UN environment

Global best-practice in regulating associated gas processing and treatment

Module 3

Summary description of module

An overview of global and local standards for treating associated gas

- Discuss global standards for associated gas treatment and oil and gas industry in general, with country examples
- Discuss national standards and regulatory practices and identify potential areas for improvement

Best-practice in Alberta, Canada
Alberta CEMS Code: Continuous Emission Measurement Systems for stationary sources

- The code by which the CEM is designed, installed, operated and maintained
  - A proper QA (Quality Assurance) / QC (Quality Control) plan is required
  - Daily validations, regular inspection and maintenance, and audits
- Considerations include the need for a representative sample that is homogenous (i.e., well mixed) and is readily accessible for maintenance

Best-practice in Alberta, Canada
Alberta CEMS Code: Continuous Emission Measurement Systems for stationary sources – continued

- Depending on the industry and plant permit, a CEMS may measure SO_2, NO_x, CO, TRS (Total Reduced Sulfurs), CO_2 and PM (Particulate Matter)
- The permit also determines reporting requirements
  - Emission rates reported in tons (1000 kg) per day are common
- A CEMS will typically not measure wind speed and direction nor the low concentration levels that an ambient station does
- A CEMS must pass a third-party audit or manual stack survey conducted in accordance with the Alberta Stack Sampling Code

Best-practice in Alberta, Canada
Alberta CEMS Code: Continuous Emission Measurement Systems for stationary sources – continued

CEM typical methods of measurement – common but not exclusive

- SO_2 – UV absorption
- NOx – UV absorption or Chemiluminescence
- CO and CO_2 – NDIR
- Particulate Matter – Opacity

Best-practice in Alberta, Canada
Alberta CEMS Code: Continuous Emission Measurement Systems for stationary sources – continued

CEM sampling methods – to extract a sample or not

- In-situ measurement
  - Measurement "in the natural or original position"
  - Across the stack design is most common
  - Opacity is a common example

- Extractive
  - Sample is removed (extracted) from the stack
    1. Hot / wet sample
    2. Cool / dry sample
    3. Diluted sample

In-situ vs extractive CEMS sampling

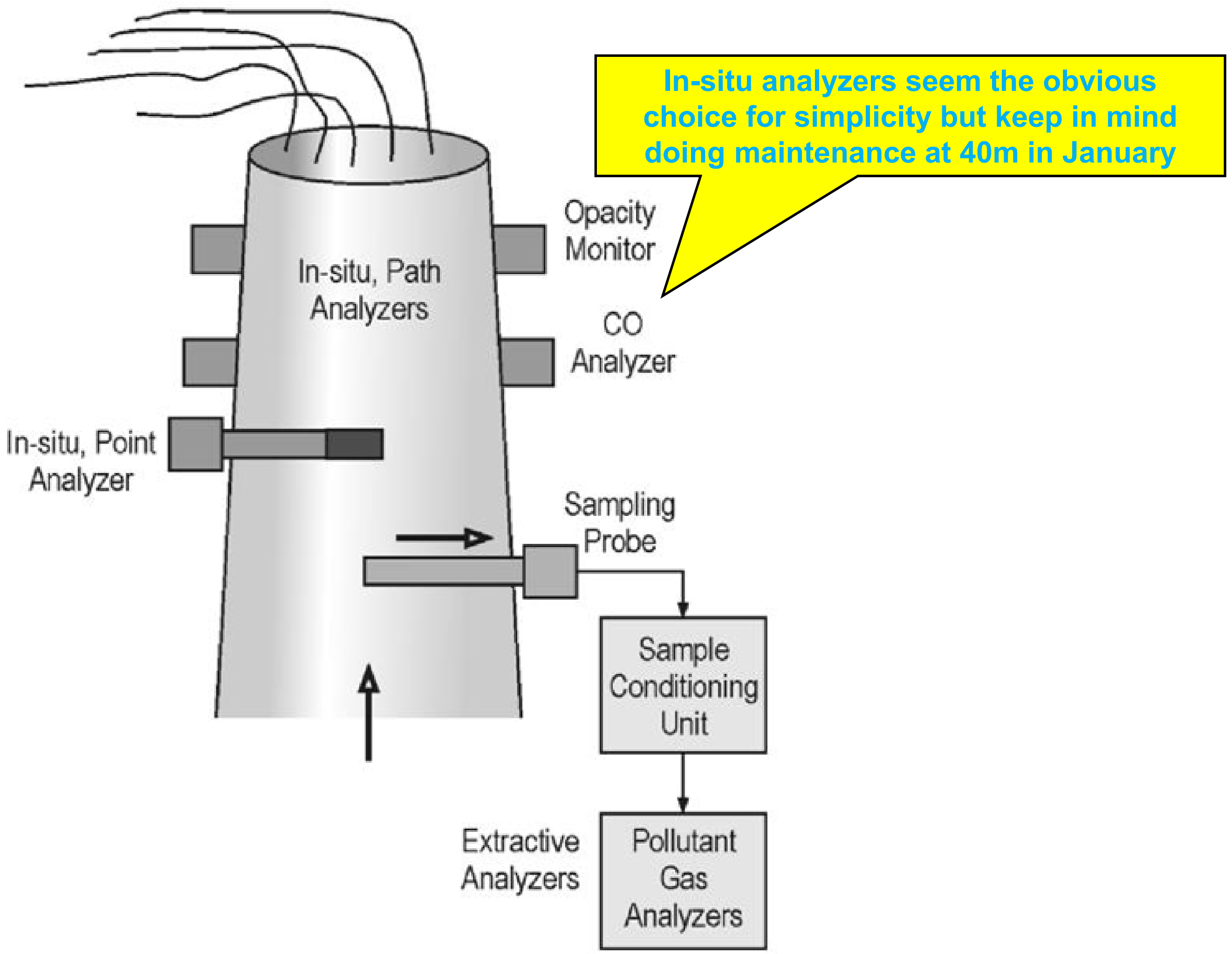


Figure 1. Types of CEM technology. Adapted from Instrument Technician ILM, Environmental Monitoring – Part A, 310404cA, (2019)

Opacity measurement

- Based on transmittance of light across the stack
- Percent opacity is reported in percent of light not transmitting across the stack

% Opacity = 100 - %T

E.g. 30% Opacity = 100 - 70%T

Where:

%T = percentage of light transmitting across the stack

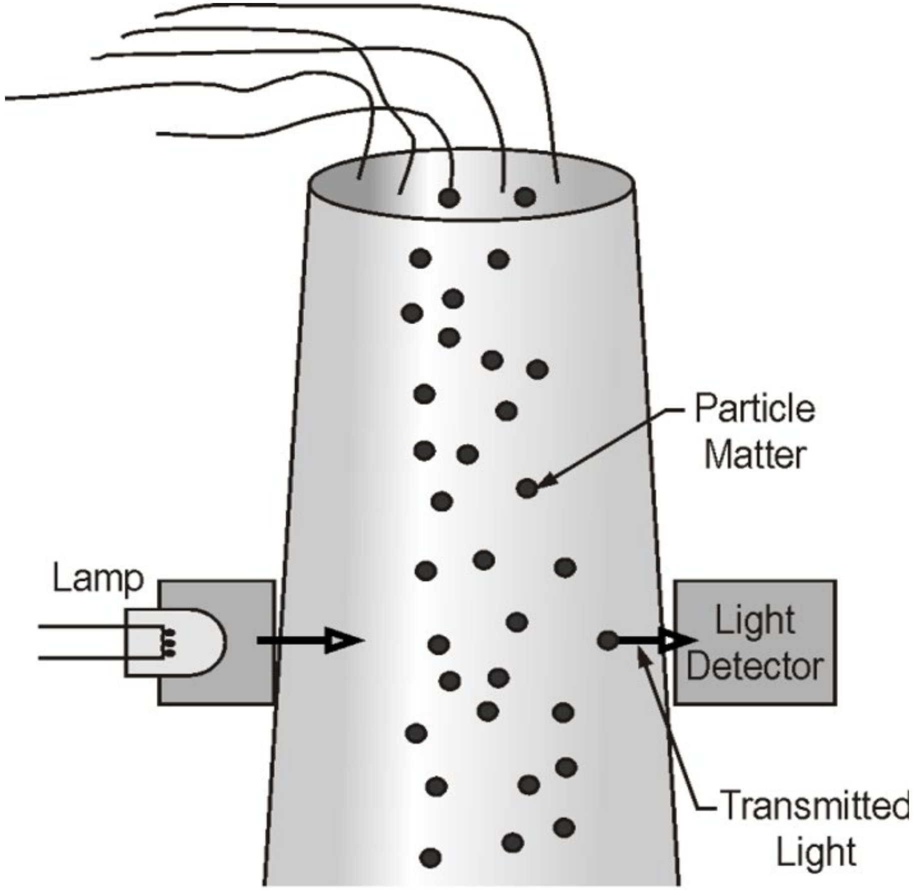


Figure 2. In-situ stack opacity measurement. Adapted from Instrument Technician ILM, Environmental Monitoring – Part A, 310404cA, (2019)

Extractive systems: cool-dry or hot-wet

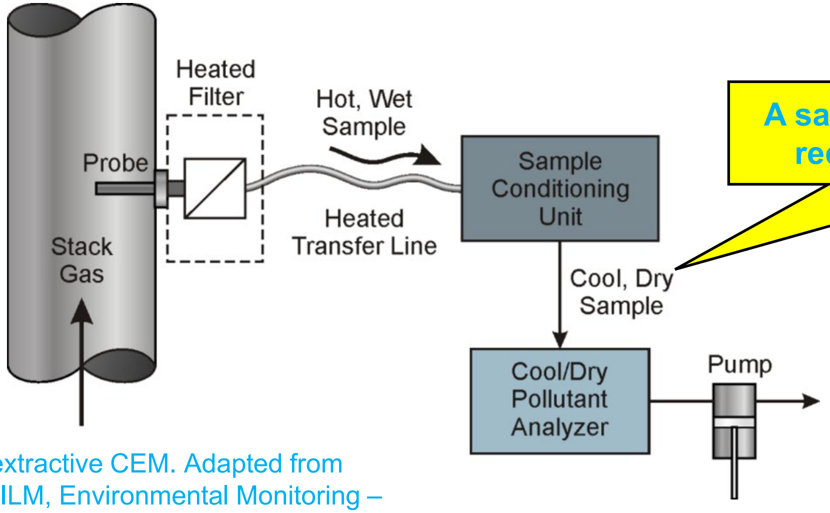


Figure 3. Cool dry extractive CEM. Adapted from Instrument Technician ILM, Environmental Monitoring – Part A, 310404cA, (2019)

A sample dryer is not shown but is required for a cool/dry sample.

Think of the CEMS in the lab

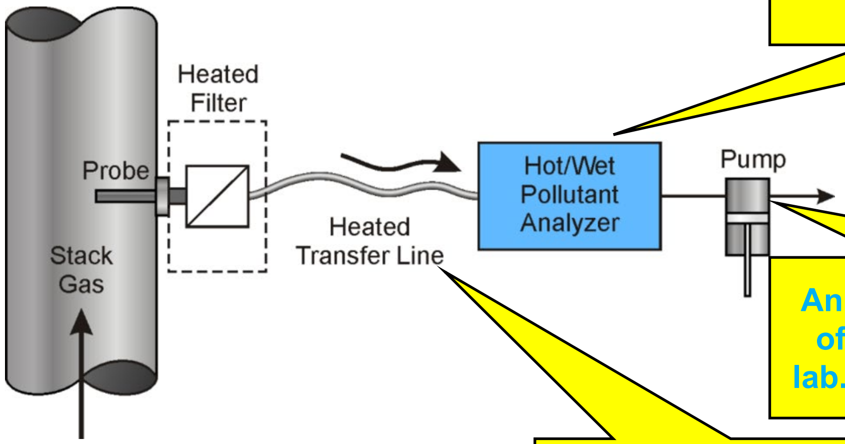


Figure 4. Hot wet extractive CEM. Adapted from Instrument Technician ILM, Environmental Monitoring – Part A, 310404cA, (2019)

An aspirator / eductor can be used in place of a pump. Again, think of the CEM in the lab. It has an aspirator integral to its design.

A heated sample bundle is common to both designs

Extractive dilution systems

- Dilute sample at controlled dilution ratio
  - Dilution lowers dew point to accommodate dry measurement analyzers
  - The target gas concentrations are also reduced
- Use highly sensitive analyzers to measure the resulting lower concentrations

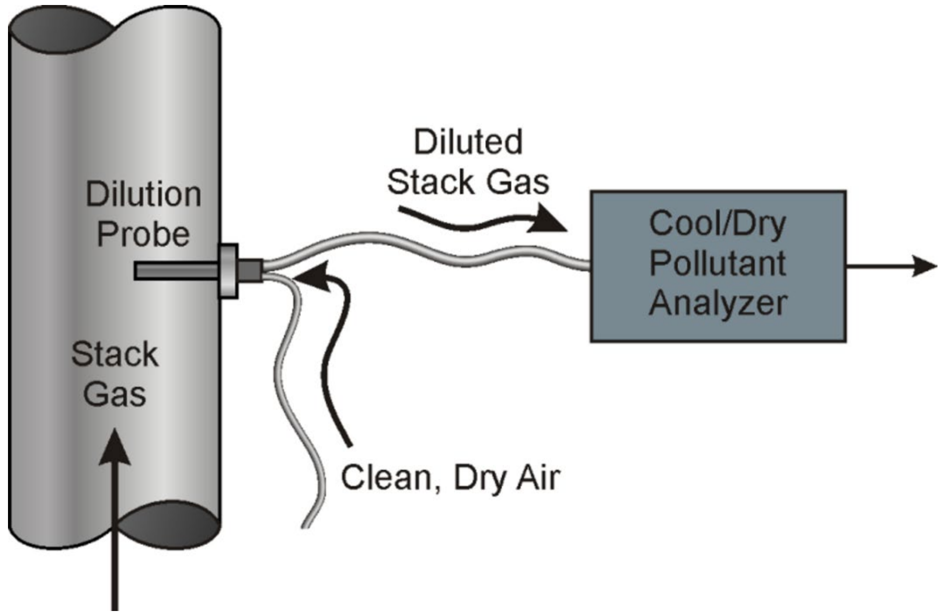


Figure 5. Diluted gas CEM system. Adapted from Instrument Technician ILM, Environmental Monitoring – Part A, 310404cA, (2019)

CEMS Code: Continuous Emission Measurement Systems for stationary sources

- The code by which the CEM is designed, installed, operated and maintained [2]
  - A proper QA (Quality Assurance) / QC (Quality Control) plan is required
  - Daily validations, regular inspection and maintenance, and audits
- Considerations include the need for a representative sample that is homogenous (i.e., well mixed) and is readily accessible for maintenance

CEMS Code – continued

- Performance Specifications evaluate the acceptability of the CEMS at the time of or soon after installation:
  - Linearity
  - Relative accuracy
  - Bias
  - Zero drift – 24 hr
  - Span drift – 24 hr
  - Availability per month

CEMS Code – continued

Performance specifications excerpt

Analyzer	Linearity	Relative accuracy	Bias	Zero drift-24 hr	Span drift-24 hr	Availability
Sulfur dioxide	≤ ± 2.0% of span	≤ ± 10.0% of RM	≤ ± 5.0% of FS	≤ ± 2.5% of span	≤ ± 2.5% of span	≥ 90.0%
Nitrogen oxides	≤ ± 2.0% of span	≤ ± 10.0% of RM	≤ ± 5.0% of FS	≤ ± 2.5% of span	≤ ± 2.5% of span	≥ 90.0%

Table1. Performance specifications. Adapted from Government of Alberta CEMS Code – Draft Version, (2018)

What is the same from your government?

CEMS Code – continued

- Figure 6. Air quality monitoring station (Warren 2018).

Airshed zones: ambient air quality measurement

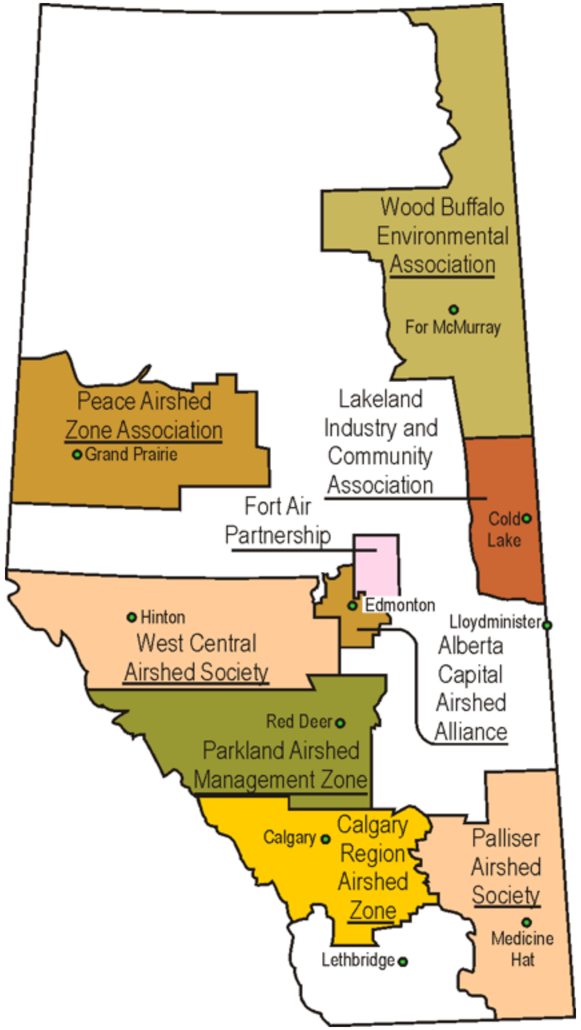


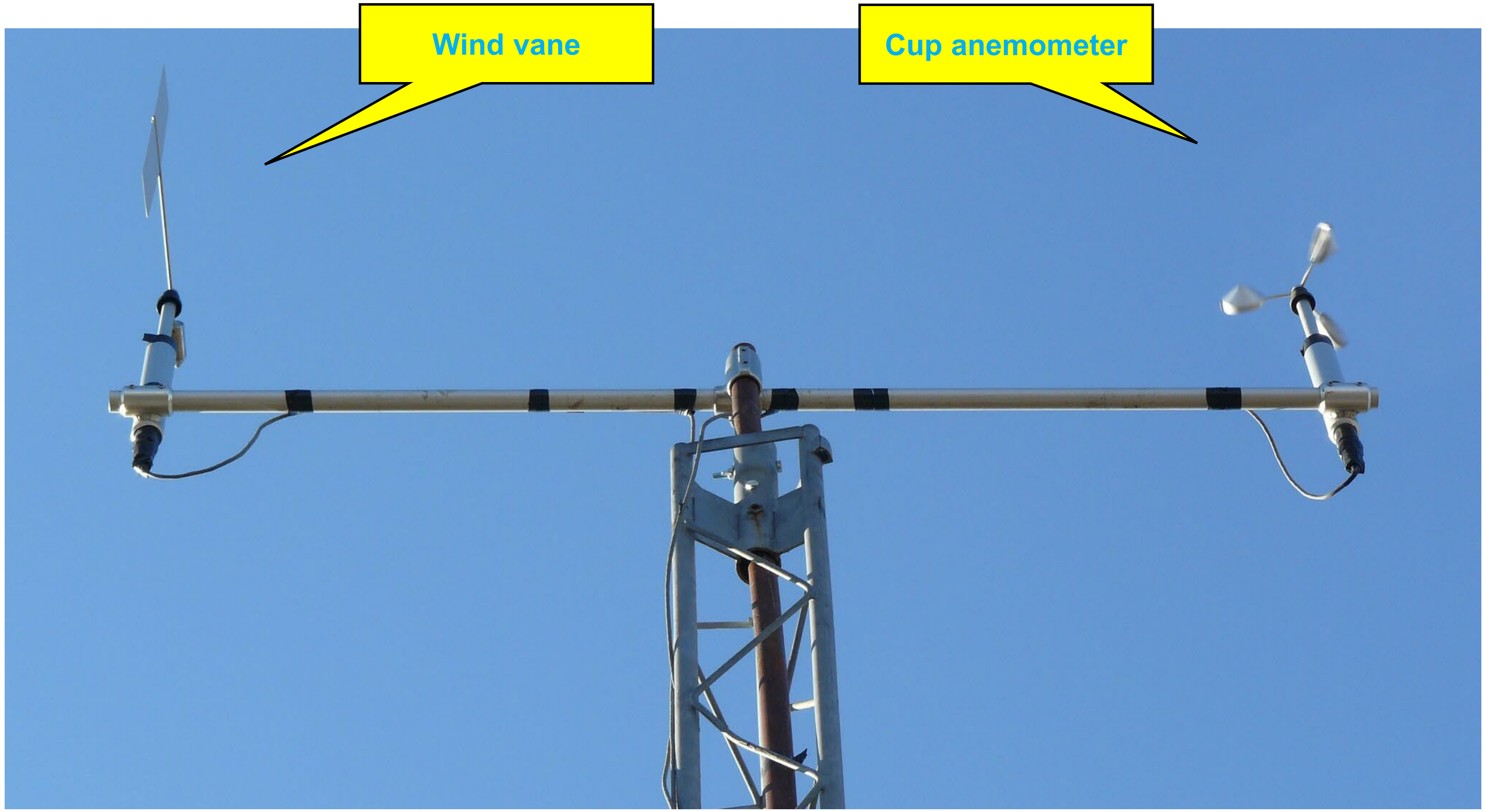
Figure 7. Alberta's airshed zones. Adapted from Instrument Technician ILM, Environmental Monitoring – Part B, 310404cB, (2019)

What is in your country?

Ambient typical methods of measurement

- H_2S and SO_2 – UV Fluorescence
- NO_x – Chemiluminescence
- CO and CO_2 – NDIR
- Ozone – UV Absorption
- THC (total hydrocarbons) – Flame Ionization Detector
- VOC – GC or Mass Spectrometry
- Particulate Matter – Tapered Element Oscillating Microbalance
- Total Suspended Particulate – High Volume Sampler c/w a weight analysis

Wind speed and direction



- Figure 8. Wind speed and direction (Warren 2018).

Fugitive emissions – unwanted escape

- Pollutants released by leaks from pressurized process equipment
  - VOCs (volatile organic compounds) are commonly monitored fugitive emissions
- Measure at multiple sample points near high-risk sources
- Possible measuring techniques
  - Mass spectrometer
  - Open-path devices

Acid rain formation

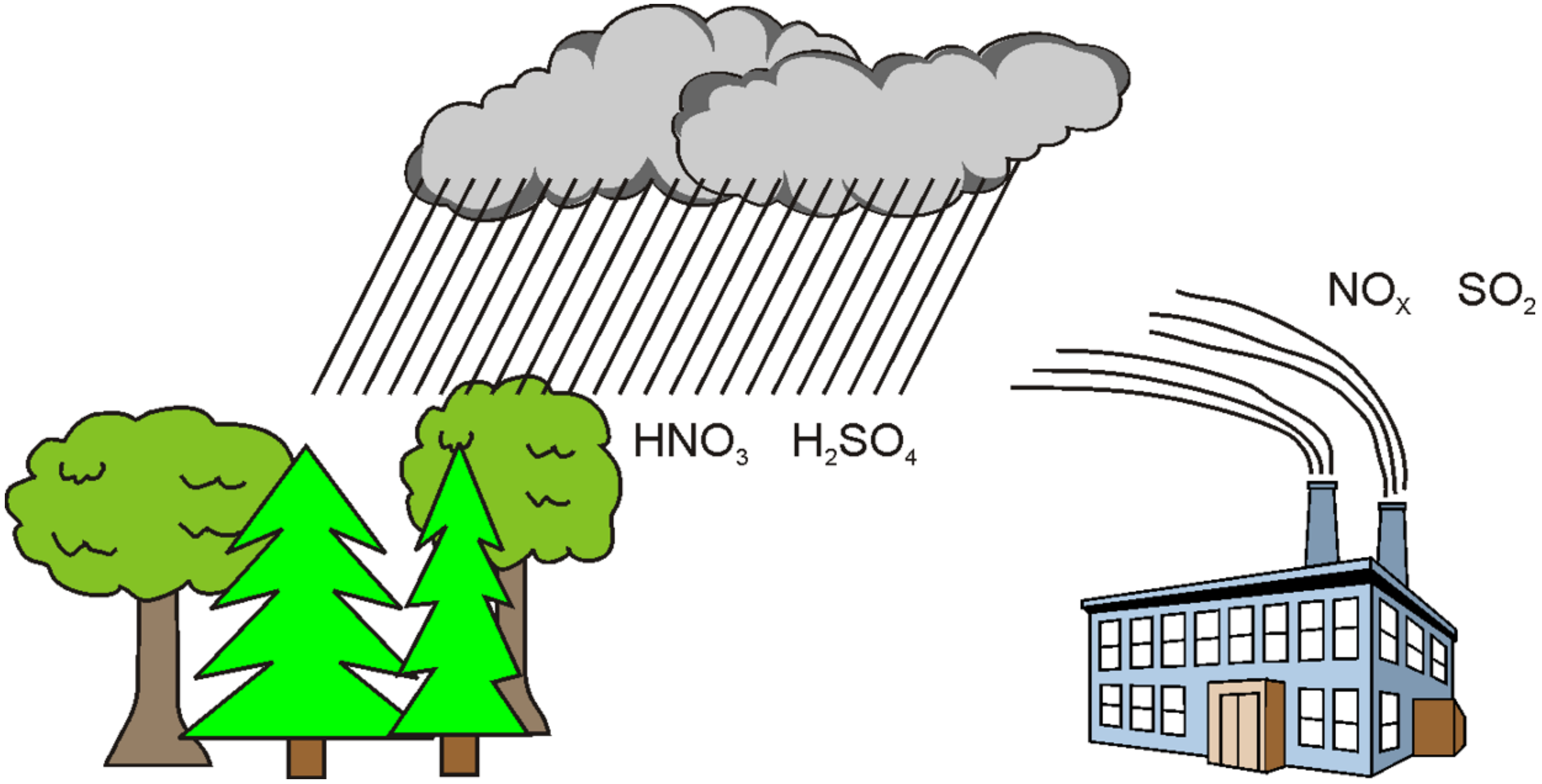


Figure 9. Acid Rain. Adapted from Instrument Technician ILM, Environmental Monitoring – Part A, 310404cA, (2019)

Acid rain – SO_2, NOx and H_2S + water

- SO_2, NO_x, H_2S react with water vapor in the atmosphere to form acid rain
- A pH of less than 5 defines acid rain

Sulfur emissions – think acid rain

- Sulfuric acid formation in the atmosphere contributes to acid rain
  - $S + O_2 \longrightarrow SO_2$
  - $SO_2 + H_2O \longrightarrow H_2SO_3$ (sulfurous acid)
  - SO_2 + oxidize $\longrightarrow SO_3 + H_2O \longrightarrow H_2SO_4$ (sulfuric acid)

Sulfur emission harmful effects – continued

- Physiological
  - E.g., tiny sulphate particles penetrate the lungs which can aggravate respiratory conditions or diseases
- Defoliation and other harmful effects to plants
- Corrosion

Nitrogen oxides (NO_x) – acid rain and smog contributor

- A product of high temperature combustion
  - Consider temperatures in excess of 1200 °C
  - Internal combustion engines a major source
- Reacts with oxygen to create ground-level ozone
  - Ozone contributes to smog

Smog formation – remember the Calgary photo?

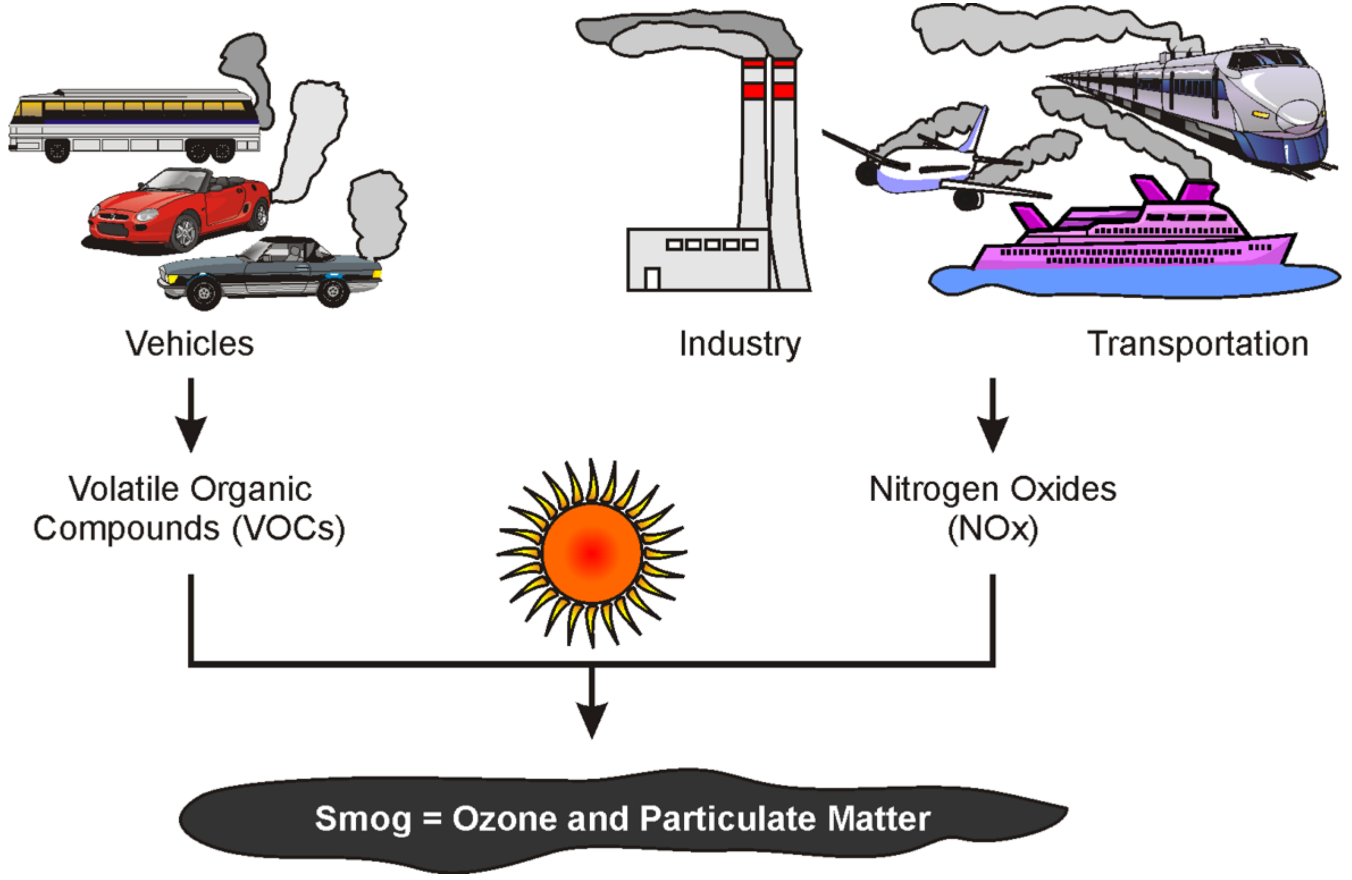
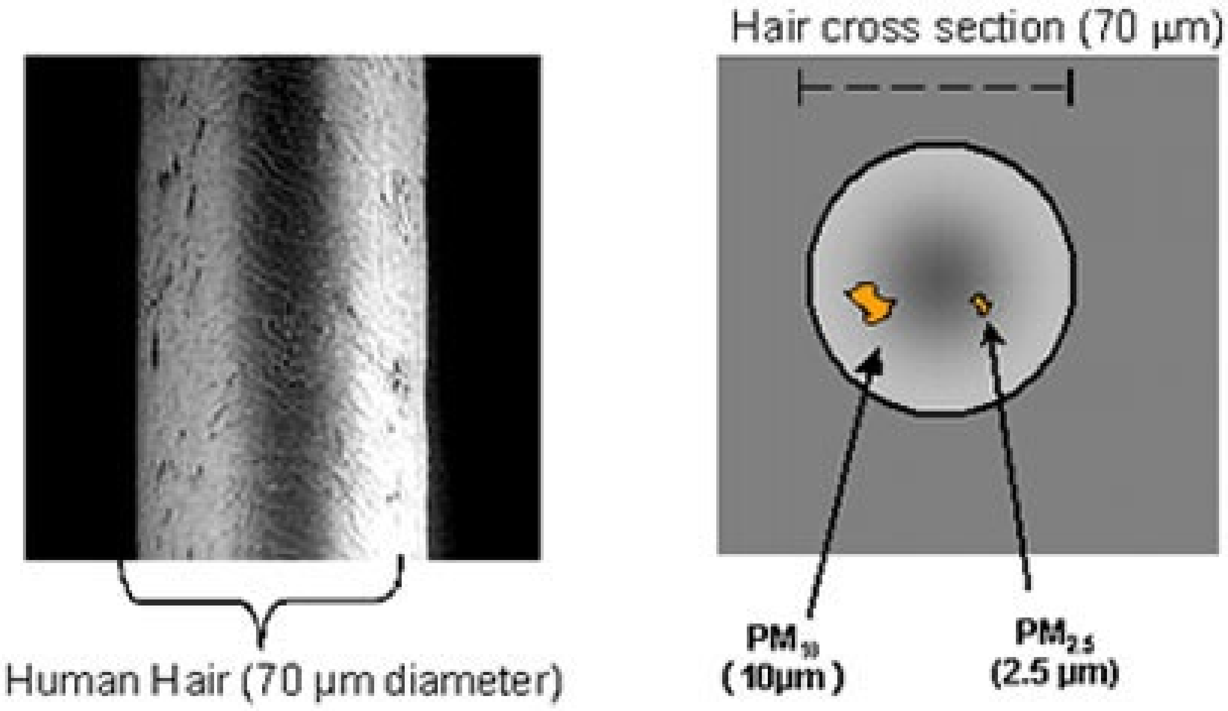


Figure 10. Smog. Adapted from Instrument Technician ILM, Environmental Monitoring – Part A, 310404cA, (2019)

Smog: air pollutants + particulates

- Originally coined from a contraction of the words “smoke” and “fog”
- Composed of nitrogen oxides, sulfur oxides, ozone and particulates
- Particulate matter size is very important when assessing risk to human health
  - PM_{10} and $PM_{2.5}$ refer to the particulate diameter size in μm
  - $PM_{2.5}$ is the more dangerous particulate because it refers to particulate size 2.5 μm or less, which is more easily lodged in the lungs when inhaled

Fine particulate matter PM_{10} vs $PM_{2.5}$ vs human hair



- Figure 11. $PM_{2.5}$ (Warren 2018).

Greenhouse effect

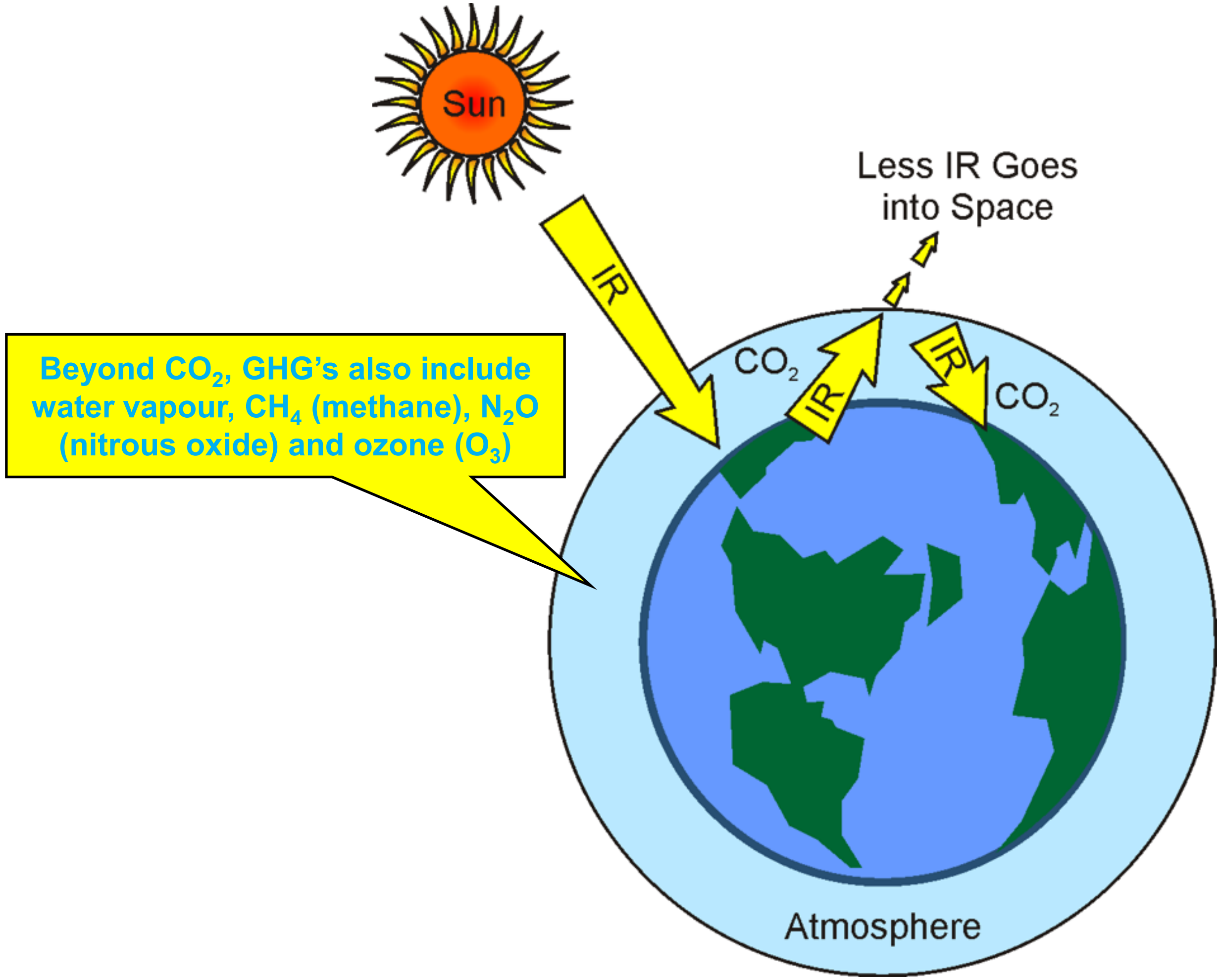


Figure 12. Greenhouse effect. Adapted from Instrument Technician ILM, Environmental Monitoring – Part A, 310404cA, (2019)

Greenhouse gases (GHGs)

- Major GHGs are water vapour, CO_2, CH_4 (methane), N_2O (nitrous oxide) and ozone (O_3)
- Abnormal amounts of GHGs absorb IR energy emitted from earth's surface, resulting in a warming of the atmosphere
- Acidification of the oceans (i.e. absorption of CO_2 forms carbonic acid) is also a huge concern

Ambient water quality measurement

- Two sources include:
  - Surface water
  - Ground water – water below the surface accessible by wells
- Water-effluent contaminants and conditions needing measurement include:
  - Dissolved oxygen
  - pH
  - Temperature
  - Turbidity

Water quality measurement categories

Measurement Category	Examples
Physical characteristics	Temperature, colour, turbidity and conductivity.
Chemical characteristics	Dissolved oxygen, pH, minerals and chemical pollutants.
Biological characteristics	Bacteria, parasites, plants and animals.

Figure 6. Water quality measurement categories. Adapted from Instrument Technician ILM, Environmental Monitoring – Part A, 310404cA, (2019)

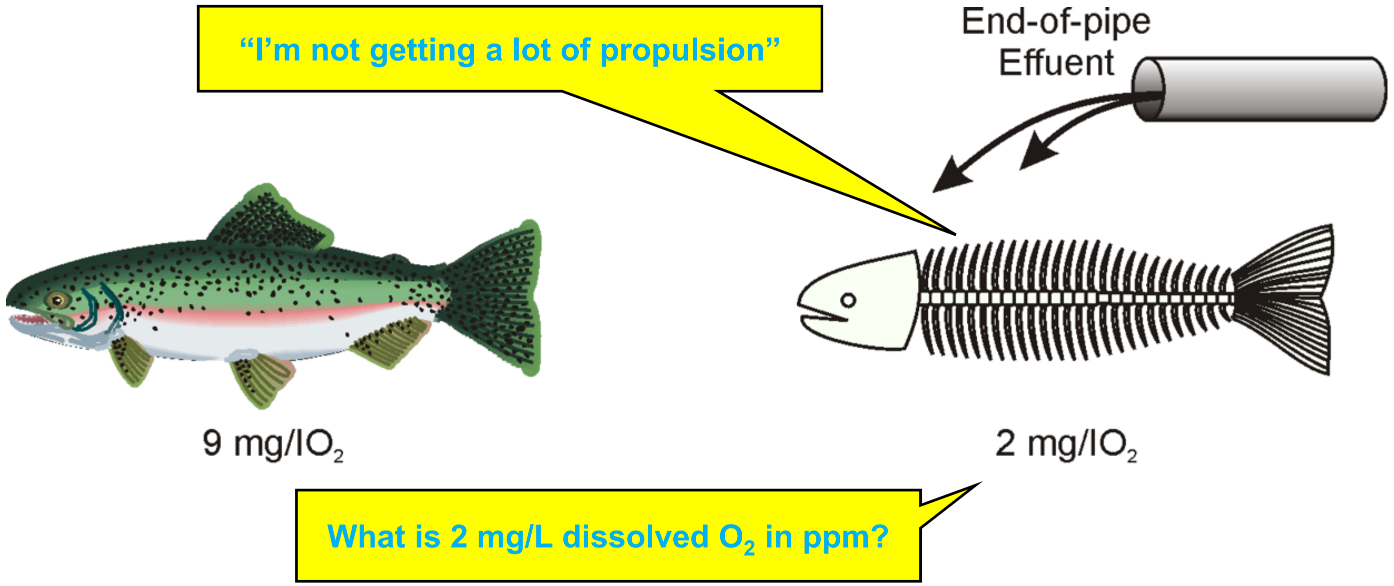


Figure 13. Water quality measurements for fish. Adapted from Instrument Technician ILM, Environmental Monitoring – Part A, 310404cA, (2019)

Industrial air quality management

- Management accomplished through:
  - Regulation
  - Environmental assessment
  - Approvals
  - Enforcement

Government regulation

- Through one type of body:
  - Government ministries
    1. Part of the whole country‘s government

Government roles

- Government's bodies
  - Ministries include
    i. Environment
    ii. Agriculture
    iii. Health
    iv. Transport
  - Independent agencies
    i. Environmental Assessment Agency
    ii. National Energy Board (e.g. Energy East Pipeline assessment)
    iii. Regulating agencies

Country’s key acts – acts are laws

- Environmental Protection and Enhancement Act
- Water Act
- Climate Change Emissions Management Act

Regulatory compliance

- The government's bodies enforce regulatory compliance under the Environmental Protection and Enhancement Act
- Compliance program consists of:
  - Inspection
  - Investigation
  - Compulsory monitoring
  - Reclamation programs

Case study: Alberta ESRD (AEP) – key acts are laws

- Environmental Protection and Enhancement Act
- Water Act
- Climate Change Emissions Management Act

Case study: regulatory compliance – continued

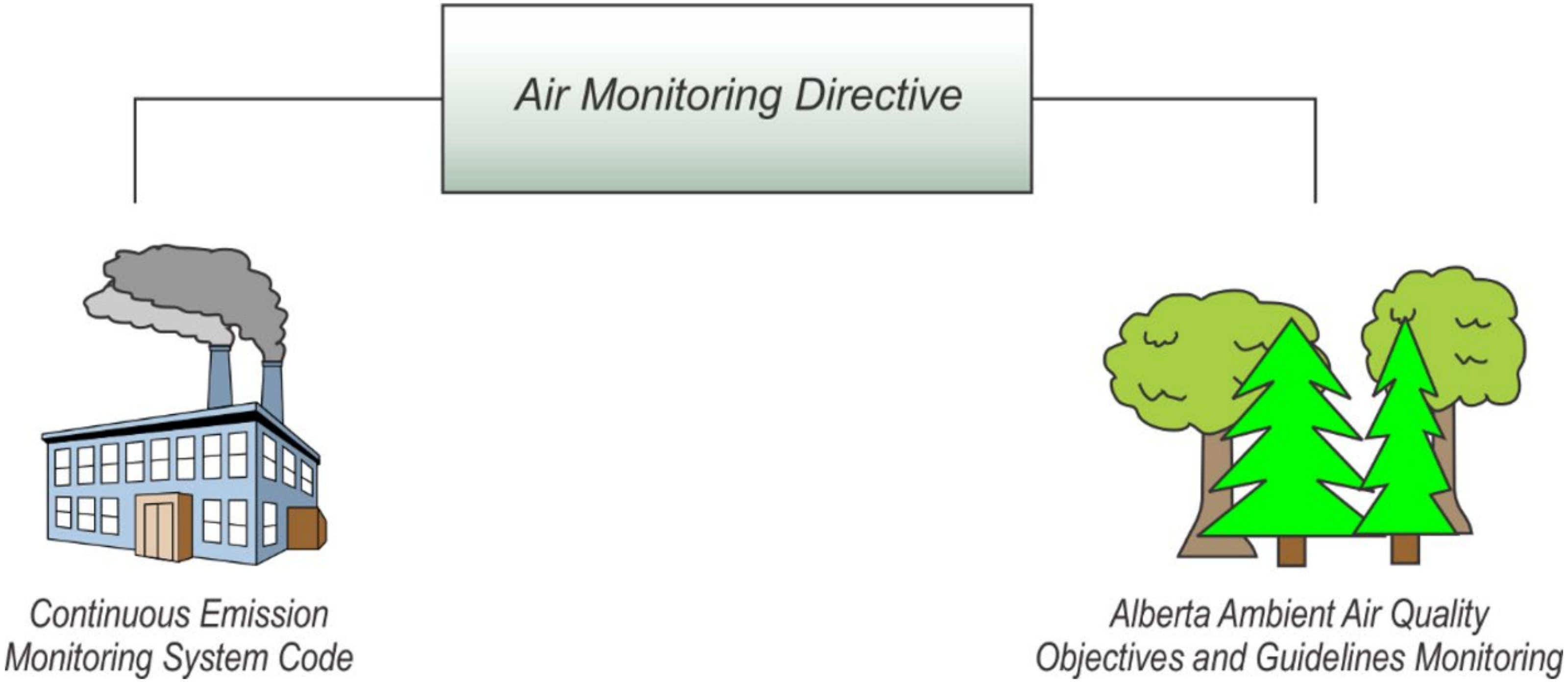
- The ESRD (AEP) enforces regulatory compliance under the Environmental Protection and Enhancement Act
- Compliance program consists of:
  - Inspection
  - Investigation
  - Compulsory monitoring
  - Reclamation programs

Case study: regulatory compliance – continued Government roles

- Environmental protection enacted through by-laws

- Examples:
  i. Regulate drainage in storm sewers
  ii. Transportation of dangerous goods
  iii. Waste management
  iv. Wastewater disposal
  v. Water utility system protection

Air Monitoring Directive (AMD): it starts here



Applicable standards and codes for CEMS and ambient stations

- Follow these codes and guidelines when working on air pollution monitoring equipment
  - Air Monitoring Directive
    1. General document addressing all major air pollutants
    2. Procedures for following proper monitoring and reporting protocol for both source (CEM) and ambient stations
  - Continuous Emission Monitoring System (CEMS) Code
    1. Installation, operation, maintenance and certification of the CEM
  - Ambient Air Quality Objectives and Guidelines
    1. Maximum acceptable ambient air concentrations

Management framework
Approvals are at the centre of most tasks

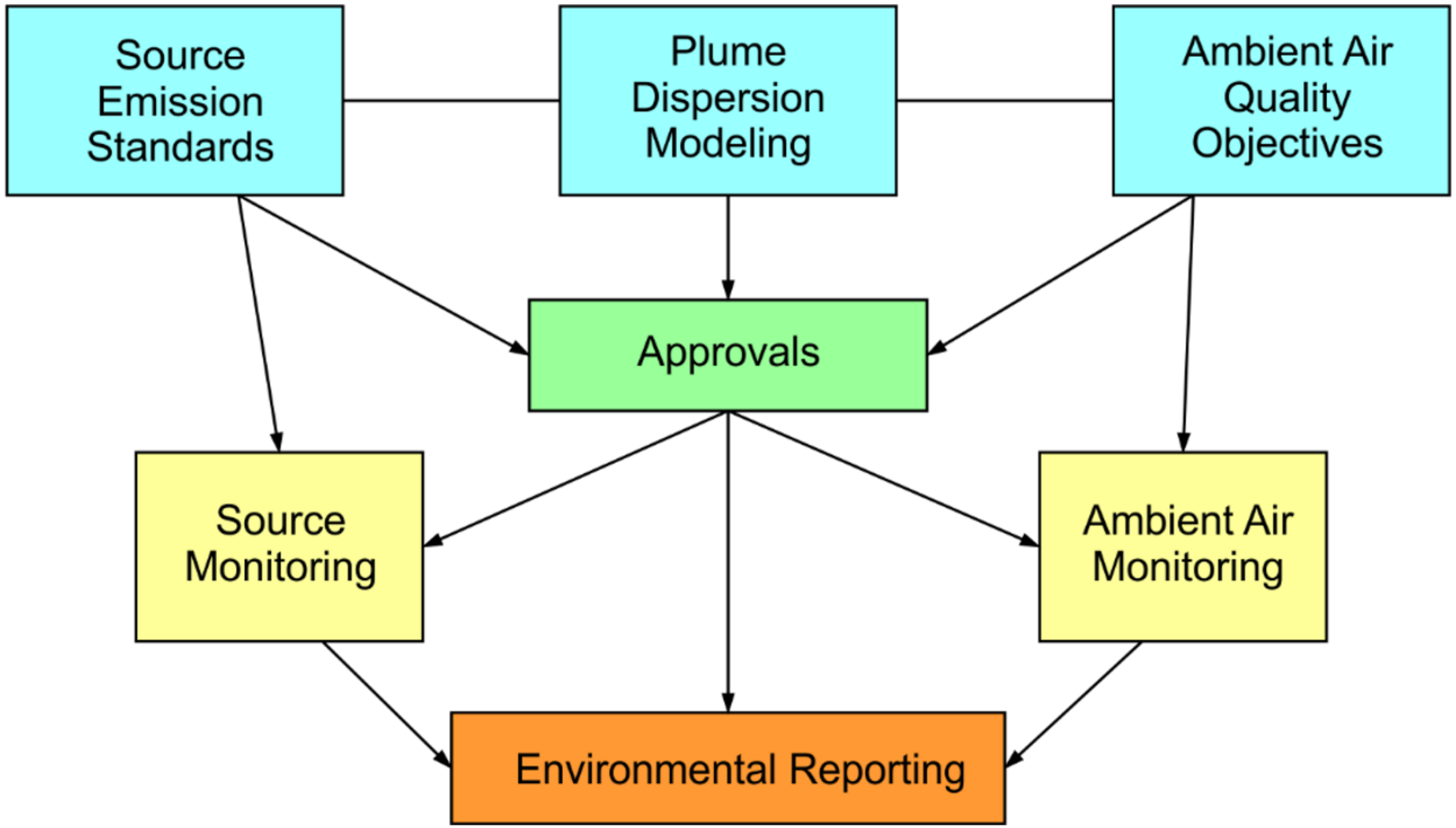


Figure 1. Industrial air quality management. Adapted from Instrument Technician ILM, Environmental Monitoring – Part A, 310404cA, (2019)

Main take-aways

- Compare standards in your country to standards that Alberta, Canada is adopting
- Suggest an addition to current regulatory measures in your country
- Apply the BAT mentioned in Module 2 to current local standards
- Consider safety and mitigation SOPs in the local standard proposed "suggested" changes as mentioned in Module 2

References

- 1. Buracas, Ted. (2008). Smoggy Calgary-800x600[Image file.] Retrieved from: https://www.flickr.com/photos/teddyboy/412721365/in/photolist-2iCj8ui-H4cBEd-HyB495-4QLc1x-CtiFB-4oi76c-5zScLo-5zMUSM-5zSe9s-5zMV3H-hM9iy9
- 2. Government of Alberta – Environment and Parks (Draft Version, 2018). Alberta Continuous Emission Monitoring System (CEMS) Code.
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- 4. Government of Alberta – Advanced Education (2019). Instrument Technician ILM, Environmental Monitoring – Part B, 310404cB
- 5. United States Environmental Protection Agency – Acid Rain Division (1994). An Operator's Guide to Eliminating Bias in CEM Systems.
- 6. Warren, Kevin – AMAROK Consulting (2018). Parkland Airshed Management Zone (PAMZ) [PowerPoint slides]