caps representing a 60%\* national capture of mercury from coal burned, or 70%\* including recognition for early action (percents are subject to change when Ontario finalizes mercury cap); and
- Capture rates or emission limits for new plants, based on best available control technology, effective October 2006.

**Table 2.24. Provincial Caps for Annual Mercury Emissions from Coal-fired Plants**

Province	Estimated Emissions in 2002—2004 (kg/yr)	2010 Cap (kg/yr)
Alberta	1,180 <sup>1</sup>	590
Saskatchewan	710	430 <sup>2</sup>
Manitoba	20	20
Ontario	495	<sup>3</sup>
New Brunswick	140	25
Nova Scotia	150	65
<b>Total</b>	<b>2,695</b>	<b>1,130<sup>4</sup></b>

<sup>1</sup> Alberta's commitment is through the implementation of the Clean Air Strategic Alliance Electricity Project Team recommendations. Alberta emissions are based on a 90% capacity factor.

<sup>2</sup> Saskatchewan's early actions, between 2004 and 2009, will be used to meet its provincial caps for the years 2010 to 2013. Examples of early actions include a mercury switch collection program and early mercury controls at the Poplar River Power Station.

<sup>3</sup> Ontario will help meet the CWS of 60% capture of mercury by 2010, and help exceed it in the near future with an ultimate Ontario goal of 0 mercury emissions from coal-fired power generation. The Lakeview coal-fired electricity generating station was closed in 2005. Ontario is committed to phasing out coal-fired electricity, and within 12 months Ontario will finalize its mercury emission plan for 2010.

<sup>4</sup> The percent capture rate is based on best available technologies economically achievable.

A second phase of the CWS may explore the capture of 80% or more of mercury from coal burned for 2018 and beyond.

Mercury emissions from new facilities are not included in the provincial caps for existing facilities. A new coal-fired EPG unit will achieve a capture of mercury from coal burned no less than specified in Table 2.25 or an average annual mercury emission rate no greater than specified in Table 2.25.

**Table 2.25. Provincial Mercury Emission/Capture Standards for Coal Coal-fired Plants**

Coal type	Percent capture in coal burned* (%)	Emission rate <sup>a</sup> (kg/TWh)
Bituminous coal	85	3
Sub-bituminous coal	75	8
Lignite	75	15
Blends	85	3

<sup>a</sup> The capture/emission rate is based on best available technologies economically achievable.

## Monitoring

Part 2 of the *Canada-Wide Standards for Mercury Emissions from Coal-Fired Electric Power Generation Plants CWSs* states that jurisdictions will establish and maintain testing in accordance with *Monitoring Protocol in Support of the Canada-Wide Standards for Mercury Emissions from Coal-Fired Electric Generation Plants*.<sup>304</sup> The *Monitoring Protocol* addresses: monitoring, reporting, record keeping, quality assurance and quality control (QA/QC), and CWSs achievement determination.

Monitoring methods outlined in the *Monitoring Protocol* include:

1. **Source testing stack surveys:** Provide a discrete “snapshot” of emissions during a specified test period. The operating conditions during the test period should be representative of normal operating conditions if used to estimate annual emissions.
2. **Continuous Emissions Monitoring Systems (CEMS):** Monitor the concentration of an air pollutant from a release source on a continuous basis;
3. **Mass balance:** Mercury in coal and residues are monitored, with the difference being determined as the amount of mercury emitted from the stack. The residue sampling must be timed such that it is representative of the coal that was burned;
4. **Established data;**
5. **Sorbent trap method (STM),** which is a non-isokinetic test method that samples flue gas while minimizing particulate capture, and provides total vapour-phase mercury emissions; and
6. **Other approaches** of equal or better accuracy.

For existing and new coal-fired EPG plants, total annual mercury emissions will be measured, including emissions occurring during both normal conditions and abnormal conditions (start-up, upsets, and equipment maintenance for example), i.e. historical results will not be used to determine the mercury content in coal, the mercury content of combustion residues (excluding bottom ash) nor the mercury content of flue gas for the CWS.

### *Coal-fired Power Generation Plants Commissioned prior to 2012*

Beginning January 1, 2008, monitoring of mercury emissions from existing plants defined in the CWS or from new units commissioned prior to 2012 shall be conducted using one of the following approaches outlined in Table 2.26.

**Table 2.26. Recommended Approaches for Monitoring Total Mercury**

Parameters	Recommended Approaches	Recommended Methods
Total annual mercury emitted	1) Stack testing and flow monitoring	<p>Stack testing using a continuous emission monitoring system (CEMS) as described in Appendix A of this Protocol. CEMS should be operated in accordance with the certification requirements of the US Environmental Protection Agency for mercury continuous emission monitoring systems, as updated [see Title 40 of the U.S. CFR §75]. The system should be operated in accordance with the manufacturer's recommended operating and QA/QC procedures, and as approved by the authority having jurisdiction.</p> <p>Mass emissions should be determined using stack gas flow data obtained from stack gas flow monitors. Specifications for stack gas flow monitors should be followed in accordance with Environment Canada's "Protocols and Performance Specifications for Continuous Monitoring of Gaseous Emissions from Thermal Power Generation" Report EPS 1/PG/7.*</p>
	2) Mass Balance	<p>Mass balance should be calculated in accordance with the requirements of the <i>Canadian Uniform Data Collection Program (UDCP) for Mercury from Coal-fired Electric Power Generation: A Guidance Document*</i> or as authorized by a jurisdiction (see Method 1 of Appendix A). Stack speciation data will be provided by the yearly stack testing done in accordance with the UDCP.</p> <p><b>Reduced Monitoring:</b>  A coal-fired EPG plant that has established, following the UDCP mass balance monitoring procedures, consistent levels of: <ul style="list-style-type: none"> <li>• total mercury content of the combusted coal; and/or</li> <li>• mercury content of coal combustion residues,</li> </ul> arising from a given technology and fuel source configuration, may apply to the authority having jurisdiction for a reduced level of mass balance monitoring. At a minimum, monitoring of mercury in coal and ash should be undertaken one week every one month.</p> <p>Where monitoring frequency has been reduced, this monitoring should be supplemented with an annual stack test to corroborate the mass balance result reported for achievement determination. Where the results of the annual stack test are not within <math>\pm 20\%</math> of the mass balance results, the utility should account for this discrepancy.</p>
	3) Other Equivalent Method	<p>By any other method demonstrated to the satisfaction of the applicable jurisdiction to yield results with an accuracy equal to or greater than that achieved by approaches 1 or 2. In comparing the accuracy of any alternate method to that of approach 1 or 2, results within <math>\pm 20\%</math> of those obtained by either approach 1 or 2 should be considered as equal results. Guidance on determining this degree of relative accuracy can be taken from Appendix K of Title 40 of US CFR §75.</p>

*New Coal-fired Power Generation Units*

For new coal-fired power generation units commissioned by 1 January 2012 and after, beginning 1 January 2012, these units shall monitor all its mercury emissions using CEMS capable of measuring total mercury and elemental mercury.

*Low Mass Emitter Option*

Beginning 1 January 2012, jurisdictions may consider exemptions from continuous emissions monitoring for low mass emitters (LME) on a per stack basis. The LME option is for those existing plants and new units whose yearly stack emissions of mercury are below the threshold set by this *Monitoring Protocol* and as authorized by each jurisdiction.

Existing plants and new units that have qualified for the LME option must still monitor their mercury emissions using the Canadian Uniform Data Collection Program (UDCP) mass balance approach as authorized by their jurisdiction. Under the LME option, monitoring only needs to be done during those periods in which the plant is in start-up, normal operating, stand-by, shutting-down, or process upset modes.

*Additional*

Between 1 January 2008 and 1 January 2012:

- Jurisdictions will require that existing plants and all new units conduct one stack speciation test per year as outlined in the *Monitoring Protocol*.
- If jurisdictions have not required that existing plants and all new units monitor their total mercury emissions using the mass balance approach, then jurisdictions will require that existing plants and all new units monitor their mercury content of coal and coal combustion residues using the Reduced Monitoring Subapproach (see Table 2.26 above)

For purposes other than assessing achievement of the CWSs' targets for total mercury emissions from existing plants and new units, this section applies to the monitoring of:

- Mercury content of coal;
- Coal combustion residues; and,
- Stack concentration of the species of mercury.

For existing plants and new units that have established consistent levels of the above listed parameters for a given technology configuration and fuel source, and with approval of the authority having jurisdiction, a utility may rely on established results for those parameters. Where a utility is relying on established results, where any change in technology or any change in fuel is expected to result in a measurable change in mercury speciation, mercury content of the combusted coal, or mercury content of coal combustion residues, and at least once every 3 years, jurisdictions should ensure that utilities monitor all of the parameters outlined in Table 2.27 using one of the recommended methods.

**Table 2.27. Recommended Approaches and Methods for Monitoring Parameters other than Total Mercury**

Parameters	Recommended Approaches	Recommended Methods
Mercury speciation in flue gas (elemental and oxidized)	a) Stack testing	i) Stack testing using CEMS (see total mercury above for more information) ii) Annual wet chemistry stack testing in accordance with the requirements of the <i>Ontario Hydro Method for the Measurement of Speciated Mercury Emissions: Sample Train Loading and Recovery Procedures</i> .
	b) Established data	See section 1.4 Established Data.
Mercury content of coal	a) Composite sampling	Sampling in accordance with the requirements of the <i>Canadian Uniform Data Collection Program (UDCP) for Mercury from Coal-fired Electric Power Generation: A Guidance Document</i> .
	b) Established data	See section 1.4 Established Data.
Mercury content of coal combustion residues (e.g. bottom ash and other waste streams)	a) Composite sampling	Sampling in accordance with the requirements of the <i>Canadian Uniform Data Collection Program (UDCP) for Mercury from Coal-fired Electric Power Generation: A Guidance Document</i> .
	b) Established data	See section 1.4 Established Data.

Modification to monitoring programs must be considered as a result of a change in technology or unanticipated change in fuel source expected to result in a measurable change in mercury speciation, mercury content of coal, or mercury content of coal combustion residues.

### **2.2.2.2 Alberta**

#### **Canada-Wide Standard**

Under the Canada-Wide Standard (see Section 2.2.2.1 above) Alberta's estimated emissions for 2002-2004 were 1,180 kg/year (based on a 90% capacity factor) and the 2010 cap is 590 kg/year.<sup>305</sup>

In Alberta, mercury will be reduced at coal-fired power plants by implementing the recommendations of the Clean Air Strategic Alliance, which is expected to lead to a 50% decrease on overall mercury of emissions by 50% in 2010.<sup>306</sup> By March 31, 2007, coal-fired plants must submit proposals on how they will capture at least 70% of the mercury in the coal they burn. Technology for mercury emission reduction must be in place by the end of 2010 at the latest. By 31 December 2011, Alberta's coal-fired power plants will have mercury emission limits and monitoring requirements. By the end of 2012, plants must submit proposals for capturing 80% of their mercury emissions.

### **2.2.3 European Union**

#### **Air Quality Framework Directive**

The *Air Quality Framework Directive* of 1996 deals with ambient air quality assessment and management. It describes the basic principles as to how air quality should be assessed and managed in the Member States.<sup>307</sup> The limit values for the specific pollutants are set through a series of Daughter Directives. The *Fourth Daughter Directive* of 2004,<sup>308</sup> which completes the list of pollutants initially described in the *Air Quality Framework Directive*, relates to mercury (in addition to arsenic, cadmium, nickel and polycyclic aromatic hydrocarbons) in ambient air. Unlike the other substances listed in the Directive, no target for the concentration of mercury is established in this legislation.

#### **Monitoring**

With respect to mercury, the Directive determines methods and criteria for assessing concentrations and deposition of this substance and ensures that adequate information is obtained and made available to the public.<sup>309</sup> For assessment of mercury ambient air concentrations and deposition rates, irrespective of concentration levels, one background sampling point shall be installed every 100,000 km<sup>2</sup>. Each Member State shall set up at least one measuring station; however, Member States may, by agreement, and in accordance with guidelines, set up one or several common measuring stations, covering neighboring zones in adjoining Member States, to achieve the necessary spatial resolution. Measurement of particulate and gaseous divalent mercury is also recommended. Where appropriate, monitoring shall be coordinated with the European Monitoring and Evaluation of Pollutants (EMEP) monitoring strategy and measurement program. The sampling sites for these pollutants shall be selected in such a way that geographical variation and long-term trends can be identified.

The data quality objectives established for mercury are:

- Uncertainty; Fixed and indicative measurements - 50 %
- Uncertainty; Modeling - 60 %
- Minimum data capture - 90 %
- Minimum time coverage; Indicative measurements (measurements which are performed at reduced regularity but fulfill the other data quality objectives) - 14 %

### *Methods*

**Sampling and Analysis:** The reference method for the measurement of total gaseous mercury concentrations in ambient air shall be an automated method based on Atomic Absorption Spectrometry or Atomic Fluorescence Spectrometry. In the absence of a CEN standardized method, Member States are allowed to use national standard methods or ISO standard methods. A Member State may also use any other methods which it can demonstrate give results equivalent to the above method.

**Deposition:** For the sampling deposited mercury, the method shall be based on the exposition of cylindrical deposit gauges with standardized dimensions. In the absence of a CEN standardized method, Member States are allowed to use national standard methods.

### **Protocol on Heavy Metals**

In a Council Decision of 2001, the European Community approved the Protocol to the 1979 Convention on Long-range Transboundary Air Pollution on Heavy Metals (adopted in 1998),<sup>310</sup> which aims to reduce emissions from heavy metals caused by anthropogenic activities that are subject to long-range transboundary atmospheric transport and are likely to have serious adverse effects on human health and the environment.<sup>311</sup> The Protocol sets a limit value for annual emissions into the of mercury (in addition to cadmium and lead) and a limit value on PM (see below). It stipulates that the signatory parties must apply the best available technologies *vis-à-vis* all the major sources of heavy metals existing, or due to be created, on their territory. The Protocol applies combustion installations with a net rated thermal input exceeding 50 MW.

The timescales for the application of limit values and best available techniques are:

1. For new stationary sources: two years after the date of entry into force of the present Protocol;
2. For existing stationary sources: eight years after the date of entry into force of the present Protocol.

If necessary, this period may be extended for specific existing stationary sources in accordance with the amortization period provided for by national legislation.

### *Limit Values*

Two types of limit value are important for heavy metal emission control. The types of limit values and the limits under the Protocol for combustion of solid fuels are:<sup>312</sup>

1. Values for specific heavy metals or groups of heavy metals - 6% O<sub>2</sub> in flue gas; and
2. Values for emissions of PM in general – 50 mg/m<sup>3</sup> @ 273.15 K, 101.3 kPa, dry gas

In principle, limit values for particulate matter cannot replace specific limit values for cadmium, lead and mercury, because the quantity of metals associated with particulate emissions differs from one process to another. However, compliance with these limits contributes significantly to reducing heavy metal emissions in general. Moreover, monitoring particulate emissions is generally less expensive than monitoring individual species and continuous monitoring of individual heavy metals is in general not feasible. Therefore, particulate limit values are of great practical importance and are also laid down in this annex in most cases complement or replace specific limit values for mercury (and cadmium and lead).

### **Monitoring**

PM emissions should be calculated as an average value of one-hour measurements, covering several hours of operation, as a rule 24 hours. Periods of start-up and shutdown should be excluded. The averaging time may be extended when required to achieve sufficiently precise monitoring results.

For heavy metals or groups of heavy metals, with regard to the oxygen content of the waste gas, the values given for selected major stationary sources shall apply. Any dilution for the purpose of lowering concentrations of pollutants in waste gases is forbidden. Limit values for heavy metals include the solid, gaseous and vapor form of the metal and its compounds, expressed as the metal. Whenever limit values for total emissions are given, expressed as g/unit of production or capacity respectively, they refer to the sum of stack and fugitive emissions, calculated as an annual value.

In cases in which an exceeding of given limit values cannot be excluded, either emissions or a performance parameter that indicates whether a control device is being properly operated and maintained shall be monitored. Monitoring of either emissions or performance indicators should take place continuously if the emitted mass flow of particulates is above 10 kg/hour. If emissions are monitored, the concentrations of air pollutants in gas-carrying ducts have to be measured in a representative fashion. If PM is monitored discontinuously, the concentrations should be measured at regular intervals, taking at least three independent readings per check. Sampling and analysis of all pollutants as well as reference measurement methods to calibrate automated measurement systems shall be carried out according to the standards laid down by the European Committee for Standardization (CEN) or the International Organization for Standardization (ISO). While awaiting the development of the CEN or ISO standards, national standards shall apply. National standards can also be used if they provide equivalent results to CEN or ISO standards.

In the case of continuous monitoring, compliance with the limit values is achieved if none of the calculated average 24-hour emission concentrations exceeds the limit



value or if the 24-hour average of the monitored parameter does not exceed the correlated value of that parameter that was established during a performance test when the control device was being properly operated and maintained. In the case of discontinuous emission monitoring, compliance is achieved if the average reading per check does not exceed the value of the limit. Compliance with each of the limit values expressed as total emissions per unit of production or total annual emissions is achieved if the monitored value is not exceeded, as described above.

### *Best Available Technologies*

The best available technologies are described in Annex III to the Protocol. Specific best available technologies guidance is provided for combustion of fossil fuels in utility and industrial boilers. It notes that:

- Improved energy conversion efficiency and energy conservation measures will result in a decline in the emissions of heavy metals because of reduced fuel requirements.
- Combusting natural gas or alternative fuels with a low heavy metal content instead of coal would also result in a significant reduction in heavy metal emissions such as mercury. Integrated gasification combined-cycle (IGCC) power plant technology is a new plant technology with a low-emission potential.
- Beneficiation, e.g. "washing" or "bio-treatment", of coal reduces the heavy metal content associated with the inorganic matter in the coal. However, the degree of heavy metal removal with this technology varies widely.
- A total dust removal of more than 99.5% can be obtained with electrostatic precipitators (ESP) or fabric filters (FF), achieving dust concentrations of about 20 mg/m<sup>3</sup> in many cases. Low filter temperature helps to reduce the gaseous mercury off-gas content.
- The application of techniques to reduce emissions of NO<sub>x</sub>, SO<sub>2</sub> and PM from the flue gas can also remove heavy metals. Possible cross media impact should be avoided by appropriate waste water treatment.

Using the techniques mentioned above, mercury removal efficiencies vary extensively from plant to plant, as seen in Table 2.28. Research is ongoing to develop mercury removal techniques, but until such techniques are available on an industrial scale, no best available technique is identified for the specific purpose of removing mercury.

**Table 2.28. Control measures, reduction efficiencies and costs for fossil-fuel combustion emissions**

Emission source	Control measure(s)	Reduction efficiency (%)	Abatement costs (total costs US\$)
Combustion of fuel oil	Switch fuel oil to gas	Cd, Pd: 100; Hg: 70-80	Highly case-specific
Combustion of coal	Switch from coal to fuels with lower heavy metals emissions	Dust 70-100	Highly case-specific
	ESP (cold-side)	Cd, Pb: > 90; Hg: 10-40	Specific investment US\$ 5-10/m <sup>3</sup> waste gas per hour (> 200,000 m <sup>3</sup> /h)
	Wet fuel-gas desulphurization (FGD) <sup>a/</sup>	Cd, Pb: > 90; Hg: 10-90 <sup>b/</sup>	15-30/Mg waste
	Fabric filters (FF)	Cd: >95; Pb: > 99; Hg: 10-60	Specific investment US\$8-15/m <sup>3</sup> waste gas per hour (> 200,000 m <sup>3</sup> /h)

<sup>a</sup> Hg removal efficiencies increase with the proportion of ionic mercury. High-dust selective catalytic reduction (SCR) installations facilitate Hg(II) formation.

<sup>b</sup> This is primarily for SO<sub>2</sub> reduction. Reduction in heavy metal emissions is a side benefit. (Specific investment US\$ 60-250/kWel.)

### *Compliance Monitoring*

Each party must keep regularly updated cadmium, lead and mercury emission registers. They must report these emissions levels. Each party must also notify the Executive Body of the Convention of the measures it has taken to apply the Protocol. An implementation Committee will carry out periodic inspections to verify compliance with the obligations under the Protocol.

### **European Pollutant Release and Transfer Register**

The European Pollutant Release and Transfer Register (E-PRTR), was signed in May 2003 by 36 economies and the European Community (see text on the E-PRTR in section 2.1.3 for additional information).<sup>313</sup>

Thermal power stations and other combustion installations with a heat input of greater than 50 megawatts (MW) – the same requirements covered by the Integrated Pollution Prevention and Control (IPPC) Directive - are required to report emissions to air under the E-PRTR for mercury and its compounds (as Hg) when they collectively exceed the threshold value of 10 kg/year.<sup>314</sup> All metals shall be reported as the total mass of the element in all chemical forms present in the release.

### **Monitoring**

Reporting is carried out based on measurement, calculation or estimation of releases and off-site transfers. The operator of the facility has to decide before collecting the data which determination methodology for a certain pollutant results in "best available information" for the reporting (see text on monitoring under the E-PRTR in section 2.1.3 for additional information).<sup>315</sup>

The approved standards for mercury are:

- European Standard (EN)13211:2001: *Air quality. Stationary source emissions. Manual method of determination of the concentration of total mercury*
- European Standards (EN) 14884:2005: *Air quality. Stationary source emissions. Determination of total mercury: automated measuring systems*

## 2.2.4 United States

### Toxics Release Inventory

Section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA) requires the US EPA and the States to annually collect data on releases and transfers of certain toxic chemicals from industrial facilities, and make the data available to the public in the Toxics Release Inventory (TRI).<sup>316</sup> The US EPA compiles the TRI data each year and makes it available through several data access tools, including the TRI Explorer and Envirofacts.

On 1 May 1997, EPA promulgated a rule (62 FR 23834) including electricity generating facilities, along with other industry groups, on the list of facilities subject to report to the TRI. In February 2000, the US EPA issued TRI Industry Guidance for *Electricity Generating Facilities*,<sup>317</sup> defined as facilities that combust coal and/or oil for the purpose of generating electricity for distribution in commerce. These facilities are subject to annual reporting requirements.

Electric generating facilities, which employ 10 or more full time employees or the equivalent, must perform a threshold determination for each TRI chemical and submit the values for each chemical exceeding a threshold. Beginning with the reporting year 2000 the reporting threshold was drastically lowered (from 25,000 pounds manufactured or processed, and 10,000 pounds otherwise used) to 10 pounds for each of these categories.<sup>318</sup>

### Monitoring

To estimate the quantities of each reportable chemical released and otherwise managed as waste, the US EPA has identified four basic methods that may be used to develop estimates (each estimate has been assigned a code that must be identified when reporting). The methods and corresponding codes are:

- Monitoring Data or Direct Measurement (M): Usually the best method for developing estimates for chemical releases and other waste management activity quantities estimates.
- Mass Balance (C): Involves determining the amount of a TRI chemical entering and leaving an operation. The mass balance is written as follows:  $\text{Input} + \text{Generation} = \text{Output} + \text{Consumption}$ . It is typically useful for chemicals that are “otherwise used” and do not become part of the final product, such as catalysts, solvents, acids, and bases. For large inputs and outputs, a mass balance may not be the best estimation method, because slight uncertainties in mass calculations can yield significant errors in the release and other waste management estimates.

- Emission Factors (E): A representative value that attempts to relate the quantity of a chemical released with an associated activity. These factors are usually expressed as the weight of chemical released divided by a unit weight, volume, distance, or duration of the activity releasing the chemical (e.g., pounds of chemical released per pounds of product produced). Emission factors, commonly used to estimate air emissions, available in EPA's *Compilation of Air Pollutant Emission Factors* (AP-42). The use of AP-42 emission factors is appropriate in developing estimates for emissions from boilers and process heaters.
- Engineering Calculations (O): Assumptions and/or judgments used to estimate quantities of TRI chemicals released or otherwise managed. The quantities are estimated by using physical and chemical properties and relationships (e.g., ideal gas law, Raoult's law) or by modifying an emission factor to reflect the chemical properties of the TRI chemical in question. Since engineering calculations rely on the process parameters; you must have a thorough knowledge of the operations at your facility to complete these calculations. The calculations can also include computer models.

Potential data sources for release and other waste management calculations are provided in Table 2.29.

**Table 2.29. Potential Data Sources for Release and Other Waste Management Calculations**

DATA SOURCES	
<p><b><u>Monitoring Data (M)</u></b></p> <ul style="list-style-type: none"> <li>• Stack monitoring data</li> <li>• Outfall monitoring data</li> <li>• Air permits</li> <li>• Industrial hygiene monitoring data</li> <li>• NPDES permits</li> <li>• POTW pretreatment standards</li> <li>• Effluent limitations</li> <li>• RCRA permit</li> <li>• Hazardous waste analysis</li> <li>• pH for acids</li> <li>• Continuous emission monitoring</li> </ul>	<p><b><u>Mass Balance (C)</u></b></p> <ul style="list-style-type: none"> <li>• Supply records</li> <li>• Hazardous material inventory</li> <li>• Air emissions inventory</li> <li>• Pollution prevention reports</li> <li>• Hazardous waste manifests</li> <li>• Spill event records</li> </ul>
<p><b><u>Emission Factors (E)</u></b></p> <ul style="list-style-type: none"> <li>• AP-42 or other EPA emission factors</li> <li>• Published facility or trade association <u>chemical-specific</u> emission factors</li> </ul>	<p><b><u>Engineering Calculations (O)</u></b></p> <ul style="list-style-type: none"> <li>• Volatilization rates</li> <li>• Raoult's Law</li> <li>• Henry's Law</li> <li>• Solubilities</li> <li>• Non-published emission factors</li> <li>• Facility or trade association <u>non chemical specific</u> emission factors (e.g., SOCOMI factors)</li> <li>• Process knowledge</li> </ul>

The US EPA does not require you to conduct additional sampling or testing for TRI reporting; however, you are required to use the best readily available information or prepare reasonable estimates. For each reported amount, only the primary method used for each estimate is identified in the report.

Releases of TRI chemicals to the stack air emission sources may be calculated using a number of methods. It is the responsibility of each facility to determine the best data to use. The best data source would be facility-specific monitoring data if enough data were available to sufficiently characterize the emissions on a EPCRA Section 313 chemical-specific basis. Unfortunately, these types of data are rarely available. One of the best practical alternatives is emission factors for the particular type of fuel that is being combusted. This document presents many of these emission factors as default values to consider if no other data exist or are readily available. Other sources, such as Electrical Power Research Institute's (EPRI) PISCES database, provide emission factors and models to calculate air emissions, including stack emissions. When other data are not available, EPA has emission factors which can be applied in calculating stack air emission estimates.

### **National-Scale Air Toxics Assessment**

The National-Scale Air Toxics Assessment (NATA) is ongoing comprehensive evaluation of air toxics in the US by the US EPA.<sup>319</sup> It covers 33 pollutants, including mercury. In February 2006, the US EPA released the results of its national-scale assessment of 1999 air toxics emissions.

#### **Monitoring**

Activities under the NATA include expansion of air toxics monitoring, improving and periodically updating emission inventories, improving national- and local-scale modeling, continued research on health effects and exposures to both ambient and indoor air, and improvement of assessment tools.

### **Clean Air Mercury Rule**

On 15 March 2005, EPA issued the Clean Air Mercury Rule (CAMR) to permanently cap and reduce mercury emissions from coal-fired power plants for the first time ever.<sup>320</sup> However, on 8 February 2008 this rule was suspended by court order<sup>321</sup> because it was found that the program violates the Clean Air Act by not requiring implementation of best available technology (BAT) in all new and existing coal-fired power plants that met certain criteria. It is now up to the US EPA to decide if they want to appeal the decision or if they want to go back and create a rule requiring BAT.<sup>322</sup>

This rule would have made the US the first economy in the world to regulate mercury emissions from utilities. The CAMR established "standards of performance" (NSPS) to limit mercury emissions from new and existing coal-fired power plants, and would have created a market-based cap and trade program. Like the stuck down CAIR, it would have applied to coal-fired units that produce electricity for sale and serve a generator with nameplate capacity > 25 megawatts.<sup>323</sup>

The CAMR regulation was rather unique, in that it was based on Section 111(d) of the Clean Air Act,<sup>324</sup> which requires States to submit a plan for a procedure to establish, implement and enforce standards of performance for any existing source for any air pollutant for which air quality criteria have not been issued, such as mercury, but to which a standard of performance under this section would apply if such existing

source were a new source.<sup>325</sup> In order to justify a section 111(d) rulemaking for a particular category of existing sources and for a particular pollutant, there must be a New Source Performance Standards (NSPS) regulation in place for the same source category and pollutant. However, prior to 2005, there was no NSPS regulation in existence for mercury emissions from coal-fired power plants. Therefore, on 18 May 2005, a mercury NSPS rule (which had been proposed on 30 January 2004) was published along with the CAMR regulation. The mercury NSPS rule provisions have been codified as amendments to Subpart Da of 40 CFR Part 60. The mercury NSPS applies to coal-fired electric generating units that have a heat input capacity > 250 mmBtu/hr and that commenced construction after 1 January 2004. The rule requires mercury emissions to be continuously monitored.<sup>326</sup>

The CAMR cap and trade program would have reduced nationwide utility emissions of mercury in two distinct phases. The first phase cap would have been 38 tons and emissions would have been reduced by taking advantage of “co-benefit” reductions—that is, mercury reductions achieved by reducing sulfur dioxide (SO<sub>2</sub>) and nitrogen oxides (NO<sub>x</sub>) emissions under Clean Air Interstate Rule (CAIR), which was stuck down by a court panel on 11 July 2008.<sup>327</sup> In the second phase, due in 2018, coal-fired power plants would have been subject to a second cap, which would have reduced emissions to 15 tons upon full implementation.

## **Monitoring**

The CAMR rule built upon the existing 40 CFR 75 infrastructure and required the emission monitoring and reporting provisions of Part 75 to be implemented. Under the CAMR, Part 75-compliant monitoring systems for Hg mass emissions and, if required, heat input had to be installed and certified by 1 January 2009.<sup>328</sup>

For any affected unit under the CAMR rule, a sorbent trap monitoring system (an alternative type of continuous Hg monitoring system) may have been used instead of an Hg CEMS.<sup>329</sup> A sorbent trap system continuously samples the stack gas for an extended period of time (anywhere from several hours to several days, depending on the Hg concentration in the stack). Hg is collected inside a tube (“trap”) that is filled with a sorbent medium such as activated carbon, and a dry gas meter is used to measure the total volume of dry stack gas sampled during the data collection period. The sorbent trap system is similar to an extractive-type CEMS, in that it continuously samples the stack gas and uses a moisture removal system. However, the similarity ends there, as the sorbent trap system differs from a CEMS in many ways:

- It does not measure the real-time Hg concentration every hour. Rather, it gives only an average Hg concentration over the data collection period, and this average concentration cannot be known until the sorbent traps have been analyzed in the lab.
- Unlike a CEMS, which samples at a constant rate, the sample flow rate through a sorbent trap is varied during the collection period, in proportion to the stack gas volumetric flow rate.
- Paired sorbent trap systems must be run simultaneously during each data collection period, and the Hg concentrations obtained from the two systems must agree to within a specified tolerance to validate the data.

- The certification and ongoing quality-assurance test requirements for sorbent trap systems are considerably different from those for an Hg CEMS. The only QA test common to both types of systems is the RATA.

The specific Hg monitoring requirements, outlined below, are found in 40 CFR Part 75, Subpart I.<sup>330</sup> Subpart I serves the same purpose for Hg mass emissions monitoring as Subpart H of Part 75 does for NO<sub>x</sub> mass emissions monitoring, in that it provides the monitoring guidelines for a multi-state trading program.

For monitoring of Hg mass emissions and heat input at the unit level, the owner or operator of the affected coal-fired unit shall either:

1. Meet the general operating requirements for continuous emission monitors, unless approval had been obtained for an alternative monitoring method:
  - An Hg concentration monitoring system or a sorbent trap monitoring system to measure the mass concentration of total vapor phase Hg in the flue gas, including the elemental and oxidized forms of Hg, in micrograms per standard cubic meter (µg/scm); and
  - A flow monitoring system; and
  - A continuous moisture monitoring system (if correction of Hg concentration for moisture is required). Alternatively, the owner or operator may use the appropriate fuel-specific default moisture value provided or a site-specific moisture value approved by petition; and
  - If heat input is required to be reported under the applicable State or Federal Hg mass emission reduction program that adopts the requirements of this subpart, the owner or operator also must meet the general operating requirements for a flow monitoring system and an O<sub>2</sub> or CO<sub>2</sub> monitor to measure heat input rate; or

For an affected unit that emits 464 ounces (29 lb) of Hg per year or less, the owner or operator shall meet the general operating requirements for the continuous emission monitors, and perform Hg emission testing for initial certification and on-going quality-assurance.

For monitoring of Hg mass emissions and heat input at an affected unit that utilizes a common stack with one or more affected units, but no non-affected units, the owner or operator shall either:

1. Install, certify, operate, and maintain the monitoring systems described for monitoring of Hg mass emissions and heat input at the unit level at the common stack, record the combined Hg mass emissions for the units exhausting to the common stack. If each of the units using the common stack is demonstrated to emit less than 464 ounces of Hg per year, the owner or operator may install, certify, operate and maintain the monitoring systems and perform the Hg emission testing. If reporting of the unit heat input rate is required, determine the hourly unit heat input rates either by:

- Apportioning the common stack heat input rate to the individual units according; or
  - Installing, certifying, operating, and maintaining a flow monitoring system and diluent monitor in the duct to the common stack from each unit; or
2. Install, certify, operate, and maintain the monitoring systems and, if applicable, perform the Hg emission testing in the duct to the common stack from each unit.

For monitoring of Hg mass emissions and heat input when one or more affected units utilizes a common stack with one or more nonaffected units, the owner or operator shall either:

1. Install, certify, operate, and maintain the monitoring systems and, if applicable, perform the Hg emission testing in the duct to the common stack from each affected unit; or
2. Install, certify, operate, and maintain the monitoring systems in the common stack; and
3. Install, certify, operate, and maintain the monitoring systems and, if applicable, perform the Hg emission testing described in the duct to the common stack from each non-affected unit. The designated representative shall submit a petition to the permitting authority and the Administrator to allow a method of calculating and reporting the Hg mass emissions from the affected units as the difference between Hg mass emissions measured in the common stack and Hg mass emissions measured in the ducts of the non-affected units, not to be reported as an hourly value less than zero. The permitting authority and the Administrator may approve such a method whenever the designated representative demonstrates, to the satisfaction of the permitting authority and the Administrator, that the method ensures that the Hg mass emissions from the affected units are not underestimated; or
  - Count the combined emissions measured at the common stack as the Hg mass emissions for the affected units, for recordkeeping and compliance purposes, in accordance with paragraph (a) of this section; or
  - Submit a petition to the permitting authority and the Administrator to allow use of a method for apportioning Hg mass emissions measured in the common stack to each of the units using the common stack and for reporting the Hg mass emissions. The permitting authority and the Administrator may approve such a method whenever the designated representative demonstrates, to the satisfaction of the permitting authority and the Administrator, that the method ensures that the Hg mass emissions from the affected units are not underestimated.

For monitoring of Hg mass emissions and heat input whenever any portion of the flue gases from an affected unit can be routed through a bypass stack to avoid the Hg monitoring system(s) installed on the main stack, the owner and operator shall either:



1. Install, certify, operate, and maintain the monitoring systems on both the main stack and the bypass stack and calculate Hg mass emissions for the unit as the sum of the Hg mass emissions measured at the two stacks;
2. Install, certify, operate, and maintain the monitoring systems at the main stack and measure Hg mass emissions at the bypass stack using the appropriate reference methods. Calculate Hg mass emissions for the unit as the sum of the emissions recorded by the installed monitoring systems on the main stack and the emissions measured by the reference method monitoring systems; or
3. Install, certify, operate, and maintain the monitoring systems and, if applicable, perform the Hg emission testing only on the main stack. If this option is chosen, it is not necessary to designate the exhaust configuration as a multiple stack configuration in the monitoring plan, since only the main stack is monitored. For each unit operating hour in which the bypass stack is used, report, as applicable, the maximum potential Hg concentration, and the appropriate substitute data values for flow rate, CO<sub>2</sub> concentration, O<sub>2</sub> concentration, and moisture (as applicable).

For monitoring of Hg mass emissions and heat input when the flue gases from an affected unit discharge to the atmosphere through more than one stack, or when the flue gases from an affected unit utilize two or more ducts feeding into a single stack and the owner or operator chooses to monitor in the ducts rather than in the stack, the owner or operator shall either:

1. Install, certify, operate, and maintain the monitoring systems and, if applicable, perform the Hg emission testing in each of the multiple stacks and determine Hg mass emissions from the affected unit as the sum of the Hg mass emissions recorded for each stack. If another unit also exhausts flue gases into one of the monitored stacks, the owner or operator shall comply with the applicable requirements, in order to properly determine the Hg mass emissions from the units using that stack; or
2. Install, certify, operate, and maintain the monitoring systems and, if applicable, perform the Hg emission testing in each of the ducts that feed into the stack, and determine Hg mass emissions from the affected unit using the sum of the Hg mass emissions measured at each duct, except that where another unit also exhausts flue gases to one or more of the stacks, the owner or operator shall also comply with the applicable requirements to determine and record Hg mass emissions from the units using that stack.

Unlike the stuck down Clean Air Interstate Rule (CAIR), implementation of the mercury trading program under the CAMR rule was expected to be more challenging, because continuous mercury monitoring has not been required by any State or Federal regulation prior to the CAMR rule. While the EPA is aware that Hg monitoring is not nearly as well-understood or as well-established as SO<sub>2</sub> and NO<sub>x</sub> monitoring technology, the results of recent field studies of mercury monitors have been encouraging. At the present rate of progress, mercury monitoring technology is expected to be sufficiently developed by the time the CAMR rule would have been implemented.

## 2.3 Carbon Dioxide (CO<sub>2</sub>)

Power generation accounts for about one-quarter of total emissions of carbon dioxide (CO<sub>2</sub>), the main culprit in global warming.<sup>331</sup> Globally, power generation emits nearly 10 billion tons of CO<sub>2</sub> per year. The US, with over 8,000 power plants out of the more than 50,000 worldwide, accounts for about 25 percent of the CO<sub>2</sub> emissions total with about 2.8 billion tons. Australia ranks 7<sup>th</sup> in total emissions from power plants. On a per capita basis, Australians are one of the largest emitters with more than 11 tons of power sector CO<sub>2</sub> emissions per person every year. Americans emit more than 9 tons per person.

### 2.3.1 Australia

In Australia, there is currently no national regulatory requirement for the control of CO<sub>2</sub> from power stations. However, several measures to track emissions and encourage reductions are under development.

#### 2.3.1.1 Federal Level

##### National Greenhouse and Energy Reporting Act 2007

The *National Greenhouse and Energy Reporting Act 2007*<sup>332</sup> establishes a single, national system for reporting greenhouse gas emissions, abatement actions, and energy consumption and production by corporations in Australia from 1 July 2008. Data reported through the system will underpin the Australian Emissions Trading Scheme.

Key features of the system are:

- A single online entry point for reporting;
- A standard data set and nationally consistent methodologies for reporting;
- Public disclosure of company level greenhouse gas emissions and energy data;
- Consistent and comparable data provided to government for policy making; secure data storage; and
- Reporting thresholds that avoid capturing small business.

Reporting requirements are:<sup>333</sup>

- Controlling corporations must register and report if they emit greenhouse gases, produce energy, or consume energy at or above specified quantities per financial year (1 July to 30 June).
- From 1 July 2008, corporations will be required to register and report if:
  - They control facilities that emit 25 kilotonnes or more of greenhouse gas (CO<sub>2</sub> equivalent), or produce/consume 100 terajoules or more of energy; or
  - Their corporate group emits 125 kilotonnes or more greenhouse gas (CO<sub>2</sub> equivalent), or produces/consumes 500 terajoules or more of energy.
- Lower thresholds for corporate groups will be phased in by 2010-11. The final thresholds will be 50 kilotonnes of CO<sub>2</sub> equivalent or 200 terajoules of energy.

- Companies must register by 31 August, and report by 31 October, following the financial year in which they meet a threshold. Data will be published by the Greenhouse and Energy Data Officer by 28 February following each reporting period.

## Monitoring

The National Greenhouse and Energy Reporting (Measurement) Determination 2008<sup>334</sup> outlines four detailed methods that can be used to estimate greenhouse gas emissions and energy produced or consumed. Corporations are required to report on which methods they are using. Broadly, the four methods are as follows:

- Method 1: The default methods, derived directly from the methods used for the National Greenhouse Accounts and the same as those used in the Online System for Comprehensive Activity Reporting (OSCAR).
  - Specifies the use of designated emission factors in the estimation of emissions. These emission factors are national average factors determined by the Department of Climate Change using the Australian Greenhouse Emissions Information System (AGEIS).
  - Likely to be most useful for emission sources where the source is relatively homogenous, such as from the combustion of standard liquid fossil fuels, where the emissions resulting from combustion will be very similar across most facilities.
- Method 2: A facility-specific method using industry sampling and Australian or international standards listed in the Determination or equivalent for analysis of fuels and raw materials to provide more accurate estimates of emissions at facility level.
  - Enables corporations to undertake additional measurements - for example, the qualities of fuels consumed at a particular facility - in order to gain more accurate estimates for emissions for that particular facility.
  - Draws on the large body of Australian and international documentary standards prepared by standards organizations to provide the benchmarks for procedures for the analysis of, typically, the critical chemical properties of the fuels being combusted.
  - Likely to be most useful for fuels which exhibit some variability in key qualities, such as carbon content, from source to source. This is the case for coal in Australia.
- Method 3: A facility-specific method using Australian or international standards listed in the Determination or equivalent standards for both sampling and analysis of fuels and raw materials.
  - Method 3 is very similar to method 2, but it requires reporters to comply with Australian or equivalent documentary standards for sampling
- Method 4: Direct monitoring of emission systems, on either a continuous or a periodic basis, using either CEMS or PEMS, respectively.
  - Can provide a higher level of accuracy in certain circumstances, depending on the type of emission process although it is more data intensive than other approaches.

## *Compliance Monitoring*

External auditors may check a corporation's compliance with the legislation (the Act, the Regulations and other instruments) and report their findings to the Greenhouse and Energy Data Officer.<sup>335</sup> Corporations may be audited only in terms of their compliance with the requirements of the legislation.

These external auditors are given the following powers to monitor compliance specifically in relation to the enforcement of this Act only.<sup>336</sup>

- Search the premises;
- Examine any activity, piece of equipment, documentation etc.;
- Collect data (photographs, copies, etc.);
- Collect items (equipment, disks, etc.) that shows evidence of unauthorized activities;
- Operate equipment; and
- Question personnel

Warrants and requests for external audits may be granted to monitor for compliance.

### **2.3.1.2 New South Wales**

The New South Wales Greenhouse Gas Reduction Scheme (GGAS) requires NSW electricity retailers and certain other parties, collectively referred to as benchmark participants, to meet mandatory targets for reducing or offsetting the emission of greenhouse gases from the production of the electricity they supply or use.<sup>337</sup>

The Electricity Supply Amendment (Greenhouse Gas Emission Reduction) Act 2002<sup>338</sup> sets a State greenhouse gas benchmark expressed in tonnes of carbon dioxide equivalent (CO<sub>2</sub>-e) per capita. The initial level was set at the commencement of GGAS in 2003 at 8.65 tonnes. The benchmark progressively drops to 7.27 tonnes in 2007, which represents a reduction of five per cent below the Kyoto Protocol baseline year of 1989-90. The per capita amount continues at this level until 2021.

Benchmark participants can reduce the average emissions intensity of the electricity they supply or use by purchasing abatement certificates. They can abate GHGs by:

- Reducing the greenhouse gas intensity of electricity generation;
- Generating low emission intensity electricity;
- Demand side abatement activities which involve reducing, or increasing the efficiency of the consumption of electricity;
- Carbon sequestration activities - managing forests so as to capture and retain carbon from the atmosphere.

Participants can also claim credit for the surrender of Renewable Energy Certificates under the Commonwealth's Mandatory Renewable Energy Target. GGAS also allows some large electricity customers to claim credit for reducing on-site emissions of greenhouse gases from (non-electricity related) industrial processes at sites which they own and control.

Assessment of the GHG reductions for a given system is established by the methods laid out in the Performance Improvement Testing Regime (PITR).<sup>339</sup> An outline of how this regime works is shown in Table 2.30.

**Table 2.30. Concept of the Performance Improvement Testing Regime (PITR) for the NSW Greenhouse Gas Reduction Scheme (GGAS)**

<p><b>Performance:</b> The performance of the Generating System in terms of the Greenhouse Intensity (GI). The reference performance is established for a specific reference period after 1 January 2002.</p>
<p><b>Improvement:</b> The performance improvement measures, regardless of the type of improvement, must result in the reduction of the Generating System's GI for the Measurement Period when compared to the reference performance.</p>
<p><b>Testing:</b> The performance improvement must be tested (or measured) in such a way that allows the accurate calculation of the Generating System's Percentage Performance Improvement for the Measurement Period.</p>
<p><b>Regime:</b> The regime developed for the performance improvement testing is an ongoing regime. The applicant must continuously (or periodically) assess its Generating System's GI performance for the determination of PPI for each subsequent Measurement Period.</p>

A *generating system* is a system comprising one or more of the physical generators of electricity and all the related equipment capable of functioning as a single entity.

A *PPI* is a percentage performance improvement, and refers to percentage figure that represents the improvement in greenhouse intensity of the Generating System resulting from performance improvement(s) that have been undertaken.

## Monitoring

### *Post-Improvement Greenhouse Intensity (GI) Performance Monitoring*

Post-improvement GI performance monitoring is required to determine and to substantiate the Percentage Performance Improvement (PPI) of the generating system for each measurement period.<sup>340</sup> The aim of post-improvement GI performance monitoring is to ensure that the net effect of performance improvement gains made in one area (e.g. due to a turbine upgrade) and losses in another area taken into account in determining the PPI.

The requirements for post-improvement greenhouse intensity (GI) performance monitoring are the:

- Establishment of a basis for the ongoing monitoring (e.g. station or unit)
  - The extent of ongoing monitoring of unit performance is a decision for each generator to make, with the aim of minimizing of Generating System PPI uncertainty.

- The minimum level of monitoring is expected to be at the unit level and including monitoring of the performance of the boiler, turbine and auxiliary demand.
- Selection of a measurement period
  - The measurement period needs to be chosen in such a way as to minimize the uncertainty in the determination of PPI. Considerations should include the accuracy of fuel analysis data, the accuracy of input data and ability to cross check against other data sources; and variability in data that may tend to average out over longer Measurement Periods.
  - The Measurement Period can be between ½ hour and one year and should be selected in a way that makes best use of available data.
- Ongoing monitoring of fuel properties

The options for ongoing GI performance monitoring are:

- **Performance Testing** – A documented procedure used to establish reference performance for individual units or components (boiler, turbine (HP, IP, LP or overall turbine) and auxiliary demand) and assessing the ongoing performance of those components against its established reference performance. PITRs must be consistent with recognized methodologies for assessing the performance, be tailored to the specific characteristics of the components being assessed and include a clear procedure for determining the percentage performance improvement.
- **Efficiency Approach (Losses Method) / Use of Unit Instruments** - Depending upon the extent and accuracy of unit instrumentation, GI can be calculated using unit instruments, or individual component performance (e.g. turbine (HP, IP, LP or overall), boiler and auxiliary demand) can be monitored on a unit by unit basis.
- **Direct Method (Input / Output)** - Direct measurement of fuel flow (either on a unit, stage or power station basis) together with fuel analysis and sent out power generation (on a unit basis).

Uncertainty in the determination of PPI is a very important criterion for determining which method should be used as the primary means of determining the PPI.

Options for post-improvement GI performance monitoring are:

- **Performance Testing** – An important method for determining the unit and Generating System PPI, either as a primary measure, or as a means of substantiating the value of PPI determined using other means. It is best used to determine Generating System PPI in conjunction with unit instruments that can provide relative trends of performance in-between performance tests.
- **Efficiency Approach** - The requirements for ongoing performance monitoring using the Efficiency Approach revolve around ensuring that the uncertainty in the determination of actual unit GI, unit PPI, and hence station PPI are at least maintained. This includes the implementation of a suitable instrument calibration and maintenance schedule, performance

testing to verify the GI calculations and key instrument measurements, error routine checking of data and reconciliation of data using alternative methods. Actual GI (for each unit) is calculated using unit instruments in four main steps (for a given time interval):

- Step 1: Calculate the boiler efficiency from the ‘heat loss method’ using unit instrumentation;
  - Step 2: Calculate the boiler thermal output (i.e. the heat transferred to the steam) by measurement of feed water and steam flows, pressures and temperatures;
  - Step 3: Calculate the fuel feed rate by dividing the boiler thermal output by the calculated boiler efficiency and the fuel calorific value (on a higher heating value basis);
  - Step 4: Calculate the greenhouse intensity (GI) using the calculated fuel feed rate, the carbon content of the fuel and the sent out power generation.
- **Use of Unit Instrumentation** - The requirements for ongoing performance monitoring using the Efficiency Approach revolve around ensuring that the uncertainty of determination of actual unit GI, unit PPI, and hence station PPI are at least maintained. The approach, which uses similar methodology to the Efficiency Approach, could be employed in conjunction with other methodology to enable ongoing performance monitoring of unit or unit component performance through the use of unit instrumentation. This will be particularly beneficial for use with Performance Testing, which cannot be used for monitoring ongoing performance over short time intervals.
  - **Direct Method** - The direct measurement of fuel flow to a unit (together with fuel analysis and sent out power generation) can be used to determine the actual GI on a unit or generating system basis for a given time interval. Since the fuel analysis needs to accurately represent the actual fuel properties supplied over any given measurement period, the selection of an appropriate measurement period is of particular importance.

### *Compliance Monitoring*

Benchmark participants must lodge an Annual Greenhouse Gas Benchmark Statement (Benchmark Statement) with the Compliance Regulator, the Independent Pricing and Regulatory Tribunal of NSW (IPART), by 18 March each year (or a later date approved by the Compliance Regulator) reporting on their compliance during the previous calendar year.<sup>341</sup> The Benchmark Statements must include, among other things, calculation of their emission reduction benchmark.

Benchmark statements must be audited prior to submission to the Compliance Regulator (generally in January or February each year). The Compliance Regulator has developed a generic scope for these audits. Benchmark participants select and engage members from the Audit and Technical Services Panel (the Panel) to undertake these audits against the Compliance Rule. The Compliance Regulator approves the appointment.

Auditors are required to prepare a report detailing the audit opinion and related findings in relation to the matters detailed in the audit scope. An audit report template

and a schedule of audit procedures and findings are available to assist auditors. Detailed guidance can be found in the *Audit Guideline*.<sup>342</sup>

## **2.3.2 Canada**

### **2.3.2.1 Federal Level**

In March 2004, the Government of Canada announced the introduction of mandatory reporting of GHG emissions by major emitters.<sup>343</sup> Unlike the National GHG Inventory which compiles GHG data at a national level, developed from national and provincial statistics, the GHG Emissions Reporting program applies only to the largest industrial GHG emitters in Canada. In the GHG emissions reporting program, all facilities that emit the equivalent of 100,000 tonnes (100kt) or more of greenhouse gases (in CO<sub>2</sub> equivalent units) per year are required to submit a report. Reporters can submit their reports for each calendar year using the Electronic Data Reporting (EDR) system on the GHG Reporting Web site.

The GHG emissions reporting program specifically targets facilities in Canada that emit the equivalent of 100,000 tonnes or more of Greenhouse Gases (in CO<sub>2</sub> equivalent units; which includes the six gases covered by the Kyoto Protocol: CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, HFCs, PFCs and SF<sub>6</sub>) annually. It is important to note that the emissions information collected and published by this program represent only a portion of industrial emitters in Canada. The totals published by the GHG Emissions Reporting program represent a subset of the larger picture provided by the National Inventory.

### **Monitoring**

The reporting facility needs to calculate and report its direct emissions of CO<sub>2</sub> (in addition to CH<sub>4</sub> and N<sub>2</sub>O) individually.<sup>344</sup> When reporting these emissions, the reporter is required to disaggregate the emissions by the following source categories:

- Stationary Fuel Combustion
- Industrial Process
- Venting and Flaring
- Other Fugitive
- Waste and Wastewater
- On-site Transportation

The reporting facility must identify and report the type of estimation method or methods used to determine the quantities of emissions reported. Such methods include:

- Monitoring or direct measurement;
- Mass balance;
- Emission factors; and
- Engineering estimates.

Reporters must keep copies of the information submitted, together with any calculations, measurements and other data on which the information is based. For the currently phase of reporting (Phase 1), there are no specific protocols to define how



reporters must calculate their GHG emissions. However, where reasonable, reporters should use methods that are consistent with the methodologies approved by the UNFCCC and developed by the IPCC. The relevant sections of the IPCC Guidelines for reporting CO<sub>2</sub> emissions for stationary fuel combustion are Chapter 1 (Energy Chapter) pages 1.1 – 1.62. The relevant sections of the *IPCC Good Practice Guidance* are Chapter 2 (Energy Chapter) pages 2.1 – 2.43.

Emissions reports will be collected electronically through an electronic data reporting (EDR) system that has been developed by Statistics Canada. Emissions reports must be accompanied by a statement of certification, a document with the company letterhead and signature of an authorized company official stating that the information contained in the attached emissions report is true, accurate and complete.

### **2.3.2.2 Alberta**

Climate change regulations that became effective 1 July 2007 required Alberta facilities that emit more than 100,000 tonnes of greenhouse gases a year to reduce their emissions intensity by 12 percent by March 31, 2008.<sup>345</sup> Companies could have made their reductions through improvements to their operations; by purchasing Alberta-based credits or by contributing to the Climate Change and Emissions Management Fund. Required reporting of CO<sub>2</sub> in Alberta is the same as federal Canadian standards.<sup>346</sup> Alberta Environment uses the information to identify emission sources.

### **Monitoring**

The *Alberta Specified Gas Reporting Standard* notes that calculation methods should be widely accepted to the industry in which the facility belongs and/or consistent with approved guidelines by the UNFCCC for National Greenhouse Gas Emission Inventories by Annex 1 Parties.<sup>347</sup> The Standard also provides guidance for some additional information that may be included in an emissions report, such as:

- The methodologies, emission factors, equations and calculations used in calculating or determining emissions;
- Citation of methodology reference publications used in calculating or determining direct emissions;
- The amount, in tonnes, of indirect emissions of CO<sub>2</sub>, CH<sub>4</sub> and N<sub>2</sub>O associated with the generation of imported/purchased electricity, steam or heat for the facility.

### **2.3.3 European Union**

In January 2005, the European Union Greenhouse Gas Emission Trading Scheme (EU ETS) commenced operation as the largest multi-economy, multi-sector Greenhouse Gas emission trading scheme world-wide.<sup>348</sup> The EU ETS has been established through binding legislation (Directive 2003/87/EC), which entered into force October 25, 2003. The scheme is based on six fundamental principles:

1. ‘Cap-and-trade.’
2. Initial focus is on CO<sub>2</sub> from big industrial emitters.

3. Implementation is to take place in phases, with periodic reviews and opportunities for expansion to other gases and sectors.
4. Allocation plans for emission allowances are to be decided periodically.
5. Strong compliance framework.
6. Market is EU-wide, but taps emission reduction opportunities in the rest of the world through the use of the Clean Development Mechanism (CDM) and Joint Implementation (JI), and provides for links with compatible schemes in third economies.

## **Permits**

Each installation in the EU ETS must have a permit from its competent authority for its emissions of all six greenhouse gases controlled by the Kyoto Protocol.<sup>349</sup> A condition for granting the permit is that the operator is capable of monitoring and reporting the plant's emissions. The permits shall contain monitoring requirements, specifying monitoring methodology and frequency. A permit is different from the allowances: the permit sets out the emissions monitoring and reporting requirements for an installation, whereas allowances are the scheme's tradable unit.

Installations must report their CO<sub>2</sub> emissions after each calendar year. The European Commission has issued a set of monitoring and reporting guidelines to be followed.

## **Monitoring**

On 29 January 2004, the Commission established guidelines for the monitoring and reporting of greenhouse gas emissions, as required by the EU ETS Directive.<sup>350</sup> Member States must ensure that emissions are monitored in accordance with these guidelines, which are legally binding. Revised Guidelines were adopted by the Commission on 18 July 2007.<sup>351</sup>

The main changes of the revised guidelines are:<sup>352</sup>

- Guidelines are closer to sector practices way of monitoring and reporting done by operators (use of standard factors for commercial fuels)
- Guidelines are more cost effective especially for small emitters (lighter monitoring requirements for small installations/small emitters < 25,000 tonnes CO<sub>2</sub>) and for installations using biomass fuels
- Guidelines are more aligned with reporting made by Member States under national greenhouse gas inventory requirements
- Integrity of the system is reinforced maintaining accuracy and credibility of monitoring and reporting
- Verification procedures of the monitoring and reporting are strengthened

## **Monitoring**

### ***General Guidelines***

General monitoring guidance is found in Annex I of the revised 2007 EU ETS guidelines.<sup>353</sup> It is based on the following monitoring principles: Completeness,

Consistency, Transparency, Trueness, Cost effectiveness, Faithfulness, and Improvement in performance in monitoring and reporting emissions.

The monitoring and reporting process for an installation shall include all relevant greenhouse gas emissions from all emission sources and/or source streams belonging to activities carried out at the installation (as required in the EU ETS Directive of 2003).

The EU ETS Directive of 2003<sup>354</sup> permits a determination of emissions using either:

1. Calculation-based methodology, determining emissions from source streams based on activity data obtained by means of measurement systems and additional parameters from laboratory analyses or standard factors;
2. Measurement-based methodology, determining emissions from an emission source by means of continuous measurement of the concentration of the relevant greenhouse gas in the flue gas and of the flue gas flow.

The operator may propose to use a measurement based methodology if he can demonstrate that:

- It reliably results in a more accurate value of annual emissions of the installation than an alternative calculation based methodology, while avoiding unreasonable costs; and
- The comparison between measurement and calculation-based methodology is based on an identical set of emission sources and source streams.

The use of a measurement-based methodology shall be subject to the approval of the competent authority. For each reporting period the operator shall corroborate the measured emissions by means of calculation-based methodology. The operator may, with the approval of the competent authority, combine measurement and calculation-based methodologies for different emission sources and source streams belonging to one installation.

#### *Calculation Based Methodologies for CO<sub>2</sub> Emissions*

Calculation of CO<sub>2</sub> emissions shall be based either on the following formula:

$$\text{CO}_2 \text{ emissions} = \text{activity data} * \text{emission factor} * \text{oxidation factor}$$

or on an alternative approach if defined in the activity-specific guidelines.

There are three categories for installations with average reported annual emissions over the previous trading period (or a conservative estimate or projection if reported emissions are not available or no longer applicable):

- **A:** Equal to or less than 50 kilotonnes of fossil CO<sub>2</sub> before subtraction of transferred CO<sub>2</sub>,
- **B:** Greater 50 kilotonnes and equal to or less than 500 kilotonnes of fossil CO<sub>2</sub> before subtraction of transferred CO<sub>2</sub> and,

- C: Greater than 500 kilotonnes of fossil CO<sub>2</sub> before subtraction of transferred CO<sub>2</sub>.

Member States shall ensure that operators apply for all major source streams, as a minimum the tiers as set out in Table 1 of the 2007 guidance, unless this is technically not feasible.

### *Measurement-Based Methodologies*

Greenhouse gas emissions may be determined by a measurement-based methodology using continuous emission measurement systems (CEMS) from all or selected emission sources using standardized or accepted methods once the operator has received approval from the competent authority before the reporting period that using a CEMS achieves greater accuracy than the calculation of emissions using the most accurate tier approach. Specific approaches for measurement based methodologies are laid down in the 2007 revised guidelines (Annex XII). Installations applying CEMS as part of their monitoring system are to be notified by Member States to the EU Commission

The procedures applied for the measurement of concentrations, as well as for mass or volume flows shall, where available, be according to a standardized method that limits sampling and measurement bias and has a known measurement uncertainty. CEN standards (i.e. those issued by the European Committee for Standardisation) shall be used, if available. If CEN standards are not available, suitable ISO standards (i.e. those issued by the International Standardisation Organisation) or national standards shall apply. Where no applicable standards exist, procedures can be carried out where possible in accordance with suitable draft standards or industry best practice guidelines.

Relevant ISO standards include, *inter alia*:

- ISO 12039:2001 Stationary source emissions — Determination of carbon monoxide, carbon dioxide and oxygen — Performance characteristics and calibration of an automated measuring method,
- ISO 10396:2006 Stationary source emission — Sampling for the automated determination of gas concentrations,
- ISO 14164:1999 Stationary source emissions. Determination of the volume flow rate of gas streams in ducts — automated method.

The highest tier level (pursuant to Annex XII) shall be used by the operator of an installation for each emission source which is listed in the greenhouse gas emissions permit and for which relevant greenhouse gas emissions are determined applying CEMS. Only if it is shown to the satisfaction of the competent authority that the highest tier approach is technically not feasible or will lead to unreasonably high costs, may a next lower tier be used for the relevant emission source.

### ***Industry Specific Guidance for Combustion Activities***

Emission sources of CO<sub>2</sub> emissions from combustion installations and processes include: boilers, burners, turbines, heaters, furnaces, incinerators, kilns, ovens, dryers,

engines, flares, scrubbers (process emissions), any other equipment or machinery that uses fuel, excluding equipment or machinery with combustion, and engines that are used for transportation purposes.

### Calculation-Based Methodologies

Activity data shall be based on fuel consumption. The quantity of fuel used shall be expressed in terms of energy content as terajoules (TJ), unless otherwise indicated in these guidelines. The emission factor shall be expressed as tCO<sub>2</sub>/TJ, unless otherwise indicated in these guidelines. When a fuel is consumed not all of the carbon in the fuel is oxidized to CO<sub>2</sub>. Incomplete oxidation occurs due to inefficiencies in the combustion process that leave some of the carbon unburned or partly oxidized as soot or ash. Un-oxidized or partially oxidized carbon is taken into account in the oxidation factor which shall be expressed as a fraction. The oxidation factor shall be expressed as a fraction of one. The resulting calculation formula is:

$$\text{CO}_2 \text{ emissions} = \text{fuel flow [t or Nm}^3\text{]} * \text{net calorific value [TJ/t or TJ/Nm}^3\text{]} * \text{emission factor [tCO}_2\text{/TJ]} * \text{oxidation factor.}$$

The activity-specific guidelines (found in Annex II: “Guidelines for combustion emissions from activities as listed in Annex I to Directive 2003/87/EC”) contain specific methodologies for determining the following variables: activity data (consisting of the two variables fuel/material flow and net calorific value), emission factors, composition data, oxidation and conversion factors. These different approaches are referred to as tiers. The increasing numbering of tiers from one upwards reflects increasing levels of accuracy, with the highest numbered tier as the preferred tier.

The activity-specific guidelines contained shall be used to monitor emissions from combustion installations with a rated thermal input exceeding 20 MW. The monitoring of emissions from combustion processes shall include emissions from the combustion of all fuels at the installation as well as emissions from scrubbing processes for example to remove SO<sub>2</sub> from flue gas.

### Activity data tiers

#### 1. Fuel Consumed

- **Tier 1:** The fuel consumption over the reporting period shall be determined by the operator or fuel supplier within a maximum uncertainty of less than ± 7.5 % taking into account the effect of stock changes where applicable.
- **Tier 2:** The fuel consumption over the reporting period shall be determined by the operator or fuel supplier within a maximum uncertainty of less than ± 5 % taking into account the effect of stock changes where applicable.
- **Tier 3:** The fuel consumption over the reporting period shall be determined by the operator or fuel supplier within a maximum uncertainty of less than ± 2,5 % taking into account the effect of stock changes where applicable.

- **Tier 4:** The fuel consumption over the reporting period shall be determined by the operator or fuel supplier within a maximum uncertainty of less than  $\pm 1.5\%$  taking into account the effect of stock changes where applicable.

The minimum tier requirements for activity data based on fuel consumed calculations for emissions from coal fired power plants are:

- Installation A, Tier 2
- Installation B, Tier 3
- Installation C, Tier 4

For details of installation information, see *Calculation Based Methodologies for CO<sub>2</sub> Emissions* in the *General Guidance Section* above.

## 2. Net Calorific Value

- **Tier 1:** Reference values for each fuel are used as specified in Section 11 of Annex I. 31.8.2007 EN Official Journal of the European Union L 229/49
  - In case volume units are used, the operator shall consider any conversion that may be required to account for differences in pressure and temperature of the metering device and the standard conditions for which the net calorific value was derived for the respective fuel type.
- **Tier 2a:** The operator applies economy-specific net calorific values for the respective fuel as reported by the respective Member State in its latest national inventory submitted to the Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC).
- **Tier 2b:** For commercially traded fuels the net calorific value as derived from the purchasing records for the respective fuel provided by the fuel supplier is used, provided it has been derived based on accepted national or international standards.
- **Tier 3:** The net calorific value representative for the fuel in an installation is measured by the operator, a contracted laboratory or the fuel supplier in accordance with the provisions of Section 13 of Annex I.

The minimum tier requirements for activity data based on net calorific value calculations for emissions from coal fired power plants are:

- Installation A, Tier 2a/2b
- Installation B, Tier 2a/2b
- Installation C, Tier 2a/2b

For details of installation information, see *Calculation Based Methodologies for CO<sub>2</sub> Emissions* in the *General Guidance Section* above.

Emission factor tiers:

1. **Tier 1:** Reference factors for each fuel are used as specified in Section 11 of Annex I.

2. **Tier 2a:** The operator applies economy-specific emission factors for the respective fuel as reported by the respective Member State in its latest national inventory submitted to the Secretariat of the UNFCCC.
3. **Tier 2b:** The operator derives emission factors for the fuel based on net calorific value for specific coals types. In combination with an empirical correlation as determined at least once per year according to the provisions of Section 13 of Annex I. The operator shall ensure that the correlation satisfies the requirements of good engineering practice and that it is applied only to values of the proxy which fall into the range for which it was established.
4. **Tier 3:** Activity-specific emission factors for the fuel are determined by the operator, an external laboratory or the fuel supplier according to the provisions of Section 13 of Annex I.

The minimum tier requirements for emission factor data calculations for emissions from coal fired power plants are:

- Installation A, Tier 2a/2b
- Installation B, Tier 2a/2b
- Installation C, Tier 2a/2b

For details of installation information, see *Calculation Based Methodologies for CO<sub>2</sub> Emissions* in the *General Guidance Section* above.

Oxidation Factor tiers:

1. **Tier 1:** An oxidation factor of 1.0 (See IPCC 2006 Guidelines for National Greenhouse Gas Inventories) is used.
2. **Tier 2:** The operator applies oxidation factors for the respective fuel as reported by the respective Member State in its latest national inventory submitted to the Secretariat of the UNFCCC.
3. **Tier 3:** For fuels activity-specific factors are derived by the operator based on relevant carbon contents of ashes, effluents and other wastes and by-products and other relevant non-fully oxidised gaseous forms of carbon emitted. Composition data shall be determined according to the provisions specified in Section 13 of Annex I.

The minimum tier requirements for emission factor data calculations for emissions from coal fired power plants are:

- Installation A, Tier 1
- Installation B, Tier 1
- Installation C, Tier 1

For details of installation information, see *Calculation Based Methodologies for CO<sub>2</sub> Emissions* in the *General Guidance Section* above.

Other CO<sub>2</sub> calculation methodologies are also provided for:

- Carbon Black Production and Gas Processing Terminals (Mass Balance Approach)
- Process Emissions

## *Measurement-Based Methodologies*

The EU ETS 2007 “Guidelines for determination of greenhouse gas emissions by continuous emission measurement systems” are found in Annex XII. Four tiers are listed for the determination of greenhouse gas emissions:

1. **Tier 1:** For each emission source a total uncertainty of the overall emissions over the reporting period of less than  $\pm 10\%$  shall be achieved.
2. **Tier 2:** For each emission source a total uncertainty of the overall emissions over the reporting period of less than  $\pm 7.5\%$  shall be achieved.
3. **Tier 3:** For each emission source a total uncertainty of the overall emissions over the reporting period of less than  $\pm 5\%$  shall be achieved.
4. **Tier 4:** For each emission source a total uncertainty of the overall emissions over the reporting period of less than  $\pm 2.5\%$  shall be achieved.

Total emissions over the reporting period shall be determined by using the below formula (Section 6 of Annex I for determination of parameters). In case several emission sources exist in one installation and cannot be measured as one, emissions from these emission sources shall be measured separately and summed up to the total emissions of the specific gas over the reporting period in the whole installation.

$$\text{GHG}_{\text{-tot ann}} [\text{t}] = \sum_{i=1}^{\text{operating\_hours\_p.a.}} \text{GHG-concentration}_i * \text{flue gas flow}_i$$

The GHG concentration in the flue gas is determined by continuous measurement at a representative point. The dry flue gas flow can be determined using one of the following methods:

- The flue gas flow  $Q_e$  is calculated by means of a mass-balance approach, taking into account all significant parameters such as input material loads, input air flow, process efficiency, etc. and on the output side the product output, the  $\text{O}_2$  concentration,  $\text{SO}_2$  and  $\text{NO}_x$  concentrations, etc.
- The flue gas flow  $Q_e$  is determined by continuous flow measurement at a representative point.

## *Compliance Monitoring*

Installations’ reports have to be checked by an independent verifier on the basis of criteria set out in the EU ETS legislation, and are made public. Operators whose emission reports for the previous year are not verified as satisfactory will not be allowed to sell allowances until a revised report is approved by a verifier.

## **Status Update on Monitoring Under the EU ETS**

According to a 2006 European Environment Agency (EEA) report titled, “Application of the emissions trading directive by EU Member States,”<sup>355</sup> the approaches and methods used to monitor emissions were only partly known in most Member States by the end of the reporting period (30 April 2005). There are several issues for which



minimum tiers are not (yet) technically feasible in several Member States. These include accreditation of laboratories, according to ISO 17025, as well as the determination of calorific values and oxidation factors.

At the time of reporting there was only limited information available on the application of continuous emissions measurement (CEM). At least 18 installations in four Member States will apply CEM. In eight Member States all installations will use the activity data approach for estimating CO<sub>2</sub> emissions (Table 2.31). In eight Member States no emissions measurement will be used for monitoring under the EU ETS.

**Table 2.31. Application of continuous emissions measurement under the EU ETS<sup>356</sup>**

	E1		E2	M1	Sum
	< 50 kt	> 50 kt	> 500 kt	> 500 kt	
Belgium					0
Czech Republic					0
Denmark				1	Min 1
Estonia	3	5			8
Ireland					0
Latvia					0
Luxembourg					0
Hungary					0
Netherlands					0
Portugal					0
Slovenia					0
Finland			1		1
United Kingdom			8		8
<b>Sum</b>	<b>3</b>	<b>5</b>	<b>9</b>	<b>1</b>	<b>18</b>

### European Pollutant Emission Register/European Pollutant Release and Transfer Register

The European Pollutant Release and Transfer Register (E-PRTR), was signed in May 2003 by 36 economies and the European Community (see text on the E-PRTR in section 2.1.3 for additional information).<sup>357</sup>

Thermal power stations and other combustion installations with a heat input of greater than 50 megawatts (MW) – the same requirements covered by the Large Combustion Plants (LCP) Directive and the Integrated Pollution Prevention and Control (IPPC) Directive - are required to report emissions under the E-PRTR for CO<sub>2</sub>. The reporting thresholds for CO<sub>2</sub> is 100 million kg/year.<sup>358</sup>

### Monitoring

Reporting is carried out based on measurement, calculation or estimation of releases and off-site transfers (see text on monitoring under the E-PRTR in section 2.1.3 for additional information).<sup>359</sup>

The approved standard for CO<sub>2</sub> is the International Standard (ISO) 12039:2001:

- Stationary source emissions;
- Determination of carbon monoxide, carbon dioxide and oxygen;
- Performance characteristics; and

- Calibration of automated measuring systems.

### 2.3.4 United States

#### Acid Rain Program

While there are no federal regulatory requirements in the United States for the reduction of greenhouse gases, under the Acid Rain Program (ARP), each unit must record its emissions of CO<sub>2</sub> in lbs/hour (in addition to continuous monitoring of SO<sub>2</sub>, NO<sub>x</sub>, volumetric flow and opacity).<sup>360</sup> Affected units under the ARP are all units over 25 megawatts and new units under 25 megawatts that use fuel with a sulfur content greater than 0.05 percent by weight.<sup>361</sup> For more detailed information, see text on the Acid Rain Program in section 2.1.4.

#### Monitoring

Although CO<sub>2</sub> emissions must be monitored under the ARP, the rule does not require a utility to use a CEMS to measure CO<sub>2</sub> (unlike for SO<sub>2</sub>, volumetric flow, NO<sub>x</sub>, diluent gas, and opacity). There are three options for monitoring CO<sub>2</sub> emissions under the 40 CFR 75 rule that pertain to the ARP. The two that involve a CEM system are:

- A CO<sub>2</sub> CEM system and a flow monitoring system with an automated data acquisition and handling system for measuring and recording CO<sub>2</sub> concentration (in ppm or percent), volumetric gas flow (in scfh), and CO<sub>2</sub> mass emissions (in tons/hr) discharged to the atmosphere; or
- A flow monitoring system and a CO<sub>2</sub> continuous emission monitoring system that uses an O<sub>2</sub> concentration monitor to determine CO<sub>2</sub> emissions with an automated data acquisition and handling system for measuring and recording O<sub>2</sub> concentration (in percent), CO<sub>2</sub> concentration (in percent), volumetric gas flow (in scfh), and CO<sub>2</sub> mass emissions (in tons/hr) discharged to the atmosphere. Detailed procedures for this option are provided in 40 CFR 75, Appendix F.<sup>362</sup>

In both cases, the CEMS system must continuous operation and must be able to sample, analyze, and record data at least every 15 minutes. All emissions and flow data will be reduced to 1-hour averages.

The third option specified for monitoring CO<sub>2</sub> under the Part 75 rule is:<sup>363</sup>

- Determination of CO<sub>2</sub> emissions based on the measured carbon content of the fuel - The procedures to estimate CO<sub>2</sub> emissions (in ton/day) discharged to the atmosphere are given in 40 CFR Part 75 Appendix G and allows CO<sub>2</sub> emissions to be determined by using:<sup>364</sup>
  - Fuel feed rates and the results of periodic fuel sampling and analysis (to determine the % carbon in the fuel); or
  - Hourly heat input rate measurements from a certified 40 CFR 75, Appendix D fuel flowmeter and a fuel-specific, carbon-based “F-factor”.

The fuel feed rate methodology option is currently not very popular for coal-fired units in the United States (it was not used by any of them as of September 2005).<sup>365</sup>

### **Regional Greenhouse Gas Initiative (RGGI)**

Established in December 2005, the Regional Greenhouse Gas Initiative (RGGI) is the first mandatory US cap and trade program for CO<sub>2</sub> emissions from power plants 25 MW and larger for ten Northeastern and Mid-Atlantic states.<sup>366</sup> The participating states are: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island and Vermont. In addition, the District of Columbia, Massachusetts, Pennsylvania, Rhode Island, the Eastern Canadian Provinces, and New Brunswick are observers in the process. The first RGGI auction will take place 25 September 2008.<sup>367</sup>

In August 2006, after a period of public comment, the participating states released the final model rule for the RGGI program, which establishes a set of regulations. These include which sources are covered, how they must demonstrate compliance and provisions for the allocation of allowances for public benefit purposes. Each participating state must now adopt the rule through legislation or regulation and determine how to allocate its emission allowances. According to the RGGI setup, all proceeds of the auctions must support consumer benefit purposes, such as increased support for end-use energy efficiency programs.

### **Monitoring**

Monitoring under RGGI is almost entirely based on the Part 75 rule under the ARP. One difference is that Equation G-1 in 40 CFR 57, Appendix G cannot be used as a method to determine CO<sub>2</sub> emissions.<sup>368</sup>

## Chapter 3. WATER CONSUMPTION AND THERMAL EFFLUENTS

### 3.1 Introduction

Water monitoring can be conducted for many purposes.<sup>369</sup> The major purposes are to:

- Characterize waters and identify changes or trends in water quality over time;
- Identify specific existing or emerging water quality problems;
- Gather information to design specific pollution prevention or remediation programs;
- Determine whether program goals - such as compliance with pollution regulations or implementation of effective pollution control actions -- are being met; and
- Respond to emergencies, such as spills and floods.

Some types of monitoring activities meet several of these purposes at once; others are specifically designed for one reason.

There are many ways to monitor water conditions, including:

- Sampling the chemical condition of water, sediments, and fish tissue to determine levels of key constituents such as dissolved oxygen, nutrients, metals, oils, and pesticides.
- Monitoring physical conditions such as temperature, flow, sediments, and the erosion potential of stream banks and lake shores.
- Biological measurements of the abundance and variety of aquatic plant and animal life and the ability of test organisms to survive in sample water

Monitoring can be conducted at regular sites ("fixed stations"):

- On a continuous basis;
- At selected sites on an as-needed basis, to answer specific questions or to characterize a watershed;
- On a temporary or seasonal basis;
- At random sites throughout an area or state; or on an emergency basis (such as after a spill).

In this section, we focus on coal-fired power plant monitoring of effluents (chemicals, biological substances and thermal pollution) and consumption in the EU and the US. Regulations in the EU and US are mainly focused on effluents, but also address consumption. Legislation regarding consumption and thermal effluents is dealt with in separate rules in the US, and is more advanced than the cross-cutting rules dealing with these issues in the EU. The consumption rules in the US are explicitly aimed at reducing entrainment and/or impingement of aquatic organisms, while no clear connection is made to these issues in EU.

## **3.2 Cross-Cutting Regulations**

### **3.2.1 European Union**

#### **Integrated Pollution Prevention and Control (IPPC) Directive**

In the Integrated Pollution Prevention and Control (IPPC) Directive of September 1996, the European Union (EU) defines the obligations with which highly polluting industrial and agricultural activities must comply. It applies to combustion installations with a rated thermal input exceeding 50 MW. It establishes a procedure for authorizing these activities and sets minimum requirements to be included in all permits. In general, the permits must account for the environmental performance of the plants as a whole, including, but not limited to air, water and waste emissions. While the Directive focuses mainly on pollutants released, it can be considered to cover thermal pollution and consumption (see sections 3.3.1.1, 3.3.2.1 and 3.4.1 for additional information).<sup>370</sup>

#### **Water Framework Directive**

In the Water Framework Directive of 2000, the European Union (EU) provides for the management of inland surface waters, groundwater, transitional waters and coastal waters in order to prevent and reduce pollution, promote sustainable water use, protect the aquatic environment, improve the status of aquatic ecosystems and mitigate the effects of floods and droughts. While it has many provisions that deal with the ecological and chemical status it also covers issues of water abstraction and/or replenishment (see sections 3.3.1.1 and 3.4.1 for additional information).<sup>371</sup>

### **3.2.2 United States**

#### **The Clean Water Act**

The Clean Water Act (CWA), amended from the Federal Water Pollution Control Act of 1972, establishes the basic structure for regulating discharges of pollutants into the waters of the United States. It gives the EPA the authority to implement pollution control programs such as setting wastewater standards for industry and water quality standards for all contaminants in surface waters (see sections 3.3.1.2, 3.3.2.2 and 3.4.2 for additional information).<sup>372</sup> Under the CWA, there are specific requirements for thermal effluents and cooling water intake structures (covering issues of consumption and impingement/entrainment).

### **3.3 Effluents**

#### **3.3.1 Substances**

##### **3.3.1.1 European Union**

#### **Regulations Specific to Coal-Fired Power Plants**

##### **Integrated Pollution Prevention and Control (IPPC) Directive**

In the Integrated Pollution Prevention and Control (IPPC) Directive of September 1996, the European Union (EU) defines the obligations with which highly polluting industrial and agricultural activities must comply. It establishes a procedure for authorizing these activities and sets minimum requirements to be included in all permits, particularly in terms of pollutants released. The aim is to prevent or reduce pollution of the atmosphere, water and soil, as well as the quantities of waste arising from industrial and agricultural installations to ensure a high level of environmental protection.<sup>373</sup>

The IPPC Directive imposes a requirement for industrial and agricultural activities with a high pollution potential to have a permit which can only be issued if certain environmental conditions are met, so that the companies themselves bear responsibility for preventing and reducing any pollution they may cause. It applies to combustion installations with a rated thermal input exceeding 50 MW.<sup>374</sup> In order to receive a permit certain basic obligations must be complied with. Specifically for water-related pollution these include:

- Using all appropriate pollution-prevention measures, namely the best available techniques (which produce the least waste, use less hazardous substances, enable the recovery and recycling of substances generated, etc.);
- Preventing all large-scale pollution
- Preventing, recycling or disposing of waste in the least polluting way possible

In addition for water-related pollution, the decision to issue a permit must contain a number of specific requirements, in particular including:

- Emission limit values for polluting substances;
- Water protection measures required;
- Waste management measures;
- Minimization of long-distance or transboundary pollution;
- Release monitoring;
- All other appropriate measures.

#### **Monitoring**

All permit applications must be sent to the competent authority of the Member State concerned, for authorization. Applications must include information on the sources of

emissions from the installation, the nature and quantities of foreseeable emissions into each medium, as well as their effects on the environment. The permit shall contain suitable release monitoring requirements, specifying measurement methodology and frequency, evaluation procedures and an obligation to supply the competent authority with data required for checking compliance with the permit.<sup>375</sup>

## **General Regulations Affecting Coal-Fired Power Plants**

### **Water Framework Directive**

In the Water Framework Directive of 2000, the European Union (EU) provides for the management of inland surface waters, groundwater, transitional waters and coastal waters in order to prevent and reduce pollution, promote sustainable water use, protect the aquatic environment, improve the status of aquatic ecosystems and mitigate the effects of floods and droughts.<sup>376</sup>

Under this Directive, Member States had to identify all the river basins lying within their national territory and assign them to individual river basin districts (river basins covering the territory of more than one Member State were assigned to an international river basin district). Four years after it was enacted in 2000, Member States had to:

1. Carry out an analysis of the characteristics of each river basin district
2. Complete a review of the impact of human activity on water and an economic analysis of water use
3. Compile a register of areas requiring special protection.
4. Identify all bodies of water used for the abstraction of water intended for human consumption providing more than 10 cubic metres a day as an average or serving more than fifty persons.

Nine years after the date of entry into force of the Directive in 2000, Member States have to generate a management plan and program of measures for each river basin district.

The measures provided for in the river basin management plan seek to:

- Prevent deterioration, enhance and restore bodies of surface water, achieve good chemical and ecological status of such water and reduce pollution from discharges and emissions of hazardous substances;
- Protect, enhance and restore all bodies of groundwater, prevent the pollution and deterioration of groundwater, and ensure a balance between groundwater abstraction and replenishment; and
- Preserve protected areas.

The abovementioned objectives have to be achieved no later than fifteen years after the date of entry into force of the Directive, but this deadline may be extended, albeit under the conditions laid down by the Directive.

Member States must introduce arrangements to ensure that effective, proportionate and dissuasive penalties are imposed in the event of breaches of the provisions of this Framework Directive.

## **Monitoring**

Member States shall ensure the establishment of programs for the monitoring of water status. For surface waters, such programs shall cover the:<sup>377</sup>

- Volume and level or rate of flow to the extent relevant for ecological and chemical status and ecological potential; and
- Ecological and chemical status and ecological potential.

For groundwaters, the programs shall cover monitoring of the chemical and quantitative status. For protected areas the programs shall be supplemented with Community legislation under which the individual protected areas have been established.

### *Monitoring of ecological status and chemical status for surface waters*

Based on the characterization and impact assessment carried out (in accordance with Article 5<sup>378</sup> and Annex II,<sup>379</sup> respectively of the Directive), Member States shall for each period to which a river basin management plan applies, establish a program for:

- Surveillance monitoring; and
- Operational monitoring.

Member States may also need in some cases to establish investigative monitoring programs, including, but not limited to, instances where the reasons for exceedances is known and to ascertain the magnitude of accidental pollution.

Member States must monitor parameters which are indicative of the status of each relevant quality element. In selecting parameters for biological quality elements, Member States shall identify the appropriate taxonomic level required to achieve adequate confidence and precision in the classification of the quality elements. Estimates of the level of confidence and precision of the results provided by the monitoring programs must be given in the plan.

*Surveillance monitoring:* Shall be carried out of sufficient surface water bodies to provide an assessment of the overall surface water status within each catchment or subcatchments within the river basin district. Member States shall ensure that, where appropriate, monitoring is carried out at points where:

- The rate of water flow is significant within the river basin district as a whole; including points on large rivers where the catchment area is greater than 2,500 km<sup>2</sup>,
- The volume of water present is significant within the river basin district, including large lakes and reservoirs,



- Significant bodies of water cross a Member State boundary,
- Sites are identified under the Information Exchange Decision 77/795/EEC, and
- At such other sites as are required to estimate the pollutant load which is transferred across Member State boundaries, and which is transferred into the marine environment.

Surveillance monitoring shall be carried out for each monitoring site for a period of one year during the period covered by a river basin management plan for:

- Parameters indicative of all biological quality elements,
- Parameters indicative of all hydromorphological quality elements,
- Parameters indicative of all general physico-chemical quality elements,
- Priority list pollutants which are discharged into the river basin or sub-basin, and
- Other pollutants discharged in significant quantities in the river basin or sub-basin.

This monitoring shall be done as noted above unless the previous surveillance monitoring exercise showed that the body concerned reached good status and there is no evidence from the review of impact of human activity in Annex II that the impacts on the body have changed. In these cases, surveillance monitoring shall be carried out once every three river basin management plans.

For the surveillance monitoring period, the frequencies for monitoring parameters indicative of physio-chemical quality elements in Table 3.1 should be applied unless greater intervals would be justified on the basis of technical knowledge and expert judgment. For biological or hydromorphological quality elements monitoring shall be carried out at least once during the surveillance monitoring period.

**Table 3.1. Frequency of Monitoring Parameters for the Surveillance Monitoring Period**

Quality element	Rivers	Lakes	Transitional	Coastal
<b>Biological</b>				
Phytoplankton	6 months	6 months	6 months	6 months
Other aquatic flora	3 years	3 years	3 years	3 years
Macro invertebrates	3 years	3 years	3 years	3 years
Fish	3 years	3 years	3 years	
<b>Hydromorphological</b>				
Continuity	6 years			
Hydrology	continuous	1 month		
Morphology	6 years	6 years	6 years	6 years
<b>Physico-chemical</b>				
Thermal conditions	3 months	3 months	3 months	3 months
Oxygenation	3 months	3 months	3 months	3 months
Salinity	3 months	3 months	3 months	
Nutrient status	3 months	3 months	3 months	3 months
Acidification status	3 months	3 months		
Other pollutants	3 months	3 months	3 months	3 months
Priority substances	1 month	1 month	1 month	1 month

*Operational monitoring:* Shall be undertaken in order to establish the status of those bodies identified as being at risk of failing to meet their environmental objectives, and assess any changes in the status of such bodies resulting from the programs of measures.

Operational monitoring shall be carried out for all those bodies of water which on the basis of either the impact assessment or surveillance monitoring are identified as being at risk of failing to meet their environmental objectives and for those bodies of water into which priority list substances are discharged.

Monitoring points shall be selected for priority list substances as specified in the legislation laying down the relevant environmental quality standard. In all other cases, including for priority list substances where no specific guidance is given in such legislation, monitoring points shall be selected as follows for bodies at risk from significant:

- Point source pressures, *such as coal-fired power plants*, sufficient monitoring points within each body in order to assess the magnitude and impact of the point source. Where a body is subject to a number of point source pressures monitoring points may be selected to assess the magnitude and impact of these pressures as a whole,
- Diffuse source pressures, sufficient monitoring points within a selection of the bodies in order to assess the magnitude and impact of the diffuse source pressures.

- Hydromorphological pressure, sufficient monitoring points within a selection of the bodies in order to assess the magnitude and impact of the hydromorphological pressures.

In order to assess the magnitude of the pressure to which bodies of surface water are subject Member States shall monitor for those quality elements which are indicative of the pressures to which the body or bodies are subject, including, as relevant:

- Parameters indicative of the biological quality element, or elements, most sensitive to the pressures to which the water bodies are subject,
- All priority substances discharged, and other pollutants discharged in significant quantities,
- Parameters indicative of the hydromorphological quality element most sensitive to the pressure identified.

For operational monitoring, the frequency of monitoring required for any parameter shall be determined by Member States so as to provide sufficient data for a reliable assessment of the status of the relevant quality element. As a guideline, monitoring should take place at intervals not exceeding those shown in Table 3.1 unless greater intervals would be justified on the basis of technical knowledge and expert judgment.

#### *Protected Areas*

The monitoring programs required above shall be supplemented in order to fulfill the following requirements:

- Drinking water abstraction points: Bodies of surface water which provide more than 100 m<sup>3</sup> a day<sup>380</sup> as an average shall be designated as monitoring sites and shall be subject to such additional monitoring that may be necessary to meet the requirements of the Directive. Such bodies shall be monitored for all priority substances discharged and all other substances discharged in significant quantities which could affect the status of the body of water and which are controlled under the provisions of the Drinking Water Directive. Monitoring shall be carried out in accordance with the frequencies set out in Table 3.2.

**Table 3.2: Monitoring Frequencies for Drinking Water Abstraction Points**

Community served	Frequency
< 10 000	4 per year
10 000 to 30 000	8 per year
> 30 000	12 per year.

- Habitat and species protection areas: Bodies of water forming these areas shall be included within the operational monitoring program if they are identified as being at risk of failing to meet their environmental objectives.<sup>381</sup> Monitoring shall be carried out to assess the magnitude and impact of all relevant

significant pressures on these bodies and, where necessary, to assess changes in the status of such bodies resulting from the programs of measures. Monitoring shall continue until the areas satisfy the water-related requirements of the legislation.

### *Standards for Monitoring Quality Elements*

Methods used for the monitoring of type parameters shall conform to the international standards listed below or such other national or international standards which will ensure the provision of data of an equivalent scientific quality and comparability.

#### Macroinvertebrate sampling

- ISO 5667-3:1995 Water quality - Sampling Part 3: Guidance on the preservation and handling of samples.
- EN 27828:1994 Water quality - Methods for biological sampling – Guidance on hand net sampling of benthic macroinvertebrates
- EN 28265:1994 Water quality - Methods of biological sampling – Guidance on the design and use of quantitative samplers for benthic macroinvertebrates on stony substrata in shallow waters
- EN ISO 9391:1995 Water quality - Sampling in deep waters for macroinvertebrates – Guidance on the use of colonization, qualitative and quantitative samplers
- EN ISO 8689-1:1999 Biological classification of rivers PART I: Guidance on the interpretation of biological quality data from surveys of benthic macroinvertebrates in running waters
- EN ISO 8689-2:1999 Biological classification of rivers PART II: Guidance on the presentation of biological quality data from surveys of benthic macroinvertebrates in running waters

### **Monitoring of Groundwater Status**

#### *Quantitative Status*

The groundwater monitoring network shall be designed so as to provide a reliable assessment of the quantitative status of all groundwater bodies or groups of bodies including assessment of the available groundwater resource. The network shall include sufficient representative monitoring points to estimate the groundwater level in each groundwater body or group of bodies taking into account short and long-term variations in recharge and in particular:

- For groundwater bodies identified as being at risk of failing to achieve environmental objectives,<sup>382</sup> ensure sufficient density of monitoring points to assess the impact of abstractions and discharges on the groundwater level,
- For groundwater bodies within which groundwater flows across a Member State boundary, ensure sufficient monitoring points are provided to estimate the direction and rate of groundwater flow across the boundary.

The frequency of observations shall be sufficient to allow assessment of the quantitative status of each groundwater body or group of bodies taking into account short and long-term variations in recharge. The frequency of monitoring shall also be appropriately adjusted take into account the same two issues noted above for the groundwater monitoring network, namely bodies identified as being at risk of failing to achieve environmental objectives and bodies where groundwater flows across Member State boundaries.

### *Chemical Status*

The monitoring network shall be designed so as to provide a coherent and comprehensive overview of groundwater chemical status within each river basin and to detect the presence of long-term anthropogenic induced upward trends in pollutants.

*Surveillance Monitoring:* The following set of core parameters shall be monitored in all the selected groundwater bodies:

- Oxygen content
- pH value
- Conductivity
- Nitrate
- Ammonium

Bodies which are identified as being at significant risk of failing to achieve good status<sup>383</sup> shall also be monitored for those parameters which are indicative of the impact of these pressures. Transboundary water bodies shall also be monitored for those parameters which are relevant for the protection of all of the uses supported by the groundwater flow.

*Operational monitoring:* Shall be carried out for all those groundwater bodies or groups of bodies which on the basis of both the impact assessment and surveillance monitoring are identified as being at risk of failing to meet the Directive objectives. The selection of monitoring sites shall also reflect an assessment of how representative monitoring data from that site is of the quality of the relevant groundwater body or bodies.

Operational monitoring shall be carried out for the periods between surveillance monitoring programs at a frequency sufficient to detect the impacts of relevant pressures but at a minimum of once per annum.

## **Discharges of Substances under the Water Framework Directive**

### *Priority Substances in the Field of Water Policy*

In 2001, the European Commission added Annex X to the Water Framework Directive, which contains a list of priority substances that present a significant risk to or via the aquatic environment.<sup>384</sup> The priority substances were identified by using a Combined Monitoring-based and Modeling-based Priority Setting (COMMPS) procedure.

The Decision ranks in order of priority the substances for which quality standards and emission control measures will be set at the Community level. Up to 33 priority substances or groups of substances have been proposed, including anthracene, benzene, cadmium and its compounds, tributyltin and naphthalene.

#### *Proposal for Environmental Quality Standards Applicable to Surface Water*

In 2006, the Commission proposed establishing environmental quality standards in order to limit the quantity of the 33 priority substances identified in Annex X of the Water Framework Directive, in addition to another eight identified since that list was generated.<sup>385</sup> These standards would be coupled with an inventory of discharges, emissions and losses of these substances in order to ascertain whether the goals of reducing or eliminating such pollution have been achieved.

The planned environmental quality standards are limits to the degree of concentration, i.e. the quantity in water of the substances concerned must not exceed certain thresholds. The proposal sets out two types of standard:

- Average quantity of the substance concerned calculated over a one-year period. The purpose of this standard is to ensure the long-term quality of the aquatic environment;
- Maximum allowable concentration of the substance measured specifically. The purpose of this second standard is to limit peaks of pollution.

The proposed quality standards are differentiated for inland surface waters (rivers and lakes) and other surface waters (transitional, coastal and territorial waters). Specific standards are also set for metals and certain other substances.

Member States must ensure compliance with these standards. They must also verify that the concentration of substances concerned does not increase in sediments or in organisms living in surface water. The proposal also provides for Member States to establish transitional areas of exceedance, where the quality standards may be exceeded provided that the rest of the surface water body complies with those standards. These areas must be clearly identified in the river basin management plans established in accordance with the Water Framework Directive.

#### **Monitoring**

For each river basin, Member States must establish an inventory of emissions, discharges and losses of all substances identified in the proposal. On the basis of this inventory, the Commission must verify whether the objectives of gradually reducing pollution from priority substances and of ceasing or phasing out emissions, discharges and losses of priority hazardous substances are reached. The proposed timetable for complying with the cessation target is 2025.

## Surface Waters/Aquatic Environment

### Other Dangerous Substances: Protection of the Aquatic Environment

The European Union lays down harmonized rules to protect the aquatic environment against the discharge of dangerous substances: it stipulates that all discharges of certain substances should be authorized, sets emission ceilings for these substances and compels the Member States to improve the quality of their water.<sup>386</sup> It applies to inland surface water, territorial waters and internal coastal waters. This Directive is repealed by the Framework Directive on Water at the end of 2013.

To combat the pollution of these waters, two lists have been compiled of dangerous substances that need to be controlled:

- Pollution caused by the discharge of certain *list I* substances, including mercury and its compounds, cadmium and its compounds and substances which have been proved to possess carcinogenic properties in or via the aquatic environment, must be eliminated;<sup>387</sup>
- Pollution from a range of *list 2* substances, including metals such as arsenic and selenium and substances which have an adverse effect on oxygen balance, must be reduced;<sup>388</sup>

The Directive sets quality objectives and emission limit values for *list I* substances based on the best available techniques. It is up to the Member States to ensure compliance with the emission standards.

### Monitoring

For the substances on *list II*, the Member States adopt and implement programs to preserve and improve water quality. All discharges are subject to prior authorization by the competent authority in the Member State concerned that lays down the emission standards.

### Water Suitable for Fish-Breeding

The Water Suitable for Fish-Breeding Directive of 2006 concerns the protection and/or improvement of the quality of running or standing fresh waters which support or which, if pollution were reduced or eliminated, would become capable of supporting certain fish species.<sup>389</sup> Member States are required to designate the fresh waters which are to be considered suitable for fish-breeding.

The Directive lays down the minimum quality criteria to be met by such waters:

- Physical, chemical and microbiological parameters;
- Binding limit values and indicative values for these parameters;
- Minimum frequency of sampling and reference methods of analysis for such waters.

Member States are required to set the values which they will apply to such waters in accordance with the guidelines contained in the Directive. They may set more

stringent requirements than those laid down in the Directive. The Directive lays down the procedure for adapting the methods of analysis and the binding limit values to technical and scientific progress.

### **Monitoring**

Annex I of the Directive lays out a list of parameters, the limit values for both salmonid waters<sup>390</sup> and cyprinid waters,<sup>391</sup> the methods of analysis or inspection, the minimum sampling and measuring frequency and other observations.<sup>392</sup> The list of parameters includes: temperature; dissolved oxygen; pH; suspended solids; BOD<sub>5</sub>; total phosphorus; nitrites; phenolic compounds; petroleum hydrocarbons; non-ionized ammonia; total ammonium; total residual chlorine; total zinc; and dissolved copper.

### **Quality of Shellfish Water**

The Quality of Shellfish Water Directive of 2006 concerns the quality of shellfish waters, i.e. the waters suitable for the development of shellfish (bivalve and gasteropod mollusks).<sup>393</sup> It applies to those coastal and brackish waters which need protection or improvement in order to allow shellfish to develop and to contribute to the high quality of shellfish products intended for human consumption. It is the Member States' responsibility to designate these waters.

The Directive establishes parameters applicable to designated shellfish waters as well as indicative values, mandatory values, reference methods of analysis and the minimum frequency for taking samples and measures. These parameters are set for pH, temperature, salinity and the presence or concentration of certain substances (dissolved oxygen, hydrocarbons, metals, organohalogenated substances, etc.).

On the basis of these criteria, Member States establish values with which the waters they have designated must comply. As a minimum, these limit values must respect the mandatory values set by the Directive. For metals or organohalogenated substances, these values must respect the emission rules established in line with Directive of 2006 on the discharge of certain substances into the aquatic environment.

### **Monitoring**

Annex I of the Directive contains a list of parameters with regard to the quality of shellfish waters, including:<sup>394</sup> pH; temperature; coloration (after filtration); suspended solids; salinity; dissolved oxygen; petroleum hydrocarbons; organohalogenated substances; arsenic; cadmium; chromium; copper; lead; mercury; nickel; silver; zinc; fecal coliforms; substances affecting the taste of the shellfish; and saxitoxin (produced by dinoflagellates). For each parameter, guidance and/or mandatory limits are provided, in addition to a reference method for analysis and a minimum sampling and measuring frequency.

Member States must establish programs allowing them to comply with the limit values they have set within six years of designation. The competent authorities for each Member State must take samples from the waters to verify their conformity with the criteria set by the Directive. The following proportions of samples must conform to the established values:



- 100% of the samples for the parameters 'organohalogenated substances' and 'metals';
- 95% of the samples for the parameters 'salinity' and 'dissolved oxygen';
- 75% of the samples for the other parameters.

## **Groundwater**

### **Protection of Groundwater against Pollution**

This Directive is designed to prevent and combat groundwater pollution.<sup>395</sup> It is known as the “daughter Directive” to the Water Framework Directive. Its provisions include:

- Criteria for assessing the chemical status of groundwater;
- Criteria for identifying significant and sustained upward trends in groundwater pollution levels, and for defining starting points for reversing these trends;
- Preventing and limiting indirect discharges (after percolation through soil or subsoil) of pollutants into groundwater.

By 22 December 2008, Member States must set a threshold value for each pollutant identified in any of the bodies of groundwater within their territory considered to be at risk. At a minimum, Member States must establish threshold values for ammonium, arsenic, cadmium, chloride, lead, mercury, sulfate, trichloroethylene and tetrachloroethylene. For each pollutant on the list, information must be provided on the groundwater bodies characterized as being at risk, as well as on how the threshold values were set. These threshold values must be included in the River Basin District Management Plans provided for under the Water Framework Directive.

### **Monitoring**

Information obtained from the monitoring of pollutants under the Water Quality Framework Directive<sup>396</sup> is to be used by Member States to establish threshold values and assess the groundwater chemical status under this Directive.

In addition, in this Directive, Member States must identify any significant and sustained upward trend in levels of pollutants found in bodies of groundwater (for a report to be published by the European Commission on 22 December 2009). In order to do so, they must establish a monitoring program in conformity with Annex IV to the Protection of Groundwater against Pollution Directive. Specifically, the monitoring frequencies and monitoring locations must be sufficient to:<sup>397</sup>

1. Provide the information necessary to ensure that such upward trends can be distinguished from natural variation with an adequate level of confidence and precision;
2. Enable the trends to be identified in sufficient time to allow measures to be implemented in order to prevent, or at least mitigate as far as practicable, environmentally significant detrimental changes in groundwater quality.

3. Take into account the physical and chemical temporal characteristics of the body of groundwater, including groundwater flow conditions and recharge rates and percolation time through soil or subsoil;

Furthermore, Annex IV of the Directive requires that the:

1. Methods of monitoring and analysis used will conform to international quality control principles, including, if relevant, CEN or national standardized methods, to ensure equivalent scientific quality and comparability of the data provided;
2. The assessment will be based on a statistical method, such as regression analysis, for trend analysis in time series of individual monitoring points;
3. All measurements below the quantification limit will be set to half of the value of the highest quantification limit occurring in time series, except for total pesticides;

For substances that occur both naturally and as a result of human activities, baseline levels, where such data are available, and the data collected before the start of the monitoring program will be used to determine trend(s).

### **Other Dangerous Substances: Protection of Groundwater**

The purpose of the 1979 Directive dealing with the Protection of Groundwater is to prevent the discharge of certain toxic, persistent and bioaccumulable substances.<sup>398</sup> This Directive is repealed by the Framework Directive on Water at the end of 2013.

There are two lists of dangerous substances drawn up for the protection of groundwater:

- Direct discharge of substances in List I is prohibited. This list includes organohalogen, organophosphorus and organotin compounds, mercury and cadmium and their compounds, and hydrocarbons and cyanides;
- Discharge of substances in List II must be limited. This list includes certain metals such as copper, zinc, lead and arsenic, and other substances such as fluorides, toxic or persistent organic compounds of silicon, and biocides and their derivatives not appearing in List I.

All indirect discharges of substances in List I and all direct or indirect discharges of substances in List II are subject to prior authorization. Such authorization:

- Requires an investigation into the receiving environment;
- Is granted for a limited period and subject to regular review;
- Lays down the conditions that have to be met for discharges. If they have not been or cannot be met, the authorization is withdrawn or refused.

## **Monitoring**

### *Discharge*

When direct discharge is authorized or when waste water disposal which inevitably causes indirect discharge is authorized, the authorization shall specify in particular the:

- Place of discharge
- Method of discharge
- Essential precautions, with particular attention paid to the nature and concentration of the substances present in the effluents, the characteristics of the receiving environment and the proximity of water catchment areas, in particular those for drinking, thermal and mineral water
- Maximum quantity of a substance permissible in an effluent during one or more specified periods of time and the appropriate requirements as to the concentration of these substances,
- Arrangements enabling effluents discharged into groundwater to be monitored;
- If necessary, measures for monitoring groundwater, and in particular its quality.

### *Compliance*

Monitoring of compliance with these conditions and of the effects of discharges on groundwater is the responsibility of the competent authorities of the Member States.

The competent authorities of the Member States must keep an inventory of authorizations of:

- Discharges of substances in List I;
- Direct discharges of substances in List II;
- Artificial recharges for the purpose of groundwater management.

The Commission must publish a report based on the information gathered and submitted by the Member States every three years.

The Member States concerned must inform one another in the event of discharges into transboundary groundwater. Member States may introduce more stringent measures than those laid down in this Directive. Member States shall supply the Commission, at its request and on a case-by-case basis, with all the necessary information, including the results of the monitoring and inspection operations carried out.

## **Drinking Water**

### **Quality of Drinking Water**

The Directive is intended to protect human health by laying down healthiness and purity requirements which must be met by drinking water within the Community.<sup>399</sup> It

applies to all water intended for human consumption (except for natural mineral waters and waters which are medicinal products).

Member States shall ensure that such drinking water:

- Does not contain any concentration of micro-organisms, parasites or any other substance which constitutes a potential human health risk;
- Meets the minimum requirements (microbiological and chemical parameters and those relating to radioactivity) laid down by the Directive.

They will take any other action needed in order to guarantee the healthiness and purity of water intended for human consumption.

Member States shall lay down the parametric values corresponding at least to the values set out in the Directive. Where parameters are not set out in the Directive limit values must be laid down by the Member States if necessary to protect health.

### **Monitoring**

Member States shall take all measures necessary to ensure that regular monitoring of the quality of water intended for human consumption is carried out, in order to check that the water available to consumers meets the requirements of this Directive and in particular the parametric values set.<sup>400</sup> Member States shall ensure that additional monitoring is carried out on a case-by-case basis of substances and micro-organisms for which no parametric value has been, if there is reason to suspect that they may be present in amounts or numbers which constitute a potential danger to human health. Samples should be taken so that they are representative of the quality of the water consumed throughout the year. For this purpose they shall determine the sampling points and draw up monitoring programs. The types of monitoring to be employed are:

1. **Check monitoring:** The purpose is regularly to provide information on the organoleptic and microbiological quality of the water supplied for human consumption as well as information on the effectiveness of drinking-water treatment (particularly of disinfection) where it is used.
  - The parameters that are subject to check monitoring, as noted in Annex II of the Directive are: aluminium (only when used as a flocculants<sup>401</sup>); ammonium; color; conductivity; *Clostridium perfringens* (including spores; only necessary if the water originates from or is influenced by surface water); *Escherichia coli* (*E. coli*); hydrogen ion concentration; iron (only when used as a flocculants); nitrite (only when chloramination is used as a disinfectant); odour; *Pseudomonas aeruginosa* (only in the case of water offered for sale); taste; colony count 22 °C and 37 °C (only in the case of water offered for sale); Coliform bacteria; turbidity.
2. **Audit monitoring:** The purpose is to provide the information necessary to determine whether or not all of the Directive's parametric values are being complied with. All parameters set must be subject to audit monitoring unless it

can be established by the competent authorities, for a period of time to be determined by them, that a parameter is not likely to be present in a given supply in concentrations which could lead to the risk of a breach of the relevant parametric value.

- The microbiological parameters subject to audit monitoring are: *Escherichia coli* and Enterococci. In addition, for water offered for sale the parameters to be monitored include; *Pseudomonas aeruginosa*; Colony count 22 °C and 37 °C.
- The chemical parameters subject to audit monitoring are: acrylamide; antimony arsenic; benzene; benzo(a)pyrene; boron; bromated; cadmium; chromium; copper; cyanide; 1,2-dichloroethane; epichlorohydrin; fluoride; lead; mercury; nickel; nitrate; nitrite; pesticides; polycyclic aromatic hydrocarbons; selenium; tetrachloroethene and trichloroethene; and trihalomethanes and vinyl chloride.
- Certain substances are subject to audit monitoring only for monitoring purposes in order to fulfill obligations imposed in the Directive.<sup>402</sup> They are: aluminum; ammonium chloride; *Clostridium perfringens* (including spores); color; conductivity 20 °C; hydrogen ion concentration; iron manganese; odor; oxidizability; sulfate sodium; colony count 22°; coliform; total organic carbon (TOC) and turbidity. Two parameters must also be measured to assess radioactivity, tritium and total indicative dose.

A Member State shall set values for additional parameters not included in Annex I where the protection of human health within its national territory or part of it so requires.

Member States must take samples at the points of compliance as defined in the Directive to ensure that water intended for human consumption meets the requirements laid out. However, in the case of a distribution network, a Member State may take samples within the supply zone or at the treatment works for particular parameters if it can be demonstrated that there would be no adverse change to the measured value of the parameters concerned.

The minimum frequency of sampling and analysis for check and audit monitoring is shown in Table 3.3.

**Table 3.3. Minimum Frequency of Sampling and Analysis for Check and Audit Monitoring**<sup>403</sup>

Volume of water distributed or produced each day within a supply zone (Notes 1 and 2) m <sup>3</sup>	Check monitoring number of samples per year (Notes 3, 4 and 5)	Audit monitoring number of samples per year (Notes 3 and 5)
≤ 100	(Note 6)	(Note 6)
> 100 ≤ 1 000	4	1
> 1 000 ≤ 10 000	4 + 3 for each 1 000 m <sup>3</sup> /d and part thereof of the total volume	1 + 1 for each 3 300 m <sup>3</sup> /d and part thereof of the total volume
> 10 000 ≤ 100 000		3 + 1 for each 10 000 m <sup>3</sup> /d and part thereof of the total volume
> 100 000		10 + 1 for each 25 000 m <sup>3</sup> /d and part thereof of the total volume

Note 1: A supply zone is a geographically defined area within which water intended for human consumption comes from one or more sources and within which water quality may be considered as being approximately uniform.

Note 2: The volumes are calculated as averages taken over a calendar year. A Member State may use the number of inhabitants in a supply zone instead of the volume of water to determine the minimum frequency, assuming a water consumption of 200 l/day/capita.

Note 3: In the event of intermittent short-term supply the monitoring frequency of water distributed by tankers is to be decided by the Member State concerned.

Note 4: For the different parameters in Annex I, a Member State may reduce the number of samples specified in the table if:

- (a) the values of the results obtained from samples taken during a period of at least two successive years are constant and significantly better than the limits laid down in Annex I, and
- (b) no factor is likely to cause a deterioration of the quality of the water.

The lowest frequency applied must not be less than 50 % of the number of samples specified in the table except in the particular case of note 6.

Note 5: As far as possible, the number of samples should be distributed equally in time and location.

Note 6: The frequency is to be decided by the Member State concerned.

#### *For Analysis of Parameters*

Each Member State must ensure that any laboratory at which samples are analyzed has a system of analytical quality control that is subject from time to time to checking by a person who is not under the control of the laboratory and who is approved by the competent authority for that purpose.<sup>404</sup> European Committee for Standardization (CEN)/ International Organization for Standardization (ISO) methods listed as guidance for analysis of microbiological parameters.

#### **European Pollutant Release and Transfer Register (E-PRTR)**

The European Pollutant Release and Transfer Register (E-PRTR) Regulation of 2006 establishes an E-PRTR, harmonizes rules for the Member States to regularly report information on pollutants to the Commission (see section 2.1.3 for more information).<sup>405</sup>

The operator of each facility that undertakes one or more of the activities specified in Annex I, which includes thermal power stations and other combustion installations with a heat input of greater than 50 megawatts (MW), shall report to the PRTR the amounts annually of releases to air, water and land for which threshold value has been exceeded for the 91 pollutants specified in Annex II of the Regulation.<sup>406</sup> Out of the 91 pollutants, a total of 71 pollutants are specified as relevant water pollutants.<sup>407</sup>

Appendix 5 of the *Guidance Document for the Implementation of the European PRTR* document lists indicative sector specific sub-list of water pollutants and their corresponding thresholds for reporting, which for thermal power stations and other combustion installations are:

- Total nitrogen – 50,000 kg/year;
- Total phosphorus – 5,000 kg/year;
- Arsenic and compounds (as As) – 5 kg/year;
- Cadmium and compounds (as Cd) – 5 kg/year;
- Chromium and compounds (as Cr) – 50 kg/year;
- Copper and compounds (as Cu) – 50 kg/year;
- Mercury and compounds (as Hg) – 1 kg/year;
- Nickel and compounds (as Ni) – 20 kg/year;
- Lead and compounds (as Pb) – 20 kg/year;
- Zinc and compounds (as Zn) – 100 kg/year;
- Halogenated organic compounds (as AOX) – 1,000 kg/year; and
- PCDD + PCDF (dioxins + furans) (as Teq) – 0.0001 kg/year.

### **Monitoring**

When reporting parameters, the operator shall use the best available information, which may include: monitoring data; emission factors; mass balance equations; indirect monitoring or other calculations; engineering judgments; and other methods. The operator shall indicate whether the information is based on measurement, calculation or estimation.

Appendix 3 of the *Guidance Document for the Implementation of the European PRTR* lists standardized internationally approved measurement methodologies for air and water pollutants.<sup>408</sup> In the case of data indicated as being based on measurement or calculation, the analytical method and / or the method of calculation shall be reported.

#### **3.3.1.2 United States**

While the regulation of electric utility water use and effluents in the United States are primarily a state or local responsibility, some guidance is also developed at the federal level. The following section focuses on federal regulations related to effluents, water intake and thermal pollution that affect coal-fired power plants.

## **Regulations Specific to Coal-Fired Power Plants**

### **The Clean Water Act**

The Clean Water Act (CWA), amended from the Federal Water Pollution Control Act of 1972, establishes the basic structure for regulating discharges of pollutants into the waters of the United States. It gives the US EPA the authority to implement pollution control programs such as setting wastewater standards for industry and water quality standards for all contaminants in surface waters.<sup>409</sup> The CWA makes it illegal for any person to discharge any pollutant from a point source into navigable waters, unless a permit is obtained under its provisions. However, permits may also authorize facilities to process, incinerate, landfill or beneficially use sewage sludge.<sup>410</sup> Regulations targeting coal-fired power plants focus on water intake, thermal pollution and water effluents.

Under the CWA, the US EPA implements two permit programs, Section 404 permits and the National Pollutant Discharge Elimination System (NPDES) permits, whose objectives are to restore and maintain the chemical, physical and biological integrity of the Nation's waters.

### **Monitoring**

#### *Responsibility to Monitor*

Specific monitoring requirements, including those for industry facilities, under CWA permit programs are specified in the permits themselves with general guidelines or requirements sometimes defined in the permitting program.

### **National Pollutant Discharge Elimination System (NPDES)**

As authorized by the Clean Water Act, the National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States (interpreted to include virtually all surface waters in the United States, but generally does not include groundwater).<sup>411</sup> Industrial, municipal and other facilities must obtain permits if their discharges go directly to surface waters. In most cases, the NPDES permit program is administered by authorized states.<sup>412</sup> States may submit State Pollutant Discharge Elimination System (SPDES) plans to the Administrator of the US EPA for approval. SPDES may outline more stringent regulations but must be at least as stringent as the NPDES.

For coal-fired power plants, a number of NPDES permit programs apply, including Technology-Based and Water-Quality Based Permitting, Stormwater Discharges from Industrial Facilities, the Pretreatment Program, Effluent Limitations Guidelines and Standards and Cooling Water Structures (Section 316(b)).<sup>413</sup>



## *Major Components of a NPDES Permit*

All NPDES permits, at a minimum, consist of five general sections:<sup>414</sup>

1. **Cover Page:** Typically contains the name and location of the permittee, a statement authorizing the discharge, and the specific locations for which a discharge is authorized.
2. **Effluent Limits:** The primary mechanism for controlling discharges of pollutants to receiving waters. Permit writers spend a majority of their time deriving appropriate effluent limits based on applicable technology-based and water quality-based standards.
3. **Monitoring and Reporting Requirements:** Used to characterize waste streams and receiving waters, evaluate wastewater treatment efficiency, and determine compliance with permit conditions.
4. **Special Conditions:** Conditions developed to supplement effluent limit guidelines. Examples include: best management practices (BMPs), additional monitoring activities, ambient stream surveys, and toxicity reduction evaluations (TREs).
5. **Standard Conditions:** Pre-established conditions that apply to all NPDES permits and delineate the legal, administrative, and procedural requirements of the permit.

## **Monitoring**

### *Permit Specifications*

The CWA and NPDES regulations require permitted facilities to monitor the quality of their discharge and report data to the permitting authority.<sup>415</sup> Each State will have unique policies and procedures to establish appropriate frequencies, procedures, and locations for monitoring; however, there are certain tenets that may not be waived by these procedures. They are:

- Any permit that does not require at least *annual* monitoring for all pollutants limited in the NPDES permit (unless the permittee has applied for and been granted a specific monitoring waiver by the permitting authority, and this specific waiver is included as a condition of the permit).
- Any permit that does not require monitoring to be performed at the location where limits are calculated and applied (i.e., the monitoring location cannot be at a location that includes flows that were not accounted for in limits development; e.g., cooling water, storm water).
- Any permit that does not require that the results of all monitoring of permitted discharges conducted using approved methods, be submitted to the permitting authority.

### *Compliance Monitoring*

The *NPDES Compliance Inspection Manual*<sup>416</sup> provides for two types of monitoring:

- Self-monitoring, where the facility must monitor itself
- Monitoring by the US EPA or the State, a process whereby the agency evaluates the self-monitoring and/or conducts its own monitoring.

The US EPA conducts inspections of facilities subject to the regulations to determine compliance. The US EPA inspections involve.<sup>417</sup>

- Reviewing discharge monitoring reports
  - Major and selected minor permittees under the National Pollutant Discharge Elimination System (NPDES) program participate in the Discharge Monitoring Report–Quality Assurance (DMR-QA) study program.<sup>418</sup> DMR-QA evaluates the analytical and reporting ability of the laboratories that routinely performing inorganic chemistry and whole-effluent toxicity self-monitoring analyses required by NPDES permits.
- Interviewing facility personnel knowledgeable of the facility
- Inspecting the processes that generate and treat wastewater
- Sampling wastewater discharges to navigable waterways and other points in the generation or treatment process
- Reviewing how samples are collected and analyzed by the laboratory

### **Effluent Limitation Guidelines and Standards**

Effluent limitations serve as the primary mechanism in NPDES permits for controlling discharges of pollutants to receiving waters.<sup>419</sup> When developing effluent limitations for an NPDES permit, a permit writer must consider limits based on both the technology available to control the pollutants (i.e., technology-based effluent limits) and limits that are protective of the water quality standards of the receiving water (i.e., water quality-based effluent limits). Permits may also include pollution monitoring requirements. While the technology-based standards take into account economic impact of the implementation, water quality-based standards typically do not.

The guidelines and standards cover three types of effluents:

- **Conventional Pollutants:** Pollutants typical of municipal sewage, and for which municipal secondary treatment plants are typically designed; defined by Federal Regulation as biochemical oxygen demand (BOD), total suspended solids (TSS), fecal coliform bacteria, oil and grease, and pH.<sup>420</sup>
- **Priority Pollutants:** Toxic pollutants considered to be of principal importance for control under the CWA.<sup>421</sup> A list of these pollutants is provided as Appendix A to 40 CFR Part 423.<sup>422</sup> Arsenic, benzene, cyanide, mercury, naphthalene and selenium are included in this list.
- **Non-Conventional Pollutants:** All pollutants that are not included in the list of conventional or toxic pollutants in 40 CFR Part 401. Includes pollutants such as chemical oxygen demand (COD), total organic carbon (TOC), nitrogen, and phosphorus.

#### *Technology-Based Standards*

The Clean Water Act requires the US EPA to specifically develop effluent guidelines that represent the following:

- **Best conventional pollutant control technology (BCT):** Technology-based standard for the discharge from existing industrial point sources of conventional pollutants including BOD, TSS, fecal coliform, pH, oil and grease.<sup>423</sup>
- **Best practicable control technology currently available (BPT):** Generally based on the average of the best existing performance by plants within an industrial category or subcategory.<sup>424</sup> Used for conventional, toxic and nonconventional pollutants and applicable to existing dischargers.
- **Best available technology economically achievable (BAT):** In general, represent the best existing performance of treatment technologies that are economically achievable within an industrial point source category or subcategory.<sup>425</sup> Used for toxic and non-conventional pollutants and applicable to existing dischargers.
- **New Source Performance Standards (NSPS)** for conventional pollutants and applicable to new sources.

*Technology-Based Standards: Steam Electric Power Generating Point Sources*

The Code of Federal Regulations, Title 40, Part 423: *Steam Electric Power Generating Point Source Category* deals with discharges resulting from the operation of a generating unit by an established primarily engaged in the generation of electricity for the distribution and sale which results primarily from a process utilizing fossil-type fuel (coal, oil or gas).<sup>426</sup> The national standards are listed in Table 3.4.

Each discharge requires a separate NPDES permit with limitations based on industry specific control technologies, such as BPT, BCT, BAT or NSPS. Facilities that discharge to publicly owned treatment works (POTWs) must comply with Pretreatment Standards for Existing Sources (PSES) or Pretreatment Standards for New Sources (PSNS).

**Table 3.4. Effluent Standards for Steam Electric Power Generating Point Sources**

Source	Parameter	Effluent Limitations	
<b>Limitations based on best practicable control technology available (BPT)</b>			
All discharges, except once through cooling water	pH	6.0 – 9.0	N/A
Any unit	Free available/total residual chlorine	Maximum discharge of 2 hours any 1 day	Unless otherwise permitted, only 1 unit in 1 plant may discharge at any one time
		<b>Max for any 1 day (mg/l)</b>	<b>Average of daily values for 30 consecutive days not to exceed (mg/l)</b>
Low volume wastes	TSS	100	30
	Oil and grease	20	15
Fly/bottom ash	TSS	100	30

Source	Parameter	Effluent Limitations	
transport water	Oil and grease	20	15
Metal cleaning wastes	TSS	100	30
	Oil and grease	20	15
	Copper, total	1	1
	Iron, total	1	1
		<b>Max concentration (mg/l)</b>	<b>Average concentration (mg/l)</b>
Once through cooling water/cooling tower blowdown	Free available chlorine	0.5	0.2
		<b>Max concentration for any time (mg/l)</b>	
Coal pile runoff <sup>a</sup>	TSS	50	N/A
<b>Limitations based on best practicable control technology economically achievable (BAT)</b>			
		<b>Max concentration (mg/l)</b>	
Plants $\geq$ 25MW once through cooling water from each discharge point	Total residual chlorine	0.20	N/A
Any unit in plant $\geq$ 25MW	Total residual chlorine	Maximum discharge of 2 hours any 1 day	Simultaneous multi-unit chlorination is permitted
Plants < 25MW, once through cooling water from each discharge point	Total residual chlorine	0.20	N/A
Any unit in plant < 25MW	Free available/total residual chlorine	Maximum discharge of 2 hours any 1 day	Unless otherwise permitted, only 1 unit in 1 plant may discharge at any one time
		<b>Max concentration (mg/l)</b>	<b>Average concentration (mg/l)</b>
Cooling tower blowdown	Free available chlorine	0.5	0.2
		<b>Max for any 1 day (mg/l)</b>	<b>Average of daily values for 30 consecutive days not to exceed =(mg/l)</b>
	126 priority pollutants contained in chemicals added for cooling tower maintenance, except: <sup>b</sup>	No detectable amount	No detectable amount
	Chromium, total	0.2	0.2
	Zinc, total	1.0	1.0
Any cooling tower blowdown unit	Free available/total residual chlorine	Maximum discharge of 2 hours any 1 day	Unless otherwise permitted, only 1 unit in 1 plant may discharge at any one time
		<b>Max for any 1 day (mg/l)</b>	<b>Average of daily values for 30 consecutive days not to exceed – (mg/l)</b>
Chemical metal cleaning wastes	Copper, total	1.0	1.0
	Iron, total	1.0	1.0
<b>New Source Performance Standards (NSPS)</b>			
All discharges, except once through cooling	pH	6.0 – 9.0	N/A

Source	Parameter	Effluent Limitations	
water			
		<b>Max for any 1 day (mg/l)</b>	<b>Average of daily values for 30 consecutive days not to exceed (mg/l)</b>
Low volume wastes	TSS	100	30
	Oil and grease	20	15
Metal cleaning wastes	TSS	100	30
	Oil and grease	20	15
	Copper, total	1	1
	Iron, total	1	1
Bottom ash transport water	TSS	100	30
	Oil and grease	20	15
		<b>Max concentration (mg/l)</b>	
Plants $\geq$ 25MW once through cooling water from each discharge point	Total residual chlorine	0.20	N/A
Any unit in plants $\geq$ 25MW	Free available/total residual chlorine	Maximum discharge of 2 hours any 1 day	Simultaneous multi-unit chlorination is permitted
		<b>Max concentration (mg/l)</b>	<b>Average concentration (mg/l)</b>
Plants < 25MW once through cooling water from each discharge point	Free available chlorine	0.5	0.2
Any unit in plants < 25MW	Free available/total residual chlorine	Maximum discharge of 2 hours any 1 day	Unless otherwise permitted, only 1 unit in 1 plant may discharge at any one time
		<b>Max concentration (mg/l)</b>	<b>Average concentration (mg/l)</b>
Cooling tower blowdown	Free available chlorine	0.5	0.2
		<b>Max for any 1 day (mg/l)</b>	<b>Average of daily values for 30 consecutive days not to exceed =(mg/l)</b>
	126 priority pollutants contained in chemicals added for cooling tower maintenance, except: <sup>b</sup>	No detectable amount	No detectable amount
	Chromium, total	0.2	0.2
	Zinc, total	1.0	1.0
Any cooling tower blowdown unit	Free available/total residual chlorine	Maximum discharge of 2 hours any 1 day	Unless otherwise permitted, only 1 unit in 1 plant may discharge at any one time
		<b>NSPS limitation for any time</b>	
Coal pile runoff <sup>a</sup>	TSS	Not to exceed 50 mg/l	N/A
<b>Pretreatment Standards for Existing Sources (PSES)</b>			
		<b>Maximum for 1 day (mg/l)</b>	
Chemical metal	Copper, total	1.0	N/A

Source	Parameter	Effluent Limitations	
cleaning wastes			
		<b>Max for any 1 day (mg/l)</b>	
Cooling tower blowdown	126 priority pollutants contained in chemicals added for cooling tower maintenance, except: <sup>b</sup>	No detectable amount	N/A
	Chromium, total	0.2	N/A
	Zinc, total	1.0	N/A
<b>Pretreatment Standards for New Sources (PSNS)</b>			
		<b>Maximum for 1 day (mg/l)</b>	
Chemical metal cleaning wastes	Copper, total	1.0	N/A
		<b>Max for any 1 day (mg/l)</b>	
Cooling tower blowdown	126 priority pollutants contained in chemicals added for cooling tower maintenance, except: <sup>b</sup>	No detectable amount	N/A
	Chromium, total	0.2	N/A
	Zinc, total	1.0	N/A

<sup>a</sup> Runoff associated with a 10 year, 24 hour rainfall event is excluded

<sup>b</sup> The list of 126 priority pollutants can be obtained in “Appendix A to Part 423—126 Priority Pollutants,” Code of Federal Regulations, Title 40: Protection of Environment, Part 423—Steam Electric Power Generating Point Source Category.

Source: Code of Federal Regulations, Title 40: Protection of Environment, Part 423—Steam Electric Power Generating Point Source Category. <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&rgn=div5&view=text&node=40:28.0.1.1.23&idno=40>

### Water-Quality Based Limits

Permit writers must consider the potential impact of every proposed surface water discharge on the quality of the receiving water. A permit writer may find that technology-based effluent limits are not sufficient to ensure that water quality standards, designed to protect the water quality, will be attained in the receiving water. In such cases, the CWA (section 303(b)(1)(c)) and NPDES regulations (40 CFR 122.44(d)) require that the permit writer develop more stringent, water quality-based effluent limits designed to ensure that water quality standards are attained.

Although water effluent standards vary significantly by application, industry and location, the EPA Water Quality Standards in Table 3.5 are the most commonly used.

**Table 3.5. Commonly Used US EPA Water Quality Standards**

Pollutant	Discharge Standard (mg/l, Average Monthly Limit)
Biochemical Oxygen Demand (BOD)	15
Chemical Oxygen Demand (COD)	50 to 200
Total Suspended Solids (TSS)	10
Ammonia	10
Cyanide	1.0
Phenols (4AAP)	0.025
Sulfide	0.1
Nitrate	100
Fluoride	100
Arsenic	5.0
Barium	100
Boron	50
Cadmium	1.0
Chromium	5.0
Lead	5.0
Mercury	0.2
Selenium	1.0
Silver	5.0
Zinc	20

*Whole Effluent Toxicity*

Whole Effluent Toxicity (WET) is a term used to describe the aggregate toxic effect of an aqueous sample (e.g., whole effluent wastewater discharge) as measured by an organism's response upon exposure to the sample (e.g., lethality, impaired growth or reproduction).<sup>427</sup> WET tests replicate, to the greatest extent possible, the total effect and actual environmental exposure of aquatic life to toxic pollutants in an effluent without requiring the identification of the specific pollutants. WET testing is a vital component of the water quality standards implementation through the NPDES permitting process.

**Monitoring**

WET monitoring requirements are included in NPDES permits to generate data for use in assessing whether a WET limit has been exceeded (i.e. compliance monitoring) or to assess if a WET limit is needed.<sup>428</sup> The WET methods are specified in 40 CFR 136.3, Table IA.<sup>429</sup>

*Compliance Monitoring*

Major and selected minor permittees under the NPDES program participate in the Discharge Monitoring Report–Quality Assurance (DMR-QA) study program.<sup>430</sup> DMR-QA evaluates the analytical and reporting ability of the laboratories that routinely perform inorganic chemistry and whole-effluent toxicity self-monitoring analyses required by NPDES permits.

## Stormwater Discharge

Stormwater pollution is a significant source of water quality problems for US waters.<sup>431</sup> In order to minimize the impact of stormwater discharges from industrial facilities, the NPDES program includes an industrial stormwater permitting component, which includes water discharge requirements for steam electric power generating facilities, including coal handling sites.<sup>432</sup> Compliance with stormwater requirements can be included within an individual NPDES permit or a Multi-Sector Permit (MSGP) in areas where the US EPA is the NPDES permitting authority.<sup>433</sup>

## Monitoring

Requirements under individual NPDES permits require the facility to fulfill control and monitoring requirements subject to the judgment of the permit writer. Coverage under a general stormwater permit requires the implementation of a stormwater pollution prevention plan, “reasonable and appropriate” control measures, and 1 or 2 years of monitoring and reporting. General permit requirements include recommended best practices for stormwater at steam electric facilities, landfills, treatment works, and construction areas greater than five acres. Requirements are additive across industrial sectors, requiring a facility with operations that fall under more than one category (i.e. a utility with onsite ash landfill) to comply with all requirements for each appropriate industry sector.<sup>434</sup>

### *Compliance Monitoring*

The US EPA conducts inspections of facility operations subject to the storm water regulations. These inspections involve:<sup>435</sup>

- Reviewing the storm water permit, the Storm Water Pollution Prevention Plan (SWPP), and storm water records and reports
- Interviewing personnel knowledgeable of the SWPP and facility operations
- Reviewing and observing best management practices and control measures in place; and
- Sampling storm water discharges (if appropriate).

Details on storm water inspections can be found in Chapter 11 of the *NPDES Compliance Inspection Manual*.<sup>436</sup>

## Section 404 Permits

Section 404 of the CWA established a program to regulated the discharge of dredged (or fill) materials into US waters, including wetlands.<sup>437</sup> Section 404 permits prohibit the discharge of dredged or fill materials if there is a practicable alternative that is less damaging to the aquatic environment or if the discharge would results in significant degradation of US waters.



## **Monitoring**

### **Compliance Monitoring**

EPA conducts inspections of sites to:<sup>438</sup>

- Determine whether dredged or fill material is being illegally dumped into wetlands in violation of the regulations and statute;
- Verify whether and if facilities/sites have a wetlands permit and are complying with it; and
- Monitor steps taken to minimize or avoid wetland impacts where practicable.

These inspections involve inspecting the physical site and interviewing personnel knowledgeable of the site.

### **General Regulations Affecting Coal-Fired Power Plants**

#### **The Clean Water Act**

The Clean Water Act (CWA), amended from the Federal Water Pollution Control Act of 1972, establishes the basic structure for regulating discharges of pollutants into the waters of the United States. It gives the US EPA the authority to implement pollution control programs such as setting wastewater standards for industry and water quality standards for all contaminants in surface waters(see text above on the CWA in this section for additional information).<sup>439</sup>

The CWA established a process for States to use or develop information on the quality of the Nation's water resources, known as the National Water Quality Inventory (actual process requirements can be found in CWA Sections 106(e), 204(a), 303(d), 305(b) and 314(a)).<sup>440</sup>

## **Monitoring**

### *Responsibility to Monitor*

The responsibility to monitor general water quality rests with many different agencies.<sup>441</sup>

- State pollution control agencies and Indian tribes have key monitoring responsibilities, which can be funded, to some degree, by pollution control and environmental management grants from the US EPA.
- Interstate commissions may also receive grants and maintain monitoring programs.
- Many local governments, such as city and county environmental offices, also conduct water quality monitoring within their boundaries.
- The US EPA helps administer grants for water quality monitoring and provides technical guidance on how to monitor and how to report monitoring results. It also conducts some limited monitoring of its own. For example, US EPA Regional Offices conduct compliance and inspection monitoring of wastewater discharged by industries and municipal treatment facilities.

- The US Geological Survey (USGS) conducts extensive chemical monitoring through its National Stream Quality Accounting Network (NASQAN) at fixed locations on large rivers around the country.
- National and state-level statistical surveys - designed using modern survey techniques in which random sites are sampled to reflect all waters that have similar ecological characteristics -- are providing a new, scientifically-valid baseline of information to help us evaluate the success of our national efforts to protect and restore water quality.

### **National Water Quality Inventory**

Each State must develop a program to monitor the quality of its surface and ground waters and prepare a report every two years describing the status of its water quality.<sup>442</sup> The US EPA then compiles the original State reports and transmits the summaries to Congress with an analysis of status of the water quality nationwide (called the National Water Quality Inventory). This Water Quality Inventory (305(b))<sup>443</sup> process is the principal means by which the EPA, Congress and the public evaluate whether US waters meet water quality standards, the progress made in maintaining water quality and the extent of remaining problems.

An updated 305(b) process established a long-term goal to include comprehensive assessments of the State's waters using a combination of monitoring designs and evaluative techniques. These techniques may include a combination of traditional targeted monitoring and probability-based designs. Beginning in 1998, States were asked to report on their progress toward achieving this goal.

### **Monitoring**

The CWA (Section 106(e)(1)) requires the US EPA to determine that a State is monitoring the quality of navigable waters, compiling, and analyzing data on water quality and including it in the State's Section 305(b) report prior to the award of monitoring grant funds.<sup>444</sup> States have taken very different approaches to implement their monitoring programs, applying a range of monitoring and assessment approaches (e.g., water chemistry, sediment chemistry, biological monitoring) to varying degrees, both spatially and temporally, and at varying levels of sampling effort.

The US EPA is working toward having a common foundation for water monitoring programs within the next ten years. In order to meet this goal, for CWA Section 106(e) grants for the Fiscal Year (FY) 2004, the US EPA suggests that a State should, in addition to continuing to submit reports under Section 305(b) and annual data updates, have a monitoring strategy in place or commit to complete development of such a strategy. The monitoring program strategy is a long-term implementation plan and should include a timeline, not to exceed ten years (i.e. no later than the end of FY 2014), for completing implementation of the strategy.

A number of questions remain from various sources about the US EPA's ability to make credible assessments about differences in water quality over a period of time and across the nation, in general. Some recommendations have included that the US EPA develop a uniform, consistent approach to ambient monitoring and data

collection; coordinate monitoring with program needs; and endorse statistical approaches and explicitly acknowledge uncertainty; and combine monitoring and modeling.

In March 2003, the US EPA issued national guidance to promote and structure consistency in State monitoring programs and to ensure that the Section 305(b) process provides nationally comparable data with known accuracy. The US EPA recommends the following elements of a state monitoring program:

1. **Monitoring Program Strategy:** A long-term implementation plan that should include a timeline (no later than the end of FY 2014) for completing the strategy. It should reference how the other elements of the monitoring program will be achieved.
2. **Monitoring Objectives:** Such as, establishing, reviewing and revising water quality standards; determining water quality standards attainment; identifying impaired waters; identifying causes and sources of water quality impairments; supporting the implementation of water management programs; supporting the evaluation of program effectiveness
3. **Monitoring Design:** Will likely integrate several monitoring designs (e.g., fixed station, intensive and screening-level monitoring, rotating basin, judgmental and probability design) to meet the full range of decision needs. It should include probability-based networks (at the watershed or state-level) that support statistically valid inferences about the condition of all State water types, over time.
4. **Core and Supplemental Water Quality Indicators:** Tiered approach to monitoring that includes core indicators selected to represent each applicable designated use, plus supplemental indicators selected according to site-specific or project-specific decision criteria.
  - Core indicators for each water resource type include physical/habitat, chemical/toxicological, and biological/ecological endpoints as appropriate, and can be used routinely to assess attainment with applicable water quality standards throughout the State.
  - Supplemental indicators are used when there is a reasonable expectation that a specific pollutant may be present in a watershed, when core indicators indicate impairment, or to support a special study such as screening for potential pollutants of concern.
5. **Quality Assurance:** Plans are established, maintained, and peer reviewed in accordance with US EPA policy to ensure the scientific validity of monitoring and laboratory activities, and to ensure that State reporting requirements are met.
6. **Data Management:** State uses an accessible electronic data system for water quality, fish tissue, toxicity, sediment chemistry, habitat, biological data, with timely data entry (following appropriate metadata and State/Federal geolocational standards) and public access.
7. **Data Analysis/Assessment:** The State has a methodology for assessing attainment of water quality standards based on analysis of various types of

data (chemical, physical, biological, land use) from various sources, for all waterbody types and all State waters.

8. Reporting: The State produces timely and complete water quality reports and lists as required under the CWA.
9. Programmatic Evaluation: The State, in consultation with its EPA Region, conducts periodic reviews of each aspect of its monitoring program to determine how well the program serves its water quality decision needs for all State waters, including all waterbody types.
10. General Support and Infrastructure Planning: The State identifies current and future resource needs it requires to fully implement its monitoring program strategy.

## **Total Maximum Daily Load**

### *Surface Waters/Aquatic Environment*

Under section 303(d) of the 1972 Clean Water Act, states, territories, and authorized tribes are required to develop lists of impaired waters.<sup>445</sup> These impaired waters do not meet water quality standards that states, territories, and authorized tribes have set for them, even after point sources of pollution have installed the minimum required levels of pollution control technology. The law requires that these jurisdictions establish priority rankings for waters on the lists and develop Total Maximum Daily Loads (TMDLs), i.e. the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, for these waters.

By law, the US EPA must approve or disapprove lists and TMDLs established by states, territories, and authorized tribes. If a state, territory, or authorized tribe submission is inadequate, EPA must establish the list or the TMDL. EPA issued regulations in 1985 and 1992 that implement section 303(d) of the Clean Water Act - the TMDL provisions.

While TMDLs have been required by the Clean Water Act since 1972, until recently states, territories, authorized tribes, and EPA have not developed many. Several years ago citizen organizations began bringing legal actions against EPA seeking the listing of waters and development of TMDLs. To date, there have been about 40 legal actions in 38 states. EPA is under court order or consent decrees in many states to ensure that TMDLs are established, either by the state or by EPA.

As a result of court orders requiring prompt development of TMDL standards, EPA proposed regulatory changes in 1999 and issued a final rule in July 2000 (65 FR 43586). However, in March 2003, this rule was withdrawn because it was found to be “unworkable.”<sup>446</sup> As a result, the 1992 TMDL regulations remain in effect.

## **Monitoring**

US EPA, states and tribes conduct intensive monitoring, assessment and watershed planning activities to develop TMDLs.<sup>447</sup> In addition, the CWA requires states and territories to issue water quality status reports every two years, which, among other things, target waters for TMDL development.

## *Compliance Guidance*

The US EPA issued guidance in August, 1997, to respond to some of the issues raised as the TMDL program developed, which include states, territories, and authorized tribes developing schedules for establishing TMDLs expeditiously, generally within 8-13 years of being listed. Factors to be considered in developing the schedule could include:

- Number of impaired segments;
- Length of river miles, lakes, or other waterbodies for which TMDLs are needed;
- Proximity of listed waters to each other within a watershed;
- Number and relative complexity of the TMDLs;
- Number and similarities or differences among the source categories;
- Availability of monitoring data or models; and
- Relative significance of the environmental harm or threat.

## **Safe Drinking Water Act**

### *Drinking Water*

The Safe Drinking Water Act (SDWA) requires that the US EPA establish health-based regulations to protect humans from contaminants in national drinking water.<sup>448</sup> The act requires the US EPA to set national drinking water standards and create a joint Federal-State system to ensure compliance. US EPA is also required to protect underground drinking water sources by regulating and controlling the underground injection of liquid waste, which is done through the Underground Injection Control (UIC) Program. The provisions of the SDWA apply directly to public water systems in each state. The 1996 SDWA amendments greatly enhanced the existing law by recognizing source water protection, operator training, funding for water system improvements, and public information as important components of safe drinking water.

The most direct oversight of water systems is conducted by state drinking water programs. States can apply to US EPA for "primacy," the authority to implement SDWA within their jurisdictions, if they can show that they will adopt standards at least as stringent as US EPA's and make sure water systems meet these standards.

The US EPA has set primary and secondary drinking water standards. Primary drinking water standards are contaminant specific and consist of maximum contaminant level goals (MCLGs), which are non-enforceable health based goals, and maximum contaminant levels (MCLs), which are enforceable limits set as close to MCLGs as economically and feasibly possible. These are presented in Table 3.6.

**Table 3.6. Selected National Primary Drinking Water Standards**

CONTAMINANT	MCLG (mg/l)	MCL (mg/l)
<b>Inorganic Chemicals</b>		
Antimony	0.006	0.006
Arsenic	None	0.01
Barium	2	2
Beryllium	0.004	0.004
Cadmium	0.005	0.005
Chromium (total)	0.1	0.1
Cyanide	0.2	0.2
Fluoride	4.0	4.0
Lead <sup>a</sup> (treatment requirement)	Zero	0.015 (action level)
Mercury	0.002	0.002
Selenium	0.05	0.05
<b>Organic Chemicals</b>		
Benzene	Zero	0.005

<sup>a</sup> Lead is regulated by a treatment technique that requires systems to control the corrosiveness of the water. If more than 10% of tap water samples exceed the action level, water systems must take additional steps.

National Secondary Drinking Water Regulations (NSDWRs or secondary standards) are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards to water systems but does not require systems to comply. However, states may choose to adopt them as enforceable standards.<sup>449</sup>

Drinking water standards are related to electric power generation because it results in waste streams that contain detectable levels of elements or compounds that have established drinking water standards. Regulations under the Resource Conservation and Recovery Act (RCRA) for ground water contamination resulting from the disposal of solid wastes are tied to the contaminant levels established under the SDWA. Furthermore, deposition of emissions from the atmosphere may result in increased ambient contaminant levels in surface waters. Together, these conditions may hinder the ability of a public water system to meet the Federal or State standards and may result in additional effluent regulations at point sources.

Even properly operated cooling towers have the potential to breed microorganisms, therefore routinely requiring the addition of disinfectants. Measures to address water quality issues resulting from recycled cooling water include MCLs for common chlorinated water treatment chemicals, along with treatment requirements for *Legionella* and heterotrophic plate count (HPC), a quantitative measure of the amount of bacteria present in the water.

#### *Compliance and enforcement*

National drinking water standards are legally enforceable, which means that both US EPA and states can take enforcement actions against water systems not meeting safety

standards. US EPA and states may issue administrative orders, take legal actions, or fine utilities. US EPA and states also work to increase water systems, understanding of, and compliance with, standards.<sup>450</sup>

## Monitoring

The monitoring and analytical requirements for the SDWA are listed in 40 CFR 141, Subpart C.<sup>451</sup> Detailed monitoring requirements under Subpart C for: coliform can be found in 40 CFR 141.21<sup>452</sup>; for turbidity in 40 CFR 141.22;<sup>453</sup> Inorganic Contaminants (IOCs) in 40 CFR 141.23;<sup>454</sup> for Volatile Organic Contaminants (VOCs) and Synthetic Organic Contaminants (SOCs) in 40 CFR 141.24;<sup>455</sup> and Radionuclides in 40 CFR 141.26.<sup>456</sup>

*Inorganic Contaminants, Volatile Organic Contaminants (VOCs), Synthetic Organic Contaminants (SOCs) and Radionuclides*

A standardized monitoring framework (SMF) for IOCs, SOCs, VOCs and radionuclides, was developed in the Phase II Rule on January 30, 1991.<sup>457</sup> The SMF reduces the variability within monitoring requirements for chemical and radiological contaminants across system sizes and types.

IOCs include: antimony, arsenic, asbestos, barium, beryllium, cadmium, chromium, cyanide, mercury, nickel, nitrate, nitrite, selenium and thallium. Monitoring for IOCs shall be conducted as follows.<sup>458</sup>

1. Groundwater systems shall take a minimum of one sample at every entry point to the distribution system which is representative of each well after treatment (sampling point) beginning in the initial compliance period. The system shall take each sample at the same sampling point unless conditions make another sampling point more representative of each source or treatment plant.
2. Surface water systems shall take a minimum of one sample at every entry point to the distribution system after any application of treatment or in the distribution system at a point which is representative of each source after treatment (sampling point) beginning in the initial compliance period. The system shall take each sample at the same sampling point unless conditions make another sampling point more representative of each source or treatment plant.
3. If a system draws water from more than one source and the sources are combined before distribution, the system must sample at an entry point to the distribution system during periods of normal operating conditions ( *i.e.* , when water is representative of all sources being used).
4. The State may reduce the total number of samples which must be analyzed by allowing the use of compositing. Composite samples from a maximum of five samples are allowed, provided that the detection limit of the method used for analysis is less than one-fifth of the maximum contaminant level (MCL). Compositing of samples must be done in the laboratory.
  - If the concentration in the composite sample is greater than or equal to one-fifth of the MCL of any inorganic chemical, then a follow-up sample must be taken within 14 days at each sampling point included in the

composite. These samples must be analyzed for the contaminants which exceeded one-fifth of the MCL in the composite sample.

- If the population served by the system is >3,300 persons, then compositing may only be permitted by the State at sampling points within a single system. In systems serving ≤3,300 persons, the State may permit compositing among different systems provided the 5-sample limit is maintained.
- If duplicates of the original sample taken from each sampling point used in the composite sample are available, the system may use these instead of resampling. The duplicates must be analyzed and the results reported to the State within 14 days after completing analysis of the composite sample, provided the holding time of the sample is not exceeded.

5. The frequency of monitoring can be found in the SMF, Table 3.7.

Table 3.7 also summarizes the federal monitoring requirements, including frequencies, for SOCs, VOCs and radionuclides.

**Table 3.7. Standardized Monitoring Framework for IOCs, SOCs and VOCs**<sup>459</sup>

IOCs, SOCs, VOCs		Second Cycle									Third Cycle									
		1 <sup>st</sup> Period			2 <sup>nd</sup> Period			3 <sup>rd</sup> Period			1 <sup>st</sup> Period			2 <sup>nd</sup> Period			3 <sup>rd</sup> Period			
		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	
Inorganic Contaminants (IOCs) <sup>1</sup>	Groundwater (Below MCL)																			
	Waiver <sup>2</sup>				*										*					
	No Waiver	*				*		*			*			*		*		*		
	Surface Water (Below MCL)																			
	Waiver <sup>2</sup>				*										*					
	No Waiver	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Groundwater and Surface Water (Above MCL) <sup>3</sup>																			
	Reliably and Consistently ≤ MCL for Groundwater Systems	*				*			*		*			*		*		*		
	Reliably and Consistently ≤ MCL for Surface Water Systems	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	> MCL or Not Reliably and Consistently ≤ MCL	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****
Synthetic Organic Contaminants (SOCs)	Population >3,300 (Below Detection Limit)	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	
	Waiver		X			X			X			X			X			X		
	< Detect and No Waiver		**			**			**			**			**			**		
	Population ≤3,300 (Below Detection Limit)																			
	Waiver		X			X			X			X			X			X		
	< Detect and No Waiver		*			*			*			*			*			*		
	Above Detection Limit																			
	Reliably and Consistently ≤ MCL <sup>4</sup>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
≥ Detect or Not Reliably and Consistently ≤ MCL	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	
Volatile Organic Contaminants (VOCs)	Groundwater (Below Detection Limit)																			
	< Detect, Vulnerability Assessment, and Waiver <sup>5</sup>				*				*					*			*		*	
	No Waiver <sup>6</sup>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Surface Water (Below Detection Limit)																			
	< Detect, Vulnerability Assessment, and Waiver <sup>7</sup>		X			X			X			X			X			X		
	No Waiver <sup>8</sup>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Above Detection Limit																			
	Reliably and Consistently < MCL <sup>4</sup>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
≥ Detect or Not Reliably and Consistently ≤ MCL	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	



Legend	
*	= 1 sample at each entry point to distribution system (EPTDS).
**	= 2 quarterly samples at each EPTDS. Samples must be taken during 1 calendar year during each 3-year compliance period.
****	= 4 quarterly samples at each EPTDS within time frame designated by the primacy agency.
X	= No sampling required unless required by the primacy agency.
#	= Systems must monitor at a frequency specified by the primacy agency.
!	= When allowed by the primacy agency, data collected between June 2000 and December 8, 2003 may be grandfathered to satisfy the initial monitoring requirements due in 2004 for gross alpha, radium 226/228, and uranium.

<sup>1</sup>Until January 22, 2006 the maximum contaminant level (MCL) for arsenic is 50 µg/L; on January 23, 2006 the MCL for arsenic becomes 10 µg/L.  
<sup>2</sup>Based on 3 rounds of monitoring at each EPTDS with all analytical results below the MCL. Waivers are not permitted under the current arsenic requirements, however systems are eligible for arsenic waivers after January 23, 2006.  
<sup>3</sup>A system with a sampling point result above the MCL must collect quarterly samples, at that sampling point, until the system is determined by the primacy agency to be reliably and consistently below the MCL.  
<sup>4</sup>Samples must be taken during the quarter which previously resulted in the highest analytical result. Systems can apply for a waiver after 3 consecutive annual sampling results are below the detection limit.  
<sup>5</sup>Groundwater systems must update their vulnerability assessments during the time the waiver is effective. Primacy agencies must re-confirm that the system is non-vulnerable within 3 years of the initial determination or the system must return to annual sampling.  
<sup>6</sup>If all monitoring results during initial quarterly monitoring are less than the detection limit, the system can take annual samples. If after a minimum of 3 years of annual sampling with all analytical results less than the detection limit, the primacy agency can allow a system to take 1 sample during each compliance period. Systems are also eligible for a waiver.  
<sup>7</sup>Primacy agencies must determine that a surface water system is non-vulnerable based on a vulnerability assessment during each compliance period or the system must return to annual sampling.  
<sup>8</sup>If all monitoring results during initial quarterly monitoring are less than the detection limit, the system can take annual samples. Systems are also eligible for a waiver.  
<sup>9</sup>Samples must be taken during the quarter which previously resulted in the highest analytical result.  
<sup>10</sup>Systems are required to monitor for asbestos during the first 3-year compliance period of each 9-year compliance cycle. A system vulnerable to asbestos contamination due solely to corrosion of asbestos-cement pipe must take 1 sample at a tap served by that pipe. A system vulnerable to asbestos contamination at the source must sample at each EPTDS.

Table 3.8 summarizes the federal monitoring requirements, including frequencies for exceptions for the SMF, which include nitrate, nitrite, radionuclides, and asbestos.

**Table 3.8. Exceptions Under the Standardized Monitoring Framework for Nitrate, Nitrite, Radionuclides and Asbestos<sup>460</sup>**

EXCEPTIONS	Second Cycle									Third Cycle									
	1 <sup>st</sup> Period			2 <sup>nd</sup> Period			3 <sup>rd</sup> Period			1 <sup>st</sup> Period			2 <sup>nd</sup> Period			3 <sup>rd</sup> Period			
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	
Nitrate	CWSs & NTNCWSs																		
	Surface Water with 4 Quarters of Results < 1/2 MCL <sup>9</sup>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Groundwater Reliably and Consistently < MCL <sup>9</sup>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	≥ 1/2 MCL	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****
	TNCWSs																		
Standard Monitoring	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Nitrite	< 1/2 MCL	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
	Reliably and Consistently < MCL <sup>9</sup>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	≥ 1/2 MCL or not Reliably and Consistently < MCL	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****
	#																		
Radionuclides	< Detection Limit	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19
	≥ Detection Limit but ≤ 1/2 MCL	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!
	> 1/2 MCL but ≤ MCL	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!
	> MCL	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!	!
	****																		
Asbestos	Waiver	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	No Waiver, Reliably and Consistently ≤ MCL, or vulnerable to asbestos contamination <sup>10</sup>	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	> MCL	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****	****

Legend	
*	= 1 sample at each entry point to distribution system (EPTDS).
**	= 2 quarterly samples at each EPTDS. Samples must be taken during 1 calendar year during each 3-year compliance period.
****	= 4 quarterly samples at each EPTDS within time frame designated by the primacy agency.
X	= No sampling required unless required by the primacy agency.
#	= Systems must monitor at a frequency specified by the primacy agency.
!	= When allowed by the primacy agency, data collected between June 2000 and December 8, 2003 may be grandfathered to satisfy the initial monitoring requirements due in 2004 for gross alpha, radium 226/228, and uranium.

<sup>1</sup>Until January 22, 2006 the maximum contaminant level (MCL) for arsenic is 50 µg/L; on January 23, 2006 the MCL for arsenic becomes 10 µg/L.  
<sup>2</sup>Based on 3 rounds of monitoring at each EPTDS with all analytical results below the MCL. Waivers are not permitted under the current arsenic requirements, however systems are eligible for arsenic waivers after January 23, 2006.  
<sup>3</sup>A system with a sampling point result above the MCL must collect quarterly samples, at that sampling point, until the system is determined by the primacy agency to be reliably and consistently below the MCL.  
<sup>4</sup>Samples must be taken during the quarter which previously resulted in the highest analytical result. Systems can apply for a waiver after 3 consecutive annual sampling results are below the detection limit.  
<sup>5</sup>Groundwater systems must update their vulnerability assessments during the time the waiver is effective. Primacy agencies must re-confirm that the system is non-vulnerable within 3 years of the initial determination or the system must return to annual sampling.  
<sup>6</sup>If all monitoring results during initial quarterly monitoring are less than the detection limit, the system can take annual samples. If after a minimum of 3 years of annual sampling with all analytical results less than the detection limit, the primacy agency can allow a system to take 1 sample during each compliance period. Systems are also eligible for a waiver.  
<sup>7</sup>Primacy agencies must determine that a surface water system is non-vulnerable based on a vulnerability assessment during each compliance period or the system must return to annual sampling.  
<sup>8</sup>If all monitoring results during initial quarterly monitoring are less than the detection limit, the system can take annual samples. Systems are also eligible for a waiver.  
<sup>9</sup>Samples must be taken during the quarter which previously resulted in the highest analytical result.  
<sup>10</sup>Systems are required to monitor for asbestos during the first 3-year compliance period of each 9-year compliance cycle. A system vulnerable to asbestos contamination due solely to corrosion of asbestos-cement pipe must take 1 sample at a tap served by that pipe. A system vulnerable to asbestos contamination at the source must sample at each EPTDS.

### Coliform and Heterotrophic Bacteria

For routine monitoring of coliform, public water systems must collect total coliform samples at sites which are representative of water throughout the distribution system according to a written sample siting plan.<sup>461</sup> These plans are subject to State review and revision. The minimum frequency of coliform sampling required depends on the population of the water supply, varying from one time per month for populations between 25 and 1,000 to 480 times per month for a population of 3,960,001 or more.

The monitoring frequency for total coliforms for non-community water systems is also specified. Procedures are also defined for routine testing if a routine sample is found to be coliform-positive. Acceptable methodologies for measuring coliform and heterotrophic bacteria are listed in 40 CFR 141.74.<sup>462</sup> The methods for total coliform are: the total coliform fermentation technique; the total coliform membrane filter technique; and the ONPG-MUG Test. For fecal coliforms, the methods are the fecal coliforms procedure and the fecal coliforms filter procedure. For heterotrophic bacteria, the pour plate method and the SimPlate are listed.

### *Turbidity*

For turbidity (the cloudiness or haziness of a fluid) measurements:<sup>463</sup>

- Samples shall be taken by suppliers of water for both community and non-community water systems at a representative entry point(s) to the water distribution system at least once per day, for the purposes of making turbidity measurements.
  - If the State determines that a reduced sampling frequency in a non-community will not pose a risk to public health, it can reduce the required sampling frequency. The option of reducing the turbidity frequency shall be permitted only in those public water systems that practice disinfection and which maintain an active residual disinfectant in the distribution system, and in those cases where the State has indicated in writing that no unreasonable risk to health existed under the circumstances of this option.
- Turbidity measurements shall be made as directed 40 CFR 141.74 and include the Nephelometric Method, Great Lakes Instruments and Hach Filter Trak.<sup>464</sup>
- If the result of a turbidity analysis indicates that the maximum allowable limit has been exceeded, the sampling and measurement shall be confirmed by resampling as soon as practicable and preferably within one hour.
  - If the repeat sample confirms that the maximum allowable limit has been exceeded, the supplier of water shall report to the State within 48 hours. The repeat sample shall be the sample used for the purpose of calculating the monthly average. If the monthly average of the daily samples exceeds the maximum allowable limit, or if the average of two samples taken on consecutive days exceeds 5 TU, the supplier of water shall report to the State and notify the public.
- The requirements apply only to public water systems which use water obtained in whole or in part from surface sources.

Under the 1996 SDWA Amendments, a State exercising primary enforcement authority for public water systems may adopt permanent alternative monitoring requirements in accordance with EPA guidelines, if the State has an approved source water assessment program.<sup>465</sup> The alternative requirements may not apply to regulated microbial contaminants or indicators thereof (e.g., Giardia, coliform), disinfectants or disinfection by-products, or corrosion by-products.

### *Compliance Monitoring*

States, or the US EPA acting as a primacy agent, make sure water systems test for contaminants, review plans for water system improvements, conduct on-site inspections and sanitary surveys, provide training and technical assistance, and take action against water systems not meeting standards.<sup>466</sup>

Three US EPA resources provide tools to states, tribes and the regulated community to help them comply with safe drinking water requirements.<sup>467</sup> They are:

- The Drinking Water Academy - A long-term training initiative whose primary goal is to expand U.S EPA, state and tribal capabilities to implement the 1996 Amendments to SDWA.
- Sanitary Survey Training - Training to upgrade and maintain the ability of inspectors to conduct comprehensive, technically sound sanitary surveys of small water systems.
- Laboratories and Monitoring – US EPA provides analytical methods that laboratories use to analyze drinking water samples and certifies the laboratories.

### **Toxics Release Inventory**

Section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA) requires the US EPA and the States to annually collect data on releases and transfers of certain toxic chemicals from industrial facilities, and make the data available to the public in the Toxics Release Inventory (TRI).<sup>468</sup> See section 2.2.4 for additional information.

Electric generating facilities, which employ 10 or more full time employees or the equivalent, must perform a threshold determination for each TRI chemical and submit the values for each chemical exceeding a threshold.<sup>469</sup> All direct wastewater discharges to a receiving stream or surface water body must be included. Discharges usually occur under a National Pollutant Discharge Elimination System (NPDES) permit. In addition, disposal into an underground well at the facility must also be included.

A list of chemicals commonly found manufactured, processed, and otherwise used at electric generating facilities is listed in Table 3.9. The reporting thresholds are 25,000 pounds for compounds manufactured and processed during combustion and 10,000 pounds for chemicals “otherwise used.”

**Table 3.9. Chemicals Commonly Manufactured, Processed, and “Otherwise Used” at Electric Generating Facilities**

EPCRA Section 313 Chemicals that Electricity Generating Facilities May Manufacture During Combustion	EPCRA Section 313 Chemicals that Electricity Generating Facilities May Process (in Ash for Direct Reuse)	EPCRA Section 313 Chemicals that Electricity Generating Facilities May Otherwise Use
Antimony compounds Arsenic compounds Barium compounds Cadmium compounds Chromium compounds Copper compounds Formaldehyde Hydrochloric acid (acid aerosols) Hydrogen fluoride Lead compounds Manganese compounds Mercury/Mercury compounds Nickel compounds Selenium compounds Silver compounds Sulfuric acid (acid aerosols) Vanadium fume or dust Zinc compounds	Antimony compounds Arsenic compounds Barium compounds Cadmium compounds Chromium compounds Copper compounds Lead compounds Manganese compounds Mercury Nickel compounds Selenium compounds Silver compounds Vanadium fume or dust Zinc compounds	Ammonia Bromine Chlorine Chlorine dioxide Copper compounds Ethylene glycol Formic acid Hydrazine Hydrochloric acid (acid aerosols) PAC compounds Thiourea 1,2,4 Trimethylbenzene Zinc compounds

Wastewaters discharged include process wastewater, coal pile run-off, and storm water. The two main sources of wastewater are ash transport water and cooling water.

### Monitoring

To estimate the quantities of each reportable chemical released and otherwise managed as waste, the US EPA has identified four basic methods that may be used to develop estimates (see section 2.2.4 for more detailed descriptions of each methods and the types of potential data sources), which are:

- Monitoring Data or Direct Measurement (M);
- Mass Balance (C);
- Emission Factors (E);
- Engineering Calculations (O).

Based on the concentration and wastewater flow data available, an estimate of discharges to water can be calculated. Facilities should calculate the daily average discharges of a reportable TRI chemical in pounds and should use those estimates to determine the annual discharge in pounds per year. Using the daily concentration data available for the reportable chemical combined with the wastewater flow data for each of the sampling dates, calculate an estimate of pounds per day for each sampling date. After the calculations are made for each monitoring point (e.g., daily, monthly), the

pounds discharged are averaged to determine an average daily discharge amount, which would be multiplied by the number of days discharges were possible (e.g., 365 days a year). If no chemical-specific monitoring data exist, process knowledge (or in some cases, mass balance) may be used to develop an estimate.

### **3.3.2 Thermal Effluents**

#### **3.3.2.1 European Union**

##### **Integrated Pollution Prevention and Control (IPPC) Directive**

In the Integrated Pollution Prevention and Control (IPPC) Directive of September 1996, the European Union (EU) defines the obligations with which highly polluting industrial and agricultural activities must comply. It establishes a procedure for authorizing these activities and sets minimum requirements to be included in all permits, particularly in terms of pollutants released. It applies to combustion installations with a rated thermal input exceeding 50 MW. In general, the permits must account for the environmental performance of the plants as a whole, including, but not limited to air, water and waste emissions. (see section 3.3.1.1 for more information).<sup>470</sup>

#### **3.3.2.2 United States**

##### **The Clean Water Act**

The Clean Water Act (CWA), amended from the Federal Water Pollution Control Act of 1972, establishes the basic structure for regulating discharges of pollutants into the waters of the United States. It gives the EPA the authority to implement pollution control programs such as setting wastewater standards for industry and water quality standards for all contaminants in surface waters (see sections 3.2.2 and 3.3.1.2 for more information).<sup>471</sup>

##### **Heated Discharges (Thermal Pollution)**

Section 316(a) of the CWA regulates heated discharges (thermal pollution) into US waters. The current language allows EPA to vary a generator's heat-pollution standards depending upon the receiving water body's ability to dissipate the heat and preserve a "balanced and indigenous" wildlife population.<sup>472</sup> Furthermore, it allows plant owner or operator to request alternative effluent limitations (which refers to all effluent limitations or standards of performance for the control of the thermal component of any discharge) if they can demonstrate that the thermal discharge limitations are stricter than they need to be to preserve the wildlife population.<sup>473</sup> As a result, there is no set standard, or maximum temperature for thermal water discharge from coal-fired power plants. Instead, the required thermal properties of the discharged water will be determined in the individual NPDES permit. This approach is different from other CWA requirements that limit what a source can put into the water, not the ultimate effect of that discharge.

## **Monitoring**

### *Alternative Effluent Limitations Request*

In order to request alternative effluent limitations, an application must be submitted that includes a general description of the type of data, studies, experiments and other information which the discharger intends to submit for the demonstration. After submitting the early screening information, within 60 days after the application is filed, the discharger shall submit for approval a detailed plan of study which the discharger will undertake to support its demonstration. The discharger must specify the nature and extent of the following type of information to be included in the plan of study: Biological, hydrographical and meteorological data; physical monitoring data; engineering or diffusion models; laboratory studies; representative important species; and other relevant information. In selecting representative important species, special consideration shall be given to species mentioned in applicable water quality standards.

### **3.4 Consumption**

#### **3.4.1 European Union**

##### **Integrated Pollution Prevention and Control (IPPC) Directive**

In the Integrated Pollution Prevention and Control (IPPC) Directive of September 1996, the European Union (EU) defines the obligations with which highly polluting industrial and agricultural activities must comply. It establishes a procedure for authorizing these activities and sets minimum requirements to be included in all permits, particularly in terms of pollutants released. It applies to combustion installations with a rated thermal input exceeding 50 MW. In general, the permits must account for the environmental performance of the plants as a whole, including, but not limited to air, water and waste emissions. (see section 3.3.1.1 for more information).<sup>474</sup>

##### **Water Framework Directive**

In the Water Framework Directive of 2000, the European Union (EU) provides for the management of inland surface waters, groundwater, transitional waters and coastal waters in order to prevent and reduce pollution, promote sustainable water use, protect the aquatic environment, improve the status of aquatic ecosystems and mitigate the effects of floods and droughts (see section 3.3.1.1 for more information)<sup>475</sup>

#### **3.4.2 United States**

##### **The Clean Water Act**

The Clean Water Act (CWA), amended from the Federal Water Pollution Control Act of 1972, establishes the basic structure for regulating discharges of pollutants into the waters of the United States. It gives the EPA the authority to implement pollution control programs such as setting wastewater standards for industry and water quality

standards for all contaminants in surface waters (see section 3.3.1.2 for more information).<sup>476</sup>

### **Cooling Water Intake Structures**

The construction of surface water intake and discharge structures is a particularly critical issue that impacts all fossil-fuel power plants since withdrawal of cooling water removes billions of aquatic organisms from waters of the US each year, including fish, fish larvae and eggs, crustaceans, shellfish, sea turtles, marine mammals, and many other forms of aquatic life. Most impacts are to early life stages of fish and shellfish.<sup>477</sup> Generally, the larger the volume of the water quality drawn, the larger the number of organisms affected. Intakes in coastal waters, estuaries, and tidal rivers tend to have greater ecological impacts than those in freshwater lakes and offshore ocean intakes, since these areas are usually more biologically productive and have more aquatic organisms in early life stages.

The CWA, under Section 316(b), provides that any effluent standards or national performance standards set under the NPDES and applicable to a point source shall require the location, design, construction, and capacity of the cooling water intake structures (CWIS) reflect the best technology available for minimizing adverse environmental impact.<sup>478</sup>

The CWIS regulation is unique in that it applies to the intake of water and not the discharge. It covers two types of situations:

- **Impingement:** When fish and other aquatic life are pinned against screens or other parts of a cooling water intake structure.
- **Entrainment:** When fish and other aquatic life are drawn into cooling water systems and subjected to thermal, physical or chemical stresses.

EPA divided this rulemaking into three phases, two of which (Phases I and II) pertain to power plants.

#### *Phase I*

Phase I for new facilities was completed in November 2001.<sup>479</sup> This rule applies to new electric generating plants and manufacturers that withdraw more than two million gallons per day (MGD) from waters of the US, if they use 25 percent or more of their intake water for cooling.

With respect to velocity and flow requirements:<sup>480</sup>

- For facilities that choose certainty and fast permitting over greater flexibility, the rule sets standards to limit intake capacity and velocity.
- Facilities that are located near fisheries need additional protection must use special screens, nets or similar devices.
- Facilities withdrawing less than 10 MGD are not required to reduce intake capacity, but must use special screens, nets or similar devices if they do not.
- For facilities that choose to perform site-specific studies, the rule sets a framework for demonstrating that alternative approaches provide comparable protection.

- All facilities must limit their withdrawals to no more than a defined proportion of their source body of water.

### *Phase II*

Phase II, completed in February 2004, addresses large existing power plants that are designed to withdraw 50 million gallons per day or more and that use at least 25 percent of their withdrawn water for cooling purposes only.<sup>481</sup> In March 2007, the EPA suspended this rule in response to the 2<sup>nd</sup> Circuit Court of Appeals decision in *Riverkeeper, Inc., v. EPA*. Currently, permits for CWIS at Phase II facilities must be granted on a case by case best professional judgment basis.<sup>482</sup>

The final Phase II rule required that the number of organisms pinned against parts of the intake structure be reduced by 80 to 95 percent from uncontrolled levels.<sup>483</sup> Entrainment requirements called for the number of aquatic organisms drawn into the cooling system to be reduced by 60 to 90 percent from uncontrolled levels. Large power plants had flexibility to comply and to ensure energy reliability. The rule provided several compliance alternatives, such as using existing technologies, selecting additional fish protection technologies (such as screens with fish return systems), and using restoration measures.

## **Monitoring**

### *Phase I*

Owner or operators of a Phase I facility are required to perform monitoring to demonstrate your compliance with the CWIS regulation.<sup>484</sup> The types of monitoring required are:

1. **Biological monitoring:** The determination of the effects on aquatic life. Involves both impingement and entrainment of the commercial, recreational, and forage base fish and shellfish species identified in either the Source Water Baseline Biological Characterization data (40 CFR 122.21(r)(3)) or the Comprehensive Demonstration Study (40 CFR 125.86(c)(2)), depending on whether you chose to comply with Track I or Track II (see below for explanation).
  - The monitoring methods used must be consistent with those used for the Source Water Baseline Biological Characterization data or the Comprehensive Demonstration Study.
  - Must follow the monitoring frequencies identified below for at least two years after the initial permit issuance.
  - Two years after the permit was issued, the Director may approve a request for less frequent sampling in the remaining years of the permit term and when the permit is reissued, if supporting data show that less frequent monitoring would still allow for the detection of any seasonal and daily variations in the species and numbers of individuals that are impinged or entrained.



2. **Impingement sampling:** Must collect samples to monitor impingement rates (simple enumeration) for each species over a 24-hour period and no less than once per month when the cooling water intake structure is in operation.
3. **Entrainment sampling:** Must collect samples to monitor entrainment rates (simple enumeration) for each species over a 24-hour period and no less than biweekly during the primary period of reproduction, larval recruitment, and peak abundance identified during the Source Water Baseline Biological Characterization or the Comprehensive Demonstration Study. Must collect samples only when the cooling water intake structure is in operation.
4. **Velocity monitoring:** Facilities that use surface intake screen systems must monitor head loss across the screens and correlate the measured value with the design intake velocity. The head loss across the intake screen must be measured at the minimum ambient source water surface elevation (best professional judgment based on available hydrological data). The maximum head loss across the screen for each cooling water intake structure must be used to determine compliance with the velocity requirement (40 CFR 125.84(b)(2) or (c)(1)). If the facility uses devices other than surface intake screens, velocity at the point of entry through the device must be monitored. In addition, head loss or velocity during initial facility startup, and thereafter, at the frequency specified in the NPDES permit (but no less than once per quarter) must be monitored.
5. **Visual or remote inspections:** Must either conduct visual inspections or employ remote monitoring devices during the period the cooling water intake structure is in operation. Must conduct visual inspections at least weekly to ensure that any design and construction technologies required (40 CFR 125.84(b)(4) and (5), or (c)(3) and (4)) are maintained and operated to ensure that they will continue to function as designed. Alternatively, inspection via remote monitoring devices to ensure that the impingement and entrainment technologies are functioning as designed must be performed.

Track I (for new facilities that withdraw equal to or greater than 10 MGD) requires.<sup>485</sup>

1. Reduction of intake flow, at a minimum, to a level commensurate with that which can be attained by a closed-cycle recirculating cooling water system;
2. Design and construction of each cooling water intake structure to have a maximum through-screen design intake velocity of 0.5 ft/s;
3. Design and construction of the cooling water intake structure such that the total design intake flow from all cooling water intake structures meets the following requirements:
  - For cooling water intake structures located in a freshwater river or stream, the total design intake flow must be no greater than 5 percent of the source water annual mean flow;
  - For cooling water intake structures located in a lake or reservoir, the total design intake flow must not disrupt the natural thermal stratification or turnover pattern (where present) of the source water except in cases where the disruption is determined to be beneficial to the management of fisheries for fish and shellfish by any fishery management agency(ies);

- For cooling water intake structures located in an estuary or tidal river, the total design intake flow over one tidal cycle of ebb and flow must be no greater than 1 percent of the volume of the water column within the area centered about the opening of the intake with a diameter defined by the distance of one tidal excursion at the mean low water level;

Track II allows for the choice of alternate technologies and methods as long they reduce the level of adverse impact from the cooling water intake structures to a level that is comparable to what would be achieved under implementation of Track I.<sup>486</sup> This must be clearly demonstrated to the appropriate authority. Furthermore, the appropriate authority may impose stricter requirements that deemed reasonable for compliance.

### *Phase II*

Owners or operators of a Phase II existing facility must perform monitoring, as applicable, in accordance with the:<sup>487</sup>

1. Technology Installation and Operation Plan (40 CFR 125.95(b)(4)(ii)), which includes a list of operational and other parameters to be monitored, and the location and frequency that you will monitor them.<sup>488</sup>
2. Restoration Plan (40 CFR 125.95(b)(5)), which includes a monitoring plan that lists the restoration parameters that will be monitored, the frequency at which you will monitor them, and success criteria for each parameter. If the applicable requirements are not being met, a process for revising the Restoration Plan must be included to assess new information, including monitoring data.<sup>489</sup>
3. Verification Monitoring Plan (40 CFR 125.95(b)(7)), which includes a plan to conduct, at a minimum, two years of monitoring to verify the full-scale performance of the proposed or already implemented technologies and/or operational measures.<sup>490</sup> The verification study must begin once the design and construction technologies and/or operational measures are installed and continue for a period of time that is sufficient to demonstrate to the Director whether the facility is meeting the applicable performance standards in or site-specific requirements developed. The plan must provide a description of the frequency and duration of monitoring, the parameters to be monitored, and the basis for determining the parameters and the frequency and duration for monitoring.
4. Any additional monitoring specified by the Director to demonstrate compliance with the applicable requirements (40 CFR 125.94)

## **Chapter 4. WASTE EMISSIONS**

### **4.1 Cross-Cutting Waste Regulations**

#### **4.1.1 European Union**

In the EU, the Framework Directive on Waste Disposal and the Integrated Pollution Prevention and Control (IPPC) Directive cover a number of aspects of waste disposal from coal-fired power plants, including storage, landfill leachate and recycling.

#### **Framework Directive on Waste Disposal**

The measures outlined in the Framework Directive on Waste Disposal of 2006 apply to all substances or objects which the holder disposes of or is obliged to dispose of pursuant to the national provisions in force in the Member States.<sup>491</sup> Member States must prohibit the abandonment, dumping or uncontrolled disposal of waste, and must promote waste prevention, recycling and processing for re-use. Member States must ensure that any holder of waste has it handled by a private or public waste collector or a disposal undertaking, or disposes of the waste himself in compliance with these measures.

Undertakings or establishments treating, storing or tipping waste on behalf of third parties must obtain a permit from the competent authority relating, in particular, to the types and quantities of waste to be treated, the general technical requirements and the precautions to be taken. Recovery centers and undertakings disposing of their own waste also require a permit. The cost of disposing of waste must be borne by the holder who has waste handled by a waste collector or an undertaking and/or by previous holders or the producer of the product giving rise to the waste.

#### **Monitoring**

##### *Permits*

Permits shall cover the:<sup>492</sup>

- Types and quantities of waste;
- Technical requirements;
- Safety precautions to be taken;
- Disposal site;
- Treatment method.

For permit holders, all required establishments or undertakings referred to in the Directive shall:

- Keep a record of the quantity, nature, origin and, where relevant, the destination, frequency of collection, mode of transport and treatment method in respect of the waste referred to in the Directive
- Make this information available, on request, to the competent authorities

## *Compliance*

The competent authorities designated by the Member States for the implementation of these measures are required to draw up one or more management plans, which shall include:<sup>493</sup>

- The type, quantity and origin of waste to be recovered or disposed of;
- General technical requirements;
- Any special arrangements for particular wastes;
- Suitable disposal sites or installations.

The plans may also, for example, cover:

- The natural or legal persons empowered to carry out waste management;
- The estimated costs of the recovery and disposal operations;
- Appropriate measures to encourage rationalization of the collection, sorting and treatment of waste.

The competent authorities may periodically check that the conditions of the permit are being complied with. They also monitor undertakings which transport, collect, store, tip or treat their own waste or third parties' waste.

## **Integrated Pollution Prevention and Control (IPPC)**

The Integrated Pollution Prevention and Control (IPPC) Directive of 1996<sup>494</sup> imposes a requirement for industrial activities with high pollution potential, including combustion activities with a rated thermal input exceeding 50 MW and landfills receiving more than 10 tonnes per day or with a total capacity exceeding 25,000 tonnes, excluding landfills of inert waste,<sup>495</sup> to have a permit.

In order to receive a permit an industrial or agricultural installation must comply with certain basic obligations. In particular, it must:<sup>496</sup>

- Use all appropriate pollution-prevention measures, namely the best available techniques (which produce the least waste, use less hazardous substances, enable the recovery and recycling of substances generated, etc.);
- Prevent all large-scale pollution;
- Prevent, recycle or dispose of waste in the least polluting way possible;
- Use energy efficiently;
- Ensure accident prevention and damage limitation;
- Return sites to their original state when the activity is over.

In addition, the decision to issue a permit must contain a number of specific requirements, in particular including:

- Emission limit values for polluting substances;
- Any soil, water and air protection measures required;
- Waste management measures;
- Measures to be taken in exceptional circumstances (leaks, malfunctions, temporary or permanent stoppages, etc.);

- Minimization of long-distance or transboundary pollution;
- Release monitoring;
- All other appropriate measures.

## **Monitoring**

All permit applications must include information on:

- The sources of emissions from the installation, and the nature and quantities of foreseeable emissions into each medium, as well as their effects on the environment;
- The proposed technology and other techniques for preventing or reducing emissions from the installation;
- Measures for the prevention and recovery of waste;
- Measures planned to monitor emissions including:
  - Measurement methodology and frequency
  - Evaluation procedure

## *Compliance*

The permit application must also include an obligation to supply the data required for checking compliance with the permit. The Member States are responsible for inspecting industrial installations and ensuring they comply with the Directive.

### **4.1.2 United States**

In the US more than one-third of the waste generated by coal-fired power plants is recycled into cement or other products, while the rest is stored in surface impoundments, landfills or depleted strip mines. The Resource Recovery and Conservation Act, like the EU's Framework Directive on Waste Disposal and IPPC Directive, covers a number of issues related to coal-fired power plant waste.

### **Resource Recovery and Conservation Act**

The Resource Conservation and Recovery Act (RCRA), passed in 1976, is the primary US law governing the disposal of solid and hazardous waste.<sup>497</sup> RCRA, passed to address the growing volume of municipal and industrial waste, amended the Solid Waste Disposal Act of 1965. It set national goals for:

- Protecting human health and the environment from the potential hazards of waste disposal.
- Conserving energy and natural resources.
- Reducing the amount of waste generated.
- Ensuring that wastes are managed in an environmentally-sound manner.

To achieve these goals, RCRA established three distinct, yet interrelated, programs:

- **Solid Waste Program:** *RCRA Subtitle D* encourages states to develop comprehensive plans to manage nonhazardous industrial solid waste and municipal solid waste, sets criteria for municipal solid waste landfills and

other solid waste disposal facilities, and prohibits the open dumping of solid waste.

- **Hazardous Waste Program:** *RCRA Subtitle C* establishes a system for controlling hazardous waste from the time it is generated until its ultimate disposal – in effect, from "cradle to grave".
- **Underground Storage Tank (UST) Program:** *RCRA Subtitle I* regulates underground storage tanks containing hazardous substances and petroleum products.

RCRA banned all open dumping of waste, encouraged source reduction and recycling, and promoted the safe disposal of municipal waste. RCRA also mandated strict controls over the treatment, storage, and disposal of hazardous waste. RCRA was amended and strengthened by Congress in November 1984 with the passing of the Federal Hazardous and Solid Waste Amendments (HSWA). These amendments to RCRA required the phasing out of land disposal of hazardous waste.

### *Fossil Fuel Combustion Wastes*

Fossil Fuel Combustion (FFC) wastes<sup>498</sup> are categorized by EPA as a "special waste" and have been exempted from federal hazardous waste regulations under Subtitle C of RCRA.<sup>499</sup> In addressing the regulatory status of FFC wastes, EPA divided the wastes into two categories:

- Large-volume coal combustion wastes generated at electric utility and independent power producing facilities that are managed separately.
- All remaining FFC wastes, including:
  - Large-volume coal combustion waste generated at electric utility and independent power producing facilities that are co-managed with certain other coal combustion wastes (referred to as "comanaged wastes");
  - Coal combustion wastes generated at non-utilities;
  - Coal combustion wastes generated at facilities with fluidized bed combustion (FBC) technology;
  - Petroleum coke combustion wastes;
  - Waste from the combustion of mixtures of coal and other fuels;
  - Waste from the combustion of oil; and
  - Waste from the combustion of natural gas.

In two separate regulatory determinations, the USEPA determined that neither large-volume wastes, nor the remaining FFC wastes, warrant regulation as a hazardous waste under Subtitle C of RCRA and therefore remain excluded (as listed under the 40 CFR 261.4(b)(4):<sup>500</sup> *Exclusions* include "fly ash waste, bottom ash waste, slag waste, and flue gas emission control waste, generated primarily from the combustion of coal or other fossil fuels"). EPA did determine, however, that coal combustion wastes (CCWs) that are disposed in landfills<sup>501</sup> and surface impoundments<sup>502</sup> should be regulated under Subtitle D of RCRA (i.e., the solid waste regulations), whereas CCW used to fill surface or underground mines (minefill) should be regulated under authority of Subtitle D of RCRA, the Surface Mining Control and Reclamation Act (SMCRA), or a combination of these authorities. So that coal combustion wastes are consistently regulated across all waste management scenarios, the US EPA intends to

make these Subtitle D regulations applicable to large volume CCWs that had previously been exempt.

The regulatory determination (April 2005) is significant in that it marks the first time the US EPA stated its intent to develop nationwide regulations for the disposal of coal utilization by-products; prior to this, all regulations governing their disposal had to come from individual states. Even though the regulations are being developed under RCRA Subtitle D (rather than the more rigorous Subtitle C), the uncertainty caused by the possibility of having to comply with national regulations, which may not coincide with current disposal practices, is causing a great deal of concern within the utility industry.

The US EPA is still working on developing these regulations. Under this process, in August 2007, the US EPA issued a Notice of Data Availability (NODA) on the Disposal of Coal Combustion Waste in Landfills and Surface Impoundments,<sup>503</sup> which included a request for public comments on a joint US EPA and US Department of Energy (DOE) report titled, *Coal Combustion Waste Management at Landfills and Surface Impoundments, 1994-2004*.<sup>504</sup> The report analyzed practices at 56 disposal units in the US; compiled regulatory data for 11 states with high coal combustion rates; and reviewed 65 permits issued for CCW disposal units in 16 states. The study produced the following key findings:

- Disposal management practices and the enforcement of state requirements have resulted in liners for virtually all newly built or expanded units (97% of landfills and 100% of surface impoundments) and groundwater monitoring for the majority of units (97% of landfills and nearly 80% of surface impoundments) (See Figure 9.3).
- During the time period analyzed (a majority of the 11 states reviewed tightened regulation of landfill liners, leachate-collection systems, and groundwater monitoring).
- A detailed analysis of variance requests (i.e., requests to obtain exceptions to relevant regulations) in 65 permits in 16 states indicates that state regulators have not issued variances without a sound scientific basis supporting the request.

## **Monitoring**

Requirements for monitoring under the RCRA Solid Waste Program (under Subtitle D) can be found in 40 CFR 257<sup>505</sup> and 40 CFR 258.<sup>506</sup>

### *Criteria for the Classification of Solid Waste Disposal Facilities and Practices*

40 CFR 257 titled, “Criteria for the Classification of Solid Waste Disposal Facilities and Practices,” applies to non-municipal non-hazardous waste disposal units that receive Conditionally Exempt Small Quantity Generator (CESQG) waste (a generator that in a calendar month generates no more than 100 kilograms of hazardous waste).<sup>507</sup>

### *Groundwater Monitoring*

To monitor groundwater, facility owners and operators must install a groundwater monitoring system that can collect samples from the uppermost aquifer (defined as the geological formation nearest the natural surface that is capable of yielding significant quantities of groundwater to wells or springs).<sup>508</sup> The groundwater monitoring system consists of a series of wells placed upgradient and downgradient of the MSWLF. The samples from the upgradient wells show the background concentrations of constituents in the groundwater, while the downgradient wells show the extent of groundwater contamination caused by the MSWLF. The required number of wells, spacing, and depth of wells is determined on a site-specific basis based on the aquifer thickness, groundwater flow rate and direction, and the other geologic and hydrogeologic characteristics of the site. All groundwater monitoring systems must be certified by a qualified groundwater scientist and must comply with the sampling and analytical procedures outlined in the regulations. More detailed information on the regulations for groundwater systems, sampling and analysis requirements, detection monitoring, assessment monitoring, assessment of corrective measures and record keeping requirements are provided below.

Groundwater monitoring requirements may be suspended by the Director of an approved State for a unit if the owner or operator can demonstrate that there is no potential for migration of hazardous constituents from that unit to the uppermost aquifer during the active life of the unit plus 30 years. This demonstration must be certified by a qualified ground-water scientist and approved by the Director of an approved State, and must be based upon:

- Site-specific field collected measurements, sampling, and analysis of physical, chemical, and biological processes affecting contaminant fate and transport; and
- Contaminant fate and transport predictions that maximize contaminant migration and consider impacts on human health and environment.

### *Groundwater Monitoring Systems*

A groundwater monitoring system must be installed that consists of a sufficient number of wells, installed at appropriate locations and depths, to yield ground-water samples from the uppermost aquifer that:<sup>509</sup>

- Represent the quality of background ground water that has not been affected by leakage from a unit; and
- Represent the quality of ground water passing the relevant point of compliance specified by the Director of an approved State or at the waste management unit boundary in an unapproved State. The downgradient monitoring system must be installed at the relevant point of compliance that ensures detection of ground-water contamination in the uppermost aquifer. In determining the relevant point of compliance, which shall be no more than 150 meters from the waste management unit boundary and shall be located on land owned by the owner of the facility, the State Director shall consider at least the following factors:



- The hydrogeologic characteristics of the unit and surrounding land;
- The volume and physical and chemical characteristics of the leachate
- The quantity, quality and direction of flow of ground water;
- The proximity and withdrawal rate of the ground-water users;
- The availability of alternative drinking water supplies,
- The existing quality of the ground water, including other sources of contamination and their cumulative impacts on the ground water; and
- Whether the ground water is currently used or reasonably expected to be used for drinking water, public health, safety, and welfare effects, and practicable capability of the owner or operator.

A multi-unit ground-water monitoring system, instead of separate ground-water monitoring systems for each unit, may be approved when a facility has several units, provided the multi-unit ground-water monitoring system meets the general requirements outlined above and will be as protective of human health and the environment as individual monitoring systems for each unit. Approval should be based on the following factors:

- Number, spacing, and orientation of the units;
- Hydrogeologic setting;
- Site history;
- Engineering design of the units; and
- Type of waste accepted at the units.

Monitoring wells must be cased in a manner that maintains the integrity of the monitoring well bore hole. This casing must be screened or perforated and packed with gravel or sand, where necessary, to enable collection of ground-water samples. The annular space (i.e., the space between the bore hole and well casing) above the sampling depth must be sealed to prevent contamination of samples and the ground water.

- The owner or operator must notify the State Director that the design, installation, development, and decommission of any monitoring wells, piezometers and other measurement, sampling, and analytical devices documentation has been placed in the operating record; and
- The monitoring wells, piezometers, and other measurement, sampling, and analytical devices must be operated and maintained so that they perform to design specifications throughout the life of the monitoring program.

The number, spacing, and depths of monitoring systems shall be:

- Determined based upon site-specific technical information that must include thorough characterization of:
  - Aquifer thickness, ground-water flow rate, ground-water flow direction including seasonal and temporal fluctuations in ground-water flow; and
  - Saturated and unsaturated geologic units and fill materials overlying the uppermost aquifer, materials comprising the uppermost aquifer, and materials comprising the confining unit defining the lower boundary of the uppermost aquifer; including, but not limited to:

thicknesses, stratigraphy, lithology, hydraulic conductivities, porosities and effective porosities.

- Certified by a qualified ground-water scientist or approved by the Director of an approved State.

*Groundwater Sampling and Analysis Requirements*

The groundwater monitoring program must include consistent sampling and analysis procedures that are designed to ensure monitoring results that provide an accurate representation of ground-water quality at the background and downgradient wells. The program must include appropriate procedures and techniques for:

- Sample collection;
- Sample preservation and shipment;
- Analytical procedures;
- Chain of custody control; and
- Quality assurance and quality control.

Groundwater samples shall not be field-filtered prior to laboratory analysis. Groundwater elevations must be measured in each well immediately prior to purging, each time ground water is sampled. The owner or operator must determine the rate and direction of ground-water flow each time ground water is sampled. Ground-water elevations in wells which monitor the same waste management area must be measured within a period of time short enough to avoid temporal variations in ground-water flow which could preclude accurate determination of ground-water flow rate and direction.

Requirements are also specified for how to establish background groundwater quality, and how to use appropriate statistical procedures to determine the number of samples needed. In addition, statistical methods are provided that must be used to evaluate groundwater monitoring data for each hazardous constituent in each well.

Within a reasonable period of time after completing sampling and analysis, the owner or operator must determine whether there has been a statistically significant increase over background at each monitoring well.

*Detection Monitoring Program*

Detection monitoring is required at all ground-water monitoring wells covered under 40 CFR 257. At a minimum, a detection monitoring program must include the monitoring for the constituents listed Table 4.1.<sup>510</sup>

**Table 4.1. Constituents for Detection Monitoring**

Common name <sup>1</sup>	CAS RN <sup>2</sup>
<i>Inorganic Constituents:</i>	
(1) Antimony	(Total)
(2) Arsenic	(Total)
(3) Barium	(Total)
(4) Beryllium	(Total)

(5) Cadmium	(Total)
(6) Chromium	(Total)
(7) Cobalt	(Total)
(8) Copper	(Total)
(9) Lead	(Total)
(10) Nickel	(Total)
(11) Selenium	(Total)
(12) Silver	(Total)
(13) Thallium	(Total)
(14) Vanadium	(Total)
(15) Zinc	(Total)
<i>Organic Constituents:</i>	
(16) Acetone	67-64-1
(17) Acrylonitrile	107-13-1
(18) Benzene	71-43-2
(19) Bromochloromethane	74-97-5
(20) Bromodichloromethane	75-27-4
(21) Bromoform; Tribromomethane	75-25-2
(22) Carbon disulfide	75-15-0
(23) Carbon tetrachloride	56-23-5
(24) Chlorobenzene	108-90-7
(25) Chloroethane; Ethyl chloride	75-00-3
(26) Chloroform; Trichloromethane	67-66-3
(27) Dibromochloromethane; Chlorodibromomethane	124-48-1
(28) 1,2-Dibromo-3-chloropropane; DBCP	96-12-8
(29) 1,2-Dibromoethane; Ethylene dibromide; EDB	106-93-4
(30) o-Dichlorobenzene; 1,2-Dichlorobenzene	95-50-1
(31) p-Dichlorobenzene; 1,4-Dichlorobenzene	106-46-7
(32) trans-1, 4-Dichloro-2-butene	110-57-6
(33) 1,1-Dichlorethane; Ethylidene chloride	75-34-3
(34) 1,2-Dichlorethane; Ethylene dichloride	107-06-2
(35) 1,1-Dichloroethylene; 1,1-Dichloroethene; Vinylidene chloride	75-35-4
(36) cis-1,2-Dichloroethylene; cis-1,2-Dichloroethene	156-59-2
(37) trans-1, 2-Dichloroethylene; trans-1,2-Dichloroethene	156-60-5
(38) 1,2-Dichloropropane; Propylene dichloride	78-87-5
(39) cis-1,3-Dichloropropene	10061-01-5
(40) trans-1,3-Dichloropropene	10061-02-6
(41) Ethylbenzene	100-41-4
(42) 2-Hexanone; Methyl butyl ketone	591-78-6
(43) Methyl bromide; Bromomethane	74-83-9
(44) Methyl chloride; Chloromethane	74-87-3
(45) Methylene bromide; Dibromomethane	74-95-3
(46) Methylene chloride; Dichloromethane	75-09-2
(47) Methyl ethyl ketone; MEK; 2-Butanone	78-93-3
(48) Methyl iodide; Iodomethane	74-88-4

(49) 4-Methyl-2-pentanone; Methyl isobutyl ketone	108-10-1
(50) Styrene	100-42-5
(51) 1,1,1,2-Tetrachloroethane	630-20-6
(52) 1,1,2,2-Tetrachloroethane	79-34-5
(53) Tetrachloroethylene; Tetrachloroethene; Perchloroethylene	127-18-4
(54) Toluene	108-88-3
(55) 1,1,1-Trichloroethane; Methylchloroform	71-55-6
(56) 1,1,2-Trichloroethane	79-00-5
(57) Trichloroethylene; Trichloroethene	79-01-6
(58) Trichlorofluoromethane; CFC-11	75-69-4
(59) 1,2,3-Trichloropropane	96-18-4
(60) Vinyl acetate	108-05-4
(61) Vinyl chloride	75-01-4
(62) Xylenes	1330-20-7

<sup>1</sup> Common names are those widely used in government regulations, scientific publications, and commerce; synonyms exist for many chemicals.

<sup>2</sup> Chemical Abstract Service registry number. Where “Total” is entered, all species in the ground water that contain this element are included.

Any of the constituent monitoring parameters listed in Table 4.1 may be removed for a unit if it can be shown that the removed constituent(s) are not reasonably expected to be contained in or derived from the waste contained in the unit. An alternative list of indicator parameters may also be established if the alternative parameters provide a reliable indication of releases from the unit to the ground water. Factors to be considered when developing the alternative list are provided in 40 CFR 257.24.

#### *Assessment Monitoring Program*

Assessment monitoring is required whenever a statistically significant increase over background has been detected for one or more of the constituents listed Table 4.1 or in the alternative approved list. Within 90 days of triggering an assessment monitoring program, and annually thereafter, the owner or operator must sample and analyze the ground water for all constituents identified in 40 CFR 258 Appendix II (which is much more extensive list, consisting of 214 substances, than presented in Table 4.1).<sup>511</sup> A minimum of one sample from each downgradient well must be collected and analyzed during each sampling event. For any constituent detected in the downgradient wells as the result of the complete 40 CFR 258 Appendix II analysis, a minimum of four independent samples from each well (background and downgradient) must be collected and analyzed to establish background for the new constituents.

As for detection monitoring, with approval, any of the 40 CFR 258 Appendix II monitoring parameters for a unit can be removed if it can be shown that the removed constituents are not reasonably expected to be in or derived from the waste contained in the unit. The approver may also specify an appropriate alternate frequency for repeated sampling and analysis for the full set of 40 CFR 258 Appendix II constituents, or the alternative approved list approved, during the active life plus 30 years.

After obtaining the results from the initial or subsequent sampling events required the owner or operator must:

1. Within 14 days, place a notice in the operating record identifying the 40 CFR Appendix II constituents that have been detected;
2. Within 90 days, and on at least a semiannual basis thereafter, resample all wells, conduct analyses for all constituents in Table 4.1 or the alternative approved list, and record their concentration. At least one sample from each well (background and downgradient) must be collected and analyzed during these sampling events.
3. Establish background concentrations for any constituents detected in Table 4.1 or 40 CFR 258 Appendix II.
4. Establish ground-water protection standards for all constituents detected pursuant to Table 4.1 or 40 CFR 258 Appendix II. (Full procedures are specified 40 CFR 257.25(h) and (i) for establishing these standards).
  - The ground-water protection standard shall be:
    - The maximum contaminant level (MCL) for constituents for which an MCL has been promulgated under section 1412 of the Safe Drinking Water Act (codified) under 40 CFR part 141;
    - The background concentration for the constituent established from wells for constituents for which MCLs have not been promulgated; or
    - The background concentration, for constituents for which the background level is higher than the MCL identified under 40 CFR 257.25(h)(1) or health based levels identified under 40 CFR 257.25(i)(1) of this section.

If the concentrations of all 40 CFR 258 Appendix II constituents are:

- Shown to be at or below background values, (using the statistical procedures provided in 257.23(g)) for two consecutive sampling events, the owner or operator may return to detection monitoring.
- Above background values, but all concentrations are below the ground-water protection standards established the owner or operator must continue assessment monitoring in accordance with this section.
- Detected at statistically significant levels above the ground-water protection standards established, the owner or operator must, within 14 days of this finding, place a notice in the operating record identifying the constituents that have exceeded the ground-water protection standard. The owner or operator must also:
  - Characterize the nature and extent of the release by installing additional monitoring wells as necessary;
  - Install at least one additional monitoring well at the facility boundary in the direction of contaminant migration and sample according to this regulation;
  - Notify all persons who own the land or reside on the land that directly overlies any part of the plume of contamination if contaminants have migrated off-site if indicated by sampling of the wells.

- Initiate an assessment of corrective measures as required within 90 days; or demonstrate that a source other than the non-municipal non-hazardous waste disposal unit caused the contamination, or that the statistically significant increase resulted from error in sampling, analysis, statistical evaluation, or natural variation in ground-water quality.

#### *Assessment of Corrective Measures*

Within 90 days of finding that any of the constituents listed in 40 CFR 258 Appendix II have been detected at a statistically significant level exceeding the ground-water protection standards, the owner or operator must initiate an assessment of corrective measures. Such an assessment must be completed within a reasonable period of time.

During this time, the owner or operator must continue to monitor in accordance with the assessment monitoring program.

#### *Recordkeeping Requirements*

The owner/operator must record and retain near the facility in an operating record or alternative approved location, in addition to other data, all required monitoring records.

#### *Criteria for Municipal Solid Waste Landfills*

40 CFR 258 titled, “Criteria for Municipal Solid Waste Landfills,” applies to Municipal Solid Waste Landfill (MSWLF) units, except if the owner or operator can demonstrate that there is no potential for migration of hazardous constituents from that MSWLF unit to the uppermost aquifer during the active life of the unit and the post-closure care period.<sup>512</sup>

Fossil fuel combustion (FFC) waste may apply because a MSWLF unit also may receive other types of RCRA Subtitle D wastes, such as industrial solid waste. Specifically, industrial solid waste means solid waste generated by manufacturing or industrial processes that is not a hazardous waste regulated under subtitle C of RCRA. This may include, but is not limited to, waste resulting from electric power generation

The standards in 40 CFR 258 for MSWLFs include:<sup>513</sup>

- Location restrictions: Ensure that landfills are built in suitable geological areas away from faults, wetlands, flood plains, or other restricted areas.
- Composite liners requirements: Include a flexible membrane (geomembrane) overlaying two feet of compacted clay soil lining the bottom and sides of the landfill, protect groundwater and the underlying soil from leachate releases.
- Leachate collection and removal systems: Sit on top of the composite liner and removes leachate from the landfill for treatment and disposal.
- Operating practices: Include compacting and covering waste frequently with several inches of soil help reduce odor; control litter, insects, and rodents; and protect public health.

- Groundwater monitoring requirements: Requires testing groundwater wells to determine whether waste materials have escaped from the landfill.
- Closure and postclosure care requirements: include covering landfills and providing long-term care of closed landfills.
- Corrective action provisions: Control and clean up landfill releases and achieves groundwater protection standards.
- Financial assurance: Provides funding for environmental protection during and after landfill closure (i.e., closure and postclosure care).

### *Groundwater Monitoring*

Groundwater monitoring, including the requirements for the systems, the sampling and analysis, detection monitoring, assessment monitoring and the procedures for assessment of corrective measures, for MSWLFs in 40 CFR 258 is identical to the classification of solid waste disposal facilities and practices in 40 CFR 257.

### *Explosive gases control*

Owners or operators of all MSWLF units must ensure that:

- The concentration of methane gas generated by the facility does not exceed 25 percent of the lower explosive limit for methane in facility structures (excluding gas control or recovery system components); and
- The concentration of methane gas does not exceed the lower explosive limit for methane at the facility property boundary.

Owners or operators of all MSWLF units must implement a routine methane monitoring program to ensure that the standards for the concentration of methane gas are met. The type and frequency of monitoring must be determined based on:

- Soil conditions;
- The hydrogeologic conditions surrounding the facility;
- The hydraulic conditions surrounding the facility; and
- The location of facility structures and property boundaries.

Generally, monitoring shall be carried out no less than quarterly. Alternative frequencies for monitoring may be established after public review and comment, for any owners or operators of MSWLFs that dispose of 20 tons of municipal solid waste per day or less, based on an annual average.

### *Post-Closure Care*

Following closure of each MSWLF unit, the owner or operator must conduct post-closure care. Post-closure care must be conducted for 30 years, except, with approval, if:

- The owner or operator demonstrates that a reduced period is sufficient to protect human health and the environment; or
- The Director of an approved State determines that a lengthened period is necessary to protect human health and the environment.

Prior to closure, the owner or operator of all MSWLF units must prepare a written post-closure plan that includes, for monitoring, at a minimum, a description of the monitoring and maintenance activities required during post-closure for each MSWLF unit, and the frequency at which these activities will be performed. Groundwater and gas monitoring in accordance with the requirements must be performed during the determined post-closure time period.

#### *Recordkeeping requirements*

The owner or operator of a MSWLF unit must record and retain, with respect to monitoring:

- The gas monitoring results from monitoring and any remediation plans required; and
- Any demonstration, certification, finding, monitoring, testing, or analytical data required for groundwater monitoring and corrective action.
- Closure and post-closure care plans and any monitoring, testing, or analytical data as required under the closure criteria (40 CFR 258.60) and Closure and Post-Closure Care (40 CFR 258.61) of this part;

#### *Compliance Monitoring*

The state must have the authority to:<sup>514</sup>

- Obtain any and all information necessary, including records and reports, from an owner or operator of a Subtitle D regulated facility, to determine whether the owner or operator is in compliance with the state requirements;
- Conduct monitoring or testing to ensure that owners and operators are in compliance with the state requirements; and
- Enter any site or premise subject to the permit program or in which records relevant to the operation of Subtitle D regulated facilities or activities are kept.

A state must demonstrate that its compliance monitoring program provides for inspections adequate to determine compliance with the approved state permit program. A state must also demonstrate that its compliance monitoring program provides mechanisms or processes to:

- Verify the accuracy of information submitted by owners or operators of Subtitle D regulated facilities;
- Verify the adequacy of methods (including sampling) used by owners or operators in developing that information;
- Produce evidence admissible in an enforcement proceeding; and
- Receive and ensure proper consideration of information submitted by the public.



## 4.2 Landfill Leachate

### 4.2.1 European Union

In the EU, the Landfill of Waste Directive deals specifically with issues of landfill leachate.

#### Landfill of Waste

The Landfill of Waste Directive of 1999 is intended to prevent or reduce the adverse effects of the landfill of waste on the environment, in particular on surface water, groundwater, soil, air and human health.<sup>515</sup> It defines the different categories of waste (municipal waste, hazardous waste, non-hazardous waste and inert waste) and applies to all landfills, defined as waste disposal sites for the deposit of waste onto or into land.

Landfills are divided into three classes:

- Hazardous waste;
- Non-hazardous waste;
- Inert waste.

A standard waste acceptance procedure is laid down so as to avoid any risks. Waste must be treated before being landfilled. The Directive sets up a system of operating permits for landfill sites. The permits must consider location of the landfill, appropriate measures for water control and leachate management and conditions for protection of soil and water.<sup>516</sup> In addition to the geologic barrier defined in the Directive, a leachate collection and sealing system must be added to ensure that leachate collection at the base of the landfill is minimized. The sealing system must be in accordance with the following principles in Table 4.2.

**Table 4.2. Leachate Collection and Bottom Sealing**

Landfill category	non hazardous	hazardous
Artificial sealing liner	required	required
Drainage layer $\geq 0,5$ m	required	required

If, after a consideration of the potential hazards to the environment, an official finds that the prevention of leachate formation is necessary, a sealing surface may be prescribed. Recommendations for the sealing surface are found in Table 4.3.

**Table 4.3. Recommendations for a sealing surface to prevent leachate formation**

Landfill category	non hazardous	hazardous
Gas drainage layer	required	not required
Artificial sealing liner	not required	required
Impermeable mineral layer	required	required
Drainage layer > 0,5 m	required	required
Top soil cover > 1 m	required	required.

Furthermore, there are provisions for the control of gas, nuisances and hazard, the stability of the site and the barriers that must be erected to prevent site access.

### Monitoring

Applications for permits must contain, among other things, the proposed operation, monitoring and control plan.<sup>517</sup> The Directive establishes control and monitoring requirements for the operational and after-care phases in Annex III.<sup>518</sup>

Specifically, Annex III provides the minimum procedures for monitoring to be carried out to check that the:

- Waste has been accepted to disposal in accordance with the criteria set for the category of landfill in question,
- Processes within the landfill proceed as desired,
- Environmental protection systems are functioning fully as intended,
- Permit conditions for the landfill are fulfilled.

### *Meteorological data*

Member States should supply data on the collection method for meteorological data. It is up to Member States to decide how the data should be collected (in situ, national meteorological network, etc.).

Should Member States decide that water balances are an effective tool for evaluating whether leachate is building up in the landfill body or whether the site is leaking, it is recommended that the data described in Table 4.4 are collected from monitoring at the landfill or from the nearest meteorological station.

**Table 4.4. Data recommended to be monitored (or collected from the nearest meteorological station) at a landfill to determine site leakage**

	Operation phase	After-care phase
1.1. Volume of precipitation	daily	daily, added to monthly values
1.2. Temperature (min., max., 14.00 h CET)	daily	monthly average
1.3. Direction and force of prevailing wind	daily	not required
1.4. Evaporation (lysimeter) <sup>(1)</sup>	daily	daily, added to monthly values
1.5. Atmospheric humidity (14.00 h CET)	daily	monthly average

<sup>(1)</sup> Or through other suitable methods.

*Emission Data: Water, Leachate and Gas Control*

Sampling of leachate and surface water, if present, must be collected at representative points. Sampling and measuring (volume and composition) of leachate must be performed separately at each point at which leachate is discharged from the site. (Reference: General Guidelines on Sampling Technology, ISO 5667-2 (1991)).

Monitoring of surface water present shall be carried out at not less than two points, one upstream from the landfill and one downstream.

Gas monitoring must be representative for each section of the landfill. The frequency of sampling and analysis is listed in Table 4.5. For leachate and water, a sample, representative of the average composition, shall be taken for monitoring. The frequency of sampling could be adapted on the basis of the morphology of the landfill waste (in tumulus, buried, etc). This has to be specified in the permit.

**Table 4.5. Frequency of sampling and analysis for gas monitoring**

	Operating phase	After-care phase <sup>(?)</sup>
2.1. Leachate volume	monthly <sup>(1)</sup> <sup>(2)</sup>	every six months
2.2. Leachate composition <sup>(2)</sup>	quarterly <sup>(3)</sup>	every six months
2.3. Volume and composition of surface water <sup>(2)</sup>	quarterly <sup>(3)</sup>	every six months
2.4. Potential gas emissions and atmospheric pressure <sup>(4)</sup> (CH <sub>4</sub> , CO <sub>2</sub> , O <sub>2</sub> , H <sub>2</sub> S, H <sub>2</sub> etc.)	monthly <sup>(3)</sup> <sup>(5)</sup>	every six months <sup>(6)</sup>

<sup>(1)</sup> The frequency of sampling could be adapted on the basis of the morphology of the landfill waste (in tumulus, buried, etc.). This has to be specified in the permit.

<sup>(2)</sup> The parameters to be measured and the substances to be analysed vary according to the composition of the waste deposited; they must be laid down in the permit document and reflect the leaching characteristics of the wastes.

<sup>(3)</sup> If the evaluation of data indicates that longer intervals are equally effective, they may be adapted. For leachates, conductivity must always be measured at least once a year.

<sup>(4)</sup> These measurements are related mainly to the content of organic material in the waste.

<sup>(5)</sup> CH<sub>4</sub>, CO<sub>2</sub>, O<sub>2</sub>, regularly, other gases as required, according to the composition of the waste deposited, with a view to reflecting its leaching properties.

<sup>(6)</sup> Efficiency of the gas extraction system must be checked regularly.

<sup>(?)</sup> On the basis of the characteristics of the landfill site, the competent authority may determine that these measurements are not required, and will report accordingly in the way laid down in Article 15 of the Directive.

2.1 and 2.2 apply only where leachate collection takes place (see Annex I(2)).

## Protection of Groundwater

### For Sampling:

- The measurements must be such as to provide information on groundwater likely to be affected by the discharging of waste, with at least one measuring point in the groundwater inflow region and two in the outflow region. This number can be increased on the basis of a specific hydrogeological survey and the need for an early identification of accidental leachate release in the groundwater.
- Sampling must be carried out in at least three locations before the filling operations in order to establish reference values for future sampling. (Reference: Sampling Groundwaters, ISO 5667, Part 11, 1993).

### For Monitoring:

- The parameters to be analyzed in the samples taken must be derived from the expected composition of the leachate and the groundwater quality in the area. In selecting the parameters for analysis account should be taken of mobility in the groundwater zone. Parameters could include indicator parameters in order to ensure an early recognition of change in water quality (The recommended parameters are pH, TOC, phenols, heavy metals fluoride, AS, oil/hydrocarbons).

Table 4.6 shows the minimum frequency required for assessing the level of groundwater and the groundwater composition.

**Table 4.6. Frequency for assessing level of groundwater and the groundwater composition**

	Operation phase	After-care phase
Level of groundwater	every six months <sup>(1)</sup>	every six months <sup>(1)</sup>
Groundwater composition	site-specific frequency <sup>(2)</sup> <sup>(3)</sup>	site-specific frequency <sup>(2)</sup> <sup>(3)</sup>

<sup>(1)</sup> If there are fluctuating groundwater levels, the frequency must be increased.

<sup>(2)</sup> The frequency must be based on possibility for remedial actions between two samplings if a trigger level is reached, i.e. the frequency must be determined on the basis of knowledge and the evaluation of the velocity of groundwater flow.

<sup>(3)</sup> When a trigger level is reached (see C), verification is necessary by repeating the sampling. When the level has been confirmed, a contingency plan (laid down in the permit) must be followed.

### For Trigger Levels:

- Significant adverse environmental effects should be considered to have occurred in the case of groundwater, when an analysis of a groundwater sample shows a significant change in water quality.
- A trigger level must be determined taking account of the specific hydrogeological formations in the location of the landfill and groundwater quality. The trigger level must be laid down in the permit whenever possible.

- The observations must be evaluated by means of control charts with established control rules and levels for each downgradient well. The control levels must be determined from local variations in groundwater quality.

#### *Topography of the Site: Data on the Landfill Body*

Minimum frequency required for collecting data on the topography of the landfill body is shown in Table 4.7.

**Table 4.7. Frequency for collecting data on the topography of the landfill bill**

	Operating phase	After-care phase
5.1. Structure and composition of landfill body <sup>(1)</sup>	yearly	
5.2. Settling behaviour of the level of the landfill body	yearly	yearly reading

<sup>(1)</sup> Data for the status plan of the concerned landfill: surface occupied by waste, volume and composition of waste, methods of depositing, time and duration of depositing, calculation of the remaining capacity still available at the landfill.

## **4.2.2 United States**

See section 4.1.2 above.

## **4.3 Chemical Releases**

### **4.3.1 European Union**

#### **European Pollutant Release and Transfer Register (PRTR)**

The European Pollutant Release and Transfer Register (E-PRTR) Regulation of 2006 establishes an E-PRTR, harmonizes rules for the Member States to regularly report information on pollutants to the Commission (see section 2.1.3 for additional information).<sup>519</sup>

The operator of each facility that undertakes one or more of the activities specified in Annex I, which includes thermal power stations and other combustion installations with a heat input of greater than 50 megawatts (MW), shall report to the PRTR the amounts annually of releases to air, water and land for which threshold value has been exceeded for the pollutants specified in Annex II of the Regulation.<sup>520</sup> Out of the 91 pollutants, a total of 61 pollutants are specified as relevant pollutants for releases to land.<sup>521</sup>

#### *Releases to Land*

The thresholds for the releases to land are the same as the thresholds for the sub-list of water pollutants identified for thermal power stations and other combustion installations in Appendix 5 of the *Guidance Document for the Implementation of the European PRTR*.<sup>522</sup> They are:

- Total nitrogen – 50,000 kg/year;
- Total phosphorus – 5,000 kg/year;
- Arsenic and compounds (as As) – 5 kg/year;

- Cadmium and compounds (as Cd) – 5 kg/year;
- Chromium and compounds(as Cr) – 50 kg/year;
- Copper and compounds (as Cu) – 50 kg/year;
- Mercury and compounds (as Hg) – 1kg/year;
- Nickel and compounds (as Ni) – 20 kg/year;
- Lead and compounds (as Pb) – 20 kg/year;
- Zinc and compounds (as Zn) – 100 gh/year;
- Halogenated organic compounds (as AOX) – 1,000 kg/year; and
- PCDD + PCDF (dioxins + furans) (as Teq) – 0.0001 kg/year.

The reporting on “releases to land” applies only to pollutants in waste which is subject to the disposal operations “land treatment” or “deep injection.” If waste is treated in such a way, only the operator of the facility originating the waste shall report it.

### **Monitoring**

When reporting parameters, the operator shall use the best available information, which may include: monitoring data; emission factors; mass balance equations; indirect monitoring or other calculations; engineering judgments; and other methods. The operator shall indicate whether the information is based on measurement, calculation or estimation.

#### **4.3.2 United States**

##### **Toxics Release Inventory**

Section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA) requires the US EPA and the States to annually collect data on releases and transfers of certain toxic chemicals from industrial facilities, and make the data available to the public in the Toxics Release Inventory (TRI).<sup>523</sup> (See Section 2.2.4 for additional information).

Electric generating facilities, which employ 10 or more full time employees or the equivalent, must perform a threshold determination for each TRI chemical and submit the values for each chemical exceeding a threshold.<sup>524</sup> All releases to land on site, both planned (i.e., disposal) and unplanned (i.e., accidental release or spill) must be included. The four predefined subcategories for reporting quantities released to land within the boundaries of the facility are: landfill; land treatment/application farming; surface impoundment; and other disposal. TRI chemicals transferred off-site for the purposes of waste treatment, disposal, recycling, or energy recovery must also be included.

A list of chemicals commonly found manufactured, processed, and otherwise used at electric generating facilities is listed in Table 4.8. The reporting thresholds are 25,000 pounds for compounds manufactured and processed during combustion and 10,000 pounds for chemicals “otherwise used.”

**Table 4.8. Chemicals Commonly Manufactured, Processed, and “Otherwise Used” at Electric Generating Facilities**

EPCRA Section 313 Chemicals that Electricity Generating Facilities May Manufacture During Combustion	EPCRA Section 313 Chemicals that Electricity Generating Facilities May Process (in Ash for Direct Reuse)	EPCRA Section 313 Chemicals that Electricity Generating Facilities May Otherwise Use
Antimony compounds Arsenic compounds Barium compounds Cadmium compounds Chromium compounds Copper compounds Formaldehyde Hydrochloric acid (acid aerosols) Hydrogen fluoride Lead compounds Manganese compounds Mercury/Mercury compounds Nickel compounds Selenium compounds Silver compounds Sulfuric acid (acid aerosols) Vanadium fume or dust Zinc compounds	Antimony compounds Arsenic compounds Barium compounds Cadmium compounds Chromium compounds Copper compounds Lead compounds Manganese compounds Mercury Nickel compounds Selenium compounds Silver compounds Vanadium fume or dust Zinc compounds	Ammonia Bromine Chlorine Chlorine dioxide Copper compounds Ethylene glycol Formic acid Hydrazine Hydrochloric acid (acid aerosols) PAC compounds Thiourea 1,2,4 Trimethylbenzene Zinc compounds

Some types of solid waste from coal-fired power plants are:

- Combustion Wastes:* Some electricity generating facilities dispose of large amounts of ash containing reportable TRI chemicals on-site. Most electricity generating facilities dispose of ash at sites that are not contiguous or adjacent to the facility. Bottom or fly ash may be disposed in landfills, surface impoundments, or other waste management units. Some facilities may also dispose boiler slag (bottom ash particles in a molten state) containing TRI chemicals.
- Flue Gas Desulfurization (FGD) Wastes:* Wet FGD systems result in a waste slurry of hydrated calcium sulfate and sulfite, and unreacted lime, which may be dewatered and/or stabilized with fly ash and disposed in impoundments or landfills. Dry FGD systems spray an alkaline solution into the flue gas to react with the sulfur oxides. The water from the solution evaporates into the flue gas, leaving a dry powder, which is collected by a particulate collector such as a baghouse, and often disposed onsite. Metal compounds coincidentally manufactured in FGD systems must be considered toward threshold determinations and release and other waste management calculations, and are not subject to the *de minimis* exemption.
- Other Wastes:* Such as filtration and coagulation residues, demineralization regenerant products, brine from reverse osmosis, slurries from polishers, blowdown from boilers and recirculating cooling water systems, cooling tower sludges, solids from oil filtration and settled materials from coal pile runoff.

## Monitoring

To estimate the quantities of each reportable chemical released and otherwise managed as waste, the US EPA has identified four basic methods that may be used to develop estimates (see section 2.2.4 for more detailed descriptions of each methods and the types of potential data sources), which are:

- Monitoring Data or Direct Measurement (M);
- Mass Balance (C);
- Emission Factors (E);
- Engineering Calculations (O).

For:

- *Combustion Wastes*: Facilities must report all non-exempt releases of TRI chemicals in ash that is disposed on-site, regardless of concentration, provided that thresholds have been exceeded for these chemicals. Ash disposed in a landfill or otherwise applied to the land is considered a waste management activity and must be reported. Facility specific information, such as waste analyses and process knowledge, can be used to estimate amounts of reportable chemicals in combustion wastes. In the absence of data determined to be better, facilities can use default values for concentrations of metals in ash.<sup>525</sup>
- *FGD*: Sources include waste analyses, NPDES permits, and waste characterization performed to meet state or other solid waste management requirements. The best “readily available” data should be used to estimate concentrations of chemicals in FGD sludge solids and liquors. In the absence of facility specific data, the values are provided to estimate concentrations of certain trace metals<sup>526</sup> in FGD sludge solids and liquors. Only the weight of the parent metal must be considered when reporting releases and other waste management activities of metal compounds.
- *Other Wastes*: To calculate quantities of other wastes that may be present, facilities can use waste analyses, process knowledge, operating records, pollution prevention data, mass balance or other readily available information sources.

## 4.4 Recycling

### 4.4.1 European Union

#### European Pollutant Release and Transfer Register (PRTR)

The European Pollutant Release and Transfer Register (E-PRTR) Regulation of 2006 establishes an E-PRTR, harmonizes rules for the Member States to regularly report information on pollutants to the Commission (see section 2.1.3 for additional information).<sup>527</sup>



### *Off-site Transfers*

An off-site transfer of waste means the movement beyond the boundaries of a facility of waste destined for disposal or recovery, including recycling.<sup>528</sup> With the exception of the disposal operations of land treatment and deep injection (which must be reported as releases to land), operators shall report off-site transfers of:<sup>529</sup>

- Hazardous waste (HW) exceeding 2 tonnes per year
- Non hazardous waste (non-HW) exceeding 2,000 tonnes per year

The threshold value applies to the sum of all waste transferred off-site (i.e., it includes all waste transferred within or out of the economy and whether it is disposed of or recovered).

### **Monitoring**

Operators should indicate whether the amount of waste was measured (e.g. by the method of weighing), calculated (e.g. by emission or release factors) or estimated.<sup>530</sup>

The operator has to indicate whether the waste is destined for recovery (“R”) or for disposal (“D”). If the waste is destined for waste treatment that includes both recovery and disposal operations (e.g. sorting), the treatment operation (R or D) for which more than 50% of the waste is destined should be reported. In those rare cases where the facility is not able to trace whether more than 50% of the waste is disposed or recovered, then code “D” should be used. For transboundary movements of hazardous waste, the name and address of the person who recovers the waste or the person who disposes the waste and the actual recovery or disposal site have to be reported.

#### **4.4.2 United States**

TRI chemicals transferred off-site for the purposes of waste treatment, disposal, recycling, or energy recovery must also be included (see section 4.3.2 for additional information).

## Chapter 5. MONITORING FRAMEWORK IN CHINA

### 5.1 Introduction

In China, responsibility for the development and implementation of environmental policy is divided between national and local levels. At the national level, the two major regulatory bodies are the State Council, which delivers broad policy guidance, and the State Environmental Protection Agency (SEPA), which is charged with developing this policy into specific regulations. The provincial, regional, and municipal Environmental Protection Bureaus (EPB) are responsible for designing, implementing, and enforcing environmental regulations at the local level. Typically, the regulations announced by the State Council and SEPA consist of general policy goals and targets that leave it up to the individual provinces and municipalities to develop specific rules and standards for their implementation and monitoring.

The Law on Environmental Monitoring of Thermal Power Plants (DL/T 414-2004) and the Thermal Power Industry Environmental Monitoring Management Regulations (1996/280) stipulate the environmental monitoring parameters, sampling techniques, analytical method and quality assurance requirements for all thermal power plants in China.<sup>531</sup> Table 5.1 Outlines Monitoring Parameters for Thermal Power Plants including those for water effluents, coal waste, and air emissions. There are no guidelines for water consumption.

**Table 5.1 Monitoring Parameters for Thermal Power Plants in China**

	Parameters
Ash water	PH, Suspended Substances (SS), Chemical Oxygen Demand (COD), Fluoride, Sulphide, Arsenic, Discharge Volume, Lead*, Tin*, Chromium*, Hardness
Industrial wastewater	PH, SS, COD, Fluoride*, Arsenic*, Oil, Volatile Phenol*, Lead*, Tin*, Chromium*, Water Temperature, Discharge Volume
Municipal wastewater	COD, SS, Biochemical Oxygen Demand (BOD <sub>5</sub> ), Discharge Volume
Desulfurized wastewater	PH, SS, COD, Fluoride, Sulphide, Arsenic, Ammonia Nitrogen, Lead*, Tin*, Chromium*, Mercury*, Chloride Ion, Discharge Volume
Flue gas	Sulfur Dioxide (SO <sub>2</sub> ), Nitrogen Oxides (NO <sub>x</sub> ), Smoke Dust, Oxygen Content, Dust Abatement Efficiency, Flue Gas Volume (standard dry flue gas volume), Carbon Monoxide (CO), Desulfurization Efficiency, Humidity
Electromagnetic pollution	Area of the plant and major equipment, major cables
Ash (dry)	SO <sub>2</sub> , Burnt Volume, Extract (pH, Hardness, Fluoride, Cadmium (Cd), Arsenic (As), Zinc (Zn), Nickel (Ni), Copper (Cu), Pb, Hg and etc)
Noise	Environmental noise of the production area, noise at the boundary
	* optional items

Over the past ten years power plants have had to cope with a series of new environmental rules and procedures, some of which are overlapping and ambiguously defined, and many of which have changed repeatedly in recent years. Meanwhile these utilities are expected to be operated as commercially viable entities. The response is that many utilities install modern generating technologies to reduce fuel costs and invest in expensive environmental cleanup technologies to meet emerging environmental regulations. In many cases they are even installing state-of-the-art equipment.<sup>532</sup> However, emissions data suggests that the environmental controls are not being operated on a regular basis and that monitored data is often not being collected by local authorities and used for compliance. As it works to strengthen its

environmental framework, the Chinese government should therefore focus on improving the capabilities and reliability of the monitoring system, as well as the enforcement effectiveness of the local authorities in China.

The following provides an overview of monitoring standards and requirements for air emissions, water effluents, solid waste, and coal quality. The monitoring guidance for air emissions is much more developed than for some of the other environmental areas, and there is thus much more information available for this category of monitoring.

## **5.2 Air Emissions**

The Law of the People's Republic of China on Prevention and Control of Atmospheric Pollution is the key legislation for preventing and controlling atmospheric pollution. It was updated in 2000 and includes provisions on controlling SO<sub>2</sub>, NO<sub>x</sub> and PM, and encouraging desulfurization at coal-fired power plants.

### **5.2.1 Indirect Monitoring**

China's National Ambient Air Quality Standards (NAAQS) were established in 1982 (Regulation GB 3095-82) and revised in 1996. The standards, which are listed in Table 5.2 on the next page, set maximum allowable ambient pollution concentrations for different types of areas in China and cover TSP, PM<sub>10</sub>, SO<sub>2</sub>, NO<sub>x</sub>, carbon monoxide (CO), and ozone (O<sub>3</sub>). Class I standards are the most stringent and apply to national nature reserves, tourist and historic areas, and conservation sites (20 µg/m<sup>3</sup> SO<sub>2</sub> annual average; 50 µg/m<sup>3</sup> SO<sub>2</sub> daily average). Class II standards apply to residential, commercial traffic, cultural, ordinary industrial and rural zones (60 µg/m<sup>3</sup> SO<sub>2</sub> annual average; 150 µg/m<sup>3</sup> SO<sub>2</sub> daily average). Class III standards apply to specific industrial areas (100 µg/m<sup>3</sup> SO<sub>2</sub> annual average; 250 µg/m<sup>3</sup> SO<sub>2</sub> daily average).

**Table 5.2 National Ambient Air Quality Standards in China  
(Regulation No. GB 3095-1996)**

Pollutant	Average Period	Unit	Concentration Limit		
			Grade 1 (a)	Grade 2 (b)	Grade 3 (c)
SO <sub>2</sub>	Annual	mg/m <sup>3</sup>	0.02	0.06	0.10
	Daily	(standard	0.05	0.15	0.25
	1-hour	state)	0.15	0.50	0.70
TSP	Annual	mg/m <sup>3</sup>	0.08	0.20	0.30
	Daily	(standard	0.12	0.30	0.50
PM <sub>10</sub>	Annual	mg/m <sup>3</sup>	0.04	0.10	0.15
	Daily	(standard	0.05	0.15	0.25
NO <sub>x</sub>	Annual	mg/m <sup>3</sup>	0.05	0.05	0.10
	Daily	(standard	0.10	0.10	0.15
	1-hour	state)	0.15	0.15	0.30
NO <sub>2</sub>	Annual	mg/m <sup>3</sup>	0.04	0.04	0.08
	Daily	(standard	0.08	0.08	0.12
	1-hour	state)	0.12	0.12	0.24
CO	Daily	mg/m <sup>3</sup>	4.00	4.00	6.00
	1-hour	(standard	10.00	10.00	20.00
O <sub>3</sub>	1-hour	mg/m <sup>3</sup> (standard state)	0.12	0.16	0.20
Pb	Quarterly	µg/m <sup>3</sup>	1.50		
	Annual	(standard	1.00		
benzo[a]pyrene	Daily	µg/m <sup>3</sup> (standard state)	0.01		
			<b>Urban</b>	<b>Pastoral (d)</b>	<b>Agricultural (e)</b>
Flouride	Daily		7.00		
	1-hour		20.00		
	Monthly			1.80	3.00
	Plant Season			1.20	2.00

(a) Grade 1 standards apply to Type I regions: Natural conservation areas, scenic spots, historical sites, and areas in need of special protection.

(b) Grade 2 standards apply to Type II regions: Residential areas, mixed areas of residential, commercial, and roadway areas, cultural areas, industrial areas and rural areas.

(c) Grade 3 standards apply to Type III regions: Special industrial areas.

(d) Includes pastoral regions, mixed agriculture and pasture, and sericulture regions.

(e) Applicable to agricultural areas and forest regions.

The Chinese air quality monitoring system is at a relatively early development stage. At the present time, most of its local and regional monitoring systems cannot separate the impact of different sources of pollution. In particular, it cannot separate urban pollution from the pollution contributed by major sources, such coal-fired power plants, or by transboundary sources.<sup>533</sup> This is because ambient air quality monitoring stations are typically designed to measure only one of the following sources of pollution:

- Urban pollution (i.e., households, commercial buildings, automobiles, small industry);
- Transboundary pollution (i.e., background pollution); and
- Pollution from major sources (i.e., large industrial facilities and power plants).

In developed economies, this is usually not a problem because most of the large industrial sources and power plants are located outside urban centers. However, in China, power plants are often located in the middle of urban areas. Because monitoring stations can only track one type of pollutant at a time, stations located in

urban areas in China often cannot provide an accurate measurement of the contribution from an individual power plant versus that of other urban sources.

As a result, local and provincial authorities do not have sufficient information to determine whether targeted pollution reduction measures are effective at meeting their objectives. This became an issue when authorities wanted to reduce air pollution prior to the 2008 Beijing Olympics. Because the authorities did not know the specific contribution of individual industrial, power generation, and transportation sources, they did not know to what extent they needed to shut down plants and/or reduce traffic. Instead, operations were shut down based on estimates of their expected impact, and it was not until right before the opening of the Olympics that it became clear whether the selected strategies were sufficient and whether adjustments should be made.

### **5.2.2 Direct Monitoring**

Emission standards for coal-fired plants were introduced in 1991 and upgraded in 1996 and 2003. The 2003 standards were implemented on January 1, 2004, and specify much stricter SO<sub>2</sub>, NO<sub>x</sub> and particulate emission limits for all thermal plants, existing and new. The new standards apply to plants on a ‘Period’ basis – each of the three Periods encompasses all of the plants that were constructed or passed their environmental impact review within a given time frame.<sup>534</sup> Within each Period, implementation dates are specified for different emission limits.

In general, emission limits are specified in terms of concentrations (i.e., mg pollutant/m<sup>3</sup> exhaust gas), but the State Environmental Protection Agency (SEPA) also sets limits for the total quantity of SO<sub>2</sub> emissions allowed from power plants in Period three (measured in kg pollutant/hour). Allowed quantities of SO<sub>2</sub> emissions are determined on a plant-by-plant basis using a number of plant-specific parameters, including location (e.g., provincial location and proximity to urban areas), height of exhaust stacks and wind speed. Limits for allowable particulate emissions from coal plants are higher for rural areas than for urban areas.<sup>535</sup> The revised emission standards are provided in Table 5.3.

Local environmental agencies at the provincial and city level can enact stricter regulations than the ones identified in Table 5.3. Regional and local initiatives, implemented to improve existing emission standards, include output-based emission standards. In partnership with SEPA, three provinces – Shandong, Zhejiang, and Shanxi – have volunteered to test the use of an output-based approach to allocate their provincial SO<sub>2</sub> emissions cap.<sup>536</sup> This approach limits emissions of SO<sub>2</sub>, NO<sub>x</sub>, and particulates in terms of grams per kilowatt-hour (g/kWh). This approach is encouraged by SEPA because it may provide incentives for highly polluting facilities to improve their generation mix.

**Table 5.3 SO<sub>2</sub>, NO<sub>x</sub>, and PM<sub>10</sub> Emission Standards for Power Plants in China**

Maximum Emission Levels (mg/m <sup>3</sup> )							
Time Period (Power Plant Construction Date)			Period I (Pre-12/31/96)		Period II (1/1/97-1/1/04)		Period III (Post-1/1/04)
Date of Implementation			1/1/05	1/1/10	1/1/05	1/1/10	1/1/04
NO <sub>x</sub>	Coal Fired	V <sub>daf</sub> < 10%	1,500	-	1300	-	1,100
		10% ≤ V <sub>daf</sub> ≤ 20%	1,100	-	650	-	650
		V <sub>daf</sub> > 20%	1,100	-	650	-	450
	Oil Fired (Boiler)		650	-	400	-	200
	Oil Fired (Turbine)	All	-	-	-	-	150
	Gas Fired (Turbine)	All	-	-	-	-	80
SO <sub>2</sub>	Coal/Oil Fired	General	2,100*	1,200*	2,100	400	400
		Approved / Non-TCZ	-	-	1,200	1,200	-
		Coal Mine Waste	-	-	-	-	800
		Mine Mouth					1,200
PM <sub>10</sub>	Coal Fired	Urban Areas	300	200	200	50	50
		Rural Areas	600	200	600	50	50
		Approved / Non-TCZ	-	-	-	100	100
		Coal Mine Waste	-	-	-	200	200
	Oil Fired	All	200	100	100	50	50

Notes:

V<sub>daf</sub>: Volatiles content of dry, ash free coal

Approved/Non-TCZ: Applies to the overall average emissions from boiler plants with more than one boiler system, Period one only before January 1, 2004, and to coal mine mouth power plants burning ultra-low sulfur coal (S < 0.5%) in the western portion of the non "Two Control Zone" areas (including Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shanxi, Gansu, Qinghai, Ningxia, Xinjiang and Inner Mongolia).

Coal Mine Waste: Applies to resource comprehensive utilization power plants whose dominant fuel is coal mine waste (heating value < 12,550 kJ/kg).

Mine Mouth: Applies to coal mine mouth power plants burning ultra-low sulfur coal (S < 0.5%) in the western portion of the non-"Control Zone" areas (including Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shanxi, Gansu, Qinghai, Ningxia, Xinjiang and Inner Mongolia).

Urban Areas: Applies to thermal power plants located in the developed regions and the planning regions of cities at or above the county level

Rural Areas: Applies to thermal power plants located outside the developed regions and the planning regions of cities or above the county level

Source: PRC State Environmental Protection Administration. "Emission Standard of Air Pollutants for Thermal Power Plants," December 23, 2003. <http://www.sepb.gov.cn/biaozhun/huodianchang.pdf>

Newly built, renovated and expanded power plants that passed their environmental impact review in Phase III are required to meet the maximum allowable emission speed of SO<sub>2</sub>. The formula for calculating the speed is described below:

$$(1) Q = P \times \bar{U} \times H_g^2 \times 10^{-3}$$

$$(2) \bar{U} = \frac{1}{N} \sum_{i=1}^N U_i$$

$$(3) H_g = \sqrt{\frac{1}{N} \sum_{i=1}^N H_{ei}^2}$$

Where:

Q = Maximum allowable emission speed of SO<sub>2</sub> of the power plant, *kg/h*;

P = Emission control coefficient;

$\bar{U}$  = Average value of the wind speed at the exit of the stack, *m/s*;

H<sub>g</sub> = Equivalent unisource height of the stake in the power plant, *m*;

H<sub>ei</sub> = Effective height of the *i* stack, *m*;

U<sub>i</sub> = the wind speed at the exit of the *i* stack, *m/s*;

The effective height of the stack is: H<sub>e</sub> = H<sub>s</sub> + ΔH

Where:

H<sub>e</sub> = Effective height of the stake, *m*;

H<sub>s</sub> = Geometric height of the stack, *m*; when the geometric height of the stack exceeds 240m, use 240m for calculation;

ΔH = Raised height of the stack, *m*;

Table 5.4 provides the allowable emission control coefficient P value in different regions.

**Table 5.4 Maximum Allowable Emission Control Coefficient P Value in Different Regions**

Region	Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Hainan	Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, Hunan	Chongqing, Sichuan, Guizhou, Yunnan, Xizhuang, Shanxi, Gansu, Qinghai, Ningxia, Xinjiang, Inner Mongolia, Guangxi
Constructed and planned area in important city <sup>1</sup>	≤ 2.6	≤ 3.8	≤ 5.1
Constructed and planned area in ordinary city <sup>2</sup>	≤ 6.7	≤ 8.2	≤ 9.7
Area excluded from the city constructed and planned area	≤ 11.5	≤ 13.3	≤ 15.4

Notes: 1) "Important cities" include cities that have been prioritized for atmospheric pollution prevention by the State Council; and 2) "Ordinary cities" include country and other cities.

### Monitoring Parameters

The parameters that must be monitored at coal-fired power plants include the concentration and volume of PM, SO<sub>2</sub> and NO<sub>x</sub>, and auxiliary parameters such as oxygen content, temperature, humidity, pressure, speed and volume of the flue gas.

If CEMS are installed, the method used to monitor PM, SO<sub>2</sub>, NO<sub>x</sub> and other auxiliary parameters of the flue gas must follow the *Technical Standard for Continuous Emissions Monitoring of Flue Gas Emitted from Thermal Power Plants (HJ/T 75-2001)*.<sup>537</sup> The requirements of HJ/T 75-2001 are covered in Section 5.2.4 on CEMS.

Power plants that have not installed CEMS may use direct sampling or a hand-held PM monitoring instrument in accordance with the regulation *Determination of Particulates and Sampling Methods of Gaseous Pollutants Emitted Gas of Stationary Sources (GB/T16157-1996)*.<sup>538</sup>

### Monitoring Locations

The selection and set up of locations/points for monitoring PM, SO<sub>2</sub>, and NO<sub>x</sub> must follow the guidance in *The Determination of Particulates and Sampling Methods of Gaseous Pollutants Emitted Gas of Stationary Source (GB/T16157-1996)*. If the conditions at the power plant are such that the monitoring locations cannot meet the requirements in *GB/T16157-1996*, the plants must follow the specifications in the *Standard for Environmental Monitoring of Thermal Power Plants (DL/T 414-2004)*.

### Monitoring Frequency

Power plants must monitor the concentration and volume of PM, SO<sub>2</sub>, and NO<sub>x</sub> emissions once per year. Measurement of the auxiliary parameters must be undertaken prior to and after any repair of the PM abatement equipment.

### Analysis of Monitored Data

Measurement of the emissions volume and circulation rate of PM, and the emissions volume of SO<sub>2</sub> and NO<sub>x</sub> must follow the *Standard for Environmental Monitoring of Thermal Power Plants* and is further described in Tables 5.5 and 5.6.

**Table 5.5 Analytical Method for Measuring PM Emissions**

Monitoring Items	Analysis Method		Scope of Application
Smoke Dust	Gravimetric method		GB / T16157
	Optics Method	Opacity Method <sup>a</sup>	HJ / T75
		Light Scattering Method <sup>a</sup>	
a. Use hand-held smoke dust testing instrument, e.g. laser opacity instrument, infra red light scattering instrument.			



**Table 5.6 Analytical Method for Measuring SO<sub>2</sub> and NO<sub>x</sub> Emissions**

Monitoring Parameters		Analysis Method	Standard	Scope of Application
SO <sub>2</sub>		Iodometric method		Direct sampling method
		Formaldehyde absorbing-pararosaniline spectrophotometry	GB/ T15262	
		Fixed – potential electrolysis method	HJ/ T46	
		UV Fluorescence Method	HJ/ T75	Instrument monitoring method
		Non- dispersive infrared spectrometry		
NO <sub>x</sub>	NO or NO <sub>2</sub>	Griess-saltzman method	HJ/T43	Direct sampling method
		Fixed – potential electrolysis method	HJ/T45	
		Non- dispersive infrared spectrometry	HJ/T75	Instrument monitoring method
		Chemiluminescence Method		

### 5.2.3 Compliance Monitoring

The level of monitoring and compliance reporting varies throughout China. As noted in the introduction to this Chapter, local governments are responsible for monitoring and enforcing environmental regulations. Despite an extensive regulatory network, local enforcement efforts are not always very effective and, in the past, the central government has had limited success in enforcing environmental regulations, especially outside the major cities. Funding is limited and most local environmental bureaus are understaffed. Moreover, environmental protection goals often conflict with local employment and economic goals, reducing the incentives for local governments to adhere with national pollution control standards.

However, there are signs that the national authorities are beginning to take more direct measures to enforce regulations by ensuring that data reporting and compliance monitoring takes place as directed. Moreover, public concern surrounding local air pollution and the associated health impacts are driving more and more local governments to strengthen their monitoring frameworks.

For example, the city of Huainan in mid-eastern China required the installation of CEMS for PM, SO<sub>2</sub>, and NO<sub>x</sub> at its six thermal power plants, starting in 2005. This includes an online tracking system that collects read-outs from stack monitors every five minutes as well as stations for monitoring of emissions in the vicinity of the plant. The collected data is reported continuously to the city. It is also made available for public viewing and any exceedences are automatically reported to the plant operators, who are required to address problems according to back-up strategies that have been pre-approved by the city.<sup>539</sup> Along with the online monitoring, the plants must also undertake manual sampling every two months to determine whether there are any problems with the CEMS equipment.

The national monitoring office led by the Environmental Protection Office of the Department of Power and Industry is also investigating the success of China's efforts to improve its monitoring framework and increase the use of continuous monitoring. In 2006, it issued a plan for monitoring the implementation of China's SO<sub>2</sub> regulations during the 11<sup>th</sup> Five-Year Plan which runs from 2006 to 2010.<sup>540</sup> As part of the plan, data from 203 coal-fired power plants will be tracked and analyzed,

including information on SO<sub>2</sub>, NO<sub>x</sub>, and smoke dust emissions, sulfur content of the fuel, other required monitoring data, and basic information on the environmental controls used by the monitored plants. The investigation also covers how plants operate their online monitoring system. The results from the investigation will be compared with the results from the online monitoring systems to determine their accuracy and effectiveness.

The environmental monitoring authorities at the provincial level are responsible for sampling and monitoring the plants surveyed within their individual governing areas. They must then submit a monitoring report to the national monitoring office describing how the environmental controls and the CEMS were operated, analyzing plant effectiveness at achieving the emission standards, and comparing the result of the on-line monitoring with the regular monitoring of emissions and coal quality.

#### 5.2.4 Continuous Emissions Monitoring

There are a number of federal standards and guidelines requiring subsets of coal-fired power plants to install and use CEMS.

The *Emissions Standard for Air Pollutants at Thermal Power Plants (GB13223-1996)* introduced the first legal requirement in China for installing CEMS in Thermal Power Plants (it was issued in 1996 and implemented in January 1, 1997). The *Standard* requires thermal power plants to install CEMS for monitoring of:

- Flue gas in newly built, renovated and expanded power plants approved during Period III (i.e., after 1 January 2004);
- SO<sub>2</sub> in power plants within the Acid Rain Control Area and the SO<sub>2</sub> Pollution Control Area, and at thermal power plants with FGDs; and
- NO<sub>x</sub> at units of 300MW and above.

The *Standard* also stipulates that thermal power plants approved during Period II must gradually implement CEMS and must use the data obtained from the CEMS for monitoring of their legally required data.

In addition, the *Proposal for the Division of the Acid Rain and SO<sub>2</sub> Pollution Control Area*<sup>541</sup> published in 1998 required the installation of CEMS and the introduction of continuous monitoring of significant SO<sub>2</sub> emission sources. This includes thermal power plants within the Two Control Zone.<sup>542</sup> In 2001, in the *Tenth Five-Year National Environmental Protection Plan*, the State Council required the installation of on-line monitoring equipment by 2005 for the tracking of flue gas at coal-fired power plants.<sup>543</sup>

Starting July 1, 2003, according to Article 10 of the *Management Ordinance of the Levy and Use of Emission Fee*, monitored data must be used for the calculation of pollutants emitted by power plants and this data must be based on automatic monitoring equipment.<sup>544</sup> The SO<sub>2</sub> emissions levy is commonly based on the mass balance approach, also known in China as ‘the balanced calculation of materials.’ Since calcium in the coal can lead to desulfurization, and thus lowering emissions, the use of the mass balance approach generally overestimates SO<sub>2</sub> emission. As a result, plants may be charged a higher fee than would be required if the actual emissions

level were known. In 2002, to rectify this, the government required coal-fired power plants to install on-line CEMS to enable better and more accurate tracking of SO<sub>2</sub> and PM in the flue gas exhaust.<sup>545</sup>

Starting in 2004, SEPA required that thermal power boilers must be equipped with CEMS equipment<sup>546</sup> and that this equipment must meet the technical requirements of the *Technical Standard for Continuous Emissions Monitoring of Flue Gas Emitted from Thermal Power Plants (HJ/T175)*. The CEMS installation must be inspected and approved by the Environmental Protection Administration Department at the provincial or above level. The data obtained from the approved installation will be recognized as valid during the effective duration of the installed equipment.

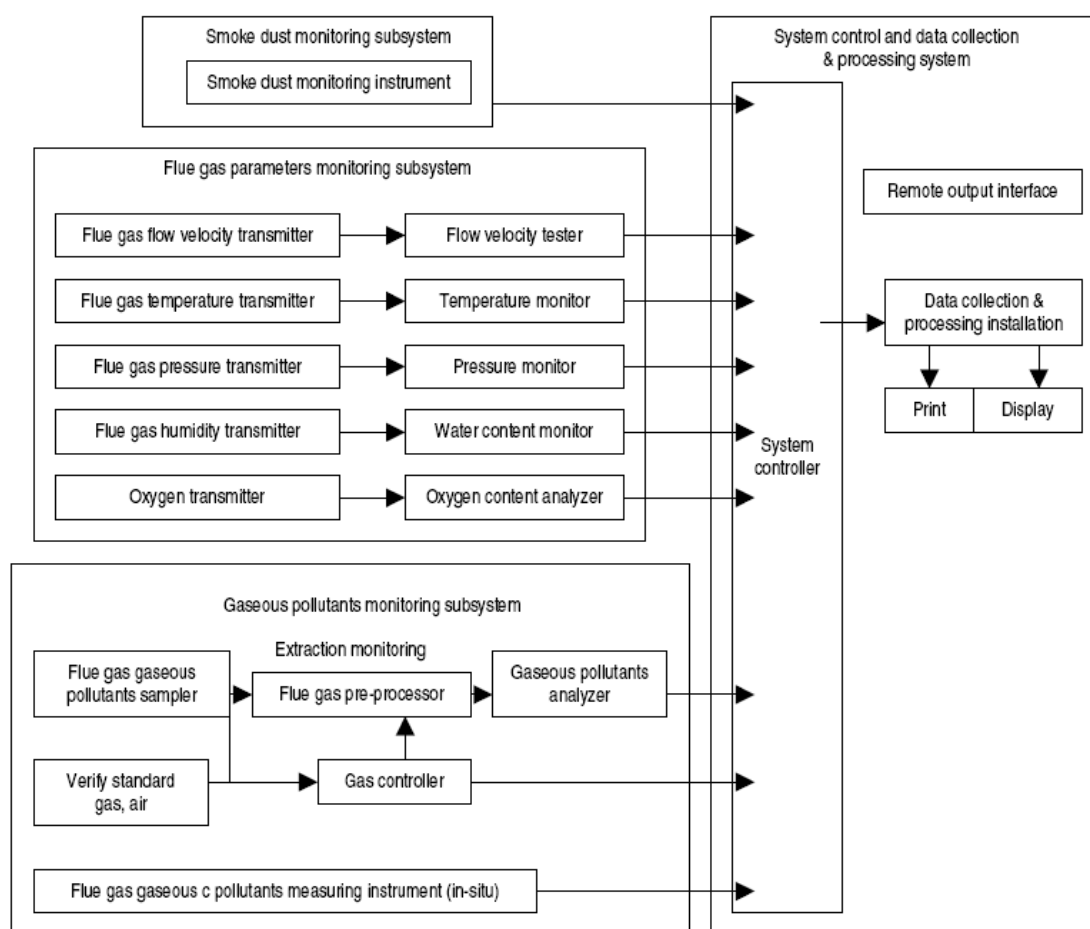
Also in 2004, SEPA required that all thermal power plants must install CEMS for monitoring of flue gas in accordance with the specifications in *HJ/T175*, and that they must do so before January 1, 2008.

In 2007, new CEMS specifications were announced through *The Specifications for Continuous Emissions Monitoring of Flue Gas Emitted from Stationary Sources* (on trial) (HJ / T 75-2007).<sup>547</sup> This document supersedes the 2001 version and was implemented on August 1, 2007. However, the new specifications are still at the trial stage and have not yet been formally published. The new specifications expand the CEMS guidance as follows:

- The application extends to industrial stationary sources;
- It provides more detail on the required monitoring locations;
- It provides more detail on data audit and management once the CEMS data has been obtained;
- It regulates the operation, management, and quality assurance of CEMS equipment; and
- It provides supplementary guidance on monitoring methods, technical requirements, and record sheets.

The *Technical Standard for Continuous Emissions Monitoring of Flue Gas Emitted from Thermal Power Plants (HJ/T 75-2007)* describes the specific monitoring requirements for tracking flue gas, SO<sub>2</sub> and NO<sub>x</sub>. Figure 5.1 depicts the basic composition of this monitoring system including the PM monitoring subsystem, the gaseous pollutants monitoring subsystem, the flue gas emission parameters monitoring subsystem, the system control, and the data collection and processing subsystem.

**Figure 5.1 Continuous Emission Monitoring System for Tracking Flue Gas**



In addition to the procedures outlined in Figure 5.1, plants must adhere to the following guidelines:

- The turbidimetric method and light scattering method must be used for monitoring of PM
- Gaseous pollutant monitoring must be used for monitoring of SO<sub>2</sub> and NO<sub>x</sub>. Here a sampling method must be used which can be classified as Sampling Continuous Monitoring and Insitu Continuous Monitoring. Sampling Continuous Monitoring is further divided into a dilution sampling method and a direct sampling method.
- The humidity, oxygen content and flow volume of flue gas must be included in any flue gas monitoring. The thermocouple method must be used for flue gas humidity monitoring and Zirconia must be used for oxygen content monitoring. Monitoring of flue gas flow volume can be done either through continuous monitoring or non-continuous monitoring.

### *Status of Continuous Emissions Monitoring*

Although several national monitoring guidelines now require installation of CEMS, the use of these is still not as wide-spread as originally intended. In 2004, the Environmental and Resources Department of the China Power Enterprise Alliance

Association surveyed the installation of CEMS in thermal power plants. The key findings are summarized below:

- The first installation of CEMS was run by a Guangdong Power Plant in 1986
- About 400 CEMS were installed in about 180 power plants by the time of the survey
- About 80% of the 400 CEMS were installed in the latest 2-3 years included in the survey period
- An analysis of the 101 CEMS installed at 75 representative power plants found that about 20% of the CEMS were in normal operation, 50% were run irregularly because of the quality of the CEMS and 27% of the CEMS could not be operated
- Only CEMS data from one power plant was accepted by the local Environmental Protection Department for calculating the emission fee.

In short, the survey revealed that more than half of the CEMS could not operate properly and that the monitored data from the CEMS typically was not accepted by the local authorities.

The survey identified the following limitations for the CEMS market:

- *The CEMS market is not standardized:* CEMS are either purchased as an attachment to the boiler / generation unit or purchased on the lowest cost basis. Insufficient quality control during procurement led to unsatisfied after-sale services including delayed and low quality installation, insufficient knowledge of the CEMS technical operators, lack of quality assurance and lack of components supply.
- *Lack of government management:* The Environmental Protection Department (EPD) only certifies whether the CEMS is installed, who is responsible for regular inspection, and the frequency of the inspection. However, the Department does not track usage of the CEMS data. Technically, the implementation of CEMS is advanced in China but the management has lagged behind, e.g., there is no internet or networking facilities at the EPD.
- *Lack of incentives for using CEMS for other purposes:* Since the levy is rarely calculated on the basis of CEMS data, power plant operators are not motivated to improve the accuracy and efficiency of the CEMS. The CEMS is not included in the testing system of the power plant operation and there is no competent staff for operating the CEMS.
- *Difficulty in the implementation of regulation:* Legislation requires verification of the environmental monitoring equipment prior to the operation. However, the survey shows that only 3 out of 75 power plants verify that their CEMS equipment is working despite the fact that the CEMS currently operating in the power plants were approved by the local Environmental Protection Department.
- *Insufficient regulation:* The technical specifications provided at the national level relate only to the types of CEMS that can be used. However, they do not

provide any standards, management and oversight of the inspection, verification, networking, and data use of the CEMS.

- *Tampering with the CEMS monitoring parameters:* To save costs some power plants have eliminated some of the required monitoring parameters and functions. For example, some plants reported taking out the humidity measurement and changing it to a fixed value, which affected the accuracy of the CEMS data.

The China Power Enterprise Alliance Association's survey was conducted in 2004. Since then some of the market barriers outlined above may have been mitigated through improved regulations and standards, including the publication of the new 2007 trial technical standards for CEMS. However, a survey conducted by Massachusetts Institute (MIT) in 2007, indicated that as of 2007, utilities still did not operate many of their environmental controls on a regular basis, even though they had often invested in state-of-the-art equipment.<sup>548</sup> For example, using self-reported CEMS data, four out of six plants belonging to the strictest regulatory category tracked in the survey were non-compliant with their required emission levels. These plants are some of China's newest, and still appear unable to meet their targets. Possible reasons for the high emissions include the fact that plants do not use low sulfur coal as required since this coal is more expensive and is in shortage in some areas; the use of an emissions levy as a compliance tool that is too low to act as a proper incentive; and the lack of preferential policies for plants that have installed FGDs.<sup>549</sup>

Based on the survey results, the MIT authors concluded that while market pressures have driven substantial improvements to the coal combustion technologies used at China's plants and regulatory pressures have brought about widespread installation of environmental cleanup systems, neither of these forces appears to have led to sound environmental practices at the plant level.

The MIT study thus confirms the findings of the earlier survey which indicate that although China has made great strides in terms of requiring the use of CEMS, it still needs to develop processes for operating, using, collecting, and analyzing the collected data and for ensuring that the reported data is used for compliance purposes. The findings also underscore the need for China to begin developing the infrastructure for collecting and analyzing available emissions data in a proper inventory.

### **5.3 Water Effluents**

There are no water effluents and discharge standards developed specifically for coal-fired power plants. Instead, the Standard for Pollution Control of Sewage Marine Disposal Engineering (GB18486 - 2001) applies to discharges to the marine environment and the Integrated Wastewater Discharge Standard (GB8979 - 1996) applies to discharges to river bodies or pipeline networks. The monitoring standards supporting these regulations vary according to the receiving body of the discharge, but none of them involve continuous monitoring.

The specific parameters and methods are outlined in the subsections below.

### *Monitoring Parameters*

The following parameters must be monitored related to water discharges:

- PH Value\
- Suspended Substances (SS)
- Chemical Oxygen Demand (COD)
- Oil
- Fluoride
- Arsenic and Arsenic Compounds
- Sulfide
- Volatile acid
- Ammonia Nitrogen
- Biochemical Oxygen Demand (BOD5)
- Animal and Vegetable Oil
- Water Temperature
- Discharge Volume

### *Monitoring Location*

Monitoring locations vary with the type of discharge that's being regulated. If the discharge is centralized to a specific point, the monitoring must take place at the major discharge point. If the discharge is dispersed across different points, the sampling must be done at the exit of each of these discharge points. Table 5.7 shows the monitoring locations for different water effluents.

In general, samples of water released from pipelines must be taken at the middle of the water current. If the depth of the water in the pipeline is high (e.g., >1m), the sampling must be done at the depth of 1/4 from the surface of the water body.

**Table 5.7 Monitoring Locations for Water Effluents from Coal-fired Plants**

Type of Discharge	Monitoring Location
Integrated wastewater from plant	Exit of the major discharge point outside the plant
Ash lagoon	Exit of the discharge point of the ash lagoon
Industrial wastewater (exclude ash water and municipal wastewater)	Exit of the discharge point of the plant
Municipal wastewater from plant	Exit of the discharge point outside the plant
Other wastewater	Exit of the discharge point
Treated wastewater	Exit of the discharge point

### *Monitoring Frequency*

Two samples from both the morning and afternoon shall be taken in each monitoring for regular discharge. The required monitoring frequency is outlined in Table 5.8.

**Table 5.8 Monitoring Frequency of Water Effluents**

Parameters	Discharge Type*				
	Ash lagoon	Industrial discharge from plant	Municipal discharge from plant	Treated discharge**	Other discharge**
pH Value	1/ 10 days	1/ 10 days			
SS	1/ 10 days	1/ 10 days	1/ month		
COD	1/ 10 days	1/ 10 days	1/ month		
Oil		> 2/ month			
Fluoride	1/ month	1/ month			
Arsenic and Arsenic Compounds	1/ month	1/ month			
Sulphide	1/ month				
Volatile acid	1/ year	1/ year			
Ammonia Nitrogen					
BOD <sub>5</sub>			1/ season		
Animal and Vegetable Oil			1/ month		
Water temperature		1/ month			
Discharge Volume	1/ month	1/ month	1/ month		

\* The monitoring parameters can be adjusted according to any special requirements of the Local Environmental Protection Department

\*\* Monitoring parameters must be determined by the nature of the discharge

### *Analysis of Monitored Water Effluent Data*

The analysis of the monitoring parameters must follow the hierarchy outlined below:

- National Standard on Water Quality Analysis
- Industrial Standard
- Other reference, including those developed at the local level

Table 5.9 outlines the required methods for analyzing the data collected through water quality monitoring.



**Table 5.9 Method for Analyzing Monitored Water Quality Data**

Monitoring Parameters	Method	Scope of Application	Testing Method
pH Value	Glass electrode method	Industrial wastewater	GB/T 6920
SS	Gravimetric method	Surface water, underground water, industrial wastewater	GB/T 11901
COD	Dichromate method	COD > 30mg/L water sample	GB/T 11914
Oil & Animal and Vegetable Oil	Near-infrared Spectrophotometry	Surface water, municipal wastewater, industrial wastewater	GB/T 16488
	Gravimetric method		SD 164
Fluoride	Ion selective electrode method	Surface water, underground water, industrial wastewater	GB/T 7484
	Fluor reagent spectrophotometric method		GB/T 7483
	Visual colorimetry with zirconium alizarinsulfonate	Drinking water, surface water, underground water, industrial wastewater	GB/T 7482
Arsenic and Arsenic Compounds	Silver diethyldithiocarbamate spectrophotometry	Water and wastewater	GB/T 7485
	Spectrophotometric method with silver salt	Surface water, underground water and drinking water	GB/T 11900
Sulfide	Methylene blue spectrophotometry	Underground water, surface water, municipal wastewater and industrial wastewater	GB/T 16489
	P-aminodimethyl aniline spectrophotometry	Wastewater	SD 164
	Iodometric method	Underground water and wastewater	HJ/T60 SD164
Volatile Acid	After distillation by means of 4-AAP spectrophotometric method	Drinking water, surface water, underground water and industrial wastewater	GB/T 7490
Ammonia Nitrogen	Nessler's reagent colorimetric method	Industrial wastewater	GB/T 7478
	Distillation and striation method		GB/T 7479
BODs	Dilution and seeding method	Scope: 2mg/L ~ 6000mg/L	GB/T 7488
Water Temperature	Thermometer	Surface water	GB/T 13195

## 5.4 Solid Waste

The Standard for Pollution Control on the Storage and Disposal Site for General Industrial Solid Wastes (GB18599-2001) includes standards for how power plants should dispose of coal ash.<sup>550</sup> Most commonly the ash is landfilled. However, there are no specific federal standards for monitoring this and other waste generated from coal-fired power plants.

## 5.5 Coal Quality

Coal mines and power plants are required to report the quality of their coal to the local authorities. However, there is no specific requirement for monitoring coal quality of coal-fired power plants. The local environmental authorities must use The Method of Quality Acceptance and Selective Examination for Receiving Coal in Power Plants (DL/T 570-1995) for the inspection and sampling of coal used in power plants. Specifically, they must inspect the coal in batch in accordance with the source of the coal, and the coal mine it comes from.

The inspected items include  $M_t$ ;  $M_{ar}$ ;  $A_d$ ;  $V_{daf}$ ;  $Q_{gr,d}$ ;  $S_{t,d}$  and  $H_{ad}$ . For the same batch of coal, inspection of  $S_{t,d}$  and  $H_{ad}$  must be undertaken once per quarter. The coal sample to be inspected must be compressed to a size of no less than 6mm and the quality no less than 7.5kg.

The quality of the coal is determined by the deviation between the  $Q_{gr,d}$  and  $A_d$  reported by the coal mine and the power plant. If the value of the deviation does not exceed the limits listed in Table 5.10, the coal will be considered qualified.

**Table 5.10 Allowable Deviation of  $A_d$ ,  $Q_{gr}$  and  $M_{ar}$**

Type of Coal	Scope of Ash $A_d$ (%)	Allowable Deviation		Scope of Water Content $M_{ar}$ (%)	Allowable Deviation $ \Delta M_{ar} $ (%)
		$ \Delta A_d $ (J/g)	$ \Delta Q_{gr,d} $ (MJ/kg)		
Raw coal, selected coal	> 20	$\leq 2.0$	$\leq 0.80$		
	$\leq 20$	$\leq 1.1$	$\leq 0.50$		
Other washed coal except head coal (include middings, slime)		$\leq 1.5$	$\leq 0.50$	All scope	$\leq 1.11$

## Chapter 6. Monitoring Frameworks in Other Developing Asian Economies

Asian economies have adopted a wide range of environmental regulations and emission standards for coal-fired plants, with Japan and Korea following some of the most stringent requirements in the world and developing Asian economies such as Indonesia, Philippines, Thailand, and Viet Nam using more lenient legislation.<sup>551</sup>

Monitoring frameworks also vary among developing Asian economies. Driven largely by widespread public skepticism towards coal-fired power in Thailand, the Thai government has developed an extensive monitoring framework which is largely on par with that of the developed world. Meanwhile, Indonesia, the Philippines, and Viet Nam are in the process of tightening their monitoring frameworks, but still have significant room for improvement.<sup>552</sup>

The following provides an overview of monitoring frameworks in Indonesia, the Philippines, Thailand and Viet Nam. Most of the information relates to monitoring of air emissions as this topic tends to receive much more information than the other pollutants and thus has been summarized in English language literature. In the case of monitoring for water and solid waste, few documents were available in English and it was beyond the scope of this study to translate the remaining documents. As a result, our conclusions are drawn mostly on the basis on these economies' experience with monitoring of air emissions. However, we expect that many of the overall conclusions also will be valid for the other areas of concern.

### 6.1 Indonesia

#### 6.1.1 Air Emissions

Indonesia's emission standards for coal-fired units target SO<sub>2</sub>, NO<sub>x</sub>, and particulate matter.<sup>553</sup> As outlined in Table 6.1, the standards were strengthened significantly in 2003, setting tougher limits for all plants sited after the year 2000. The standards are the same for all units, regardless of fuel type. In addition to these emission standards, Indonesia also specifies the permitted level of opacity. All units in operation after 2000 must have opacity of 20 percent or below. So far, all units have been able to meet these standards.<sup>554</sup>

**Table 6.1. Emission Standards for Power Plants in Indonesia – All Fuel Types**

Pollutant	Year	
	1996-2000	2000 onward
<b>Emission Standard (Mg/m<sup>3</sup>)</b>		
Particulate Matter	300	150
Sulfur Dioxide	1500	750
Nitrogen Oxide	1700	850
<b>Other</b>		
Opacity	40%	20%

*Source:* Decree of the State Minister for the Environment No. 13 of 1995 on Emission Standards for Stationary Sources (KEP-13/MENLH/3/1995)

## 6.1.2 Water Consumption and Aqueous Effluents

Indonesia regulates aqueous effluents from industry and power plants under the Regulation Concerning Control of Water Pollution passed in 1990. Applicable standards for coal-fired power plants are listed in Table 6.2.

**Table 6.2 Criteria for Water Quality: Category D – Water that May be Used for Agricultural Purposes, Small Business in Cities, Industries, and Hydro-Electric Generation**

No	Parameter	Unit	Max Concentration	Notes
	<b>Physical</b>			
1	Electrical Conductivity	umhos/cm (25°C)	2250	Depending on species of vegetation. Maximum capacity is for tolerant species
2	Temperature	°C	normal water temperature	According to local conditions.
3	Dissolved Solid Substances	mg/L	2000	Depending on species of vegetation. Maximum capacity is for tolerant species.
	<b>Chemical</b>			
	<b>a. Inorganic Chemical</b>			
1	Mercury	mg/L	0,005	
2	Arsenic	mg/L	1	
3	Baron	mg/L	1	
4	Cadmium	mg/L	0,01	
5	Cobalt	mg/L	1	
6	Chromium (Hexavalent)	mg/L	0,003	
7	Manganese	%	60	
8	Na (alkali salt)	mg/L	0,06	
9	Nickel			
10	pH			
11	Selenium			
12	Zinc			
13	Sodium Absorption Ratio (SAR)			Depending on species of vegetation. Maximum capacity is for tolerant species.
14	Copper			
15	Lead			
16	Residual Sodium Carbonate (RSC)			Maximum 1.25 for sensitive species; Maximum 2,50 for less sensitive species.
	<b>Radio Activity</b>			
1	Gross Alpha activity	Bq/L	0,1	
2	Gross Beta activity	Bq/L	1,0	

Source: Regulation Concerning Control of Water Pollution, Government Regulation Number 20 of 1990 <http://law.nus.edu.sg/apcell/dbase/indonesia/regs/inrwat.html#Top>

In addition to the standards outlined in Table 4.2, the change in water temperature between inlet and outlet of the power plants must be less than or equal to 2°Celsius. None of the existing units have been able to meet this standard.<sup>555</sup>

### 6.1.3 Coal Combustion By-Products

Coal ash (fly ash and bottom ash) is regulated as a Hazardous and Toxic Material under Indonesia's Government Regulation No. 18 Jo 85/1999: Hazardous Waste Management. Power plants must write a letter to the State Ministry for the Environment describing how the ash is handled, including who is buying any of the ash. Beyond this, there are no specific regulations for ash disposal. The State Ministry is in the process of developing more guidance for fly and bottom ash management.<sup>556</sup>

### 6.1.4 Monitoring and Compliance

Every three months, plants must report their air emissions, production of fly and bottom ash, opacity, and water temperature to the State Ministry for the Environment. In principle power plants could have their operating license suspended if they fail to meet the relevant standards. However, to date violators have simply been issued a warning letter from the State Ministry for the Environment and no further action has been taken.

Implementation of existing monitoring, enforcement, and compliance measures has been complicated by unclear division of authority between national, provincial, municipal, and local bodies.

### 6.1.5 Emerging Regulatory and Monitoring Guidance

Indonesia is in the process of developing new environmental regulations and monitoring procedures which are due to be completed by December 2008. The new 2008 Decree will be specific to thermal power plants, and would include the following.<sup>557</sup>

- More stringent emission limits for new coal-fired power plants, as follows:
  - o Sulfur dioxide 700 mg/Nm<sup>3</sup>
  - o Nitrogen Oxide 450 mg/Nm<sup>3</sup>
  - o Particulates 100 mg/Nm<sup>3</sup>

Compared with the existing emission standards in Indonesia, this entails a significant tightening of the NO<sub>x</sub> limit, while the standard for SO<sub>2</sub> and particulates remains quite lenient.

- Establishment of a pollutant inventory, which includes data on CO<sub>2</sub> emissions in addition to the traditional air pollutants. This would be accompanied by detailed monitoring procedures.
- New guidelines for monitoring and reporting of ambient air quality, including and assessment of the current level and manner of ambient air quality.
- Guidelines for the installation, testing, use, maintenance, and verification of CEMS. It is expected that all new plants and existing plants with the highest emission load (i.e., capacity > 25 MW) will be required to install CEMS. All other existing plants may continue to use manual monitoring
- The CEMS reporting would include:

- Daily emissions average;
- The % by which the emission standard is exceeded; and
- The % percent by which CEMS is not operated.

The 1998, 2003 and 2008 decrees are in the form of ‘command and control’ regulations which rely on pollution control systems and specified emission limits to reach specified environmental objectives. However, another Air Pollution Act is being considered for introduction in 2013 in the form of a trading or market-based approach to regulating GHG emissions.<sup>558</sup> Indonesia plans to cut the GHG emissions intensity of its energy activities by 17 percent below current levels by 2025,<sup>559</sup> and this Act would be a key step to meeting that goal.

To prepare for future trading, the Indonesian authorities are including guidelines for a CO<sub>2</sub> inventory in the new 2008 as this will generate an emissions baseline for the economy’s power plants and other large industrial sources.

## **6.2 The Philippines**

### **6.2.1 Air Emissions**

The Philippines’ air pollution control policy is outlined in the Philippine Clean Air Act (PCAA) and its Implementing Rules and Regulations (DAO 2000-81).<sup>560</sup> The air quality guidelines and standards that apply to coal-fired power generation are outlined in Tables 6.3, 6.4, and 6.5 and include emission limits for PM<sub>10</sub>, SO<sub>2</sub>, and NO<sub>x</sub>. The emission standards outlined in Table 6.1 are not stringent enough to result in the use of advanced clean coal combustion technology, but they will require the use of low-NO<sub>x</sub> burners and SO<sub>2</sub> scrubbers at new plants. The PCAA includes emission limits for mercury that apply to any industrial source. The standard is 5 mg/nm<sup>3</sup>, which is significantly higher than any possible emissions from coal-fired power plants.

Under the PCAA, emission permits will be issued for existing and new plants. Emissions quotas will be prescribed for each regional industrial center which then allocates emission allowances to pollution sources under their jurisdiction. However, there is no specific guidance on the process for how these allowances must be allocated.

For industrial sources, including coal-fired power plants, the PCAA introduced an emission charge system which includes fees proportional to the amount of pollutant emitted. However, this charge has not yet been implemented following a request by industry for a grace period while they implement the necessary controls.<sup>561</sup> The PCAA also allows tax incentives such as total credits and/or accelerated depreciation deductions for plants installing or retrofitting pollution control equipment.

**Table 6.3 National Emission Standards for Source Specific Air Pollutants**

Pollutant	Plant Type	Maximum Permissible Limit (mg/nm <sup>3</sup> )
Nitrogen Oxides (NO <sub>x</sub> ) as NO <sub>2</sub>	Fuel Burning Steam Generators: Existing Source	1,500
	New Source: Coal-fired	1,000
	Oil-fired	500
Sulfur dioxide (SO <sub>2</sub> )	Fuel Burning Equipment: Existing Source	1,500
	New Source	700
Particulate Matter (PM <sub>10</sub> )	Fuel Burning Equipment: Urban or Industrialized Area	150
	All other areas	200
Carbon Monoxide (CO)	Any industrial source	500
Mercury (Hg) as elemental Hg	Any source	5

*Note:* The Philippines did not have natural gas-fired electricity at the time the Clean Air Act was passed. Hence, it does not include NO<sub>x</sub> emission standards for this fuel option.

*Source:* The Philippine Clean Air Act of 1999. Republic Act (RA) 8749.

[http://www.tanggol.org/environmental\\_laws/cleanair.html](http://www.tanggol.org/environmental_laws/cleanair.html)

The PCAA became effective in 2001 and its standards are to be reviewed and/or updated every two years. No review has been undertaken of the standards pertaining to coal-fired electricity, and it is not anticipated that they will be updated in the near future.<sup>562</sup> However, there has been some discussion that the PCAA should be revised to distinguish between small and large sources. At the moment the law applies equally to all sizes, which places a higher burden on smaller entities as these typically are less efficient.

**Table 6.4 National Ambient Air Quality Guidelines for Criteria Pollutants**

Pollutants	Short Term			Long Term		
	µg/nm <sup>3</sup>	ppm	Ave. Time	µg/nm <sup>3</sup>	ppm	Ave. Time
Sulfur Dioxide (SO <sub>2</sub> )	180	0.07	24 hrs	80	0.03	1 year
Nitrogen Dioxide (NO <sub>2</sub> )	150	0.08	24 hrs			1 year
Suspended Particulate Matter:						
Total Suspended Particulate (TSP)	230		24 hrs	90		1 year
PM <sub>10</sub>	150		24 hrs	60		1 year
Photochemical Oxidants						
As Ozone	140	0.07	1 hr			
As Carbon Monoxide (CO)	60	0.03	8 hrs			
	35	30	1 hr			
	10	9	8 hrs			

*Source:* The Philippine Clean Air Act of 1999. Republic Act (RA) 8749.

[http://www.tanggol.org/environmental\\_laws/cleanair.html](http://www.tanggol.org/environmental_laws/cleanair.html)

**Table 6.5 National Ambient Air Quality Standards for Source Specific Air Pollutants from Industrial Sources/Operations**

Pollutants	Concentration		Averaging Time
	µg/nm <sup>3</sup>	ppm	(Minutes)
Sulfur Dioxide (SO <sub>2</sub> )	470	0.18	30
	340	0.13	60
Nitrogen Dioxide (NO <sub>2</sub> )	375	0.20	30
	260	0.14	60
Suspended Particulate Matter:			
Total Suspended Particulate (TSP)	150		60
PM <sub>10</sub>	200		60

*Source:* The Philippine Clean Air Act of 1999. Republic Act (RA) 8749.

[http://www.tanggol.org/environmental\\_laws/cleanair.html](http://www.tanggol.org/environmental_laws/cleanair.html)

The government has considered introducing SO<sub>2</sub> and NO<sub>x</sub> emissions trading for large sources because these would normally be run by large multinational corporations that are more experienced with the required continuous emissions monitoring systems.<sup>563</sup> However, before creating such as trading system, the government would have to determine the carrying capacity of each region, which would require extensive and costly modeling which the Philippine government currently cannot afford.

### 6.2.2 Water Consumption and Aqueous Effluents

The Clean Water Act of 2004 (RA 9275) includes effluent standards for water use (Table 6.6) that also apply to coal-fired power plants. There are no rules on the amount of water consumed by coal-fired plants as long as they are located near the coast and use sea water. Plants are not allowed to use ground water, and must certify this in the EIA.<sup>564</sup>

**Table 6.6 Effluent Standards: Toxic and Other Deleterious Substances (Maximum Limits for the Protection of Public Health)**

Parameter	Unit	Protected Waters Category I Class AA & SA		Protected Waters Category II Class A, B, & SB		Inland Waters Class C		Marine Waters Class SC		Marine Waters Class SD	
		OEI	NPI	OEI	NPI	OEI	NPI	OEI	NPI	OEI	NPI
Arsenic	mg/L	(b)	(b)	0.2	0.1	0.5	0.2	1.0	0.5	1.0	0.5
Cadmium	mg/L	(b)	(b)	0.05	0.02	0.1	0.05	0.2	0.1	0.5	0.2
Chromium	mg/L	(b)	(b)	0.1	0.05	0.2	0.1	0.5	0.2	1.0	0.5
Cyanide	mg/L	(b)	(b)	0.2	0.1	0.3	0.2	0.5	0.2	-	-
Lead	mg/L	(b)	(b)	0.2	0.1	0.5	0.3	1.0	0.5	-	-
Total Mercury	mg/L	(b)	(b)	0.05	0.005	0.005	0.005	0.005	0.005	0.05	0.01
PCB	mg/L	(b)	(b)	0.03	0.003	0.003	0.003	0.003	0.003	-	-
Formaldehyde	mg/L	(b)	(b)	2.0	1.0	2.0	1.0	2.0	1.0	-	-

Notes: "NPI" means New/Proposed Industry or wastewater treatment plants to be constructed.

"OEI" means Old or Existing Industry.

Source: DENR Administrative Order No. 35, Series of 1990. "Revised Effluent Regulations of 1990, Revising and Amending the Effluent Regulations of 1982."

<http://www.emb.gov.ph/laws/water%20quality%20management/dao90-35.html>

### 6.2.3 Coal Combustion By-Products

The Ecological Solid Waste Management Act of 2000 (RA 9003) sets guidelines and targets for solid waste avoidance and volume reduction through source reduction and waste minimization measures, including composting, recycling, re-use, recovery, green charcoal process, and others, before collection, treatment and disposal in appropriate and environmentally-sound solid waste management facilities. It places the primary enforcement and responsibility of solid waste management with local government units while encouraging cooperation among the national government, other local government units, non-government organizations, and the private sector for waste management.

Although coal ash is classified as a solid waste, the Act includes little guidance and monitoring for its disposal, except for the requirement that the landfills used for fly



ash must be lined.<sup>565</sup> All power plants have contracts to sell their fly ash for cement production, but the demand for fly ash is not enough to meet all the supply, so the remaining ash is dumped in landfills.

#### **6.2.4 Monitoring and Enforcement**

All government-owned and controlled corporations and private entities must prepare an environmental impact statement for every proposed project that may have a significant impact on the environment.<sup>566</sup> The screening and categorization of projects is based on their type, location and scale of the proposed technology, the sensitivity of the project site, and the nature and magnitude of the potential impacts. Once a plant is in operation it must submit a quarterly report, including a discussion of its maintenance of the air pollution control systems.

Environmental regulations are being enforced by a combination of measures, including:

- Monitoring by inspectors from the Department of Environment and Natural Resources;
- Inspection by local government units;
- Compliance monitoring of any “Special Conditions” listed in the Environmental Compliance Certificate (ECC);
- Submission of self-monitoring reports; and
- Multi-Partite/Stakeholder Monitoring (MMT)

Within this scheme the power plant operator is responsible for monitoring and self-reporting of emissions. Their quarterly monitoring reports are then validated by community stakeholders in the form of a ‘multi-partite monitoring team (MMT)’ and audited by inspectors from the Department of Environment and Natural Resources (DENR). This process was developed to increase public acceptance of coal-fired power and was intended to make it easier for the determination of non-compliance situations and potential corrective measures.<sup>567</sup>

However, the Philippines face several challenges with the implementation of this monitoring system including:

- Insufficient funding for monitoring and inspection at DENR;
- Lack of proper delineation of functions among agencies;
- Absence of adequate monitoring equipment among the plant operators and the MMT team;
- Different interpretation of environmental laws among regions;
- Lack of accredited sampling and monitoring providers in the economy;
- Absence of adequate laboratory facilities;
- Lack of funds for power plants to implement all environmental requirements (especially government-owned power plants); and

- Limited capacity and capability of monitoring agencies and its personnel to monitor and enforce regulations.<sup>568</sup>

For better monitoring, power plants are required to install CEMS. However, due to a shortage of funds, only the major international power providers are able to install these.

## 6.3 Thailand

### 6.3.1 Air Emissions

The emission standards for existing coal-fired units in Thailand target SO<sub>2</sub>, NO<sub>x</sub>, and particulate matter (Table 6.7). The limits differ, depending on whether they apply to units which acquired a permit of operation or expansion before or after 1996. They also are more stringent for larger units. In June 2008, Thailand significantly strengthened its emission standards for new power plants. The new standards are described in Table 6.8.<sup>569</sup>

In addition to meeting the emission standards specified in Tables 6.7 and 6.8, local authorities consider the impact of a new coal-fired power plant on local air pollution before agreeing to a permissible emission level. For example, if NO<sub>x</sub> concentrations are high in a specific region, a proposed plant could be asked to reduce NO<sub>x</sub> emissions even further than specified in Table 6.7 or 6.8.<sup>570</sup> There are no general guidelines for how such a decision would be made.

Table 6.9 describes Thailand's national ambient air quality standards.

**Table 6.7 Emission Standards for Existing Power Plants in Thailand\***

Type and Size of Power Plant	Emission Standard		
	Sulfur Dioxide (ppm)	Oxides of Nitrogen (ppm)	Particulates (mg/m <sup>3</sup> )
<b>Old Power Plant</b> (Permitted after January 31, 1996 or October 31, 2004 for Biomass and before June 2008)			
<b>Coal</b>			
<300 MWe	640	350	120
300-500 MWe	450	350	120
> 500 MWe	320	350	120
<b>Oil</b>			
<300 MWe	640	180	120
300-500 MWe	450	180	120
> 500 MWe	320	180	120
<b>Natural Gas</b>			
All sizes	20	120	60
<b>Biomass</b>			
All sizes	60	200	120
<b>Old Power Plant</b> (Permitted before January 31, 1996 or October 31, 2004 for Biomass)			
<b>Coal</b>	700	400	320
<b>Oil</b>	950	200	240
<b>Natural Gas</b>	60	200	60
<b>Biomass</b>	60	200	320
<b>Existing Power Plant</b>			
<b>Bang Pakong</b>			

Unit 1-4 (Thermal)	320	200	120
Unit 1-2 (Combined Cycle)	60	450	60
Unit 3-4 (Combined Cycle)	60	230	60
<b>South Bangkok</b>			
Thermal	320	180	120
Unit 1 (Combined Cycle)	60	250	60
Unit 2 (Combined Cycle)	60	175	60
<b>North Bangkok</b>	500	180	150
<b>Surat Thani</b>			
Gas Turbine	60	230	60
Combined Cycle	20	120	60
<b>Lan Krabu</b>	60	250	60
<b>Nong Chok</b>			
Gas Turbine	60	230	60
<b>Wang Noi</b>	60	175	60
<b>Num Phong</b>			
Combined Cycle	60	250	60
<b>Mae Moh†</b>			
Unit 1-3	1,300	500	180
Unit 4-13	320	500	180

\* 25°C, 1 atm (760 mm Hg), 7% O<sub>2</sub> on a dry basis.

† total SO<sub>2</sub> from Mae Moh plants 1-13 must not exceed 11 t/h (short tons)

Source: Notification of the Ministry of Industry B.E.2547 (2004), issued under Factory Act B.E.2535 (1992), dated September 28, B.E.2547 (2004). It w

**Table 6.8 Emission Standards for New Power Plants in Thailand**

Power Plant Type (size and fuel type)	TSP (mg/m <sup>3</sup> )	SO <sub>2</sub> (ppm)	NO <sub>x</sub> (ppm)
Coal			
≤ 50 MW	80	360	200
> 50 MW	80	180	200
Oil	120	260	180
Natural gas	60	20	120
Biomass	120	60	200

**Table 6.9 National Ambient Air Quality Standards – Thailand**

Pollutant	1 Hour Average	8 Hours Average	24 Hours Average	1 Month Average	1 Year Average
CO (ppm)	30	9	-	-	-
NO <sub>2</sub> (ppm)	0.17	-	-	-	-
SO <sub>2</sub> (ppm)	0.3	-	0.12	-	0.04
TSP (mg/m <sup>3</sup> )	-	-	0.33	-	0.1
PM-10 (mg/m <sup>3</sup> )	-	-	0.12	-	0.05
O <sub>3</sub> (mg/m <sup>3</sup> )	0.1	-	-	-	-
Pb (mg/m <sup>3</sup> )	-	-	-	0.0015	-

### 6.3.2 Water Consumption and Aqueous Effluents

As part of the permitting process, power plants must obtain a license to consume water. The allowable volume is determined by local authorities and depends on other uses for water near the site. The specific rules for water discharge also depend on local priorities and site specific issues, such as whether the water is discharged into a river or the ocean.<sup>571</sup>

Local authorities may also regulate the allowable temperature change from the intake. For example, Banpu Public Company's coal-fired plant, BLCF, must keep the

temperature change below 3° Celsius. Panpu has installed continuous emissions monitoring at the cooling tower, and is required to reduce the amount of water discharged if the temperature change is greater than 3°. Thailand's water quality standards are outlined in Table 6.10.

**Table 6.10 Effluent Standards for Industrial Plants and Estates**

Items	Unit	Standard Values
1. pH Value	-	5.5-9.0
2 Total Dissolved Solids (TDS)	mg/l	2.1) not more than 3,000 mg/l depending on receiving water or type of industry considered by Pollution Control Committee (PCC), but not to exceed 5,000 mg/l 2.2) not more than 5,000 mg/l exceed TDS of receiving water having salinity of > 2,000 mg/l or TDS of sea if discharge to sea
3. Suspended Solids (SS)	mg/l	≤ 50 mg/l depending on receiving water, type of industry, or type of waste water treatment system under consideration of PCC but not to exceed 150 mg/l
4. Temperature	°C	≤ 40
5. Color and Odor	-	Not objectionable
6. Sulfide (as H <sub>2</sub> S)	mg/l	≤ 1.0
7. Cyanide (as HCN)	mg/l	≤ 0.2
8. Heavy Metals		
8.1 Zinc (Zn)	mg/l	≤ 5
8.2 Chromium (Hexavalent)	mg/l	≤ 0.25
8.3 Chromium (Trivalent)	mg/l	≤ 0.75
8.4 Arsenic (As)	mg/l	≤ 0.25
8.5 Copper (Cu)	mg/l	≤ 2.0
8.6 Mercury (Hg)	mg/l	≤ 0.005
8.7 Cadmium (Cd)	mg/l	≤ 0.03
8.8 Barium (Ba)	mg/l	≤ 1.0
8.9 Selenium (Se)	mg/l	≤ 0.02
8.10 Lead (Pb)	mg/l	≤ 0.2
8.11 Nickel (Ni)	mg/l	≤ 1.0
8.12 Manganese (Mg)	mg/l	≤ 5.0
9. Formaldehyde	mg/l	≤ 1.0
10. Phenols	mg/l	≤ 1.0
11. Free Chlorine	mg/l	≤ 1.0

*Source:* Notification of Ministry of Science, Technology and Environment No.3, B.E. 2539 (1996), Dated January 3, B.E. 2539 (1996), published in the Royal Government Gazette, Vol. 113, Part 13 D, Dated February 13, B.E. 2539 (1996); Notification of Ministry of Industry, no.2, B.E. 2539 (1996), issued under Factory Act B.E. 2535 (1992), dated June 14, B.E. 2539 (1996), published in the Royal Government Gazette, Vol. 113, Part 52 D, dated June 27, B.E. 2539 (1996).

### 6.3.3 Coal Combustion By-Products

As part of the Environmental Impact Assessment (EIA), coal-fired power plants must describe how solid waste, including fly ash, is disposed of.<sup>572</sup> New plants are required to at least landfill ash in order to obtain an operating permit. Some power plants sell their ash to cement manufacturing companies for recycling. Fly ash is collected from six Mae Moh units and supplied to such companies.<sup>573</sup> The Thai Petrochemical Industry's (TPI) coal-fired plant in Rayong uses the ash in its own cement manufacturing facility. Most other coal-fired units in Thailand dump the ash in various places without any prior processing. For example, unused ash from Mae Moe is stored in a disused mine.

### **6.3.4 Monitoring and Compliance**

Power plants report their emissions to the Department of Industrial Works (DIW). If they exceed the specified emission standards, DIW has the authority to stop plants from operating for a given period. There have been cases in the past, where DIW has done so.<sup>574</sup>

In 1992, an air pollution incident occurred at the large Mae Moh power plant in the northern part of Thailand. The SO<sub>2</sub> concentrations were high enough to cause respiratory problems in local villages and damage to crops and livestock. The incident led to a tightening of air quality standards and installation of environmental controls. However, in 1998 a second pollution incident occurred before all the improvements had taken effect.

Even though operations at Mae Moh have been much more efficient since then and environmental controls (i.e., FGDs) have been installed at all units, the two pollution incidents led to significant public opposition to coal-fired power.<sup>575</sup> To address the public's concerns, the Thai government tightened regulations and instituted an extensive monitoring framework for the economy's thermal power plants. This includes a requirement that all power plants install CEMS for the monitoring of SO<sub>2</sub>, NO<sub>x</sub>, carbon monoxide, excess oxygen, opacity, flue gas temperature, and flue gas flow. Ambient air quality monitoring stations must also be installed for monitoring of air quality in the vicinity of plants. Newer plants also use CEMS for monitoring of water temperature.

All of the data collected through these monitoring systems must be collected through the plant's online monitoring system and be reported daily, weekly, and monthly to the local and national monitoring authorities. In the case of the Mae Moh power plant, the data is also reported daily to the local health authorities.

The DIW has established a pollutant inventory for tracking and analyzing reported emissions and effluent data.

## **6.4 Viet Nam**

### **6.4.1 Air Emissions**

In December 2006, the government of Viet Nam introduced new emissions standards for thermal power plants through the passage of the New Environmental Protection Law (2005). The standards, which are described in Table 6.11, include a site-specific formula for determining each unit's SO<sub>2</sub>, NO<sub>x</sub>, or PM limits. In this way, plants located near an urban or protected area will be required to use more efficient controls. The regulation also differentiates between plants that use coal with a high or low VOC content. Viet Nam has some domestic coal with a VOC content of less than 10%. However, a majority of this low VOC-content coal is exported, making most new plants subject to the more stringent target of 650 mg/nm<sup>3</sup>.

Until 2015, power plants permitted before 2006 are allowed to use a set of older emission standards. These are outlined in Table 6.13. After this, all plants will be subject to the new regulation. Plant operators will be charged a fee if the plants do

not comply with the standards, but the fee is very low at about 10 percent of the cost of environmental clean-up. It will increase gradually over the next 10 years until it covers the full treatment cost.

The standards are most challenging for NO<sub>x</sub> emissions. They are very strict compared with the older 1995 standards and are stronger than those applied by many neighboring economies. Power plant operators do not expect to have difficulties meeting the SO<sub>2</sub> standards.<sup>576</sup>

**Table 6.11 Emission Standards for Thermal Power Plants – New Build Units and Capacity Expansions Permitted in 2006 and Later**

Parameter	Fuel Type (mg/nm <sup>3</sup> )			Standard/Regulation Referenced
	Coal	Oil	Natural Gas	
Particulate matter	200	150	50	TCVN 5977: 1995
NO <sub>x</sub>	650 (coal with VOC content > 10%)	600	250	TCVN 7172: 2002
	1,000 (coal with VOC content ≤ 10%)			
SO <sub>2</sub>	500	500	300	TCVN 6750: 2000

*Notes:* The temperature of the boiler must be operated in standard condition. The oxygen concentration must be 6% at the boiler and 15% at the exhaust. The numbers in the table are invalid if diluting methods are applied.

*Source:* The Decision Requiring Use of Vietnamese Standards Regarding the Environment. Decision No 22/2006/QĐ-BTNMT, Ha Noi, Vietnam. December 18, 2006

Referring to Table 6.10 above, the emission standards for each individual unit should be calculated using the following equation:

$$C_{max} = C * K_q * K_v$$

Where

- C = the specific emission limit listed in Table 6.10
- K<sub>q</sub> = 1 if the unit capacity is ≤ 300 MW
- K<sub>q</sub> = 0.8 if the unit capacity is >300 MW and ≤ 600 MW
- K<sub>q</sub> = 0.7 if the unit capacity is > 600 MW
- K<sub>v</sub> = 0.6 if located < 2km from a natural, cultural, or historic heritage site (urban area Type I)
- K<sub>v</sub> = 0.8 if located inside or < 2 km from urban areas Type II, III, and IV, and outside Type I
- K<sub>v</sub> = 1.0 if located inside or < 2 km from an industrial zone or urban area Type V, and outside Types I, II, III, and IV
- K<sub>v</sub> = 1.2 if located in a valley
- K<sub>v</sub> = 1.4 if located in a mountain area

**Table 6.12 Sample Standards for New Individual Coal-fired plants, Depending on Location (mg/nm<sup>3</sup>)**

	< 2 km from heritage site (Type 1)		Inside or < 2 km from industrial zone or urban area Type V		Mountain area	
	300 MW	600 MW	300 MW	600 MW	300 MW	600 MW
PM <sub>10</sub>	120	84	200	140	280	588
NO <sub>x</sub> > 10% VOC	390	273	650	455	910	637
NO <sub>x</sub> ≤ 10% VOC	600	420	1,000	700	1,400	980
SO <sub>2</sub>	300	210	500	350	700	490

**Table 6.13 Industrial Emission Standards, Including Coal-fired Power – Units Permitted Before 2006**

Parameter	Power Plants Permitted before 1995	Power Plants Permitted in 1995-2005
	(mg/nm <sup>3</sup> )	
Particulate matter	600	400
NO <sub>x</sub>	2500	1000
SO <sub>2</sub>	1500	500

Source: Air Quality – Industrial Emission Standards – Inorganic Substances and Dust. TCVN 5939: 1995

#### 6.4.2 Water Consumption and Aqueous Effluents

In the case of waste water regulations, there are 37 parameters that industrial sources have to comply with, some of which are applicable to water from coal-fired power plants (Table 6.14). The standards that plant operators may have difficulty meeting, include those for temperature, suspended solids, and heavy metals like mercury.

**Table 6.14 Industrial Waster Water – Discharge Standards**

Items	Unit	Implementation Period		
		A	B	C
Temperature	°C	40	40	45
pH	-	6 – 9	5.5 – 9	5 – 9
Suspended Solids (TSS)	mg/l	50	100	200
Arsenic (As)	mg/l	0.05	0.1	0.5
Mercury (Hg)	mg/l	0.005	0.01	0.01
Lead (Pb)	mg/l	0.1	0.5	1
Cadmium (Cd)	mg/l	0.005	0.01	0.5
Chromium (VI)	mg/l	0.05	0.1	0.5
Chromium (III)	mg/l	0.2	1	2
Copper (Cu)	mg/l	2	2	5
Sulfide (as H <sub>2</sub> S)	mg/l	0.2	0.5	1

Source: Industrial Waste Water – Discharge Standards. TCVN 5945: 2005

#### 6.4.3 Coal Combustion By-Products

There are no requirements for ash handling and all ash from coal-fired plants is deposited in open dumps. Viet Nam does not have the technology for ash recycling. The concentration of carbon in the ash is high (about 10%). As a result, specialized techniques for processing would be required, but the government has postponed investment in relevant research activities due to cost.<sup>577</sup>

#### 6.4.4 Monitoring and Enforcement

All thermal power projects with a capacity of more than 50 MW must prepare an EIA and address how each of the standards outlined above will be satisfied. The EIA is therefore the first step in ensuring that the power plants comply with relevant environmental regulations. Table 6.15 outlines the pollutants monitored at sample power plants in Viet Nam. As illustrated, not all power plants are required to monitor the same pollutants.

**Table 6.15 Monitoring Requirements at Sample Thermal Power Plants**

Project	Monitoring	Monitoring Frequency (annual)
Phu My 2 thermal power plant	Surrounding air, surface water, aquatic organisms	3
Dien Dam complex	No information	
Hiep Phuoc thermal power plant	Surrounding air, surface water, waste water	3
Uong Bi thermal power plant	Surrounding air, surface water, underground water, soil	3
Phu My 1 power plant	Surrounding air, surface water	3
Western thermal power plant in O Mon (Can Tho province)	Surrounding air, surface water	4
Wartsila Diesel power plant	Surrounding air	4
Pha Lai 2 thermal power plant	Surrounding air, surface water	12
Amata gas-turbine power plant in Bien Hoa, electricity utility	Surrounding air	4
Can Tho thermal power plant	Surrounding air, surface water	4
Diesel thermal power plant in Nomura Industrial Park, Hai Phong	Surrounding air, surface water	4
Na Dương thermal power plant, vinacomin	No information	

Source: Hoang Duong Tung, Environmental Issues of Thermal Power Plants, Paper presented at: Cleaner Coal Asia 2008, Ha Long, Vietnam, 19-21 Aug 2008, [http://www.egcfe.ewg.apec.org/publications/proceedings/CleanerCoal/HaLong\\_2008/Day%202%20Session%201C%20-%20Huang%20Duong%20Tung%20Environmental%20Issues.pdf](http://www.egcfe.ewg.apec.org/publications/proceedings/CleanerCoal/HaLong_2008/Day%202%20Session%201C%20-%20Huang%20Duong%20Tung%20Environmental%20Issues.pdf)

Once operation of the power plant has begun, it is much harder to ensure compliance because the monitoring system in Viet Nam is very weak. None of Viet Nam's power plants have CEMS in place. All monitoring takes place manually and is required only three or four times a year. There is no current emission inventory for the existing units and no requirements for ambient air monitoring in the vicinity of the plants.<sup>578</sup>

Power plants self-monitor and every three to six months, depending on their size, report on their progress to the local authorities or the Ministry of Natural Resources and the Environment (MONRE). Only large plants (>300 MW) submit monitoring reports directly to MONRE. In a few cases where plants are located inside a sensitive area, the EIA also specifies that smaller plants must report to MONRE. From time to time, MONRE and the local authorities send out inspectors to monitor. However, this is not enough to ensure full compliance.<sup>579</sup>



The system does include some incentives for compliance. For example, if plant operators do not comply with the specified standards and/or fail to install necessary pollution controls, they are not allowed to expand capacity at their existing sites. If, during the permitting process, it is found that the plant operator is out of compliance, the operator will not be granted a permit for new units until a remediation plan has been agreed upon.<sup>580</sup> In 2006, a total of 11 thermal power plants conducted sufficient monitoring to pass the requirements established under their EIA. Only the OMon-3 Thermal Power Plant was rejected because the plant had started using diesel thus increasing emissions 2.5 times above the permitted level.<sup>581</sup> As illustrated in Table 6.16 is also taking action to resolve environmental problems at some of the existing plants, including completely shutting down the Tuy Hoa power plant.

**Table 6.16 Environmental Remedies at Sample Thermal Power Plants**

<b>Power plant</b>	<b>Issues to be solved</b>	<b>Resolution</b>
Chut power plant- Khanh Hoa	Movement to other place	Not moved due to budget shortfall
Tuy Hoa power plant - Phu Yên	Movement out of urban area	Stopped work
Power plant of Kon Tum Province - Kon Tum	Movement out of residential area, completion of noise-gas treatment system	About to be moved
Uong Bi power plant - Quang Ninh	Installation of toxic gas elimination system and ESP	Completed
Pha Lai 1,2 power plants - HaiDương	Water and gas emission treatment	Completed

Source: Hoang Duong Tung, Environmental Issues of Thermal Power Plants, Paper presented at: Cleaner Coal Asia 2008, Ha Long, Vietnam, 19-21 Aug 2008, [http://www.egcfe.ewg.apec.org/publications/proceedings/CleanerCoal/HaLong\\_2008/Day%20%20Session%201C%20-%20Huang%20Duong%20Tung%20Environmental%20Issues.pdf](http://www.egcfe.ewg.apec.org/publications/proceedings/CleanerCoal/HaLong_2008/Day%20%20Session%201C%20-%20Huang%20Duong%20Tung%20Environmental%20Issues.pdf)

## **Chapter 7. RECOMMENDATIONS FOR STRENGTHENING MONITORING FRAMEWORKS IN DEVELOPING APEC ECONOMIES**

Developing Asian economies continue to introduce and strengthen environmental regulations and monitoring for coal-fired power, focusing on efforts to limit conventional air pollutants, water effluents, and coal waste. The standards imposed in developing APEC economies are beginning to influence the use of environmental controls at new and existing capacity, but, except for China, they have not led to significant improvement in the use of more efficient combustion technology. Even though the use of environmental controls has increased, local air pollution and carbon dioxide emissions are growing.

Some of the reason for the continued growth in air pollution stems from the weak monitoring and enforcement frameworks in the region. APEC economies such as Thailand are almost on a par with developed nations with respect to regulating and monitoring emissions while other Asian economies, such as China, Indonesia, the Philippines, and Viet Nam have significant room for improvement. In the latter economies, technical monitoring standards are weak, maintenance requirements are not sufficient, the market for continuous emissions monitoring equipment is not standardized, and data is not yet tracked in public inventories that facilitate review and analysis of reported data.

If monitoring is weak, it is harder to determine compliance with applicable regulations and emission standards. It is also difficult to determine which plants should be rehabilitated or retrofitted with new technology. Lack of good data makes it difficult to determine whether current standards are sufficient or whether they should be strengthened specifically for coal-fired power plants versus other industrial sources. A move towards increased measurement and monitoring in developing Asian economies would help evaluate areas of concern to produce the most effective national and regional policies. Finally, the absence of good data may erode public confidence that plants actually are getting better at cleaning up pollutants.

As developing Asian APEC economies work to establish, implement, or strengthening monitoring requirements for coal-fired power plants, they can utilize and benefit from many of the practices in place in developed economies. This report presents recommendations tailored to developing Asian APEC economies based on lessons learned and effective practices in Australia, Canada, the EU, and the US. They are:

***Strengthen the Overall Air Quality Monitoring Framework:*** The air quality monitoring systems in China and other developed Asian economies are at a relatively early development stage. Many of the local and regional monitoring systems cannot separate the impact of different sources of pollution and, as a result, authorities may not have sufficient information to determine whether measures targeting coal-fired power and other large industrial sources are effective at meeting their objectives.

To strengthen the ambient air quality framework, national authorities may want to require air quality monitoring in the vicinity of large plants. They could also require monitoring of coal-fired power plants prior to obtaining a permit for building a new unit or expanding an existing unit. In this case, the monitoring station must be set up

before the new facility is built to assess air quality before the operation of the facility; this is usually done for at least one year.<sup>582</sup> The monitoring has to be undertaken near and surrounding the source of interest and it has to be upwind and downwind of the prevailing wind direction. To meet this requirement, each source would need a minimum of three monitoring stations to produce a useful result. In addition, a dispersion model must be developed to predict the pollution around the source before the project is implemented. The model would be calibrated using the actual measurements and would then be used after project implementation to assess the impact of the new generating unit.

If interference from other pollution sources is low, the difference between the upwind and downwind measurements could be representative of the impact of the new emission source. However, in some cases, existing urban pollution in Asian cities may be too high to produce accurate results. In that case, local authorities must critically reevaluate their entire air quality monitoring network to:

- 1) Determine the effectiveness of individual stations in monitoring desired parameters;
- 2) Assess the optimum location of monitoring stations; and
- 3) Identify and use dispersion models that can be used to evaluate pollutant impacts.

Authorities should also begin to develop emission inventories of large sources that can be used for identifying and categorizing various sources. This should include any new sources that are expected within the near future.

Developing a more sophisticated air quality monitoring system will require a substantial amount of resources, both on the part of the utilities which will be required to install monitoring stations in the vicinity of the plants and on the part of the local authorities that must enhance the capabilities of the overall monitoring framework and dispersion modeling system. Significant support from international organizations would likely be required. National and regional authorities must also weigh the near-term financial costs with the long-term benefits of improving air quality and reducing negative health impacts to local populations.

***Streamline Regulations and Monitoring Practices:*** In some economies, such as China, a series of new regulations and monitoring guidance affecting coal-fired power have been introduced over the past ten years. In some cases, these national requirements have been augmented by local guidelines and standards. As a result, it is not always easy for plant operators to determine which practices to follow and local authorities have not always adapted to the federal mandates. For example, many local governments do not always incorporate data collected from CEMS into the calculation of emission fees thereby removing the incentive for using these systems once installed. Better coordination and streamlining among all regulatory and implementing bodies would help alleviate this problem.

***Establish Pollutant Inventories for Public Data Disclosure and Regulatory Review:***

Public data disclosure, in addition to public involvement, is a key component of successful monitoring frameworks in developed economies and one that is often missing or underutilized in developing economies. Australia, Canada, and the EU each require coal-fired power plants to report on pollutants released to the air, water, and waste to national inventory programs in order to provide free, public information about environmental areas of concern. The information is also used to evaluate progress towards meeting environmental objectives and for identifying areas that need improvement. Over the years, these national inventories have become important indicators of environmental management in each individual economy.

A key component in developing an effective monitoring framework in developed Asian economies would be to establish such inventories. This would include investment in /development of the infrastructure required to support automated public data reporting, as well as guidance documents and training for operators.

***Comprehensive Guidance for CEMS:*** If continuous emissions monitoring is not already required, national governments should begin working towards the use of such systems. If resources are short, governments may begin by requiring new facilities to adopt these. In the medium term, once the use of PEMS has become more established in the US and other developed economies, Asian economies may also want to begin including these in their monitoring regimes.

The use of CEMS should be accompanied by extensive technical guidance for its certification, operation and management. This includes standards for the plants using these and the local authorities overseeing their implementation and analyzing the reported data. The US CEMS protocol is the most comprehensive in this area and is typically referenced by other economies in the development of their monitoring standards.<sup>583</sup> This document can be accessed at:

- US EPA, *Plain English Guide to the Part 75 Rule (Continuous Emission Monitoring Rule)*, September 2005  
[http://www.epa.gov/airmarkt/emissions/docs/plain\\_english\\_guide\\_part75\\_rule.pdf](http://www.epa.gov/airmarkt/emissions/docs/plain_english_guide_part75_rule.pdf)

Guidance targeted to directly to power plant operators should include.<sup>584</sup>

- Specifications for the types of technologies that can be used. This would ensure that only well-established systems with proven accuracy, precision, and reliability are being purchased;
- Clear performance specifications to define the required accuracy, precision, and stability of the CEMS. In the US, performance criteria are demonstrated during the initial certification for CEMS;
- Establishment of allowable design and installation criteria;
- Performance criteria for CEMS certification;
- Guidance on calibration checks, reporting (i.e., electronically), gases to be checked, operation, third party involvement, and quality assurance;

- Steps for development of a quality assurance and quality control (QA/QC) plan; and
- Specification of frequency of data transmittal.

Guidance targeted to directly to power plant operators should include:<sup>585</sup>

- Creation of networking facilities for collecting data reported from power plants;
- Development of auditing software for analyzing reported data;
- Training of staff to understand CEMS technologies, use auditing software, conduct site visits to check certification and operation of CEMS, and verify QA/QC procedures; and
- Specify enforcement procedures.

***Develop Streamlined Monitoring Support Documents:*** Organized, easy-to-find references and guidance manuals on regulations and monitoring practices provide a meaningful, relatively simple way to help utilities fulfill their monitoring responsibilities.

In many cases the regulations and monitoring regulations are highly detailed and potentially hard to follow. Good examples of simplified references include:

- EU, Directive Summaries, e.g., *Summary of Directive 2001/80/EC on the limitation of emissions of certain pollutants into the air from large combustion plants (the LCP Directive)*,  
<http://ec.europa.eu/environment/air/pollutants/stationary/lcp.htm>
- US EPA, *Plain English Guide to the Clean Air Act*, April 2007  
<http://www.epa.gov/air/caa/peg/peg.pdf>
- US EPA, *Plain English Guide to the Part 75 Rule (Continuous Emission Monitoring Rule)*, September 2005  
[http://www.epa.gov/airmarkt/emissions/docs/plain\\_english\\_guide\\_part75\\_rule.pdf](http://www.epa.gov/airmarkt/emissions/docs/plain_english_guide_part75_rule.pdf)

It often easiest to follow and understand regulations and corresponding monitoring requirements when all the information – including emissions to air, water and land – is in one document. Presenting the material in such a manner may allow operators to use of synergies between different monitoring practices. The following example was developed for inventory reporting but could also be applied to broader industry practices:

- Australian Government, National Pollutant Inventory, Emission Estimation Technique Manual for Fossil Fuel Electric Power Generation, March 2005, Version 2.4, 15 March 2005,  
[http://www.npi.gov.au/handbooks/approved\\_handbooks/pubs/elec-supply.pdf](http://www.npi.gov.au/handbooks/approved_handbooks/pubs/elec-supply.pdf)

***Ensure Effective Enforcement:*** A critical component of a successful monitoring framework is ensuring that monitoring practices are followed in order to meet all applicable standards/goals. Inconsistent, infrequent or minimal enforcement is a

problem in a number of developing Asian economies. Suggested improvements include:

- Additional financial support to increase the number of auditors and their efforts;
- Increased frequency and number of site-visits;
- Development of metrics for tracking and improving performance;
- Monitoring by techniques, such as CEMS or PEMS, that automate all data acquisition, so it can be reported and processed in a timely manner directly to authorities with minimal, if any, manual interference; and
- Purchase/development of automated auditing software for tracking and analyzing reported data.

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<sup>1</sup> EIA. 2008. International Energy Outlook-Table H.4co2 World Carbon Dioxide Emissions from the Consumption of Coal, 1980-2006. U.S. Department of Energy (DOE) Energy Information Administration (EIA). <http://www.eia.doe.gov/emeu/international/carbondioxide.html>

<sup>2</sup> EIA. 2008. International Energy Outlook-Table H.4co2 World Carbon Dioxide Emissions from the Consumption of Coal, 1980-2006. U.S. Department of Energy (DOE) Energy Information Administration (EIA). <http://www.eia.doe.gov/emeu/international/carbondioxide.html>

<sup>3</sup> EIA. 2008. International Energy Outlook- Figure 82: World Carbon Dioxide Emissions from Coal Combustion, 1990-2030. In: Chapter 7- Energy-Related Carbon Dioxide Emissions. U.S. Department of Energy (DOE) Energy Information Administration (EIA). <http://www.eia.doe.gov/oiaf/ieo/emissions.html>. Accessed 18 November 2008.

<sup>4</sup> Including coarse (PM<sub>10</sub>) and fine particulate matter (PM<sub>2.5</sub>)

<sup>5</sup> For SO<sub>2</sub>, NO<sub>x</sub> and PM, but also an increasing amount for Hg and CO<sub>2</sub>.

<sup>6</sup> Agriculture and Resource Management Council of Australia and New Zealand, National Water Quality Management Strategy, April 1994, [http://www.mincos.gov.au/\\_\\_data/assets/pdf\\_file/0009/316098/doc2-policies-principles.pdf](http://www.mincos.gov.au/__data/assets/pdf_file/0009/316098/doc2-policies-principles.pdf)

<sup>7</sup> How Can Environmental Regulations Promote Clean Coal Technology Adoption in APEC Developing Economies?, APEC#207-207-RE-01.12, November 2007, [http://www.apec.org/apec/publications/all\\_publications/energy\\_working\\_group.html](http://www.apec.org/apec/publications/all_publications/energy_working_group.html)

<sup>8</sup> US EPA, Plain English Guide to the Part 75 Rule, [http://epa.gov/airmarkets/emissions/docs/plain\\_english\\_guide\\_part75\\_rule.pdf](http://epa.gov/airmarkets/emissions/docs/plain_english_guide_part75_rule.pdf)

<sup>9</sup> US EPA, Plain English Guide to the Clean Air Act, <http://epa.gov/air/caa/peg/peg.pdf>

<sup>10</sup> US EPA, Office of Air and Radiation, Six Common Air Pollutants, SO<sub>2</sub>: What is it? Where does it come from?, <http://www.epa.gov/air/urbanair/so2/what1.html>

<sup>11</sup> US EPA, Office of Air and Radiation, Six Common Air Pollutants, NO<sub>x</sub>: What is it? Where does it come from?, <http://www.epa.gov/air/urbanair/nox/what.html>

<sup>12</sup> US EPA, Office of Air and Radiation, Six Common Air Pollutants, Particulate Matter, <http://www.epa.gov/air/particlepollution/index.html>

<sup>13</sup> Alberta Government, What is monitored?, May 12, 2005 <http://www3.gov.ab.ca/env/air/AmbientAirMonitoring/whatismonitored.html>

<sup>14</sup> Ambient air quality is a measure of the substances dispersed in the air, and is used to indicate the state of the air. What effect air emissions (the quantity of a substance released to the air from a given

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source) have on ambient air quality depends on numerous factors including: winds, topography, temperature, precipitation, sunlight and height of the emitting source.

<sup>15</sup> NO<sub>2</sub> is one of several oxides of nitrogen and one of the most prominent air pollutants.

<sup>16</sup> Energy Technologies Enterprises Corporation. Shandong SO<sub>2</sub> Control Assessment. Draft report prepared for the US Environmental Protection Agency. June 2006.

<sup>17</sup> New Source Review – Prevention of Significant Deterioration permits

<sup>18</sup> Alberta Air Emission Standards for Electricity Generation, Environmental Policy Branch, December 2005, [http://www3.gov.ab.ca/env/air/Documents/2006\\_Power\\_Plant\\_Emission\\_Standards.pdf](http://www3.gov.ab.ca/env/air/Documents/2006_Power_Plant_Emission_Standards.pdf)

<sup>19</sup> Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales, Department of Environment and Conservation (NSW), Revised: August 26, 2005, <http://www.environment.nsw.gov.au/resources/ammodeling05361.pdf>

<sup>20</sup> Prevention of Significant Deterioration (PSD) permits are for attainment areas.

<sup>21</sup> Australian Government, National Pollutant Inventory, Emission Estimation Technique Manual for Fossil Fuel Power Generation, Version 2.4, 15 March 2005, [http://www.npi.gov.au/handbooks/approved\\_handbooks/pubs/elec-supply.pdf](http://www.npi.gov.au/handbooks/approved_handbooks/pubs/elec-supply.pdf)

<sup>22</sup> Environment Canada, Guide for Reporting to the National Pollutant Release Inventory 2006, [http://www.ec.gc.ca/pdb/npri/2006Guidance/Guide2006/2006\\_NPRI\\_Guide\\_e.pdf](http://www.ec.gc.ca/pdb/npri/2006Guidance/Guide2006/2006_NPRI_Guide_e.pdf)

<sup>23</sup> For monitoring emissions of mercury (Hg) to the air, a sorbent trap monitoring system – an alternative type of continuous Hg monitoring system – may be used instead of an Hg CEMS.

<sup>24</sup> Australian Government, National Pollutant Inventory, <http://www.npi.gov.au>

<sup>25</sup> Environment Canada, National Pollutant Release Inventory, [http://www.ec.gc.ca/pdb/npri/npri\\_home\\_e.cfm](http://www.ec.gc.ca/pdb/npri/npri_home_e.cfm)

<sup>26</sup> Europa, The European Pollutant Emission Register (EPER) and the European Pollutant Release and Transfer Register (E-PRTR), <http://ec.europa.eu/environment/ippc/eper/index.htm>

<sup>27</sup> U.S. EPA, Technology Transfer Network Clearinghouse for Inventories & Emissions Factors, What is the National Emissions Inventory (NEI)?, <http://www.epa.gov/ttn/chief/net/neiwhatis.html>

<sup>28</sup> Protection of the Environment Operations (Clean Air) Regulation 2002, New South Wales, <http://www.legislation.nsw.gov.au/viewtop/inforce/subordleg+642+2002+first+0+N>

<sup>29</sup> Department of Environment and Conservation (NSW), Load Calculation Protocol (February 2005), <http://www.environment.nsw.gov.au/resources/loadcalprotfeb05.pdf>

<sup>30</sup> Environment Canada, Clean Air Online, Guidelines and Codes of Practice, [http://www.ec.gc.ca/cleanair-airpur/Pollution\\_Sources/Electricity\\_Generation/Guidelines\\_and\\_Codes\\_of\\_Practice-WS047445FC-1\\_En.htm](http://www.ec.gc.ca/cleanair-airpur/Pollution_Sources/Electricity_Generation/Guidelines_and_Codes_of_Practice-WS047445FC-1_En.htm)

<sup>31</sup> Alberta Air Emission Standards for Electricity Generation, Environmental Policy Branch, December 2005, [http://www3.gov.ab.ca/env/air/Documents/2006\\_Power\\_Plant\\_Emission\\_Standards.pdf](http://www3.gov.ab.ca/env/air/Documents/2006_Power_Plant_Emission_Standards.pdf)

<sup>32</sup> European Commission, Stationary Source Emissions, Large Combustion Plants Directive, <http://ec.europa.eu/environment/air/stationary.htm#1>

<sup>33</sup> European Commission, The IPPC directive, <http://ec.europa.eu/environment/ippc/index.htm>

<sup>34</sup> Though under the ambient standard for PM<sub>2.5</sub>, new sources in areas not meeting the standard will likely, eventually be subject to emission limits under the US Clean Air Act New Source Review Program.

<sup>35</sup> US EPA, Compliance Monitoring, Clean Air Act Compliance Monitoring, <http://www.epa.gov/Compliance/monitoring/programs/caa/index.html>

<sup>36</sup> Canadian Council of Ministers of the Environment, Mercury, [http://www.ccme.ca/ourwork/air.html?category\\_id=85](http://www.ccme.ca/ourwork/air.html?category_id=85)

<sup>37</sup> Australian Government, Department of Environment and Water Resources, National Pollutant Inventory, List of NPI Substances, [http://www.npi.gov.au/about/list\\_of\\_subst.html#table1](http://www.npi.gov.au/about/list_of_subst.html#table1)

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- <sup>38</sup> UNECE, To The 1979 Convention on Long-Range Transboundary Air Pollution on Heavy Metals, <http://www.unece.org/env/lrtap/full%20text/1998.Heavy.Metals.e.pdf>
- <sup>39</sup> EUR-Lex, Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air, <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32004L0107:EN:HTML>
- <sup>40</sup> EUR-Lex, Council Directive 96/62/EC of 27 September 1996 on ambient air quality assessment and management, <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31996L0062:EN:HTML>
- <sup>41</sup> Canadian Council of Ministers of the Environment, Canada-Wide Standards for Mercury Emissions from Coal-Fired Electric Power Generation Plants, [http://www.ccme.ca/assets/pdf/hg\\_epg\\_cws\\_w\\_annex.pdf](http://www.ccme.ca/assets/pdf/hg_epg_cws_w_annex.pdf)
- <sup>42</sup> UNECE, To The 1979 Convention on Long-Range Transboundary Air Pollution on Heavy Metals, <http://www.unece.org/env/lrtap/full%20text/1998.Heavy.Metals.e.pdf>
- <sup>43</sup> The same as applies to the IPPC and LCP Directives.
- <sup>44</sup> US EPA, Clean Air Markets, Clean Air Mercury Rule (CAMR), <http://epa.gov/airmarkets/progsregs/camr/index.html>
- <sup>45</sup> State of New Jersey et al. v Environmental Protection Agency, United State Court of Appeals for the District of Columbia Circuit, No. 05-1097, Argued December 6, 2007, Decided 8 February 2008.
- <sup>46</sup> At stake in the case was the issue of whether the CAMR program violated the Clean Air Act because it did not require implementation of BAT in all new and existing coal-fired power plants that met certain criteria.
- <sup>47</sup> US EPA, Plain English Guide to the Part 75 Rule [http://www.epa.gov/airmarkets/emissions/docs/plain\\_english\\_guide\\_part75\\_rule.pdf](http://www.epa.gov/airmarkets/emissions/docs/plain_english_guide_part75_rule.pdf)
- <sup>48</sup> The units affected under the CAMR are also affected under the CAIR.
- <sup>49</sup> CEMS required for the US Acid Rain Program.
- <sup>50</sup> US EPA, Plain English Guide to the Part 75 Rule [http://www.epa.gov/airmarkets/emissions/docs/plain\\_english\\_guide\\_part75\\_rule.pdf](http://www.epa.gov/airmarkets/emissions/docs/plain_english_guide_part75_rule.pdf)
- <sup>51</sup> US EPA, Plain English Guide to the Part 75 Rule [http://www.epa.gov/airmarkets/emissions/docs/plain\\_english\\_guide\\_part75\\_rule.pdf](http://www.epa.gov/airmarkets/emissions/docs/plain_english_guide_part75_rule.pdf)
- <sup>52</sup> Science Daily, Carbon Dioxide Emissions from Power Plants Rated Worldwide, November 15, 2007, <http://www.sciencedaily.com/releases/2007/11/071114163448.htm>
- <sup>53</sup> European Commission, EU Action against Climate Change, EU emissions trading – an open scheme promoting global innovation 2005, [http://ec.europa.eu/environment/climat/pdf/emission\\_trading3\\_en.pdf](http://ec.europa.eu/environment/climat/pdf/emission_trading3_en.pdf)
- <sup>54</sup> Australian Government, Department of Climate Change, Australian Emissions Trading Scheme (ETS), <http://www.greenhouse.gov.au/emissionstrading/index.html>
- <sup>55</sup> New South Wales, Greenhouse Gas Reduction Scheme (GGAS), Overview, [http://greenhousegas.nsw.gov.au/overview/scheme\\_overview/overview.asp](http://greenhousegas.nsw.gov.au/overview/scheme_overview/overview.asp)
- <sup>56</sup> RGGI website: [http://www.rggi.org/docs/mou\\_rggi\\_overview\\_12\\_20\\_05.pdf](http://www.rggi.org/docs/mou_rggi_overview_12_20_05.pdf)
- <sup>57</sup> In this report, we focus only on emissions of CO<sub>2</sub> reported by coal-fired power-plants and are not concerned with national inventories that compile GHG data, such as those submitted by Annex 1 Parties to the United Nations Framework Convention on Climate Change (UNFCCC).
- <sup>58</sup> Environment Canada, Information on Greenhouse Gas Sources and Sinks, Facility GHG reporting, [http://www.ec.gc.ca/pdb/ghg/facility\\_e.cfm](http://www.ec.gc.ca/pdb/ghg/facility_e.cfm)
- <sup>59</sup> All units over 25 MW and new units under 25 MW that use fuel with a sulfur content greater than 0.05 percent by weight.



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- <sup>60</sup> This method is very similar to the one directly preceding it, however it requires reporters to comply with Australian or equivalent documentary standards for sampling.
- <sup>61</sup> Environment Canada, Greenhouse Gas Reporting Site, Guidance Document, <http://www.ghgreporting.gc.ca/GHGInfo/Pages/page15.aspx>
- <sup>62</sup> New South Wales, Greenhouse Gas Reduction Scheme (GGAS), Overview, [http://greenhousegas.nsw.gov.au/overview/scheme\\_overview/overview.asp](http://greenhousegas.nsw.gov.au/overview/scheme_overview/overview.asp)
- <sup>63</sup> Alberta Environment, Greenhouse Gas (Specified Gas) Reporting, <http://environment.alberta.ca/631.html>
- <sup>64</sup> European Commission, EU Action against Climate Change, EU emissions trading – an open scheme promoting global innovation 2005, [http://ec.europa.eu/environment/climat/pdf/emission\\_trading3\\_en.pdf](http://ec.europa.eu/environment/climat/pdf/emission_trading3_en.pdf)
- <sup>65</sup> RGGI website: [http://www.rggi.org/docs/mou\\_rggi\\_overview\\_12\\_20\\_05.pdf](http://www.rggi.org/docs/mou_rggi_overview_12_20_05.pdf)
- <sup>66</sup> Europa, Water Framework Directive, <http://www.europa.eu/scadplus/leg/en/lvb/l28002b.htm>
- <sup>67</sup> US EPA, Laws and Regulations, The Clean Water Act, <http://www.epa.gov/region5/water/cwa.htm>
- <sup>68</sup> European Commission, The IPPC directive, <http://ec.europa.eu/environment/ippc/index.htm>
- <sup>69</sup> US EPA, Laws and Regulations, The Clean Water Act, <http://www.epa.gov/region5/water/cwa.htm>
- <sup>70</sup> Europa, Discharge of dangerous substances: protection of the aquatic environment, <http://europa.eu/scadplus/leg/en/lvb/l28017a.htm>
- <sup>71</sup> Europa, Water suitable for fish-breeding, <http://www.europa.eu/scadplus/leg/en/lvb/l28010.htm>
- <sup>72</sup> Europa, Quality of Shellfish Water, <http://www.europa.eu/scadplus/leg/en/lvb/l28177.htm>
- <sup>73</sup> Europa, Priority substances in the field of water policy, <http://www.europa.eu/scadplus/leg/en/lvb/l28108.htm>
- <sup>74</sup> US EPA, Total Maximum Daily Loads, Overview of Current Total Maximum Daily Load - TMDL - Program and Regulations, <http://www.epa.gov/owow/tmdl/overviewfs.html>
- <sup>75</sup> A calculation of the maximum amount of a pollutant that a body of water can receive and still meet water quality standards.
- <sup>76</sup> Few TMDLs have actually been established by states or the US EPA to date.
- <sup>77</sup> Europa, Protection of groundwater against pollution, <http://www.europa.eu/scadplus/leg/en/lvb/l28139.htm>
- <sup>78</sup> This Directive is known as the “daughter Directive” to the Water Quality Framework Directive.
- <sup>79</sup> EUR-Lex, Council Directive 80/68/EEC of 17 December 1979 on the protection of groundwater against pollution caused by certain dangerous substances, <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:31980L0068:EN:HTML>
- <sup>80</sup> US EPA, Monitoring and Assessing Water Quality, An Introduction to Water Quality Monitoring, <http://www.epa.gov/owow/monitoring/monintr.html>
- <sup>81</sup> Europa, Quality of Drinking Water, <http://www.europa.eu/scadplus/leg/en/lvb/l28079.htm>
- <sup>82</sup> US EPA, Safe Drinking Water Act (SDWA), Basic Information, <http://www.epa.gov/safewater/sdwa/basicinformation.html>
- <sup>83</sup> To the extent that they are relevant for ecological and chemical status and ecological potential.
- <sup>84</sup> US EPA, Safe Drinking Water Act (SDWA), Basic Information, <http://www.epa.gov/safewater/sdwa/basicinformation.html>
- <sup>85</sup> Europa, The European Pollutant Emission Register (EPER) and the European Pollutant Release and Transfer Register (E-PRTR), <http://ec.europa.eu/environment/ippc/eper/index.htm>
- <sup>86</sup> Applies to thermal power stations with a heat input of >50 MW.
- <sup>87</sup> That employ 10 or more full time employees or the equivalent.

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<sup>88</sup> US EPA, Toxics Release Inventory (TRI) Program, What is the Toxics Release Inventory (TRI) Program

[http://www.epa.gov/tri/guide\\_docs/index.htm](http://www.epa.gov/tri/guide_docs/index.htm)

<sup>89</sup> No additional sampling or testing is required for TRI reporting.

<sup>90</sup> US EPA, Compliance Monitoring, National Pollutant Discharge Elimination System Compliance Inspection Manual, <http://www.epa.gov/compliance/resources/publications/monitoring/cwa/inspections/npdesinspect/npdesmanual.html>

<sup>91</sup> US EPA, Clean Water Act, Section 316(a) [http://www.epa.gov/region5/water/pdf/ecwa\\_t3.pdf](http://www.epa.gov/region5/water/pdf/ecwa_t3.pdf)

<sup>92</sup> This approach is different from other CWA requirements that limit what a source can put into the water, not the ultimate effect of that discharge.

<sup>93</sup> US EPA, National Pollutant Discharge Elimination System (NPDES), Cooling Water Intake Structure, <http://cfpub.epa.gov/npdes/indpermitting/cwis.cfm>

<sup>94</sup> The CWIS regulation is unique in that it applies to the intake of water and not the discharge.

<sup>95</sup> Impingement refers to when fish and other aquatic life are pinned against screens or other parts of a cooling water intake structure. Entrainment refers to when these organisms are drawn into cooling water systems, resulting in thermal, physical or chemical stresses.

<sup>96</sup> Velocity monitoring applies to systems that use intake screen systems.

<sup>97</sup> US EPA, Clean Energy, Solid Waste Generation, <http://www.epa.gov/cleanenergy/energy-and-you/affect/sw-generation.html#footnotes>

<sup>98</sup> Europa, Framework Directive on Waste Disposal, <http://www.europa.eu/scadplus/leg/en/lvb/l21197.htm>

<sup>99</sup> European Commission, The IPPC directive, <http://ec.europa.eu/environment/ippc/index.htm>

<sup>100</sup> The IPPC Directive covers combustion installations with a rate thermal input >50 MW and landfills receiving more than 10 tonnes per day or with a total capacity exceeding 25,000 tonnes, excluding inert waste.

<sup>101</sup> BAT includes techniques such as those that produce the least waste, use the least hazardous substances, enable the recycling of substances generated, etc.

<sup>102</sup> US EPA, Wastes, Laws and Regulations, <http://www.epa.gov/epaoswer/osw/laws-reg.htm>

<sup>103</sup> The determination is significant in that it marks the first time the US EPA stated its intent to develop nationwide regulations for the disposal of CCWs.

<sup>104</sup> US EPA, Special Wastes, Fossil Fuel Combustion Waste, <http://www.epa.gov/epaoswer/other/fossil/index.htm>

<sup>105</sup> Europa, Landfill of Waste, <http://www.europa.eu/scadplus/leg/en/lvb/l21208.htm>

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<sup>110</sup> US EPA, Toxics Release Inventory (TRI) Program, What is the Toxics Release Inventory (TRI) Program, [http://www.epa.gov/tri/guide\\_docs/index.htm](http://www.epa.gov/tri/guide_docs/index.htm)

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<sup>220</sup> US EPA, Office of Air Quality Planning and Standards, Air Pollution Monitoring, <http://www.epa.gov/air/oaqps/montring.html>

<sup>221</sup> US EPA, Office of Air Quality Planning and Standards, Air Pollution Monitoring, <http://www.epa.gov/air/oaqps/montring.html>

<sup>222</sup> US EPA, Office of Air Quality Planning and Standards, Air Pollution Monitoring, <http://www.epa.gov/air/oaqps/montring.html>

<sup>223</sup> Greenwire, 'Huge mess' in wake of CAIR's collapse, July 14, 2008, <http://www.eenews.net/Greenwire/2008/07/14/2/>

<sup>224</sup> Federal Register, Vol. 72, No. 79, April 25, 2007, [http://www.epa.gov/pmdesignations/documents/Mar07/PM\\_rule\\_042507.pdf](http://www.epa.gov/pmdesignations/documents/Mar07/PM_rule_042507.pdf)

<sup>225</sup> Federal Register, Vol. 72, No. 79, April 25, 2007, [http://www.epa.gov/pmdesignations/documents/Mar07/PM\\_rule\\_042507.pdf](http://www.epa.gov/pmdesignations/documents/Mar07/PM_rule_042507.pdf)

<sup>226</sup> Federal Register, Vol. 72, No. 79, April 25, 2007, [http://www.epa.gov/pmdesignations/documents/Mar07/PM\\_rule\\_042507.pdf](http://www.epa.gov/pmdesignations/documents/Mar07/PM_rule_042507.pdf)

<sup>227</sup> US EPA, Technology Transfer Network Clearinghouse for Inventories & Emissions Factors, What is the National Emissions Inventory (NEI)?, <http://www.epa.gov/ttn/chief/net/neiwhatis.html>

<sup>228</sup> US EPA, Documentation for the 2002 Electric Generating Unit (EGU) National Emissions Inventory (NEI), September 2004, <ftp://ftp.epa.gov/EmisInventory/2002finalnei/documentation/point/egu2002doc.pdf>

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<sup>230</sup> US EPA, Compliance Monitoring, New Source Performance Standards and State Improvement Plans, <http://www.epa.gov/compliance/monitoring/programs/caa/newsources.html>

<sup>231</sup> US EPA, Region 7, New Source Performance Standards, <http://www.epa.gov/region7/programs/artd/air/nsps/nsps.htm>

<sup>232</sup> 40 CFR 60, Subpart Da <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr;sid=fd38063b92ad045caeb051b7b78a87eb;rgn=div6;view=text;node=40%3A6.0.1.1.1.10;idno=40;cc=ecfr>

<sup>233</sup> US EPA, Clean Air Markets Division, Robert Vollaro Presentation, Harmonization of Part 60 and Part 75 CEM Requirements, [http://www.epa.gov/airmarket/presentations/docs/epri07/part60\\_vs\\_75.ppt](http://www.epa.gov/airmarket/presentations/docs/epri07/part60_vs_75.ppt)

<sup>234</sup> The data reporting procedures for the Part 60 rule do not allow missing data procedures and bias adjustments that are utilized in the Part 75 rule. Alternate data substitution procedures are provided.



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- <sup>235</sup> 40 CFR 60, Appendix B, <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=b6f1f969361d323a2b8092405d7b7643&rgn=div9&view=text&node=40:7.0.1.1.1.0.1.1.9&idno=40>
- <sup>236</sup> ASTM D 6216–98: Standard Practice for Opacity Monitor Manufacturers to Certify Conformance with Design and Performance Specifications. American Society for Testing and Materials (ASTM). April 1998.
- <sup>237</sup> US EPA, Clean Air Act Stationary Source Compliance Monitoring Strategy, <http://www.epa.gov/compliance/resources/policies/monitoring/caa/cmspolicy.pdf>
- <sup>238</sup> US EPA, New Source Review, <http://www.epa.gov/nsr/>
- <sup>239</sup> US EPA, New Source Review, Basic Information, <http://www.epa.gov/nsr/info.html>
- <sup>240</sup> US EPA, Clean Air Act, Title I – Air Pollution Prevention and Control, <http://www.epa.gov/oar/caa/title1.html#ic>
- <sup>241</sup> In PSD areas, major sources are any stationary pollutant source with the potential to emit more either 100 or 250 tons, depending upon the source.
- <sup>242</sup> New Source Review, Prevention of Significant Deterioration (PSD) Basic Information, <http://www.epa.gov/nsr/psd.html>
- <sup>243</sup> US EPA, Clean Air Act, Title I – Air Pollution Prevention and Control, <http://www.epa.gov/oar/caa/title1.html#ic>
- <sup>244</sup> In a nonattainment area, a major source is any stationary pollutant source with the potential to emit more than 100 tons per year.
- <sup>245</sup> LEAR is the most stringent emission limitation contained in the implementation plan of any State for such class or category of source; or in practice by such class or category of source. The emissions rate may result from a combination of emissions-limiting measures such as a change in the raw material processed, a process modification, and add-on controls.
- <sup>246</sup> US EPA, Clean Air Act, Title I – Air Pollution Prevention and Control, <http://www.epa.gov/oar/caa/title1.html#ic>
- <sup>247</sup> US EPA, New Source Review, Fact Sheet -- Prevention of Significant Deterioration for Fine Particle Pollution– Increments, Significant Impact Levels and Significant Monitoring Concentration, <http://www.epa.gov/nsr/fs20070912.html>
- <sup>248</sup> An increment is a measure of how much of a pollutant can be added to the ambient air before the air quality will significantly deteriorate.
- <sup>249</sup> The SIL is a de minimis threshold applied to individual facilities that apply for a permit to emit a regulated pollutant in an area that meets the NAAQS.
- <sup>250</sup> The PSD program requires facilities to gather and submit 1-year pre-application ambient monitoring data. As part of a permit application, the applicant must conduct modeling to demonstrate the impact of proposed emissions on air quality. If modeling shows an increase in ambient concentrations of pollution by an amount less than the SMC that EPA is proposing, the source is exempted from the monitoring data requirement.
- <sup>251</sup> US EPA, New Source Review (NSR), Policy & Guidance, Implementing New Source Review Requirements in PM<sub>2.5</sub> Nonattainment Areas, Interim Guidance, <http://www.epa.gov/air/nsr/guidance.html>
- <sup>252</sup> Major sources are defined as any source that emits or has the potential to emit 100 tons per year or more of any criteria air pollutant.
- <sup>253</sup> US EPA, Operating Permits, <http://www.epa.gov/oar/oaqps/permits/>
- <sup>254</sup> Boyle, Kathryn, “Appeals court to hear arguments on EPA monitoring,” Greenwire, February 7, 2008, <http://www.eenews.net/Greenwire/2008/02/07/15/>
- <sup>255</sup> US EPA, Clean Air Markets, Acid Rain Program: <http://epa.gov/airmarkets/progsregs/arp/basic.html#phases>

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- <sup>256</sup> US EPA, Acid Rain Program, Allowance Trading, <http://epa.gov/airmarkets/progsregs/arp/basic.html>
- <sup>257</sup> US EPA, Plain English Guide to the Clean Air Act, <http://epa.gov/air/caa/peg/peg.pdf>
- <sup>258</sup> US EPA, Clean Air Markets, Acid Rain Program, <http://epa.gov/airmarkets/progsregs/arp/basic.html#phases>
- <sup>259</sup> US EPA, Clean Air Markets, Acid Rain Permitting Fact Sheet, <http://www.epa.gov/airmarkets/progsregs/arp/permitting-factsheet.html>
- <sup>260</sup> US EPA. Continuous Emissions Monitoring Fact Sheet, <http://epa.gov/airmarkets/emissions/continuous-factsheet.html>
- <sup>261</sup> US EPA, Clean Air Markets, Title IV, Section 412, <http://epa.gov/airmarkets/progsregs/arp/sec412.html>
- <sup>262</sup> These Part 75 exemptions do not supersede the provisions of any other program, regulation, or permit that may require an opacity monitor to be installed.
- <sup>263</sup> US EPA. Continuous Emissions Monitoring Fact Sheet, <http://epa.gov/airmarkets/emissions/continuous-factsheet.html>
- <sup>264</sup> US EPA, Plain English Guide to the Part 75 Rule, [http://www.epa.gov/airmarkets/emissions/docs/plain\\_english\\_guide\\_part75\\_rule.pdf](http://www.epa.gov/airmarkets/emissions/docs/plain_english_guide_part75_rule.pdf)
- <sup>265</sup> 40 CFR 75 Subpart B, <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr;sid=e30f7ea01dafc5f9d11392ab460948d7;rgn=div5;view=text;node=40%3A16.0.1.1.4;idno=40;cc=ecfr#40:16.0.1.1.4.2>
- <sup>266</sup> 40 CFR 75 Appendix A, <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr;sid=e30f7ea01dafc5f9d11392ab460948d7;rgn=div5;view=text;node=40%3A16.0.1.1.4;idno=40;cc=ecfr#40:16.0.1.1.4.9.1.6.6>
- <sup>267</sup> 40 CFR 75 Appendix B, <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr;sid=e30f7ea01dafc5f9d11392ab460948d7;rgn=div5;view=text;node=40%3A16.0.1.1.4;idno=40;cc=ecfr#40:16.0.1.1.4.9.1.6.7>
- <sup>268</sup> 40 CFR 75 Appendix F, <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr;sid=e30f7ea01dafc5f9d11392ab460948d7;rgn=div5;view=text;node=40%3A16.0.1.1.4;idno=40;cc=ecfr#40:16.0.1.1.4.9.1.6.11>
- <sup>269</sup> 40 CFR 51 Appendix M, <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=b0f0d4d14ead6100d209c565b3771d9a&rgn=div9&view=text&node=40:2.0.1.1.2.22.11.14.25&idno=40>
- <sup>270</sup> 40 CFR 75 Subpart D, <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=17c83349e1e4406027077b8271e342c1&rgn=div6&view=text&node=40:16.0.1.1.4.4&idno=40>
- <sup>271</sup> 40 CFR 75.11, <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=17c83349e1e4406027077b8271e342c1&rgn=div8&view=text&node=40:16.0.1.1.4.2.1.2&idno=40>
- <sup>272</sup> 40 CFR 75 Appendix F, <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr;sid=e30f7ea01dafc5f9d11392ab460948d7;rgn=div5;view=text;node=40%3A16.0.1.1.4;idno=40;cc=ecfr#40:16.0.1.1.4.9.1.6.11>
- <sup>273</sup> 40 CFR 75.12, <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=17c83349e1e4406027077b8271e342c1&rgn=div8&view=text&node=40:16.0.1.1.4.2.1.3&idno=40>
- <sup>274</sup> 40 CFR 75 Appendix F, <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr;sid=e30f7ea01dafc5f9d11392ab460948d7;rgn=div5;view=text;node=40%3A16.0.1.1.4;idno=40;cc=ecfr#40:16.0.1.1.4.9.1.6.11>
- <sup>275</sup> 40 CFR 75.14 <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=17c83349e1e4406027077b8271e342c1&rgn=div8&view=text&node=40:16.0.1.1.4.2.1.5&idno=40>

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- <sup>276</sup> 40 CFR 75.16, <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=17c83349e1e4406027077b8271e342c1&rgn=div8&view=text&node=40:16.0.1.1.4.2.1.7&idno=40>
- <sup>277</sup> 40 CFR 75.17, <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=17c83349e1e4406027077b8271e342c1&rgn=div8&view=text&node=40:16.0.1.1.4.2.1.8&idno=40>
- <sup>278</sup> 40 CFR 75.18, <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=17c83349e1e4406027077b8271e342c1&rgn=div8&view=text&node=40:16.0.1.1.4.2.1.9&idno=40>
- <sup>279</sup> US EPA, Clean Air Markets, NO<sub>x</sub> Budget Trading Program/NO<sub>x</sub> SIP Call, <http://epa.gov/airmarkets/progsregs/nox/sip.html#sipcall>
- <sup>280</sup> 40 CFR 75 Subpart H, <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=b8952ca93866d569237ddd1ebee46097&rgn=div6&view=text&node=40:16.0.1.1.4.8&idno=40>
- <sup>281</sup> Greenwire, 'Huge mess' in wake of CAIR's collapse, July 14, 2008, <http://www.eenews.net/Greenwire/2008/07/14/2/>
- <sup>282</sup> US EPA, Clean Air Markets, Clean Air Interstate Rule (CAIR), <http://www.epa.gov/airmarkets/progsregs/cair/index.html>
- <sup>283</sup> US EPA, Clean Air Interstate Rule, <http://www.epa.gov/cair/>
- <sup>284</sup> US EPA, Clean Air Markets, Clean Air Interstate Rule (CAIR), <http://www.epa.gov/airmarkets/progsregs/cair/index.html>
- <sup>285</sup> US EPA, Clean Air Interstate Rule, Basic Information, <http://www.epa.gov/cair/basic.html#timeline>
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- <sup>287</sup> US EPA, Plain English Guide to the Part 75 Rule, [http://www.epa.gov/airmarkets/emissions/docs/plain\\_english\\_guide\\_part75\\_rule.pdf](http://www.epa.gov/airmarkets/emissions/docs/plain_english_guide_part75_rule.pdf)
- <sup>288</sup> Canadian Council of Ministers of the Environment, Mercury, [http://www.ccme.ca/ourwork/air.html?category\\_id=85](http://www.ccme.ca/ourwork/air.html?category_id=85)
- <sup>289</sup> Australian Government, Department of Environment and Water Resources, National Pollutant Inventory, List of NPI Substances, [http://www.npi.gov.au/about/list\\_of\\_subst.html#table1](http://www.npi.gov.au/about/list_of_subst.html#table1)
- <sup>290</sup> UNECE, To The 1979 Convention on Long-Range Transboundary Air Pollution on Heavy Metals, <http://www.unece.org/env/lrtap/full%20text/1998.Heavy.Metals.e.pdf>
- <sup>291</sup> Australian Government, Department of Environment and Water Resources, Air Quality Standards, <http://www.environment.gov.au/atmosphere/airquality/standards.html>
- <sup>292</sup> Australian Government, Department of Environment and Water Resources, National Pollutant Inventory, List of NPI Substances, [http://www.npi.gov.au/about/list\\_of\\_subst.html#table1](http://www.npi.gov.au/about/list_of_subst.html#table1)
- <sup>293</sup> National Pollutant Inventory, Guide, December 2007, Version 4.0, <http://www.npi.gov.au/handbooks/pubs/npiguide.pdf>
- <sup>294</sup> National Pollutant Inventory, Emission Estimation Technique Manual for Fossil Fuel Power Generation, Version 2.4, 15 March 2005, [http://www.npi.gov.au/handbooks/approved\\_handbooks/pubs/elec-supply.pdf](http://www.npi.gov.au/handbooks/approved_handbooks/pubs/elec-supply.pdf)
- <sup>295</sup> It is understood that this method is used by some American utilities in reporting mercury emissions to the USEPA Toxics Release Inventory (the US program similar to the NPI).
- <sup>296</sup> New South Wales Government, Protection of the Environment Operations (Clean Air) Regulation 2002, <http://www.legislation.nsw.gov.au/viewtop/inforce/subordleg+642+2002+first+0+N>
- <sup>297</sup> Department of Environment and Conservation (NSW), Load Calculation Protocol (February 2005), <http://www.environment.nsw.gov.au/resources/loadcalcprotfeb05.pdf>

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<sup>298</sup> Canadian Council of Ministers of the Environment, Canada-Wide Standards for Mercury Emissions from Coal-Fired Electric Power Generation Plants, [http://www.ccme.ca/assets/pdf/hg\\_epg\\_cws\\_w\\_annex.pdf](http://www.ccme.ca/assets/pdf/hg_epg_cws_w_annex.pdf)

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<sup>300</sup> Environment Canada, National Pollutant Release Inventory, [http://www.ec.gc.ca/pdb/npri/npri\\_home\\_e.cfm](http://www.ec.gc.ca/pdb/npri/npri_home_e.cfm)

<sup>301</sup> Environment Canada, Guide for Reporting to the National Pollutant Release Inventory 2006, [http://www.ec.gc.ca/pdb/npri/2006Guidance/Guide2006/2006\\_NPRI\\_Guide\\_e.pdf](http://www.ec.gc.ca/pdb/npri/2006Guidance/Guide2006/2006_NPRI_Guide_e.pdf)

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<sup>303</sup> Canadian Council of Ministers of the Environment, Canada-Wide Standards for Mercury Emissions from Coal-Fired Electric Power Generation Plants, [http://www.ccme.ca/assets/pdf/hg\\_epg\\_cws\\_w\\_annex.pdf](http://www.ccme.ca/assets/pdf/hg_epg_cws_w_annex.pdf)

<sup>304</sup> Canadian Council of Ministers of the Environment, Canada, Monitoring Protocol in Support of the Canada-Wide Standards for Mercury Emissions from Coal-Fired Electric Generation Plant, [http://www.ccme.ca/assets/pdf/hg\\_monitoring\\_protocol\\_e.pdf](http://www.ccme.ca/assets/pdf/hg_monitoring_protocol_e.pdf)

<sup>305</sup> Canadian Council of Ministers of the Environment, Canada-Wide Standards for Mercury Emissions from Coal-Fired Electric Power Generation Plants, [http://www.ccme.ca/assets/pdf/hg\\_epg\\_cws\\_w\\_annex.pdf](http://www.ccme.ca/assets/pdf/hg_epg_cws_w_annex.pdf)

<sup>306</sup> Alberta Environment, Mercury and Power Plants, Facts at Your Fingertips, <http://environment.alberta.ca/documents/mercuryEmissionsFactsheet2005.pdf>

<sup>307</sup> Europa, Air Quality – Existing Legislation, [http://ec.europa.eu/environment/air/existing\\_leg.htm](http://ec.europa.eu/environment/air/existing_leg.htm)

<sup>308</sup> EUR-Lex, Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air, <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32004L0107:EN:HTML>

<sup>309</sup> EUR-Lex, Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air, <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32004L0107:EN:HTML>

<sup>310</sup> UNECE, To The 1979 Convention on Long-Range Transboundary Air Pollution on Heavy Metals, <http://www.unece.org/env/lrtap/full%20text/1998.Heavy.Metals.e.pdf>

<sup>311</sup> Europa, Air Pollution – Protocol on Heavy Metals, <http://europa.eu/scadplus/leg/en/lvb/l28035.htm>

<sup>312</sup> UNECE, To The 1979 Convention on Long-Range Transboundary Air Pollution on Heavy Metals, <http://www.unece.org/env/lrtap/full%20text/1998.Heavy.Metals.e.pdf>

<sup>313</sup> Europa, The European Pollutant Emission Register (EPER) and the European Pollutant Release and Transfer Register (E-PRTR), <http://ec.europa.eu/environment/ipcc/eper/index.htm>

<sup>314</sup> EUR-Lex, Regulation (EC) No 166/2006 of the European Parliament and of the Council of 18 January 2006 concerning the establishment of a European Pollutant Release and Transfer Register and amending Council Directives 91/689/EEC and 96/61/EC, [http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l\\_033/l\\_03320060204en00010017.pdf](http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l_033/l_03320060204en00010017.pdf)

<sup>315</sup> European Commission, Directorate General for the Environment, Guidance Document for the implementation of the European PRTR, [http://ec.europa.eu/environment/ipcc/eper/pdf/en\\_prtr.pdf](http://ec.europa.eu/environment/ipcc/eper/pdf/en_prtr.pdf)

<sup>316</sup> US EPA, Toxics Release Inventory (TRI) Program, What is the Toxics Release Inventory (TRI) Program

[http://www.epa.gov/tri/guide\\_docs/index.htm](http://www.epa.gov/tri/guide_docs/index.htm)

<sup>317</sup> US EPA, EPCRA Section 313, Industry Guidance, Electricity Generating Facilities, EPA 745-B-00-004, February 2000, [http://www.epa.gov/tri/guide\\_docs/2000/00egf.pdf](http://www.epa.gov/tri/guide_docs/2000/00egf.pdf)

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- <sup>318</sup> US EPA, Emergency Planning and Community Right-To-Know Act – Section 313: Guidance for Reporting Toxic Chemicals: Mercury and Mercury Compounds Category, [http://www.epa.gov/tri/guide\\_docs/pdf/2001/hg2001.pdf](http://www.epa.gov/tri/guide_docs/pdf/2001/hg2001.pdf)
- <sup>319</sup> US EPA, Technology Transfer Network Air Toxics Website, National Air Toxics Assessments, <http://www.epa.gov/ttn/atw/natamain/>
- <sup>320</sup> US EPA, Clean Air Markets, Clean Air Mercury Rule (CAMR), <http://epa.gov/airmarkets/progsregs/camr/index.html>
- <sup>321</sup> State of New Jersey et al. v Environmental Protection Agency, United State Court of Appeals for the District of Columbia Circuit, No. 05-1097, Argued December 6, 2007, Decided February 8, 2008.
- <sup>322</sup> Pastenark, Judy, “Court rejects Bush’s mercury emissions trading plan,” LA Times, February 9, 2008, <http://www.latimes.com/news/printedition/asection/la-na-epa9feb09,1,6644718.story>
- <sup>323</sup> US EPA, Plain English Guide to the Part 75 Rule  
[http://www.epa.gov/airmarkets/emissions/docs/plain\\_english\\_guide\\_part75\\_rule.pdf](http://www.epa.gov/airmarkets/emissions/docs/plain_english_guide_part75_rule.pdf)
- <sup>324</sup> Clean Air Act, Title I, Section 111(d), <http://www.epa.gov/air/caa/caa.txt>
- <sup>325</sup> Originally rule making was to be considered under the Clean Air Act Section 112, which would require that requires that mercury regulations reflect Maximum Achievable Control Technology (MACT). However on 15 March 15 2005, in a separate but related action to the issuance of the Clean Air Mercury Rule, EPA revised and reversed its December 2000 finding that it was “appropriate and necessary” to regulate coal- and oil-fired coal-fired power plants under Section 112 of the Clean Air Act. EPA stated that the action was taken because it believed that the December 2000 finding lacked foundation and because recent information demonstrates that it is not appropriate or necessary to regulate coal- and oil-fired utility units under section 112. The decisions by the US EPA were reiterated in a May 2006 final rule.
- <sup>326</sup> US EPA, Plain English Guide to the Part 75 Rule  
[http://www.epa.gov/airmarkets/emissions/docs/plain\\_english\\_guide\\_part75\\_rule.pdf](http://www.epa.gov/airmarkets/emissions/docs/plain_english_guide_part75_rule.pdf)
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- <sup>330</sup> 40 CFR 75, Subpart I, <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=f0ecca0fc2e063f9465e5997db5d3ac8&rgn=div6&view=text&node=40:16.0.1.1.4.9&idno=40>
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- <sup>378</sup> Under Article 5 of the Water Framework Directive Each Member State must, for each river basin district or for the portion of an international river basin district falling within its territory, undertake: an analysis of its characteristics; a review of the impact of human activity on the status of surface waters and on groundwater, and an economic analysis of water use. These first two tasks must be carried out according to the technical specifications set out in Annexes II of the Directive and the third according to the specifications in Annex III of the Directive,

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- <sup>379</sup> Annex II establishes procedures for the overall characterization of water bodies, including anthropogenic pressures.
- <sup>380</sup> As designated in Article 7 of the Water Framework Directive: Waters Used for the Abstraction of Drinking Water
- <sup>381</sup> As designated in Article 4 of the Water Framework Directive: Environmental Objectives
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- <sup>391</sup> Waters which support or are capable of supporting fish belonging to the cyprinids (*Cyprinidae*), or other species such as pike (*Esox lucius*), perch (*Perca fluviatilis*) and eel (*Anguilla anguilla*).
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<sup>452</sup> 40 CFR 141.21, <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=541eaf50b10b11724bef23a111e0e2dc&rgn=div8&view=text&node=40:22.0.1.1.3.3.1.6.1&idno=40>

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<sup>457</sup> US EPA, The Standardized Monitoring Framework: A Quick Reference Guide, [http://www.epa.gov/safewater/pws/pdfs/qrg\\_smonitoringframework.pdf](http://www.epa.gov/safewater/pws/pdfs/qrg_smonitoringframework.pdf); Also see US Federal Register, Volume 56, page 3526.

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<sup>488</sup> 40 CFR 125.95, <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=70a4b2531cc2c70cdb96b0da6ac9f9ee&rgn=div8&view=text&node=40:21.0.1.1.15.1.0.16.6&idno=40>

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<sup>490</sup> 40 CFR 125.95, <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=70a4b2531cc2c70cdb96b0da6ac9f9ee&rgn=div8&view=text&node=40:21.0.1.1.15.1.0.16.6&idno=40>

<sup>491</sup> Europa, Framework Directive on Waste Disposal, <http://www.europa.eu/scadplus/leg/en/lvb/l21197.htm>

<sup>492</sup> Eur-Lex, Directive 2006/12/EC of the European Parliament and of the Council of 5 April 2006 on waste (Text with EEA relevance), [http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l\\_114/l\\_11420060427en00090021.pdf](http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l_114/l_11420060427en00090021.pdf)

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<sup>496</sup> Europa, Integrated pollution prevention and control: IPPC Directive, <http://www.europa.eu/scadplus/leg/en/lvb/l28045.htm>

<sup>497</sup> US EPA, Wastes, Laws and Regulations, <http://www.epa.gov/epaoswer/osw/laws-reg.htm>

<sup>498</sup> Fossil fuel combustion (FFC) wastes are the wastes produced from the burning of fossil fuels (i.e., coal, oil, natural gas). This includes all ash, slag, and particulates removed from flue gas.

<sup>499</sup> US EPA, Special Wastes, Fossil Fuel Combustion Waste, <http://www.epa.gov/epaoswer/other/fossil/index.htm>

<sup>500</sup> 40 CFR 261.4, <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=3fbf1dad029aa72c8cece12880b3508e&rgn=div8&view=text&node=40:25.0.1.1.2.1.1.4&idno=40>

<sup>501</sup> Landfills are excavated or engineered sites where non-liquid hazardous waste is deposited for final disposal and covered. These units are selected and designed to minimize the chance of release of hazardous waste into the environment. Design standards for hazardous waste landfills require a double liner; double leachate collection and removal systems (LCRS); leak detection system; run on, runoff, and wind dispersal controls; construction quality assurance (CQA) program. Liquid wastes may not be placed in a hazardous waste landfill. Operators must also comply with inspection, monitoring, and release response requirements. Since landfills are permanent disposal sites and are closed with waste in place, closure and post-closure care requirements include installing and maintaining a final cover, continuing operation of the LCRS until leachate is no longer detected, maintaining and monitoring the leak detection system, maintaining ground water monitoring, preventing storm water run on and runoff, and installing and protecting surveyed benchmarks. (See 40 CFR Parts 264/265, Subpart N). Waste disposal landfills typically are regulated by state agencies, and in some states obtaining approval for the location and design of a landfill can be a very difficult and time-consuming process, but is typically easier than using hazardous waste material guidelines.

<sup>502</sup> Surface Impoundments are natural topographic depressions, man-made excavations, or diked areas formed primarily of earthen materials used for temporary storage or treatment of liquid hazardous waste. Examples include holding, storage, settling, aeration pits, ponds, and lagoons. Hazardous waste

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surface impoundments are required to be constructed with a double liner system, a leachate collection and removal systems (LCRS), and a leak detection system. To ensure proper installation and construction, regulations require the unit to have and follow a construction quality assurance (CQA) program. The regulations also outline monitoring, inspection, response action, and closure requirements. (See 40 CFR Parts 264/265, Subpart K).

<sup>503</sup> US EPA, Special Wastes, Notice of Data Availability on the Disposal of Coal Combustion Waste in Landfills and Surface Impoundments, <http://www.epa.gov/epaoswer/other/fossil/noda07.htm>

<sup>504</sup> Elcock, D., N. Ranek, 2006, Coal Combustion Waste Management at Landfills and Surface Impoundments, 1994-2004, DOE/PI-0004, ANL/EVS-06-4, Aug.

<sup>505</sup> 40 CFR 257, <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=3fc44228f49b4eb9002b1ede49f7e624&rgn=div5&view=text&node=40:24.0.1.4.37&idno=40>

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<sup>508</sup> US EPA, Wastes, Groundwater Monitoring Requirements for Municipal Solid Waste Landfills (MSWFLs), <http://www.epa.gov/epaoswer/non-hw/muncpl/landfill/financial/gdwmswl.htm>

<sup>509</sup> 40 CFR 257.22, <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=afb1380ef95bdb80da5695845780a92b&rgn=div8&view=text&node=40:24.0.1.4.37.2.21.8&idno=40>

<sup>510</sup> 40 CFR 258 Appendix I, <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=6cdcc63d82dc3fb21b655b1e26bb8d12&rgn=div9&view=text&node=40:24.0.1.4.38.7.23.7.20&idno=40>

<sup>511</sup> 40 CFR 258 Appendix II, <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=f45fbdb30b882b0485ce7617e33b097&rgn=div9&view=text&node=40:24.0.1.4.38.7.23.7.21&idno=40>

<sup>512</sup> 40 CFR 258, <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=3fc44228f49b4eb9002b1ede49f7e624&rgn=div5&view=text&node=40:24.0.1.4.38&idno=40>

<sup>513</sup> US EPA, Wastes, Solid Waste Landfills, <http://www.epa.gov/epaoswer/non-hw/muncpl/landfill/industrial>

<sup>514</sup> 40 CFR 239.7, <http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=3fc44228f49b4eb9002b1ede49f7e624&rgn=div5&view=text&node=40:24.0.1.4.29&idno=40#40:24.0.1.4.29.3.17.2>

<sup>515</sup> Europa, Landfill of Waste, <http://www.europa.eu/scadplus/leg/en/lvb/l21208.htm>

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<sup>517</sup> Europa, Landfill of Waste, <http://www.europa.eu/scadplus/leg/en/lvb/l21208.htm>

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<sup>519</sup> Europa, European Pollutant Release and Transfer Register (PRTR), <http://europa.eu/scadplus/leg/en/lvb/l28149.htm>

<sup>520</sup> Eur-LEX, Regulation (EC) No 166/2006 of the European Parliament and of the Council of 18 January 2006 concerning the establishment of a European Pollutant Release and Transfer Register and amending Council Directives 91/689/EEC and 96/61/EC Text, [http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l\\_033/l\\_03320060204en00010017.pdf](http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l_033/l_03320060204en00010017.pdf)

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- <sup>523</sup> US EPA, Toxics Release Inventory (TRI) Program, What is the Toxics Release Inventory (TRI) Program, [http://www.epa.gov/tri/guide\\_docs/index.htm](http://www.epa.gov/tri/guide_docs/index.htm)
- <sup>524</sup> US EPA, EPCRA Section 313, Industry Guidance, Electricity Generating Facilities, EPA 745-B-00-004, February 2000, [http://www.epa.gov/tri/guide\\_docs/2000/00egf.pdf](http://www.epa.gov/tri/guide_docs/2000/00egf.pdf)
- <sup>525</sup> The metals with values provided for fly ash, bottom ash and oil ash residuals are: antimony, arsenic, barium, cadmium, chromium, copper, lead, manganese, mercury, nickel, selenium, silver, vanadium, and zinc.
- <sup>526</sup> The metals with values provided for sludge solids and liquors are: arsenic, boron, cadmium, chromium, copper, mercury, lead, and selenium.
- <sup>527</sup> Europa, European Pollutant Release and Transfer Register (PRTR), <http://europa.eu/scadplus/leg/en/lvb/l28149.htm>
- <sup>528</sup> Guidance Document for the implementation of the European PRTR, May 2006, [http://ec.europa.eu/environment/ippc/eper/pdf/en\\_prtr.pdf](http://ec.europa.eu/environment/ippc/eper/pdf/en_prtr.pdf)
- <sup>529</sup> Eur-LEX, Regulation (EC) No 166/2006 of the European Parliament and of the Council of 18 January 2006 concerning the establishment of a European Pollutant Release and Transfer Register and amending Council Directives 91/689/EEC and 96/61/EC Text, [http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l\\_033/l\\_03320060204en00010017.pdf](http://eur-lex.europa.eu/LexUriServ/site/en/oj/2006/l_033/l_03320060204en00010017.pdf)
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- <sup>531</sup> Power Industry Department, “Thermal Power Industry Environmental Monitoring Management Regulation”, 1996. <http://www.samsco.com.cn/eWebEditor/uploadfile/20061213223944818.PDF>
- <sup>532</sup> Steinfeld, E., et. al., Greener Plants, Grayer Skies? A Report from the Front Lines of China’s Energy Sector. China Energy Group, MIT Industrial Performance Center, August 2008 <http://web.mit.edu/ipc>
- <sup>533</sup> Energy Technologies Enterprises Corporation. Shandong SO<sub>2</sub> Control Assessment. Draft report prepared for the US Environmental Protection Agency. June 2006.
- <sup>534</sup> One exception is that proposed plants that passed their environmental impact review between 01/01/99 and 01/01/04 are automatically “bumped” up to Period III if construction on the plant is not begun within five years of passing the impact review.
- <sup>535</sup> China’s system of political divisions distinguishes between three types of cities. Municipal cities are the largest, and enjoy the same status as provinces. Prefecture-level cities are the next highest ranked type of city, and although they must have an urban population greater than 200,000, prefecture-level cities often include large tracts of rural land multiple times the size of the actual urban area. County-level cities are the smallest class of cities in China, and like prefectural-level cities, often consist of an urban area surrounded by much larger rural areas.
- <sup>536</sup> Finamore, Barbara, *et al.* “Controlling China’s Power Plant Emissions after Utility Restructuring: The Role of Output-Based Emission Controls,” *The Sinosphere Journal*. The Professional Association for China’s Environment (PACE), Volume 4, Issue 1, July 2002.
- <sup>537</sup> State Environmental Protection Administration, “Technical Norm for Continuous Emissions Monitoring of Flue Gas Emitted from Thermal Power Plants”, 2001. <http://www.zjepb.gov.cn/hbbj/hb/hj750.pdf>
- <sup>538</sup> State Environmental Protection Administration, “The Determination of Particulates and Sampling Methods of Gaseous Pollutants Emitted Gas of Stationary Source”, 1996. <http://www.sepa.gov.cn/image20010518/2436.pdf>
- <sup>539</sup> Air Emission Monitoring of Thermal Power Plants: Strategies and Methods in Huainan, China. Paper presented at: Cleaner Coal Asia 2008, Ha Long, Vietnam, August 19-21, 2008 [www.cleanerenergyasia.net](http://www.cleanerenergyasia.net)

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