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# Technical assistance on industrial emissions – Assignment #3 Online real-time monitoring of industrial emissions

## Final report

Report for the European Commission – DG Environment

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# Executive summary

This study investigates the application of online monitoring (telemonitoring) for the reporting of data acquired by continuous emission monitoring systems (CEMS).

The key aims of the study include:

1. To describe the existing telemonitoring practices in countries outside and in the EU and their main usage.
2. To describe current capabilities of telemonitoring, and where relevant CEMS, for air and water emission data.
3. To summarise information on the costs, benefits, advantages and challenges associated with the application of these systems.
4. To analyse benefits of their implementation in the IED context assuming mandatory for all continuous monitoring requirement in adopted BREFs.

To meet the objectives, the findings synthesise information from literature, in-house knowledge, and a small consultation of stakeholders (questionnaire and interviews) conducted with competent authorities, industrial operators and telemonitoring equipment vendors. The geographical scope of the research for this study covered six EU Member States (Austria, Croatia, France, Germany, Italy and Spain) and five non-EU countries (China, India, South Korea, Malaysia and the USA).

## Different telemonitoring approaches have been identified, with varying degrees of complexity

The findings of this study have shown that telemonitoring of industrial emissions data is more advanced in the non-European countries considered in this study, encompassing a larger number of installations and offering real-time publication of data online. It was found that there were different configurations used and these can be divided into four broad approaches:

- **Approach 1** – **Periodic manual submission of data**. This approach is based on the operator manually sharing data with competent authority to demonstrate compliance requirements. Compliance data are sent to the regulator by the operator at defined intervals via e-mail in a defined format.
- **Approach 2 – Periodic automatic submission of data.** As Approach 1, but the data are sent directly to the regulator via an internet connection. However, the information is shared automatically. Using defined format for inclusion into a database which is done by the regulator.
- **Approach 3 – Near real-time periodic automatic submission of data**. This approach also collects CEMS operation status by collecting status flags. The system includes provision for a regulator to monitor individual CEMS real-time (for example in response to system or compliance alarm) and may provide (limited) regulatory access to CEMS functions.
- **Approach 4 – Fully automated real-time data collection with access to CEMS.** Collection of real time or as close to real time data as possible. Also has the capability to access CEMS functions independently of the operator (for example to undertake calibration checks on a system by injecting calibration gas). Plant operation data are also collected.

The study has shown that there are no significant differences between telemonitoring applied for emissions to air and water.

## Several drivers for implementing different telemonitoring approaches have been identified, related to costs, benefits and challenges

The key reported drivers and benefits from telemonitoring include:

- Faster processing of citizens' complaints and better confidence in competent authorities;
- Faster identification of exceedances of emission limit values;
- Easier process in the revision of emission limit values;
- Public access to information;
- Deterring effect for non-compliance;
- Higher quality of industrial emission datasets;
- Streamlining reporting requirements;

- Overall faster decision-making process;
- Lower workload for inspections.

The reported costs vary across all options. Investment costs were quoted in the range of 2,000-8,000 EUR whereas operational costs range between 500-5,000 EUR/year for competent authorities and industry.

The key challenges for operators and authorities related primarily to the lack of centralised guidelines on acceptable technologies, quality assurance and reporting formats.

With respect to data analysis, three key data analysis options were identified:

- **Option 1 – Manual analysis of data in Excel/VBA;**
- **Option 2 – Application of software that delivers ready to use results;**
- **Option 3 – Hybrid between the two,** i.e. application of software that delivers ready to use results and additional statistical analysis performed in Excel.

The benefits of option 1 are that it requires no investments for the competent authority, and the operational costs are only linked to staff responsible for the data analysis in Excel. Key reported drawbacks of option 1 include differences in the reporting formats used by different installations, problems with data management of large data sets, and overall more time required for data analysis.

The benefits of option 2 are that it reduces the required time for data analysis and the potential for human error. Furthermore, the use of software allows larger data sets to be processed which is more suitable for continuous monitoring. Finally, if the same software is applied across installations, data formats and outputs should be homogenous. Key drawbacks include that training is required for those in charge of using the software. Furthermore, costs arise to purchase the software licence, software maintenance and staff time. The costs and benefits for option 3 are similar, with the operational costs likely to be slightly higher due to the additional time for data analysis.

In terms of the required technology on the competent authority premises, the consultation revealed that a standard PC is sufficient to receive tele-reported data.

### We have estimated the possible costs of implementing telemonitoring to those installations already required to carry out continuous monitoring

Regarding the application of telemonitoring in the context of the Industrial Emissions Directive 2010/75/EU, we have estimated the number of communication (reporting) devices required in EU. The estimate is based on the requirements for continuous monitoring in the Best Available Techniques Reference Documents, and ranges between 11 and 77 thousand communication devices. The lowest value assumes that only one communication device is required per industrial site. Other key assumptions include the number of plants per installation in each sector.

An investment of 27 million EUR would be required to implement one simple reporting device in each installation. The investment value for the whole EU would go up to 221 Million EUR if implementing the most sophisticated solution with larger set of functionalities. The telemonitoring connection could be implemented with existing CEMS.

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# Glossary

| Abbreviation | Definition |
|---|---|
| BAT | Best Available Techniques |
| BATCs | BAT Conclusions |
| BOD | Biochemical Oxygen Demand |
| CAA | Clean Air Act (USA) |
| CAMS | Copernicus Atmosphere Monitoring Service |
| CEMS | Continuous Emissions Monitoring System |
| CEMS-DIS | CEMS Data Interfacing System |
| $CH_2O$ | Formaldehyde |
| $Cl_2$ | Chlorine |
| CO | Carbon Monoxide |
| $CO_2$ | Carbon Dioxide |
| COD | Chemical Oxygen Demand |
| CPCB | Central Pollution Control Board (India) |
| DAHS | Data Acquisition and Handling System |
| DCS | Distributed Control System |
| DMZ | De-Militarised Zone |
| DOE | Department of Energy |
| EIA | Environmental Impact Assessment |
| ELV | Emission Limit Value |
| EPA | Environment Protection Agency |
| ETS | Emissions Trading System |
| EU | European Union |
| FTP | File Transfer Protocol |
| FTPS | File Transfer Protocol Secure |
| HCl | Hydrogen Chloride |
| HF | Hydrogen Fluoride |
| Hg | Mercury |
| MCERTS | Monitoring emissions to air, land and water |
| N | Nitrogen |
| NAAQS | National Ambient Air Quality Standards |
| NEMC | National Environmental Monitoring Centre |
| $NH_3$ | Ammonia |
| $NH_3$-N | Ammoniacal Nitrogen |
| NOx | Nitrogen Oxides |
| OECD | Organisation for Economic Co-operation and Development |
| $O_3$ | Ozone |
| P | Phosphorus |
| PM | Particulate Matter |

| Abbreviation | Definition |
|---|---|
| $PM_{10}$ | Particles < 10µm |
| $PM_{2.5}$ | Particles < 2.5µm |
| PRTR | Pollutant Release and Transfer Register |
| $SO_2$ | Sulfur Dioxide |
| SOx | Sulphur Oxides |
| SFTP | Secure File Transfer Protocol |
| SIP | State Implementation Plan |
| SPCB | State Pollution Control Board |
| SS | Suspended Solid |
| TDS | Total Dissolved Solids |
| THC | Total Hydrocarbon |
| TN | Total Nitrogen |
| TOC | Total Organic Carbon |
| TP | Total Phosphorus |
| TSP | Total Suspended Particles |
| TSS | Total Suspended Solids |
| TÜV | Technischer Überwachungsverein |
| USA | United States of America |
| VOC | Volatile Organic Compounds |
| QA/QC | Quality Assurance/Quality Control |
| QAL | Quality Assurance Level |

# 1 Introduction

This report presents the findings of the assignment entitled "Online real-time monitoring of industrial emissions" performed for DG Environment of the European Commission. The assignment is part of the call-off service contract "Technical assistance on industrial emissions" (070201/2018/791640/SFRA/ENV.C.4), which is Service Request 17 under Framework Contract ENV.C.4/FRA/2015/0042.

## 1.1 Background

The Industrial Emissions Directive (IED) and the associated Best Available Techniques Conclusions (BATCs) contain requirements to use continuous monitoring for certain pollutants and emission sources from industrial processes. For this purpose, continuous emission monitoring systems (CEMS) are applied. CEMS are broadly divided into two key categories[1]:

- Fixed in situ instruments – these instruments do not need to withdraw any sample to analyse it and are usually approved for specific applications. Regular maintenance and calibration of these instruments is essential.
- Fixed on-line instruments (also called "extractive") – these instruments continuously extract samples from the stream along a sampling line and transport them to an on-line measurement station, where the samples are analysed continuously. This type of equipment often requires pre-treatment of the sample.

Emission monitoring and reporting tools have been subject to significant improvements. As a result, many countries, inside and outside the European Union (EU), are adopting systems which allow real-time emission data transmission (telemonitoring) to competent authorities and/or to provide the general public with access to these data online. For example, the Organisation for Economic Co-operation and Development's (OECD) 'Best Available Techniques (BAT) for Preventing and Controlling Industrial Pollution'[2] has revealed extensive use of online real-time monitoring in China, Korea, the United States of America (USA) and India. Within the EU, examples of tele-reporting have been identified in this study in Germany, Spain, Croatia, France and Italy.

Figure 1-1 shows that to deliver online emission data to authorities, two different building blocks are required: a Continuous Emissions Monitoring System (CEMS) and an IT solution to share the data collected by the CEMS in real-time or at a specific frequency (e.g. half-hourly).

CEMS have been available for many years and are well described in the reference document 'Monitoring of Emissions to Air and Water from IED Installations'[3] (ROM REF), and in many of the sectoral BAT Reference documents (BREFs) prepared under the IED. These documents do however not describe the solutions required to communicate high-density emission data, for example to competent authorities.

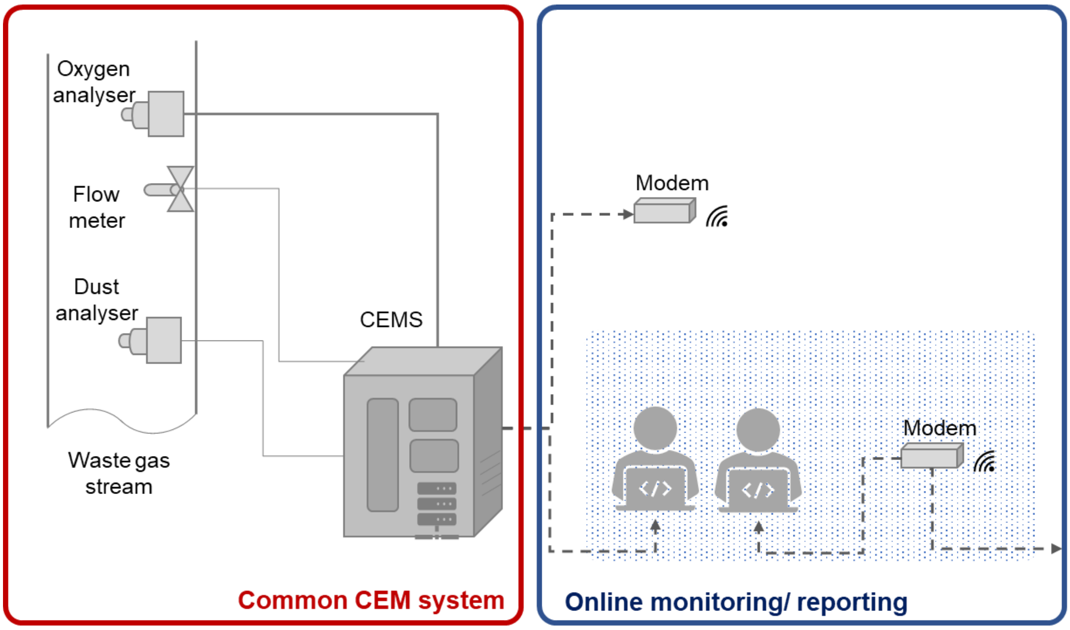
The plant distributed control system (DCS) controls the industrial processes and would be subject to a security risk if systems outside the process could access it. A firewall or similar security device is normally installed between the DCS and online data sharing items.

[1] JRC, 2019, Reference Report on Monitoring of Emissions to Air and Water from IED Installations, Available from: https://eippcb.jrc.ec.europa.eu/sites/default/files/2019-12/ROM_2018_08_20.pdf

[2]http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/JM/MONO(2019)21&docLanguage=En

[3] https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/jrc-reference-report-monitoring-emissions-air-and-water-ied-installations-industrial

Figure 1-1 CEMS used for online data reporting




## 1.2 Objectives

The telemonitoring approaches used in conjunction with CEMS in some countries may be useful in the context of the IED, specifically with regard to monitoring, reporting and facilitating public access to information. DG Environment introduced this topic in the IED Evaluation workshop[4] that took place in May 2019.

The objectives of this assignment are:

1. To describe the existing telemonitoring practices in countries outside and in the EU and their main usage.
2. To describe current capabilities of tele-reporting, and where relevant CEMS, for air and water emission data.
3. To summarise information on the costs, benefits, advantages and challenges associated with the application of these systems.
4. To analyse benefits of their implementation in the IED context assuming mandatory for all continuous monitoring requirement in adopted BREF.

The scope of the assignment primarily relates to telemonitoring and telemonitoring aspects, however connections and communication with CEMS are considered and described where relevant.

## 1.3 Methodology

To meet the objectives, our findings have synthesised information from the following sources:

- Literature;
- In-house knowledge;
- Stakeholder consultation (questionnaire and interviews) conducted with competent authorities, industrial operators and telemonitoring equipment vendors.

The geographical scope of the research for this study covered six EU Member States (Austria, Croatia, France, Germany, Italy and Spain) and five non-EU countries (China, India, South Korea, Malaysia and the USA). The selection of countries was agreed with the Commission based on the information available prior to this contract. Table 1-1 summarises the information sources used to inform findings

[4] https://circabc.europa.eu/ui/group/06f33a94-9829-4eee-b187-21bb783a0fbf/library/3ff25cee-c020-41bb-ae5b-450ce1115ef2

for each country. Representatives from all countries considered in this study were invited to participate in the stakeholder consultation.

The stakeholder consultation included an online questionnaire (presented in Annex A1) and follow up interviews to clarify or expand on feedback provided. The consultation took place during the period when most European countries had imposed lockdown restrictions due to the Covid-19 pandemic and this may have had an impact on availability and/or priorities of stakeholders to respond to the information requests. Information received from stakeholders has been summarised in an Excel spreadsheet which is provided in Annex A2.

Table 1-1 Information sources consulted for each country

| Country | Literature | Questionnaire | Interview |
|---|---|---|---|
| **In the EU** | | | |
| Austria | None identified | ✓ | ✓ |
| Croatia | ✓ | ✓ | ✓ |
| France | None identified | ✓ | ✓ |
| Germany | ✓ | ✓ | ✓ |
| Italy | ✓ | ✓ | No response |
| Spain | ✓ | ✓ | ✓ |
| **Outside the EU** | | | |
| China | ✓ | No response | ✓ |
| India | ✓ | ✓ | No response |
| Korea | ✓ | ✓ | No response |
| Malaysia | ✓ | No response | No response |
| USA | ✓ | ✓ | No response |

## 1.4 Structure of this report

This reported is structured as follows:

- **Chapter 2** summarises the information gathered about **current telemonitoring practices** within and outside the EU;
- **Chapter 3** describes the **technical capabilities** of telemonitoring systems;
- **Chapter 4** analyses the **drivers** for deciding to use telemonitoring systems, including the benefits of online real-time monitoring systems.
- **Chapter 5** summarises the **continuous monitoring requirements under the IED** and BATCs.
- **Chapter 6** provides **estimates of implementing telemonitoring** in the context of the IED related to:
    - the number of IED installations that have to be equipped with CEMS under the IED and the number of CEMS per site;
    - the resources, in particular costs for an operator to connect an existing CEMS to a telemonitoring system hosted by an authority.
    - the requirements and costs to set-up a comprehensive system for hosting, monitoring and managing such real-time emissions data – as a pilot and for all IED installations concerned with continuous monitoring requirements.
- **Chapter 7** provides conclusions and recommendations.

# 2 Description of existing telemonitoring systems

This section presents the findings of Task 1 describing the experience of telemonitoring systems used outside and within the EU in sections 2.1 and 2.2 respectively. The information was collected in the stakeholder consultation from industrial operators, competent authorities and technology vendors. The information has been compiled in an Excel (Annex A2) template with full results from the literature review and the consultation in different regions or countries including number of sites, medium (air/water) being covered and pollutants, use of data, criteria for selecting this solution, lessons learnt.

Further information on the costs, benefits and challenges in implementing telemonitoring is available in section 4, Table 4-1.

## 2.1 Overview of systems outside the EU

### 2.1.1 China

#### Telemonitoring targeted pollutants and sectors

China undertakes national development using five-year plans, which cover all aspects of development including environmental initiatives and associated regulation. The current (13$^{th}$) five-year plan includes requirements for emission reductions for NOx, $SO_2$ and VOC, for all cities to achieve 'good' air quality more than 80% of time by 2020, and for the implementation of a requirement to collect data from emissions sources via remote monitoring systems.

The telemonitoring systems required are for emissions to air and water. The monitored pollutants for air are $SO_2$, $NO_X$, PM, and associated data such as $O_2$, temperature, volume, humidity, among others. For water, the pollutants monitored include COD, P, $NH_3$-N, BOD, N, TSP and parameters such as volume and pH. The sectors required to report data online include:

- Thermal power plant boilers;
- Industrial boilers and furnaces;
- Municipal waste incinerators;
- Hazardous waste incinerators;
- Fixed pollution sources (industrial sources).

The number of installations reporting online amount to 10,492 for air monitoring data and 19,591 for water.

#### Drivers for implementation

The drivers for implementation reported by the competent authorities in China include:

- To check compliance (between ELVs or equivalent, and real emissions);
- To serve as a feedback in updating ELVs or equivalent (or other longer-term analysis);
- To facilitate reporting;
- To facilitate public access to information;
- To support dealing with complaints from citizens or neighbours;
- To reduce workload for compliance audits;
- To improve decision-making in air quality (investigation);
- To deter non-compliance.

Besides the drivers listed above, the data collected assists the Chinese government in understanding how easy or difficult it is for enterprises to meet emission limits. Consequently, it supports decision-making with regard to permissible limit values.

#### Software and hardware

The Chinese competent authorities reported the use of sophisticated software that delivers end results ready to use and a software licence that required extensive training of officials to use and fully exploit its functionalities. Software options may vary between regulated industrial installations as they are required to select a software and hire a third-party company to manage and maintain their online data[5].

With regards to hardware, the competent authority reported the use of a standard computer at the competent authorities' premises to receive the data and an advanced computer also on the authorities' premises to analyse and process data. There are several suppliers for CEMS hardware equipment, all of which should be certificated by the National Environmental Monitoring Centre (NEMC), according to guidelines HJ75/HJ76[5].

In terms of the monitoring instruments, they have a digital output interface which is connected to independent data collection and a transmitter[6]. All local data are collected and managed at the national level by the NEMC.

A series of specifications and technical guidelines for power plants and local governments have been developed to perform and supervise all the processes in the CEMS network, from operations to data collection, processing and storage[7]. In addition, HJ212 provides a standard for data format and connection[6].

Processed and filtered data are made available to the public, as reported by the competent authority. Since 2013, state-monitored industrial installations need to report data to a publicly available, online platform for the specific provinces[7]. With regards to data validation before publishing, the competent authority highlighted that there are several levels of approval from the local, provincial and national government. There is a validation step (software) to prevent manipulation of the data by the operator, a 'manual' validation step (at least one approval from a policy officer) and data are also validated by the authority. In addition, only one person has access to the specific office in the plants and not the operator.

A substantial punishment mechanism is in place, including financial penalties and criminal punishments for deleting, distorting and forcing monitored data[7].

#### Lessons learnt

No specific lessons learnt have been reported by the competent authority. However, in a previous study by Ricardo, at the start of the implementation of CEMS, there was a need for a period of capacity building for CEMS suppliers in the country (including communications systems). This was to ensure that there was a sufficient number of quality systems available. In addition, it took some time to adjust to the new performance standards and for instruments to be adapted to fit the Chinese situation.

### 2.1.2 India

India has adopted a telemonitoring system to target environmentally-damaging pollutants and highly polluting industrial sectors. The overall objective is to improve air quality and reduce the impact on public health. It was recognised that this approach had to be supported by high quality emission measurement. Consequently, QA/QC CEMS has an important role in the approach adopted.

The Indian Central Pollution Control Board (CPCB) issued directions to regional authorities for the installation of on-line effluent quality and emission monitoring systems in selected industries. There are 17 industrial sectors for which telemonitoring applies, including:

- Primary aluminium smelters;
- Caustic soda production;
- Cement manufacture;
- Non-ferrous metals;
- Distilleries;
- Manufacture of dyes and dye intermediates;
- Fertiliser manufacture;
- Iron and steel production;

[5] Recorded in private interview in previous Ricardo's work

[6] Data transmission standard for online monitoring systems of pollutant, HJ212 (in Chinese), 2017. Available at: http://www.mee.gov.cn/ywgz/fgbz/bz/bzwb/other/qt/201706/W020170608577218811635.pdf

[7] Tang et al., 2019. Substantial emission reductions from Chinese power plants after the introduction of ultra-low emissions standards. Available at: https://doi.org/10.1038/s41560-019-0468-1

- Tanneries;
- Chemical industries;
- Pulp and paper;
- Oil refineries;
- Sugar refineries;
- Thermal power plants.

Real-time monitoring is also required for common waste treatment facilities for emissions to air and water.

The total number of installations subject to telemonitoring of CEMS is over 40,000.

Pollutants monitored in releases to air, as reported by the competent authority, are $PM_{10}$, $PM_{2.5}$, $SO_2$, NOx, $O_3$ (includes industrial emissions and air quality parameters); those monitored in releases to water are pH, TSS, TDS, COD, BOD, oil and grease.

The Indian authorities have taken steps to ensure that the CEMS used are of high quality. The CPCB reviewed countries that had a mature approach for the use of CEMS, including the USA, UK, Germany and France. On the basis of this review, a systematic approach for the use of CEMS has been implemented in the country. A number of standards and practices relating to the use of CEMS have been adopted. These include the development of a CEMS certification scheme and the adoption of the United States Environmental Protection Agency (US EPA) performance specifications or EN quality assurance standards for the verification of CEMS.

### Drivers for implementation

The drivers for implementation reported by the competent authorities in India include:

- To check compliance (between ELVs or equivalent, and real emissions);
- To use for the PM emission trading scheme (ETS);
- To produce higher quality industrial emission datasets;
- To facilitate public access to information;
- To support dealing with complaints from citizens or neighbours;
- To improve decision-making in air quality policies (investigation).

### Software and hardware

In terms of hardware, a standard computer is installed at the competent authorities' premises and is used to collect and store data. Sensor data are stored on a data logger at the installation and transmitted to a central server via the internet or a private telecommunications circuit. Every unit must provide a leased line internet facility for data to be transmitted continuously from the analyser, with no delays. If a leased line is not available, a broadband connection may be installed temporarily[8].

With regards to the software used, the competent authority reported the installation of sophisticated software that delivers end results ready to use. The CPCB defined the interface and software to be used, allowing a standardised connection between the CEMS and the data collection systems for the CPCB and State Pollution Control Boards (SPCB).

Different software systems to be used include:

- CEMS vendor software;
- ETS bridge software interface to receive real time data residing on the data acquisition and handling systems (DAHS);
- ETS server software for CPCB and SPCB servers;
- User software for data visualisation/analysis etc., which are mostly browser based.

The competent authority reported that filtered/processed data are available online and can be publicly accessed through a web application[9]. There is an automated validation step (software) to prevent

[8] Online CEMs data submission procedure at CPCB

[9] https://cpcb.nic.in/online-monitoring-of-industrial-emission/

manipulation of the data by the operator and data are also validated by the authority. Industrial installations are required to allow the SPCBs/CPCB to conduct remote verification of the system whenever necessary (for example, remote initiation of response checks)[10]. In addition, the SPCBs may intervene in the monitoring of an industry to ensure high quality data[10]. The system can receive notifications of complaints and trigger supervisory or regulatory actions on industries.

In the case of exceedance or incomplete data supply, servers at the SPCB and CPCB send message alerts to industries. Operators should respond with a corrective action. If the number of message alerts sent exceeds a certain limit, CPCB and SPCB may visit the industrial facility to inspect the facility and review the emission control equipment or the water treatment facilities[11,10]. Exceedance of the prescribed standards are considered a violation. Closure or suspension of operations by SPCBs/PCCs may occur if non-compliance continues.

CEMS monitoring guidance is published by the CPCB[12], including descriptions of CEMS technologies acceptable for use in specific industries, ELVs and, suitable locations for CEMS. There is a requirement for a stratification/homogeneity test to ensure representative sampling.

This is supported by the Centre for Science and Environment which has published Technical Guidance[13], which describes:

- International best practices;
- CEMS sampling techniques for gases and PM;
- Other parameters to be monitored, such as gas flow rate, water vapour, temperature and pressure;
- Regulatory requirements;
- Roles and responsibilities;
- Vendors and suppliers;
- Installation (location provisions, reference methods);
- Quality Assurance and Quality Control;
- Calibration requirements;
- Defined parameters for DAHS.

Guidelines on CEMS Vendor Software for ETS[10] is also available on the architecture required for CEMS devices installed at sites. This includes the DAHS, the connection to the CPCB and SPCB servers and data access points (i.e. computers where CEMS data can be accessed and managed through a web-browser).

For telemonitoring, data collection systems must enable collection of real time data and to undertake remote calibrations to verify the condition of the CEMS. It is the operators' responsibility to ensure that raw data are provided continuously to at least four locations including CPCB, SPCB servers and secure back-ups at each location. Technology suppliers may be contracted to perform this role. For most CEMS, data collection is set to every 15 seconds. The data are transmitted to a cloud server in an encrypted form.

### Lessons learnt

In the stakeholder consultation, the competent authority stated the key challenges experienced in India during the implementation of telemonitoring included:

- Management of large data volumes;
- Plausibility control of data;
- Calibration of systems;
- Assessment of uncertainity;

[10] Central Pollution Control Board, 2014. Specifications and guidelines for continuous emissions monitoring systems (CEMs) for PM measurement with special reference to emission trading programs. Available at: http://mahenvis.nic.in/Pdf/Report/report_epm6.pdf

[11] OECD, 2018. Best Available Techniques (BAT) for preventing and controlling industrial pollution. Available at: http://www.oecd.org/chemicalsafety/risk-management/approaches-to-establishing-best-available-techniques-around-the-world.pdf.

[12] Central Pollution Control Board, 2018. Guidelines for Continuous Emission Monitoring Systems. Available at: https://www.nevcoengineers.com/wp-content/uploads/2018/08/revised-ocems-guidelines-29.08.2018.pdf

[13] CEMS Continous Emission Monitoring System A technical Guidance Manual Centre for Science and Envirnment 2017

- Selection of appropriate CEMS technology;
- System certification.

### 2.1.3 South Korea

#### Telemonitoring targeted pollutants and sectors

The Clean Air Conservation Act provides a focus on air pollution in urban areas and enables the designation of air quality areas. Several areas have been designated air quality areas including Seoul Metropolitan area, Busan area, Daegu area, and Gwangyangman area. An air quality area designation requires development of a plan and reporting progress towards compliance which can include measures on industrial activities, transport and other sectors.

In addition, the Clean Air Conservation Act requires management of emissions from industrial facilities through a permit and reporting system. Permits are required for industrial facilities within special counter-measures areas. ELVs are set nationally for specified air pollutants and industrial activities but stricter ELVs could be set in some instances. Under the Act, telemonitoring is also required.

In recent years, South Korea has been working to implement integrated regulation of industrial facilities, based on the principles of the IED including application of BAT. The intention is to implement legislation changes to allow a more integrated approach to permitting of industrial facilities so that all emission media, the local environment and BAT are considered[14].

A telemonitoring system is applied for industrial emissions to air (CleanSYS), ambient air quality and industrial emissions to water. The pollutants which are monitored are;

- TSP, NOx, SOx, HCl, HF, $NH_3$, CO for emissions;
- $PM_{10}$, $PM_{2.5}$, $O_3$, CO, $SO_2$, $NO_2$ for ambient air; and
- pH, temperature, flow quantity, DO, BOD, COD, SS, TN, TP for water.

The difference between air, ambient air quality and water telemonitoring is that each is managed by different authorities operating under the Ministry of Environment. The industrial sectors and concerned pollutants covered under the stack telemonitoring system (CleanSYS) are summarised in Table 2-1 below. For water, the parameters and pollutants listed above are telemonitored only in large industrial complexes that discharge more than 2000 tonnes of waste water per day. In all other installations, only water flow quantity is telemonitored.[15] Approximately 1,400 industrial installations apply telemonitoring for air and the number is similar for water.

Table 2-1 Facilities that must install CEMS and connect to the Stack Telemonitoring System

| Regulated sectors in South Korea | Pollutants | Monitoring requirement thresholds |
|---|---|---|
| Power plant | Liquid and solid fuels (PM, $NO_X$, $SO_X$), gaseous fuels (NOx) | ≥50 MW |
| Power plant – internal combustion engine | Liquid and solid fuel (PM, NOx, SOx), gaseous fuel (NOx) | >5 MW |
| Incineration plants :<br>Continuous/semi-continuous workplace incinerator,<br>Continuous/semi-continuous household waste incineration,<br>Waste gas incineration<br>Continuous/semi-continuous clinical waste incinerator,<br>Sewage sludge incineration | PM, NOx, HCl, CO, SOx for workplace incinerator<br>PM, NOx, HCl, CO for household waste incinerator<br>NOx, CO, SOx for waste gas incinerator<br>PM, NOx, HCl, CO for waste incinerator | >400 kg/hr for workplace incinerator<br>>1 tonne/hr for household waste incinerator<br>>10,000 $m^3$/h exhaust gas for waste gas incinerator<br>>200 kg/hr for waste incinerator<br>>200 kg/hr for wastewater incinerator |

[14] Information from Ministry of Environment http://eng.me.go.kr/eng/web/index.do?menuId=442

[15] Korea Environmental Policy Bulletin, 2010,

| Regulated sectors in South Korea | Pollutants | Monitoring requirement thresholds |
|---|---|---|
| | PM, NOx, CO for wastewater incinerator | |
| Coke Manufacturing Facility and Related Product Storage Facility | PM, NOx, SOx | >10,000 $m^3/h$ exhaust gas |
| Petroleum Product Manufacturing facilities including heating plant greater than ~30 kW and other process operations | PM, NOx, SOx | >10,000 $m^3/h$ exhaust gas |
| Basic organic chemicals manufacturing facility including heating plant > about 30 kW and other process operations | PM, NOx, SOx | >10,000 $m^3/h$ exhaust gas |
| Basic inorganic chemicals manufacturing facility,<br>Chemical fertiliser manufacturing facility,<br>Other chemicals processes | Pollutants dependent on process | >10,000 $m^3/h$ exhaust gas |
| Glass manufacturing facilities | PM, NOx, SOx | >10,000 $m^3/h$ exhaust gas unless using clean fuel |
| Cement, lime, plaster and its manufacturing facilities | PM, NOx, SOx | >10,000 $m^3/h$ exhaust gas<br>>30,000 $m^3/h$ exhaust gas for lime processes |
| Pottery and ceramics manufacturing facilities<br>Other non-metallic mineral product manufacturing facilities including various operations | PM, NOx, SOx | >10,000 $m^3/h$ exhaust gas |
| Primary Metal Manufacturing Facility – electric arc and other furnace, acid treatment, heating/melting/roasting furnace and sand treatment,<br>Fabricated metal products, machinery, equipment, equipment, transportation equipment, furniture manufacturing facilities - electric arc and other furnace, acid treatment, heating/converting/melting/roasting furnace, and sand treatment | PM, NOx, SOx | >10,000 $m^3/h$ exhaust gas for electric arc and other furnace, acid treatment<br>>50,000 $m^3/h$ exhaust gas for heating/melting/roasting furnace<br>>100,000 $m^3/h$ exhaust gas for sand treatment |
| All Facilities | | >1 tonne/hr solid fuel |

### Drivers for implementation

Drivers identified by the competent authority include:

- To check compliance (between ELVs and real emissions);
- To provide feedback to update ELVs or equivalent (or other longer-term analysis);
- To facilitate public access to information;
- To improve decision-making in air quality (investigation);

### Software and hardware

The competent authority reported that an advanced computer is used to analyse data. In terms of software, the authority reported that sophisticated software that delivers results ready to use is in place. Connection with CEMS at the facilities is through a data logger; data transmission devices are usually used.

Air and water data are collected every 30 minutes. However, frequencies of data collection depend on the emission parameter and the type of regulated process. Data are then aggregated/averaged and several statistical analyses are run (to remove outliers and errors). Measurement uncertainties are accounted for by the Ministry of Environment for each business.

Data from CEMS in Korea are collected and transmitted using a web server and database server architecture CleanSYS[16]. The data are collected into a database which is checked, validated and monitored by regional centres operated by Korea Environment Corporation (K-ECO)[17] .The data are then made available to the Ministry of Environment, and the local government.

Data used by the government are already analysed and are ready to use for policy development, such as preparation of the trading system's emission rights[14,18].

In terms of data verification, the Ministry of Environment can double check the monitoring data. For water, the Water Control Center is in charge of verifying the reliability of the data[18]. Technical Working Groups, which include representatives from the Ministry of Environment, business operators, industrial associations, and other experts, are in charge of handling the data used for determining BAT[19].

When emissions are close to the ELVs or these are exceeded, the operator and local government are immediately informed via an SMS text message to take action[14]. For water, an enforcement order is sent for exceedances. If emissions exceed the cap, a charge is levied and the facility's allocation for the following year is reduced. For water discharge facilities, monetary penalties are also in place for excess load[18].

Processed data are publicly available after being validated. Data for water are also published in bulletins[14].

#### Lessons learnt

No lessons were identified in the reviewed literature or by the competent authority.

#### Box 2-1 Korea's CEMS requirements

The requirements for the installation and operation of telemonitoring are specified in several pieces of legislation:

- Article 17 of Enforcement Decree of the Atmospheric Environment Conservation Act.
- Article 19 (Enforcement and Operation of the Chimney Remote Monitoring System Control Center).
- Article 66 (Consignment of Authority) Enforcement Decree of the Atmospheric Environment Conservation Act.
- Article 37-2 of the Enforcement Regulations of the Atmospheric Environment Conservation Act (Application for Attachment and Operation of Automatic Measuring Devices).
- Ministry of Environment Notice No. 2016-159 (Regulations on the function and operation of the chimney remote monitoring system control center).
- Air pollution process test standard (continuous automatic measurement method of exhaust gas).

### 2.1.4 Malaysia

#### Telemonitoring targeted pollutants and sectors

Malaysia introduced an Environmental Quality Act in 1974 and the Environmental Quality (Clean Air) Regulation in 1978. These regulations include requirements for the installation of CEMS and the

[16]Korea Research Institute of Standards and Science, 2016. Clean SYS of Korea. Available at: www.apmpweb.org/fms/get_file.php?index=NTQzOA==

[17]K -ECO is an entity specifically set-up to utilise the systems to collect the data from all aspects of environmental monitoring, including stack emissions, ambient air and water

[18] Ministry of Environment, 2010. Korea environmental policy bulletin: Water quality monitoring using IT. Available at: https://wedocs.unep.org/bitstream/handle/20.500.11822/8989/-Korea%20Environmental%20Policy%20Bulletin%20-%20Water%20Quality%20Monitoring%20Using%20IT-2010Water%20Quality%20Monitoring%20Using%20IT_KEPB2010.pdf?sequence=3&isAllowed=y

[19] OECD, 2018. Best Available Techniques (BAT) for preventing and controlling industrial pollution. Available at: http://www.oecd.org/chemicalsafety/risk-management/approaches-to-establishing-best-available-techniques-around-the-world.pdf

telemonitoring of CEMS via a defined interface and protocol. At this stage, there were 24 sites already linked via telemonitoring to regional department of environment offices. Regulations were further updated in 2014. As a result a electronic reporting system called Iremote was introduced. This system is used to collect data from installations required to use CEMS via telemonitoring.

The pollutants which are monitored are $NO_2$, CO, total PM, NMVOC (as total C), HCl, HF, $SO_2$. Telemonitoring is applied to the following activities:

- fuel burning equipment;
- heat and power generation;
- ferrous metals;
- non-ferrous metals;
- oil and gas;
- natural gas processing and storage;
- petroleum products;
- non-metallic industry including cement production, glass, ceramic products;
- waste incinerators[20].

### Drivers for implementation

The main drivers for implementing telemonitoring identified in the literature include[20]:

- To check compliance (between ELVs and real emissions);
- To facilitate reporting on stack emissions;
- To deal with complaints from citizens or neighbours;
- To improve decision-making, e.g. to inform operators' process optimisation, cost reduction and development of future programs to reduce emissions;
- For environmental preservation.

### Software and hardware

CEMS components and equipment must comply with selected international standards, such as the UK Monitoring Certification Scheme (MCERTS), the German Technical Inspection and Monitoring Association (TÜV) and the Malaysian Standard for Performance Criteria and Test Procedure for CEMS[20].

All systems should be designed to transmit data to the Department of Energy (DOE), through internet connectivity. Data are stored in the CEMS Data Interfacing System (CEMS-DIS) from the DAHS and is communicated to the DOE server. A system developed by the DOE, the iRemote, is in place in the country, where all transferred data from site is received and processed from the CEMS-DIS and is accessible to the government and plant operators[20]. The iRemote has an alert system to notify operators of any exceedances. For compliance, no daily averages should exceed ELVs and no 30 minute average should exceed two times the ELV. Data are available online but accessible only to departments within DOE and other governemental departments.

DOE requirements must be followed for the installation and operation of CEMS, including requirements for design, installation, initial performance audits and quality assurance[20]. Operators are required to use certified equipment and registered CEMS consultants (listed in the DOE website) should be responsible for CEMS installation. In addition, the DOE provides guidance for the use of CEMS and it specifies the requirements for valid data, i.e. averages based on one-minute data must contain 45 seconds of valid data points, a 30 minute average must contain at least 22 valid minute data points and the daily average must be derived from the 30 minute data.

In addition, training manuals are available for industry operators to learn about the iRemote system. The manuals include information on how to register an application for CEMS installation, QA, consultants, approved CEMS analyser list, data pooling, data compliance, query and feedback, and

[20] Department of Environment, 2019. Volume 1: Series of CEMs. Guidelines for the installation & maintenance of continuous emission monitoring systems (CEMs) for industrial premises/facilities. Available at: https://www.doe.gov.my/portalv1/wp-content/uploads/2013/01/GUIDELINE-FOR-THE-INSTALLATION-MAINTENANCE-OF-CEMS-FOR-INDUSTRIAL-PREMISES-OR-FACILITIES-VERSION-7.0-JULAI-2019.pdf

information on Predictive Emission Monitoring System[21]. There is also a training manual for online reporting by DOE[21].

#### Lessons learnt

No lessons were identified in the reviewed literature.

### 2.1.5 United States of America

#### Telemonitoring targeted pollutants and sectors

The US Clean Air Act (CAA) is a federal law established in 1970 that sets air quality standards and regulates air emissions from stationary and mobile sources. The law authorises the US EPA to establish National Ambient Air Quality Standards (NAAQS) for "criteria" pollutants[22] to protect public health and to regulate emissions of hazardous air pollutants (HAPs)[23]. The powers provided in the CAA allow the US EPA to develop Regulations to set out emission standards for certain types of industrial emission sources.

To achieve NAAQS, states are required to develop pollutant-specific State Implementation Plans (SIPs), incorporating a range of measures including regulation of industrial emissions. The SIPs are developed for each criteria pollutant, are subject to public consultation and are submitted to the US EPA for approval. SIPs are revised when a NAAQS is changed. In "non-attainment" areas, the CAA requires the adoption of additional regulatory measures to achieve and maintain compliance with the relevant NAAQS (again these include measures on industrial emissions). A SIP is also required where the State is compliant with a NAAQS but includes emission sources which contribute to non-attainment in a neighbouring State.

Continuous monitoring and centralised data collection (at city or state level) of ambient air pollution has been undertaken for many years in the USA. Use of CEMS has also been common on industrial installations but real-time collection of CEMS data by regulatory authorities is not undertaken. There are over 21,000 industrial installations reporting via telemonitoring, for emissions to air and water. The sectors concerned are summarised in Table 2-2.

Table 2-2 Telemonitoring targeted pollutants and sectors

| Regulated facilities in the USA |
| --- |
| Stationary facilities which emit ≥100 tons per annum of a regulated air pollutant (e.g. PM, VOCs, $SO_2$, and NOx). |
| Stationary facilities which emit < 100 tons per annum of a regulated air pollutant in an area that exceeds an applicable national air quality standard (emission thresholds may be dependent on designation of non-attainment area). |
| Large coal-burning utility boilers and industrial boilers subject to control requirements under the acid rain provisions of the Clean Air Act. |
| Sources that are subject to requirements under New Source Performance Standards (NSPS) and National Emission Standards for Hazardous Air Pollutants (NESHAP). |
| **Sources of toxic air pollutants.** |
| Sources required to have pre-construction or new source permits. Such facilities can be very large with a wide variety of process operations and many emission sources such as chemical plants, petroleum refineries, and large manufacturing facilities. |

#### Drivers for implementation

The main drivers for implementation reported by the US EPA include:

- To check compliance (between ELVs and real emissions);
- To provide feedback to update ELVs or equivalent (or other longer-term analysis);

[21] Department of Environment Malaysia (DOE). iRemote training manual industry.

[22] These are the air pollutants ozone, particulate matter, carbon monoxide, lead, sulfur dioxide and nitrogen dioxide.

[23] The list of air toxics and modifications are detailed here https://www.epa.gov/haps/initial-list-hazardous-air-pollutants-modifications

- To facilitate public access to information.

### Software and hardware

Different programs and different regulations are in place for the monitoring of different pollutants. In addition, there are differences in requirements among the States[24]. Some States may require higher levels of CEMS data availability or use of standby monitoring equipment for some or all monitoring parameters (redundancy). To maximise data availability, operators could include a back-up recording device or other appropriate redundancy within the data acquisition system[24] Usually, sophisticated software producing results ready to use is applied at an installation level. The data are then processed with a standard computer at the authority's premises and stored on a cloud service.

Information is reported electronically by the operator rather than collected in real time or near real time. Recent regulations and proposals have facilitated e-reporting of emission data including an electronic reporting tool and associated guidance[25] but there is no apparent centralised monitoring of CEMS outputs. The US EPA Enforcement and Compliance History Online makes data available to the public on facility emissions and compliance information but not real-time emission data[26].

Several State agencies are considering a range of alternatives: automated data reporting using alternative data storage devices, telecommunication systems for agency representatives to receive or assess data on-demand from remote locations, and real-time or intermittent telemetry systems for CEMS data[24].

The US EPA has guidance, programmes and requirements for quality management activities for data collection and technology programmes performed by or for the US EPA. Emissions monitoring methods and requirements include detailed QA and control procedures[27]. Significant differences among the various state regulations are likely[24]. A preliminary monitoring plan is requested to identify misunderstandings between the agency and operators on the requirements for applicable CEMS and acceptable monitoring approaches in the planning stage of the monitoring program. In terms of quality management, the US EPA uses Relative Accuracy Test Audit for gases and Relative Response Assessment for Particulates[28].

The US EPA can request a revision of quality assurance plans at any time based on the results of emission report reviews, inspections, audits, reviews of the QA plan, or any other information available to the agency.

Historic CEMS data are available online. For instance the Air Markets Program Data allows the public to have access to current and historical data collected through the US EPA's emissions trading programs[29].

### Lessons learnt

The key lesson learnt reported by the US EPA is that where possible it is useful to design a reporting system that encompasses more pollutants than the prescribed toxic pollutants. A single reporting system should be used to leverage information reported for other programs and environmental regulations.

[24] https://www3.epa.gov/ttn/emc/cem/nescaum.pdf

[25] https://www.epa.gov/electronic-reporting-air-emissions/electronic-reporting-tool-ert

[26] https://echo.epa.gov/facilities/facility-search/results

[27] OECD, 2018. Best Available Techniques (BAT) for preventing and controlling industrial pollution. Available at: http://www.oecd.org/chemicalsafety/risk-management/approaches-to-establishing-best-available-techniques-around-the-world.pdf

[28] Central Pollution Control Board, 2018. Guidelines for Continuous Emission Monitoring Systems. Available at: http://www.nevcoengineers.com/wp-content/uploads/2018/08/revised-ocems-guidelines-29.08.2018.pdf

[29] https://ampd.epa.gov/ampd/

## 2.2 Overview of systems in the EU

### 2.2.1 Austria (Linz)

#### Telemonitoring targeted pollutants and sectors

The Linz region is the first region that introduced telemonitoring in Austria. This was done in the 1980s, initially with simple software and hardware.

The telemonitoring system is applied only for emissions to air, whereas for water monitoring data are provided to regulators weekly by operators using Microsoft Excel templates. The air pollutants which are monitored are NOx, $N_2O$, $CH_4$, CO, Dust, $SO_2$, TVOC, HCl, HF and Hg. $NH_3$ is continuously measured, but not telemonitored. Telemonitoring is applied not only for installations with large exhaust gas volume flow rates but also for those installations with smaller flow rates if the pollutants are more dangerous. Telemonitoring is used in all industries in the region, including iron and steelworks facilities, large combustion plants, pharmaceutical production, waste incinerators and others. The total number of installations subject to telemonitoring is 50.

#### Drivers for implementation

The drivers for implementation reported by the competent authorities in Linz include:

- To facilitate faster decision-making process;
- To lower the workload for inspection or compliance checks;
- To facilitate compliance checks between ELVs and real emissions;
- To provide evidence for updating the ELV or equivalent;
- For official reporting, for example to PRTR, IED or equivalent reporting;
- To assist with dealing with complaints from citizens and neighbours;
- To deter non-compliance;
- To facilitate public access to summary emission information -this leads to faster complaint-handling and lower workload for inspection or compliance checks.

Furthermore, additional incentive for installing telemonitoring is the ease of reporting emission levels and exceedances. The authority checks the emissions of the last 24 hours every morning and sometimes identifies ELV exceedances earlier than the operator. No penalty is applied if an exceedance is reported with information about the steps taken to resolve the exceedance.

#### Software and hardware

The data from CEMS are automatically submitted to the competent authority in real-time as half-hourly means, which can be watched at several computers at the competent authority's premises around the clock. A combination of software is used. This includes a software licence from the Austrian Institute of Technology (AIT) which collects data and prepares graphs and tables of monitored emission levels as half-hourly means. The data are further analysed by officers with simpler spreadsheet tools such as Excel to generate statistics.

At the authority's premises, a standard computer is used. At the installation, the measurement device sends the data to a computer where the calculations are done, and each intervention is recorded. From there, the data are sent to the control room of the installation and in parallel to the server at the competent authority's premises. The computer of the competent authority has direct access to the server, and therefore to the validated data.

With regard to monitoring of the data, AIT develops new software to monitor telemonitored data, if necessary. In the case of disturbances of the system the data will still be recorded and later on picked up.

With regard to data verification, this is done at the site by the plant operator, but without the possibility to change the data. Contextual information like start-up and shut-down periods, as well as part-load, are automatically registered and shown.

Measurement uncertainties are accounted for in accordance with the EN14181 standard.Furthermore, data are validated prior to submission according to EN 15267-1; EN 14181 QAL1 to 3 and ÖNORM M9412 1 to 3. The data are not published online.“

#### Lessons learnt

Specific training is required for data analysis in Excel and interventions in cases of system disturbances. Furthermore, site operators are concerned about sharing data. It is therefore important to inform operators about the advantages of the system (since this might be a voluntary scheme).

Due to online monitoring it is easy to find the source of high emissions during malfunctions of an industrial installation. Therefore, telemonitoring helps to deal with complaints from citizens and to find out the reason for the complaint, which in turn promotes confidence in the competent authority.

Other aspects that have been important to the effective application of telemonitoring include:

- Having clear legal definitions of approach and scope;
- Timely data management and quality control during measurements.

### 2.2.2 Croatia

#### Telemonitoring targeted pollutants and sectors

The telemonitoring system applied in Croatia is governed by legislation[30] on continuous monitoring which applies to all industrial installations. The telemonitoring system applies only to emissions to air. The pollutants and parameters which are monitored include $SO_2$, CO, $NO_2$, $NH_3$, formaldehyde, dust, $O_2$, organic carbon, HCl and HF. Other operational aspects that are captured by the telemonitoring system include flue gas flow, operating time, humidity, temperature and flow of flue gases, fuel consumption rate, flow of waste incinerated, quantity of waste and flow of clinker produced[31]. The system took approximately one year to install, with the first CEM reporting in 2008. The acquired data are displayed in a publicly available web application, with half-hourly hourly, daily or two-day, monthly and annual reports. This is regulated by legislation and the monitoring frequency depends on the activity. The number of installations subject to telemonitoring is 28 according to the information provided by the competent authority. These operate in various IED sectors including refineries, waste incineration, large combustion plants, cement production and the chemicals industry.

#### Drivers for implementation

The drivers for implementation of this approach, as reported by the competent authority, include:

- To check compliance with ELVs;
- To provide feedback to update ELVs or equivalent (or other longer-term analysis);
- To facilitate public access to information;
- To deter non-compliance.

#### Software and hardware

The Croatian competent authorities use sophisticated software that delivers end results ready to use. With regard to hardware, a standard computer at competent authorities’ premises is used. The data are validated by the operator prior to publishing. Operators are also responsible for calculating measurement uncertainty, but the approach varies across operators. The data are then transferred using a file transfer protocol (FTP), file transfer protocol Secure (FTPS) and secure file transfer protocol (SFTP). The processed data are published online and can also be accessed via an app[32]. Inside the database are two groups of data:

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[30] Zakon o zaštiti zraka (NN 130/11, 47/11, 61/17, *Act for air protection*);
Pravilnik o praćenju emisija onečišćujućih tvari u zrak iz nepokretnih izvora (NN 129/12, 97/13, *Regulation on the monitoring of emissions of pollutant substances into the air from fixed sources*);
Uredba o graničnim vrijednostima emisija onečišćujućih tvari u zrak iz nepokretnih izvora (NN 87/17, *Regulation on limit values for emissions of pollutants into the air from stationary sources*)

[31] Croatian Ministry of Environment, 2019, Emisije iz nepokretnih izvora Priručnik za korisnike

[32] http://iszz.azo.hr/stacion/index.html

1. Metrics:
   - individual half-hourly/hourly measurement values obtained by continuous emission measurement;
   - "meta" data concerning the owner/user of the fixed source (legal entity, activity, entity identification number, contact information, etc.);
   - stationary source information (name, location, plant, plant/boiler, power, fuel, information on the technical characteristics of the pollution source, purpose and type of measurement, emission values to be measured, measurement sites, location of sampling and measurements).
2. Reports: daily, monthly and annual report on continuous measurement of pollutant emissions into the air from stationary sources in Croatia.

Croatia has published guidelines on the use of the online app on telemonitoring[33]. Several requirements are applied for emission monitoring at an industrial installation:

- CEMS have to comply with procedures specified in the standards HRN EN 1418134 and HRN CEN/TR 1598335;
- The minimum value of the upper limit of measurement should be at least 2.5 times greater than the maximum allowed value for the measured pollutant (ELV);
- The operator is obliged to ensure the regular maintenance of CEMS and the implementation of CEMS stability control in accordance to HRN EN 14181. The operator is also required to keep records of the essential features such as irregularities during operation, downtime, causes of failures and calibration;
- The operator is obliged to ensure that the CEMS is regularly checked and calibrated during the operation of the stationary source in accordance with the standards HRN EN 14181 and HRI CEN/TR 15983;
- For each pollutant where actual emissions are close to the ELV, continuous monitoring is required.

Financial penalties exist for operators who:

- Do not carry out verification of the accuracy of the measuring system for continuous measurement of emissions of pollutants from stationary sources in the manner prescribed by the regulation;
- Perform the activity of monitoring air quality, monitoring emissions of pollutants from stationary sources and checking the correctness of the measurement system for continuous measurement of emissions of pollutants from stationary sources without the permission of the Ministry;
- Perform the activity of monitoring air quality, monitoring emissions of pollutants from stationary sources and verifying the correctness of the measuring system for continuous measurement of emissions of pollutants into the air from stationary sources according to the reference method of measurement, or another method of measurement for which it did not obtain a permit from the Ministry.

The penalties for the legal entity are between HRK[36] 100 and HRK 300 (EUR 13 to EUR 40), for the responsible person HRK 25 to HRK-50 (EUR 3.3 to EUR 6.6) and for entrepreneurs HRK 70 to HRK 150 (EUR 9.2 to EUR 19.7).

### Lessons learnt

The key lessons reported by the Croatian competent authorities relate to three aspects:

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[33] Croatian Ministry of Environment, 2019, Emisije iz nepokretnih izvora Priručnik za korisnike

[34] https://ec.europa.eu/clima/sites/clima/files/ets/monitoring/docs/gd7_cems_en.pdf

[35] https://standards.cen.eu/dyn/www/f?p=204%3A110%3A0%3A%3A%3A%3AFSP_PROJECT%2CFSP_ORG_ID%3A32554%2C6296&cs=1CD2FDABD6A14F77F9BF4943A6F44F63C

[36] Where HRK is the Croatian kuna

- Sometimes there is a problem with the specification or measurement range, which results in problems with the data flow. Data management issues should be borne in mind when designing the telemonitoring system;
- There is lack of professional staff in the competent authority with enough knowledge and skills in the field of telemonitoring. For this reason, the competent authority found it more suitable to hire a sub-contractor for the technical work;
- The approach resulted in more workload and a need for higher skills. Training was required.

### 2.2.3 France

#### Telemonitoring targeted pollutants and sectors

Telemonitoring in France has been applied for emissions to water and air, with no significant difference in the approach applied to each. The monitoring approach is applied for all IED sectors and covers approximately 9,000 installations.

The following pollutants are subject to telemonitoring:

- Air: total dust, CO, $SO_x$, $NO_x$, VOC, HCl, HF, metals and others;
- Water: TSS, COD, BOD, N and P, metals, organohalogen compounds, total hydrocarbon and others.

The periodicity of data collection depends on the frequency defined in the permit or in General Binding Rules. Usually, water emission data are reported daily and air emission data are reported in accordance to the permit conditions. The minimum frequency for transferring data to the competent authority is once a year, as governed by the relevant national regulation[37]. Where the frequency of collection of emissions data is higher (i.e. at least weekly), the accumulated data are transferred to the competent authority by the operator bi-monthly. As such, the telemonitoring infrastructure in France is not used for 'real-time' monitoring.

#### Drivers for implementation

The drivers for implementation of telemonitoring in France are as follows:

- To check compliance (between ELVs and emissions);
- To assist PRTR/IED reporting;
- To minimise inspectors' workloads.
- To reduce workload for compliance audits.

The telemonitoring data are not used systematically to determine the annual tax/fee, although some of those fees are indeed proportional to emissions thresholds.

#### Software and hardware

The French competent authorities reported using a sophisticated software that delivers end results ready to use. With regard to hardware, standard computers at competent authorities' premises are used.

The reporting procedure follows the following steps :

1. Submission and validation by the operator of the installation, manually
2. Verification by the inspector in charge of the control of the installation, for the most important (i.e. most polluting) installations (i.e. those reporting to E-PRTR, IED, ETS). For other sites that have been non-compliant, inspectors check the data submitted.

In addition, for all data used for France's reporting commitments, analysis and comparison are made automatically by the software or by an external contractor with the aim to detect, for example, significant differences between similar installations or from one year to the other.

[37] Article 58, Order of February 2, 1998 relating to water withdrawals and consumption as well as to emissions of all kinds from installations classified for the protection of the environment subject to NOR authorization : ATEP9870017A. Available at: https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=LEGITEXT000005625281

Raw data and figures for annual emissions are usually publicly available online. Furthermore, processed data are also available in an online database Géorisques[38]. The ELVs are not specified online.

More detailed monitoring reports can be communicated to the general public after a request to the competent authorities. Currently such requests are not numerous.

There is no web app to access emissions data.

#### Lessons learnt

The key lessons learnt reported by the French competent authorities are as follows:

- Telemonitoring projects require regular updates, project management skills and training for software users;
- For tools connected with many databases, changes of data could lead to complex issues;
- A proactive and available support team is key to solving problems;
- Telemonitoring delivers great value in harmonising practices and information, centralising reporting practices and simplifying the administrative work for inspectors. A key problem in France is that each authority requests a different emission reporting format from the installation. There is a need for a (national) standardised approach.

### 2.2.4 Germany

While there is no legal requirement for telemonitoring in Germany, competent authorities in different regions can request data to be sent via these means[39]. Overall, telemonitoring in Germany has been applied for a total of 25 industrial installations. These installations are predominantly in the most polluting sectors such as Waste Incineration, Large Combustion Plants and Pulp and Paper. In general, the data are used to check compliance with ELVs, to assist in management of complaints from citizens and to deter non-compliance. The benefit of using telemonitoring is that it ensures higher quality data. The emissions data are not published online.

Germany has produced national guidelines on CEMS[40,41]. The guidelines also specify how emissions should be measured. Further guidelines on 'Air Pollution Prevention Manual on Emission Monitoring' are available from the Umweltbundesamt and the TÜV (2008). These guidelines describe various aspects of the application of CEMS and when it is required, and also describe telemonitoring applications. In Germany, certification and approval is applied for DAHS.

In most instances, competent authorities only require the use of a computer whereas sophisticated software is applied at the industrial installation. Whilst the capital and operational costs for the competent authority are low, there is no information about the costs for installation operators. A key lesson learnt has been that telemonitoring can be an essential point for establishing public interest and transparency.

#### 2.2.4.1 Bavaria

#### Telemonitoring targeted pollutants and sectors

In Bavaria, telemonitoring has been applied for emissions to air at one waste incineration plant in Ebenhausen only. The system monitors dust, $NO_2$, $SO_2$, total carbon, HCl, Hg, CO and $NH_3$ emissions. Telemonitoring has been in place at this installation since 1999 as a result of public complaints, to keep the public informed and show more transparency.

#### Drivers for implementation

The key driver for implementation was faster decision-making when dealing with complaints.

[38] https://www.georisques.gouv.fr/

[39] UBA, Air Pollution Prevention, Manual on Emission Monitoring, ISSN 1862-4804

[40] https://www.umweltbundesamt.de/sites/default/files/medien/370/dokumente/lesefassung_bep_2018-26-04.pdf

[41] https://qal1.de/de/index.htm

#### Software and hardware

A standard computer is used at the competent authority's premises to analyse the data published online with simple tools such as Micrsoft Access/Excel/other. The authority does not have information about which software or hardware is used at the installation for telemonitoring. However, all hardware should be selected in accordance with national guidelines on CEMS.

The competent authority receives results from monitoring from the industrial installations but does not have direct access to the telemonitoring equipment on the site. Special institutes like TÜV have to monitor the functionality of the equipment on a regular basis and report to the competent authority.

There is an automated step performed by software to change raw in validated data. Telemonitoring data are published online by the industrial installation and the competent authority has access to the data. The data are updated half-hourly. There is no special app for mobile phones available where data can be viewed. The emission calculator is protected to prevent manipulation of the data by the operator.

In the case of exceedances of ELVs, the competent authority has to be informed via email by the operator. The follow-up actions depend on the severity of the exceedance. The competent authority published a system, which complies with the standards of the IED, for periodical and for reasons inspections of the installation.

#### Lessons learnt

No specific lessons learnt have been reported.

### 2.2.4.2 Hamburg

#### Telemonitoring targeted pollutants and sectors

Telemonitoring in the Hamburg region is applied to releases to water and air from installations from waste incineration, large combustion plants, refineries and metal production sectors. The air emission telemonitoring is focused on pollutants such as $NO_x$, $SO_2$, CO, Hg, PM, $NH_3$ and HCl, and the water telemonitoring focuses on operating parameters such as temperature, flue gas volume and oxygen. The emissions to water (e.g. mercury) are monitored with another system. The monitoring frequencies are set in accordance to legal requirements. There are 10 installations subject to telemonitoring in the region. The telemonitoring system for emissions to air has been in place since the 1990s, and this for water has been in place since 2010.

#### Drivers for implementation

The key drivers for implementation of telemonitoring in Hamburg include:

- Higher quality of industrial emission datasets;
- Faster decision-making process.

#### Software and hardware

Competent authorities do not use specific hardware, however, they have hired a Cloud-based service to store the telemonitored data. At the installations, advanced software is installed that delivers processed data and accounts for uncertainties. The capital costs for telemonitoring software are paid by the plant operator. The software sends the collected data to a web portal where the data can be accessed by the competent authority. It is impossible for the operator to edit the data prior to sharing with the competent authority. Emission levels can be viewed as half-hourly, daily or yearly averages. The data can be downloaded from the web portal as PDF or Excel files.

For one installation, these data are made publicly available (daily mean only). Other data can be requested directly from the authority.

The authority does not have information about which server or computers are in use on the site of the installation for telemonitoring. However, all hardware should be selected in accordance with national guidelines on CEMS. Firewall software is installed at all sites (i.e. the industrial installation, the competent authority premises and the web platform).

Similarly to Bavaria, in the case of exceedance of ELVs, the plant operator is required to inform the competent authority by phone or email. The follow-up actions depend on the severity of the exceedance.

#### Lessons learnt

The lessons learnt with regard to telemonitoring in the Hamburg region include:

- Training is necessary for the evaluation of data;
- Telemonitoring provides real-time emissions with no need to ask the operator. This is helpful in the case of complaints from citizens and for providing information to the citizens. In case of installations with no publicly available telemonitoring, citizens have to ask the authority for data.

### 2.2.5 Italy (Lombardy)

#### Telemonitoring targeted pollutants and sectors

The telemonitoring approach in Lombardy applies only to emissions to air. The continuously monitored pollutants include $SO_2$, NOx, HCl, HF, CO, $NH_3$ and TOC. The industrial sectors obliged to tele-report continuously monitored emissions are large combustion plants, waste incineration, cement kilns and glass installations. There are approximately 100 installations in the Lombardy region which apply continuous monitoring of emissions to air, of which 44 are using a telemonitoring system (acquisition and data processing). These include the A2A waste incineration and large combustion plants in the region[42]. The number of installations per each sector is summarised in Table 2-3.

Table 2-3 Number of installations using telemonitoring per sector

| Activity | No. of plants | No. of CEMS |
|---|---|---|
| Municipal Waste Incinerators | 11 | 23 |
| Industrial Waste Incinerators | 2 | 2 |
| Large Combustion Plants | 19 | 44 |
| Cement Kilns | 5 | 6 |
| Glass Furnaces | 7 | 7 |

*Source: ARPA presentation[43]*

Outside Lombardy, telemonitoring is also applied at the ILVA steelworks[44] .

#### Drivers for implementation

The drivers for implementation of telemonitoring in Lombardy include:

- To check compliance (between ELVs and real emissions);
- Feedback to update ELVs (or other longer-term analysis);
- To streamline reporting to PRTR and IED;
- Public access to information;
- Dealing with complaints from citizens or neighbours;
- Reduce workload for compliance audits;
- Decision making in air quality (investigation)
- To deter non-compliance;

#### Software and hardware

Lombardy uses the open-access software AEDOS which performs the role of data acquisition, processing and storage[45]. AEDOS validates the data, preventing the operator from interventions, and calculates the averages required by the reference legislation (10 min, 30 min, 60 min). The same software is used in all industrial installations. The data for all installations are downloaded once a day

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[42] https://www.a2a.eu/it/sostenibilit%C3%A0/silla2-emissioni

[43] Available upon request.

[44] Ricardo, 2019, Technical assistance on industrial emissions: Assignment 1 – ILVA steelworks, Taranto, Italy
Technical assistance on industrial emissions: Assignment 1 – ILVA steelworks, Taranto, Italy

[45] https://www.arpalombardia.it/Pages/Arpa-per-le-imprese/Autorizzazioni-e-Controlli/Progetto-rete-SME.aspx?firstlevel=Autorizzazioni%20e%20Controlli

and are stored for a minimum of 5 years. The acquired data are analysed and compiled in a database at the Agenzia Regionale per la Protezione Ambientale (ARPA). ARPA is working on a project to establish a network of CEMS in the most polluting industries for which telemonitoring data are acquired. The aim is for all data to be stored and analysed in a homogenous manner. The challenge is that data are collected every 5 seconds for 2,000 parameters (of which 1,000 are pollutants) which results in 35 million data entries a day, and therefore the telemonitoring approach is used. Uncertainties are accounted for following standard EN 14181, Quality Assurance Level (QAL) 2, and with the deduction of the measurement uncertainty. The data are not publicly available online.

The industrial operator is responsible for the CEMS, including calibration of the system and analysers, according to EN 14181 (Quality assurance of automated measuring systems) and EN 15267-3 (Air quality – Certification of automated measuring systems). They are also responsible for setting up the AEDOS system and accounting for uncertainties in accordance to the limits specified in Table 2-4.

Table 2-4 Maximum permicible uncertainty in continuous emission monitoring systems in Lombardy, Italy

| Pollutant | Maximum uncertainty value |
|---|---|
| Dust | 30 % |
| TOC | 30 % |
| HCl | 40 % |
| HF | 40 % |
| $SO_2$ | 20 % |
| NOx | 20 % |
| CO | 10 % |
| $NH_3$ | 20 % |

ARPA has issued Technical Guidance with mandatory rules for the industrial installations. The Guidance covers all aspects of CEMS, including:

- Features and performance characteristics of CEMS analysers;
- Performance verification;
- Periodic maintenance of CEMS;
- Calibration;
- Protocols for data acquisition and validation;
- Data storage;
- Criteria for data processing;
- Frequency of data acquisition;
- Management of CEMS system failure;
- Management of other than normal operating conditions of the installation;
- Management of ELVs Exceedances;
- Features of sampling line and analysers are indicated in the Guidance.

#### Lessons learnt

The Italian competent authorities underlined that the homogenisation of data processing, including the accounting of uncertainties, was very important. Furthermore, they underlined that a good understanding of data management issues is required.

### 2.2.6 Spain

#### 2.2.6.1 Madrid

#### Telemonitoring targeted pollutants and sectors

The telemonitoring approach in Madrid applies only to certain pollutants emitted to air from those industrial processes for which continuous monitoring is required. In total, 16 industrial installations are required to report emissions via telemonitoring. Four of these have continuous monitoring requirements under the IED and 12 more under regional legislation. The installations are from the most polluting sectors. For example, facilities that conduct waste incineration activities (as per Real Decreto 815/2013), large combustion facilities (as per Real Decreto 430/2004) and other polluting activities included in Real Decreto 117/2003 are required to report via telemonitoring. The pollutants for which telemonitoring is required include $SO_2$, NOx, CO and PM.

#### Drivers for implementation

The drivers for implementation of telemonitoring in Madrid include:

- To check compliance (between ELVs and real emissions);
- To analyse air quality incidents;
- To facilitate reporting to PRTR, IED or equivalent reporting using data conversion calculations.

#### Software and hardware

Madrid's competent authorities use standard computers (and servers) to receive the telemonitoring data. Analysis is performed in a Microsoft Excel tool developed in Visual Basic by an employee of the authority. Therefore, no specific capital costs were required besides staff hours. The data are aggregated using the Comunidad de Madrid software, through which data containing many data points is passed periodically (between a week and a month). The software is part of the automatic monitoring system.

At the installation level, all CEMS (main and peripheral) are required to have analogue and/or digital outputs to connect with the data acquisition system at the installation and with the data acquisition system from Comunidad de Madrid.[46] The data from CEMS is communicated to the competent authority daily. Measurement uncertainties are accounted for in accordance with the EN14181 standard. Furthermore, data are validated by the operator prior to publishing according to EN 15267-1; EN 14181 QAL1 to 3 and ÖNORM M9412 1 to 3. The data are not published online.

#### Lessons learnt

A key lesson learnt is that there is a challenge in having specialised personnel at the competent authority to deal with telemonitoring data.

### 2.2.6.2 Andalucía

#### Telemonitoring targeted pollutants and sectors

Telemonitoring is used in Andalucía for emissions to air from 49 installations that are all from IED sectors. The telemonitored pollutants include PM, $SO_2$, $NO_x$, CO, HCl, HF, as well as parameters of oxygen, temperature, pressure and humidity.

#### Drivers for implementation

The drivers for implementation of telemonitoring in Andalucía include:

- To check compliance (between ELVs and real emissions);
- To faciliatete PRTR, IED or equivalent reporting;
- To support dealing with complaints from citizens or neighbours;
- To support decision making in air quality (investigation).

#### Software and hardware

The competent authorities in Andalucía use standard computers and Microsoft Excel to analyse data received from industrial operators. At the installations, raw data generated by CEMS are usually

[46] Comunidad de Madrid, 2011, Instrucción Técnica para el aseguramiento de la calidad de los Sistemas Automáticos de Medida de Emisiones a la atmósfera en focos estacionarios en la Comunidadde Madrid. Available from: https://www.comunidad.madrid/sites/default/files/doc/medio-ambiente/instruccion_tecnica_sam_rev_0_logo.pdf

collected by DAHS every 10 minutes, and in some cases data are averaged by minute or half-hourly[47]. However, it is unclear how frequently data are shared with the competent authority. The technical instructions IT-ATM-03 and IT-ATM-02 provide guidance on the selection of measurement and sampling[47].

Once data are received, the authority is responsible to verify the data and ensure they are of good quality. The authority transfers all the data across installations in the same format, for example through converting % $O_2$ content and humidity. Furthermore, it averages the data in accordance with the EN14181 standard and deducts measurement uncertainty as needed. The data are mainly used for compliance assessment and are not published online. However, data can be provided upon request. Finally, the data are used to inform annual tax fees for industrial installations which are based on quantity of emitted pollutants.

#### Lessons learnt

In Andalucía, the variety of reporting formats and ELVs across installations makes it difficult to process and approve acquired data in the current reporting system.

### 2.2.6.3 Galicia

#### Telemonitoring targeted pollutants and sectors

The telemonitoring approach in Galicia applies only to emissions to air from large combustion plants, waste incinerators, cement works and metal production activities for all pollutants regulated under the IED. Examples of telemonitored pollutants include NOx, SOx, PM and heavy metals. The total number of installations subject to telemonitoring in Galicia is 13.

#### Drivers for implementation

The drivers for implementation of telemonitoring in Galicia include:

- To check compliance (between ELVs and real emissions);
- Dealing with complaints from citizens or neighbours.

#### Software and hardware

The competent authorities in Galicia use a standard computer with Microsoft Excel to analyse data received from industrial operators. The data are not validated, and uncertainties are not accounted for if there is an outlier in the data. The frequency of data collection depends on the installation permit conditions but usually it is every 5 minutes. The data are not published online but can be shared upon request.

#### Lessons learnt

Galicia's competent authorities underline that telemonitoring should be set up with a clear view of the end use of the data. Large datasets are difficult to manage, and therefore, higher density data should be requested only if needed. Furthermore, the format of the data requirements should be considered before conveying these to industrial operators.

#### Box 2-2 Spanish industrial operator case study

The operator has introduced telemonitoring in its LCP installations in three different regions of Spain, reporting data on air pollutants and operational information (e.g. % load). Each region sets its own telemonitoring requirements and technical features (e.g. communication protocols).

| Region | Opex: Maintenance cost | Connectivity |
|---|---|---|
| Barcelona (Cataluña) | The total cost is 7,100 EUR/year including programmable logic controller for CEMs | Data from CEMS is transferred to a computer in the control room before being exported using SFTP |

[47] http://www.juntadeandalucia.es/medioambiente/portal_web/web/temas_ambientales/aire/calidad_aire/instrucciones_tecnicas_2011/ITS%20MAYO%202012/it_atm_13.pdf

| | | |
|---|---|---|
| Besos (Cataluña) | 700 EUR/year (communications only) | |
| San Roque (Andalucía) | Covered by competent authority | FTP is required (based in a computer plus a modem/router in the installation) |
| Palos (Andalucía) | Low. Maintenance issues are rare. | A simple computer hosts the data and generates FTP files before using router to send to authority. |
| Cartagena (Murcia) | | |

## 2.3 Horizontal summary

Telemonitoring of industrial emissions data are more advanced in the non-European countries considered in this study. This is illustrated by the significantly higher number of installations subject to telemonitoring requirements in non-EU countries (summarised in Table 2-6).

In four out of the five non-EU countries considered, telemonitoring is applied for both emissions to air and water (no information is available in the case of Malaysia). In the EU, this is also the case in Austria (Linz), Germany (Hamburg) and Spain (Andalucia). Overall, the countries where telemonitoring is used for both media reported no differences in approach.

The level of complexity of the telemonitoring set up differs among countries. Most countries considered in this study used an advanced software with automatic data transmission and validation and/or data processing capabilities. The typical advantages of this approach are the reduced or eliminated need for manual data processing and the reduced potential for human error. However, such software often requires additional training of staff who are in charge of using them.

In comparison, the telemonitoring undertaken in Spain (Madrid and Galicia) includes manual transmission of data from operators to competent authorities, and analysis of the data in spreadsheet software. This approach could not be considered “true telemonitoring”. The advantage of this method is the lack of investment costs associated with the purchase of software and operational costs associated with software maintenance. However, the approach results in higher data analysis workloads. Furthermore, the data may not always be submitted in the same format which increases the data analysis time for the competent authority.

Finally, Austria used a hybrid between the two approaches, where the initial analysis of the data was performed by software within an different entity, and additional statistical analysis was performed in simple spreadsheet software.

With regard to hardware used, in most instances, standard computers were used for the data analysis with the exception of China and South Korea, where the usage of advanced computers was reported. In 9 out of the 11 countries considered in the study, telemonitoring is used for real-time reporting (USA and France are the exceptions).

The stakeholder consultation asked competent authorities to report the main drivers for implementation and benefits of telemonitoring. Overall, most authorities reported that telemonitoring is used for compliance checks, to update ELVs, to meet reporting obligations and to deal with citizens complaints. The drivers per country are summarised in Table 2-5.

Table 2-5 Summary of drivers for implementation of telemonitoring

| Country | Compliance check | Updating ELVs | Reporting | Public access to information | Complaints | Incident investigating | Reduce workload (audit, inspection) | Improve decision- making | Deter non-compliance | ETS reporting | Higher quality data | Environmental protection |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| China | x | x | x | x | x | | x | x | x | | | |

| Country | Compliance check | Updating ELVs | Reporting | Public access to information | Complaints | Incident investigating | Reduce workload (audit, inspection) | Improve decision- making | Deter non-compliance | ETS reporting | Higher quality data | Environmental protection |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| India | x | | | x | x | | | x | | x | x | |
| South Korea | x | x | | x | x | | | | | | | |
| Malaysia | x | | x | | x | | | x | | | | x |
| USA | x | x | | x | | | | | | | | |
| Austria Linz | x | x | x | x | x | x | x | x | x | | | |
| Croatia | x | x | | x | | | | | x | | | |
| France | x | | x | | | | x | | | | | |
| Germany Bavaria | | | | | x | | | x | | | | |
| Germany Hamburg | | | | | | | | x | | | x | |
| Italy Lombardy | x | x | x | x | x | | x | x | x | | | |
| Spain Madrid | x | x | | | | x | | | | | | |
| Spain Andalucia | x | | x | | x | | | x | | | | |
| Spain Galicia | x | | | | x | | | | | | | |

The main challenge reported is the increased training need, which was reported even in the case of Spain where Excel is used for data analysis.

The key lessons learnt include:

- It is important to have clear legal definitions of approach and scope;
- Timely data management and quality control during measurements are important;
- Data from industrial installations should be required in the same format to reduce data analysis needs;
- Where Excel is used for data analysis, high density datasets are difficult to process and therefore fewer data entries are to be preferred.
- Telemonitoring requires specific training of competent authority staff;
- Sometimes, industrial installations are reluctant to share data.

Table 2-6 Horizontal summary of telemonitoring specification in each country/region

| Country | Number of installations | Media: Water/Air | Pollutants | Reporting frequency | Publicly available online |
|---|---|---|---|---|---|
| China | 10,492 for air; 19,591 for water | Both | Air: $SO_2$, $NO_x$, PM, $O_2$, temperature, volume, humidity<br>Water: COD, P, $NH_3$-N, volume, $BOD_5$, N, TSP, pH | Not specified **(but real-time)** | Yes |
| India | 40,000+ | Both | Air: $PM_{10}$, $PM_{2.5}$, $SO_2$, $NO_x$, $O_3$<br>Water: pH, TSS, TDS, | 15 seconds | Yes |

| Country | Number of installations | Media: Water/Air | Pollutants | Reporting frequency | Publicly available online |
|---|---|---|---|---|---|
| | | | COD, BOD, Oil & Grease | | |
| South Korea | 1,400 for air<br>~1,400 for water | Both | Air: TSP, NOx, SOx, HCl, HF, $NH_3$, CO, for air<br>Water: pH, temperature, BOD, COD, SS, TN, TP | 30 minutes | No |
| Malaysia | No info | Not specified | $NO_2$, CO, total PM, NMVOC as total C, HCl, HF, $SO_2$ | Not specified<br>**(but real-time)** | Yes |
| USA | 21,000 + | Both | Not specified, differs between States | Determined on case-by-case basis **(not real-time)** | Yes |
| Austria Linz | 50 | Both | Air: NOx, $N_2O$, $CH_4$, CO, Dust, $SO_2$, TVOC, HCl, HF and Hg<br>Water: not specified | Not specified | No |
| Croatia | 28 | Air | $SO_2$, CO, $NO_2$, $NH_3$, $CH_2O$, dust, $O_2$, org C, HCl and HF | Half-hour or hourly, daily or two-day, monthly and annual | Yes |
| France | 9,000 | Both | Air : total dust, CO, SOx, NOx, VOC, HCl, HF, metals and others<br>Water: TSS, COD, BOD, N and P, metals, organohalogen compounds, THC and others. | At least bi-monthly **(not real-time)** | Yes |
| Germany Bavaria | 1 | Air | Dust, $NO_2$, $SO_2$, total carbon, HCl, Hg, CO and $NH_3$ | Half-hourly | Yes |
| Germany Hamburg | 10 | Both | Air: $NO_x$, $SO_2$, CO, Hg, PM, $NH_3$ and HCl,<br>Water: temperature, volume and $O_2$ | According to legal requirements | No |
| Italy Lombardy | 44 | Air | $SO_2$, NOx, HCl, HF, CO, $NH_3$, TOC | 5 seconds | No |
| Spain Madrid | 16 | Air | $SO_2$, NOx, CO and PM | Not specificed | No |

| Country | Number of installations | Media: Water/Air | Pollutants | Reporting frequency | Publicly available online |
|---|---|---|---|---|---|
| Spain Andalucia | 49 | Both | PM, $SO_2$, $NO_x$, CO, HCl, HF, as well as $O_2$, temperature, pressure and humidity | Every 10 minutes | No |
| Spain Galicia | 13 | Air | NOx, SOx, PM and heavy metals | Not specified | No |

# 3 Description of technical capabilities

This section describes the technical features of the devices that can be used to send the emission data to the competent authorities. This information was gathered from the literature review, interviews with stakeholders and in-house knowledge.

## 3.1 Overview of system blocks

The complete architecture of telemonitoring solutions has been divided into three main system blocks to describe the components and capabilities of each stage of the telemonitoring process:

- Block 1: The industrial process has an installed **CEMS that generates representative data on emissions**. This system includes a **DAHS** of some form.
- Block 2: The **communication system** that transfers the emission data (mainly) to the authorities.
- Block 3: The **competent authority receives and stores the data**. This includes the IT architecture and regulator procedures, as well as staffing.

They are described in  the following sections.

## 3.2 Block One: On Process CEMS and DAHS

CEMS consist of three main components[48]:

- A sampling and conditioning system;
- Analyser and/or monitor;
- Data Acquisition and Handling System (DAS/DAHS), and controller.

Data from CEMS can be used for different purposes, such as:

- assessing compliance with permit requirements;
- analysing the balance between process yield, energy, resource and emission levels;
- assessing causes of emission behaviour (e.g. to determine reasons for changes in emissions under normal and other than normal operating conditions);
- predicting emissions behaviour of a site;
- assessing the relative contribution of different sources to the total level of emissions;
- conducting safety checks;
- compiling inventories;
- assessment of environmental impacts;
- defining environmental changes/taxes;
- contributing to BREF reviews[49];
- modelling emissions, handling complaints and investigating air quality exceedances.

### 3.2.1 Interfaces and capabilities

Depending on the CEMS type and pollutant monitored, the interface components may differ[50]. CEMS are interfaced with a DAHS, which conduct several tasks, such as capturing data, data storage, data analysis and interfacing with the site data capture systems (DCS). Data processing includes calculating time averages, correcting data to reference conditions and reporting. Some systems communicate remotely with CEMS through units such as the remote meeting point router, which enables the system to assess the operation of the CEMS and identify faults.

[48] Department of Environment, 2019. Volume 1: Series of CEMs. Guidelines for the installation & maintenance of continuous emission monitoring systems (CEMs) for industrial premises/facilities. Available at: https://www.doe.gov.my/portalv1/wp-content/uploads/2013/01/GUIDELINE-FOR-THE-INSTALLATION-MAINTENANCE-OF-CEMS-FOR-INDUSTRIAL-PREMISES-OR-FACILITIES-VERSION-7.0-JULAI-2019.pdf

[49] JRC Reference Report on Monitoring of Emissions to Air and Water from IED Installations

[50] Central Pollution Control Board, 2014. Specifications and guidelines for continuous emissions monitoring systems (CEMs) for PM measurement with special reference to emission trading programs. Available at: http://mahenvis.nic.in/Pdf/Report/report_epm6.pdf

In some cases, the CEMS and DAHS are interfaced directly to allow collecting data remotely. Network based protocols are in place to achieve remote data collection. In addition, some systems have the capability to develop remote calibration checks.

### 3.2.2 Software – capabilities

Two systems use software: the DAHS and the communication system which collects data from the CEMS. The DAHS provide reporting subject to regulatory requirements and collects data more frequently than every 5 seconds. Some communication software has the capacity to update every minute. However, the updating time depends on regulatory requirements.

The Indian Knowledge Lens Glens system deals with 1,000 sites. Some packages use machine-learning to assess data for anomalies.

### 3.2.3 Data storage capacity

Different systems are used for storing and further processing data. There is a preference for automatic data loggers, which can also communicate with a remote central processing unit. Certified digital data transfer and evaluating systems are also available. DAHS on sites usually have the capacity to store at least 5 years of data. Regulatory systems also store a similar amount of data, which can be increased by adding storage capacity. Some systems are now cloud based, thus local capacity is no longer a problem.

### 3.2.4 QA/QC checks/parameters

CEMS need to be certified. CEMS certification refers to Quality Assurance Level 1 (QA1), which is conducted by an accredited organisation before installing the equipment at the emission source. Several performance standards are met by certified CEMS, including the maximum expanded uncertainty based on IED requirements in Annexes V and VI. Other requirements include the total uncertainty of at least 25% below the maximum permissible and limits of quantification of less than 8% of the upper limit of the certification range[51].In the case of waste water telemonitoring, the certification requirements of sensors and automated measurement devices are defined in EN ISO 15839:2006. Measurement equipment certification is only available for the United Kingdom, i.e. the MCERTS, but for a limited number of measurands[52].

Two quality assurance level tests are conducted when CEMS are in operation: QAL 2 and QAL 3, both of which are defined in EN 14181:2014. There is also the Annual Surveillance Test (AST).

The QAL 2 test is required by the IED for calibrating new CEMS or CEMS against the accepted standard reference measurement. The QAL 2 test includes the functional test, calibration function, valid calibration range, variability and a servicing audit. It is conducted on new CEMS at installation and on installed CEMS at least every five years. If a unit fails an AST, a QAL 2 test is then required. An accredited or approved laboratory is required to conduct this procedure.

The QAL 3 test is for ongoing quality assurance during the CEMS operation. It is conducted on a routine basis, such as daily, weekly or monthly, depending on the certified maintenance interval time. Zero and calibration checks as well as visual checks of CEMS system indicators (e.g. vacuum and pressure gauge, rotameters, control panel) are included in this procedure. In contrast to the QAL 2 test it does not require an accredited laboratory to carry it out. It can be automated and undertaken to ensure that the instrument availability is not compromised. Data from this procedure are used in control charts, such as CUSUM and Shewart against uncertainty to show that the CEMS is in control and that the QAL 2 is valid and the data produced by the CEMS is of acceptable quality.

The AST procedure assesses the CEMS annually, to demonstrate that it continued to work correctly, that the calibration function is still valid, and that the variability is within acceptable levels. A functionality testing and parallel measurements on the CEMS are conducted.

[51] JRC Reference Report on Monitoring of Emissions to Air and Water from IED Installations, 2018. Available at: https://eippcb.jrc.ec.europa.eu/sites/default/files/2019-12/ROM_2018_08_20.pdf

[52] JRC Reference Report on Monitoring of Emissions to Air and Water from IED Installations, 2018. Available at: https://eippcb.jrc.ec.europa.eu/sites/default/files/2019-12/ROM_2018_08_20.pdf

The quality assurance levels have a logical order and aim to show that the selection, installation, calibration and operation of the CEMS at the site/facility is correct. Operators are required to have a plan for quality assurance and control management (QA/QC).

Finally, CEMS include status flags identifying faults, the need for maintenance, or the need for calibration. Some of the fault tags can have codes associated with them to give an indication of what the fault is

### 3.2.5 Process parameter data

Data on a number of process parameters are collected according to the monitored process and regulatory requirements. These include contextual operating data and information such as whether waste feed is on, auxiliary burners status, load, temperatures, boiler oxygen. These parameters are used in the determination of the operational status of the monitored activity (e.g. start-up, normal operation or shutdown). In addition, the CEMS may provide information needed for process control.

### 3.2.6 Data averaging, correction to reference conditions, and measurement uncertaintymonitored

CEMS outputs are a continuous record of gas or particulate matter concentrations in waste gas releases or water pollutant concentrations in waste water releases. Results are produced almost always in real-time. As CEMS provide instantaneous data, averages of data need to be calculated. The averaging period required for reporting is set by the permit, and may be over periods of 10 minutes, half an hour, one hour, a day, a month or a year. Data from peripheral measurements are also averaged, and the averaged pollutant concentrations are converted to standard conditions, in terms of reference oxygen conditions for extractive systems. For in situ systems, which use dust as measurement cell, data are corrected for temperature, pressure and water vapour. Values that are abnormal (i.e. outliers) may be left out of average concentration calculations.

Collected data also include measurement uncertainty, minimum and maximum values, and the $95^{th}/97^{th}$ percentile (if the information is available) as well as information on the operating conditions to differentiate normal and other than normal operating conditions.

Measurement uncertainty is subtracted in some cases from the standardised 30 minutes or hourly results to get validated averages. Negative validated averages are generally considered as zero. The expanded uncertainty may be considered for each measurement result or for the average for compliance, before comparing the values with the ELVs[53].

### 3.2.7 Review of data

Telemonitoring allows regulators to monitor emission concentrations instead of having to rely on operators to present data and notify exceedances. As data are collected in real-time, raw data needs to be processed before any action can be taken e.g. comparison with the regulatory limit value. Data processing typically includes: calculating data validity, calculation of the concentration at reference conditions, calculation of the required time average, comparison with requirements, removal of uncertainty (if required for compliance) and alarm (yes/no).

### 3.2.8 Notifications to the regulator

The verifier usually identifies values that are abnormal, non-conformities (ELV exceedances) or non-compliance with standards, such as EN 14181. The verifier must report these results to the operator. Operators then need to take corrective action. Some telemonitoring packages notify regulators and operators via SMS messages or e-mails.

[53] JRC Reference Report on Monitoring of Emissions to Air and Water from IED Installations, 2018. Available at: https://eippcb.jrc.ec.europa.eu/sites/default/files/2019-12/ROM_2018_08_20.pdf

### 3.2.9 Making data available to the public

Within the EU, competent authorities must make results of emission monitoring as required under the permit conditions available to the public under Article 24(3)(b) of the IED[54]. Examples of real-time data published online have been observed in Croatia, where half-hourly data are published via an online app, and Germany (Bavaria) where real-time raw data is available to the public. In all other instances in Europe, processed data is later published in publications or on air quality websites, or available upon request by citizens. In non-European countries, examples have been observed in China where remotely collected data has been made publicly available via the internet. Also data provided to the USEPA is published on a quarterly year basis under the Air Markets Program.

In addition to data being published and made available to the public by regulators, some operators themselves make data available on their own company web sites. This tends to be daily averages and comparisions to ELVs.

## 3.3 Block Two: Communication

There are different configurations used for communications systems. These can be divided into four broad approaches for telemonitoring:

- **Approach 1 – Croatia, Spain (Madrid, Galicia)** – **Periodic manual submission of data**. This approach is based on the operator manually sharing data with the competent authority to demonstrate compliance with requirements. Compliance data are sent to the regulator by the operator at defined intervals (for example monthly) via e-mail in a defined format. The architecture is shown in Figure 3-1.
- **Approach 2 – USA, Spain (Andalucía), Italy (Lombardy) – Periodic automatic submission of data.** Like Approach 1, but the data are sent directly and automatically to the regulator via an internet connection (**for example daily**). The information is shared using a defined format for inclusion in a database which is done by the regulator. The architecture is shown in Figure 3-2.
- **Approach 3 – China, Germany (Bavaria, Hamburg) – Periodic automatic submission of data. Collection of near to real time data**. CEMS operation status flags are also collected. The system includes provisions for a regulator to check individual CEMS outputs in real-time (for example in response to system or compliance alarm) and may provide (limited) regulatory access to CEMS functions. Plant operation data are also collected. The architecture is shown in Figure 3-3 .
- **Approach 4 – India, South Korea and Malaysia, Austria (Linz),** – **Fully automated real-time data collection with access to CEMS.** Collection of real time or as close to real time data as possible. The system has also the capability to access CEMS functions independently of the operator (for example to undertake calibration checks by injecting calibration gas). Plant operation data are also collected. The architecture is shown in Figure 3-4.

Only approaches 3 and 4 can be considered true telemonitoring in the sense that they offer the capability to collect data in real time or as close to real time as possible.

Some periodic emission data are also being shared with authorities (e.g. when data are very relevant or high frequency/density data are collected). This is enabled by approaches 1 and 2 where the interface does not involve a direct link to a regulator and relies on manual submission of data.

### 3.3.1 Approach 1

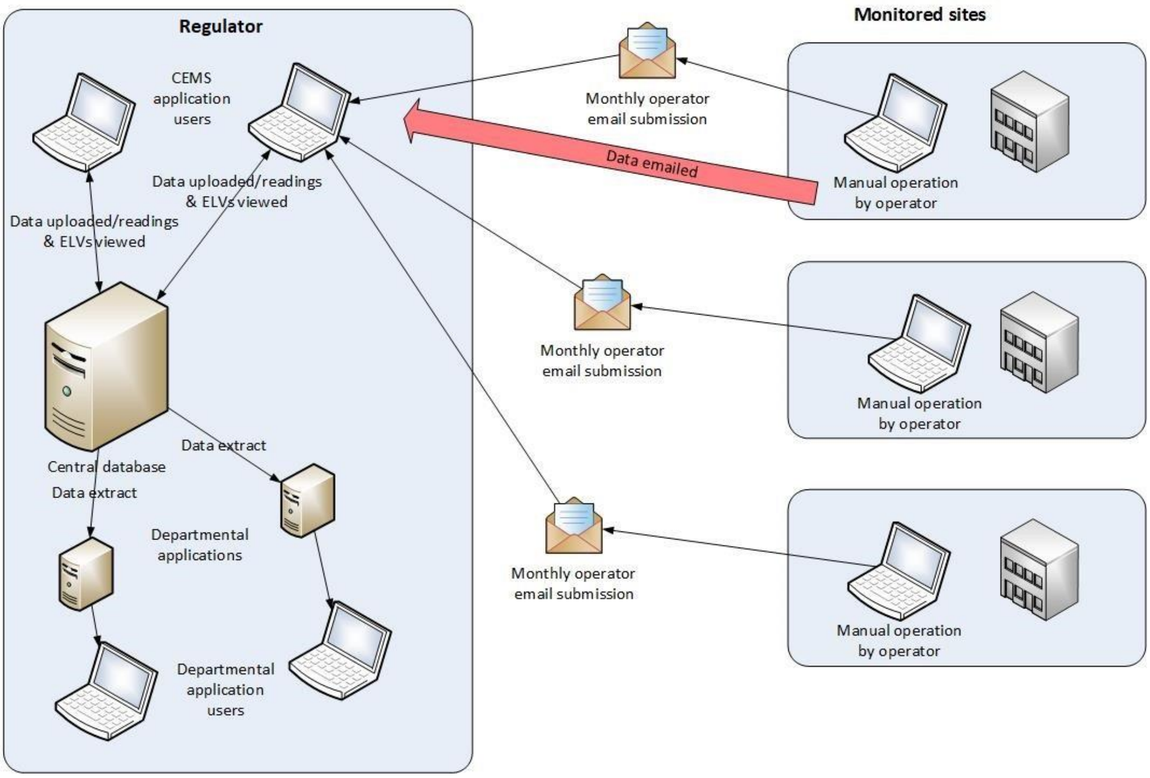
The data received by the regulator in this way are manually removed from the email and uploaded into spreadsheets, in software such as Microsoft Excel. The data are manually converted to reference conditions and then compared with emission limit values within the spreadsheet.

Useful ELV exceedance notifications can only be automatically generated in this situation retrospectively due to the delay in receiving data. Regulatory structures where this approach is utilised

[54] Guidance Document: The Monitoring and Reporting Regulation – Continuous Emissions Monitoring Systems (CEMS)

have exceedance reporting requirements in place. The operators are required to inform the regulators of any ELV exceedances.

Figure 3-1 Approach 1 Architecture




Source: Own compilation

### 3.3.2 Approach 2

Under approach 2, data are collected automatically, typically on a daily basis. This may be achieved either by operators regularly pushing data to an FTP server from where it is loaded into the database though its API, or by an application, running on a collection server or servers, polling each site in turn, requesting compliance data from web services running on the operators' collection servers.

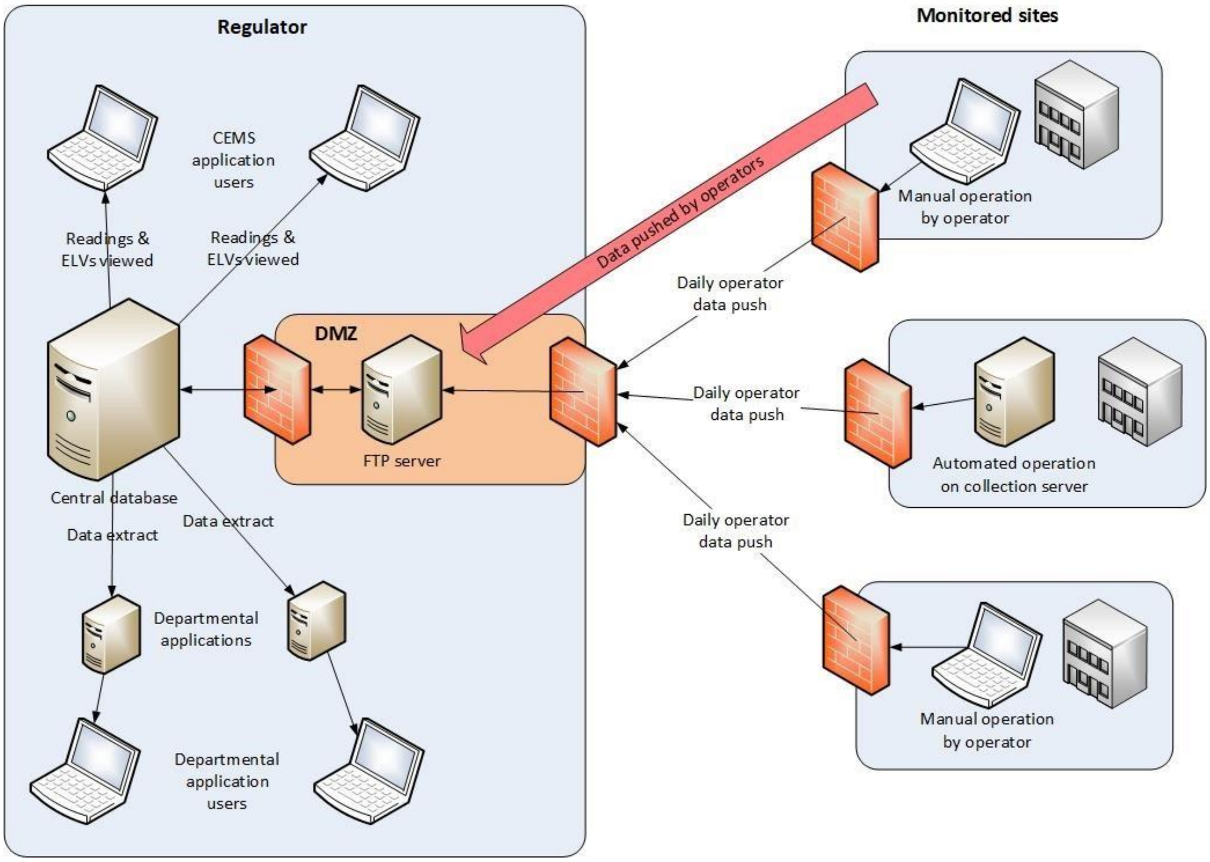
If the regulator system passively waits for data to be pushed to an FTP server, then the sending of data must be a manual task performed by the operators or an application must be running on each of the operators' systems to periodically extract the data, format it appropriately and transfer it to the regulator FTP server. Active collection of data by a regulator's system, however, would mean that an operator would only need to provide a web service allowing an application to run on a collection server to request the data.

Both approach 1 and 2 have advantages and disadvantages. The passive approach means that operators can automate their data submissions or rely on a manual process according to their available resources. Actively polling sites for data, however, makes it much easier to identify issues with data supply – if a site is polled but fails to provide the data or provides a partial submission, it is immediately obvious that data are missing, whereas if data are passively imported from an FTP server such issues must be identified by analysing the database contents for gaps in data or by logging when files are received from each operator and checking for completeness.

This approach also requires the establishment of a "De-Militarised Zone" (DMZ) within a regulator's infrastructure. When configuring a network firewall, it is common to permit connections from within the network to resources outside, but not to allow connections originating from the Internet to enter into the protected network. This approach, however, requires that operators are able to "push" data onto an administered server which would be prevented by the firewall rules.

A DMZ addresses issue by permitting pre-approved external connections to enter it but at the same time preventing any connections originating from the Internet or from the DMZ from entering the main network. It also allows connections originating within a secure regulator network to reach the FTP server, allowing data deposited there by the operators to be pulled into the central database. The DMZ, therefore, can be thought of as a purely passive area of the regulator's infrastructure, allowing data to be pushed in or pulled out, but not allowing any connection to be initiated within it or propagated through it. The net result is that the necessary data transfer may take place without compromising the security or integrity of the main part of a network in any way.

Figure 3-2 Approach 2 Architecture

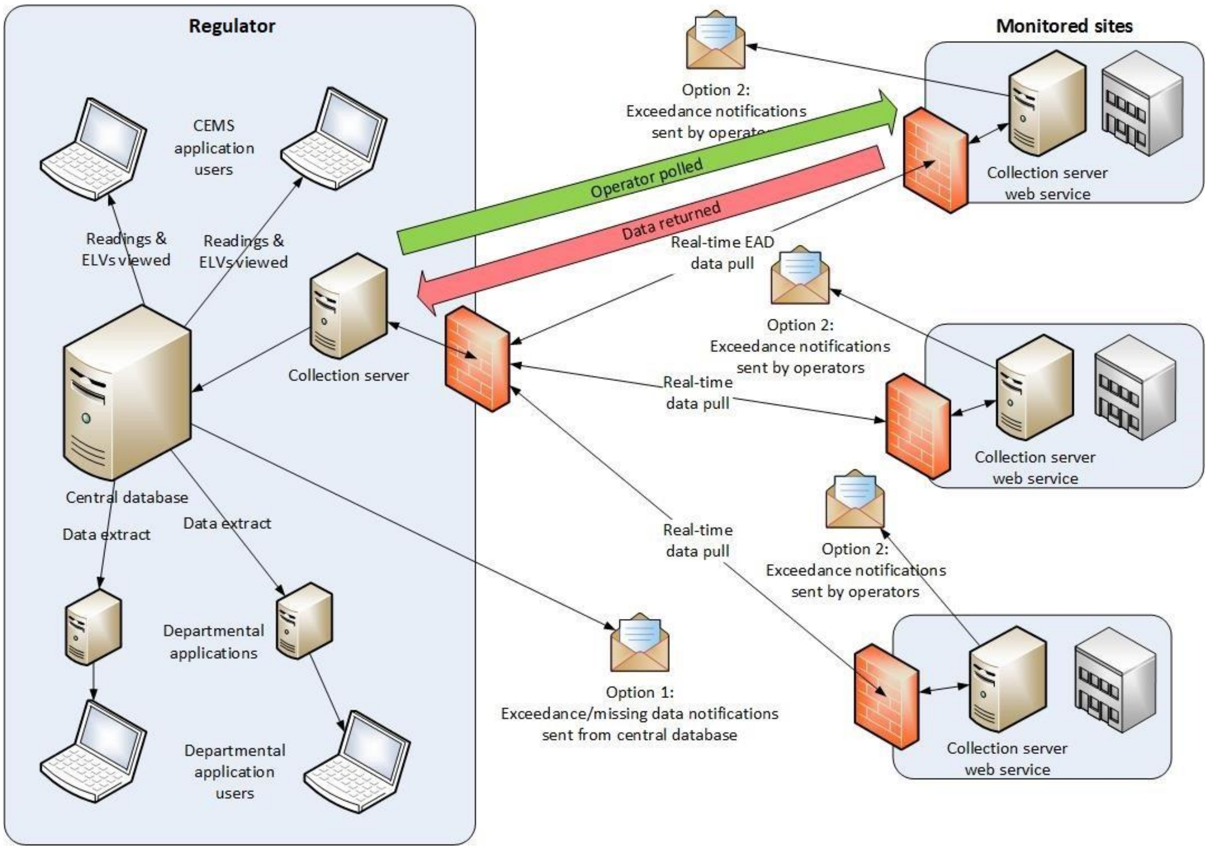



Source: Own compilation

### 3.3.3 Approach 3

Approach 3 architectures provide nearly real-time access to emissions data and CEMS operational status information. Consequently, these are used to automatically generate alerts to a regulator notifying of ELV exceedances. This is used in a number of systems such as in India, Malaysia and China.

Figure 3-3 Approach 3 Architecture

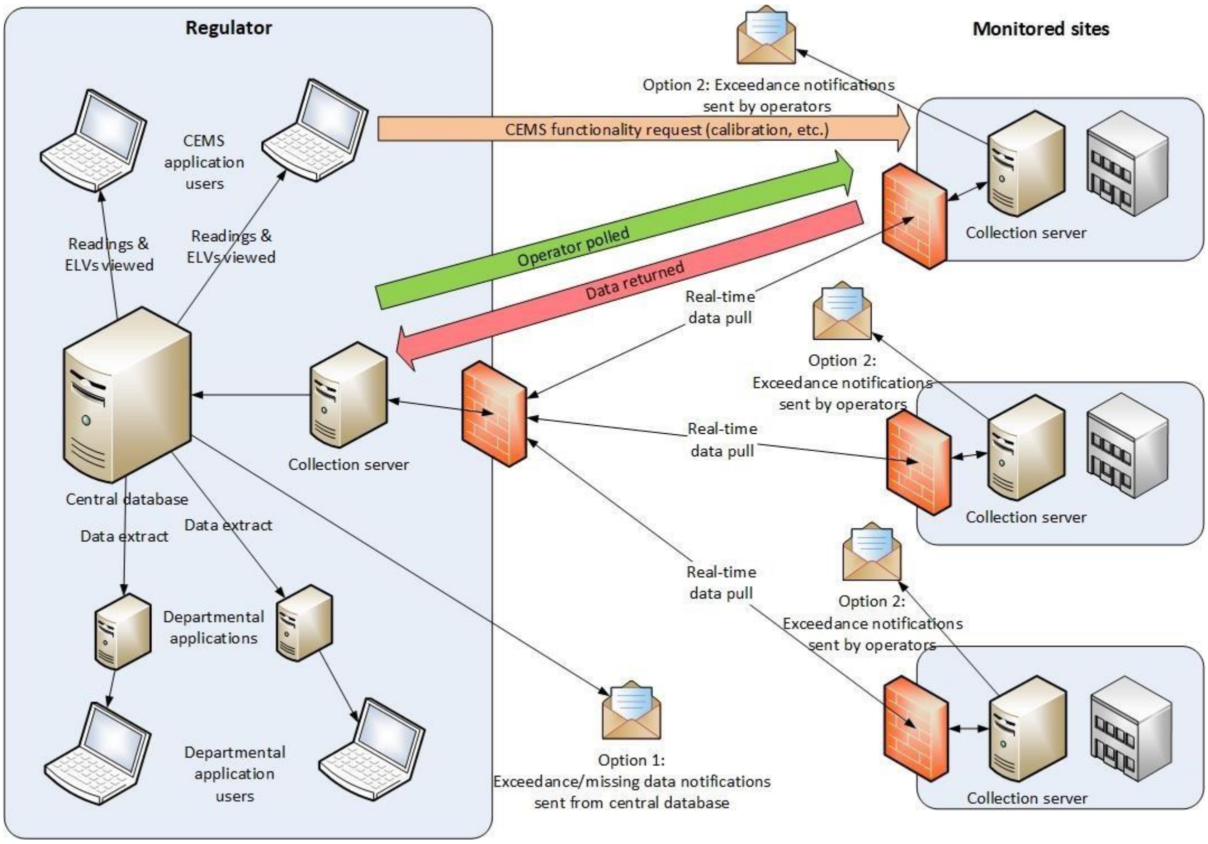



Source: Own compilation

### 3.3.4 Approach 4

Approach 4 provides the near real-time collection of data and operational information, generation of exceedance and missing data alerts, similarly as approach level 3, but with the addition of greater direct access to CEMS functionality independently of the operators. The system architecture diagrams are, therefore, similar to those for level 3 above. An example of this approach is the Knowledge Lens system used by the Indian CPCB and SPCBs, and the system used by the Austrian competent authorities.

Figure 3-4 Approach 4 Architecture




Source: Own compilation

Approaches 3 and 4 include elements found in the simpler approaches 1 and 2. This allows the regulator which uses the complex approached also to collect data via manual/periodic submissions and combine this data into a central database.

### 3.3.5 Overview of the technical specifications for the four approaches

An overview of the functionalities and technical characteristics for the four approaches used in communication systems is presented below:

- **Type of data**: the communication devices send mainly raw emission data and/or averaged data (per minute, per hour, etc.). Some installations also send contextual plant operational parameter information such as load, stack temperatures, stack pressure production rates, ambient temperatures, etc. Other installations also send data on ambient air quality at the site perimeter.
- **Rates of collection:** the information can be transferred real-time, made available for authorities to access (in a server with access permission or passwords) or can be sent periodically by operators. Most operators send data monthly (in the assessed EU Member States). Some authorities explained that an instant request can also be made when investigating air quality issues or complaints.
- **Remote calibration:** in Europe this is not a common feature deployed in telemonitoring systems. Nevertheless the equipment vendors have confirmed that this could be feasible in many configurations.
- **Data validation or assessment:** in many cases there is an opportunity in the communication path for operators to validate the data that are going to be sent (e.g. including contextual information such as monitoring issues or start-up periods). Data are typically analysed by authorities only periodically (daily/monthly/quarterly) unless an air quality incident triggers an immediate analysis.
- **Calculations**: some authorities process data to convert it for other uses (e.g. submission to PRTR). A limited number of stakeholders reported that measurement uncertainty is also extracted from raw data values to check the number of times (events) when the emission exceeded the limit value.

- **Making data available to the public**: this feature is not widely undertaken in the EU by using online data reporting. Some operators of particularly sensitive processes such as waste incineration publish CEMS data on company web pages on a monthly basis. An example has been observed in the UK, at Kent Enviropower's waste to energy plant. The company publishesh emission reports based on CEMS data on their company web site.[55] The data are presented as a proportion of ELVs. It is unclear how frequently the reports are updated as the time of access (June 2020) the most recent report is for February 2020.

The communication approaches are selected to meet the requirements of the competent authorities. Industrial operators rarely spend resources on solutions that go beyond the requirements of the permit or regulations.

## 3.4 Block Three: Central (Regulator) Software and Hardware

There are a limited number of software and hardware packages commercially available that are used to collect data from process CEMS by national and regional regulators. The following sections briefly describe the packages and systems found in literature and reviewed.

### 3.4.1 Inside the EU

There are commercial software and hardware packages available in the EU that are capable of collecting data from CEMS. An example is the ENVEA WEX XR system which is a derivative of a data collection system used for ambient air quality monitoring stations but which has been adapted for CEMS. Dduring the interviews conducted it was commonly reported that regulators were using their conventional personal computers for running telemonitoring software. It was commonly reported that additional software was purchased for the reporting and data analysis, or alternatively spreadsheet packages such as Microsoft Excel were used to process data.

### 3.4.2 Outside the EU

A number of countries outside the EU are using software packages developed specifically to collect data from CEMS. In most instances, the analysis is performed using standard computers, however China and Korea reported the use of advanced specific computer hardware as well.

#### 3.4.2.1 India - Knowledge Lens

The Knowledge Lens software package was developed to support the Indian CPCB and State PCBs to collect CEMS data. The system enables a wide range of data related functions ranging from validating data to the remote calibrations of the CEMS. The system is an MCERTS certified environmental data management solution for CEMS under the MCERTS type approval scheme.

The software is a real-time data acquisition monitoring, reporting and analytics package. In addition to collecting data from CEMS, data can be collected from air quality monitoring stations and continuous effluent monitoring stations. The system is made up of several components:

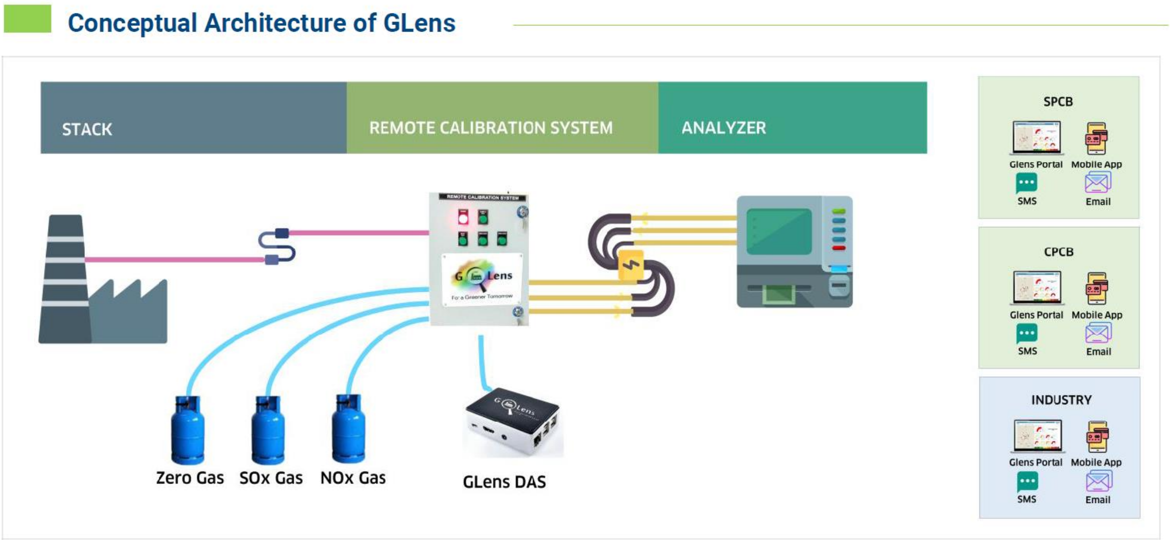
- GLens DAS software – provides integration using RS232, RS485/Modbus/Ascii protocols.
- GLens Server platform provides secure encrypted communication and uses REST based API or MQT vase protocols. Provides a common software with report alerts and ad-hoc reporting capability to analyse data of frequency down to 2 seconds.
- Knowledge Lens data logger – there is an option for a wireless data logger that eliminates the need for a client computer-based (wired) data logger.
- Knowledge Lens Mobile – enables viewing of real-time data.
- The package is available to be hosted at a site or in the cloud. The system:
    - Is scalable to handle >10,000+ analysers connected over real-time with 2 sec monitoring;
    - Can provide live alerts and alarms;

[55] https://kentenviropower.fccenvironment.co.uk/emissions-reports

- Can support forecasting models;
- Can assess data quality;

Can provide GIS-based graphics.The architecture of the Knowlegde Lens package and the remote calibration is shown in Figure 3-5.

Figure 3-5 Knowledge Lens Architecture (Provided by Knowledge Lens)




In addition, other Knowledge Lens packages can be integrated with other packages and models. These include MLens that supports high-speed data back-up and disaster recovery.

#### 3.4.2.2 Envea WEX

This package has been used in a pilot project collecting data from a power plant in Abu Dhabi. The package is designed as a data acquisition system for process and regulatory reporting and provides real-time monitoring. It can be adapted to suit different requirements. The package is certified under the MCERTS scheme for emission data acquisition, processing and regulatory reporting. The package has been developed to enable collection of data from other sources of environmental monitoring systems such as ambient air quality monitoring stations.

The system is scalable for plant size, managing various data sources, emission, meteorological, water and process information. It also includes specific functions such as reporting trends, data storage redundancy, supervision and alarms.

The package has a remote operation capability, which enables the remote configuration and control of measuring devices such as analysers DAHS and communication systems.

To enable compliance with legislation, there is a function that supports QA/QC such as control charts as used in EN14181. Also, data quality control and assurance have been considered with system determining CEMS availability and data validation and comparision against regulatory requirments for these parameters.

There is scope within the package to collect data from a number of sources to a central location. This can either be on one site with multiple CEMS monitoring a number of emissions points or collecting from a number of process sites.

#### 3.4.2.3 CleanSYS (South Korea)

The package is designed to collect data from CEMS for the following pollutants and parameters:

- Pollutant species: dust, $SO_2$, $NO_X$, HCl, HF, $NH_3$, CO;
- Parameters: waste gas flow, temperature and $O_2$

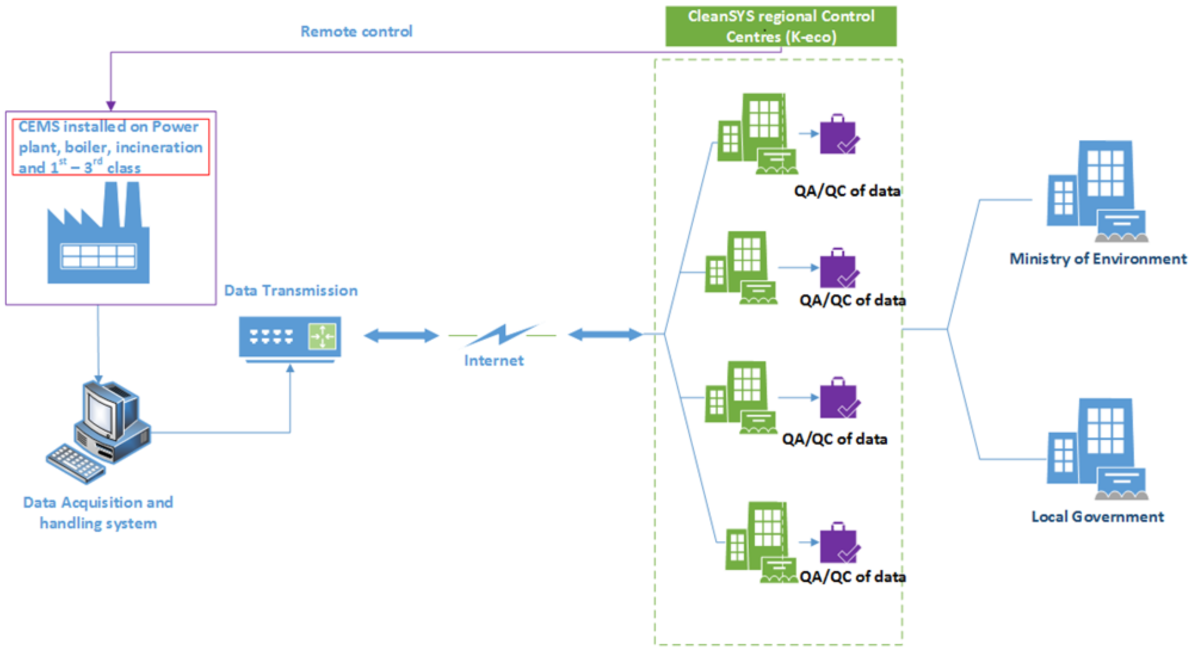
The data are collected in real-time. The system is designed to alert operators and local government via SMS messaging if an emission concentration approaches or exceeds the ELV. This enables action to be taken. The system also enables a remote check using the injection of calibration gases.

Installation and operation of the system involves three groups:

- Process operators who are responsible for the
    - Installation of the CEMS;
    - Installation of the data handling systems;
    - Transmission of the measurement data;
    - Compliance with the ELVs.
- K-eco Control Centre set up as part of the infrastructure and which is responsible for:
    - Checking the appropriateness of CEMS and other systems;
    - Supporting the collection of data.
- Administrative Institutes (Ministry of Environment/Local government).

Figure 3-6 presents an overview of the CleanSYS software.

Figure 3-6 CleanSYS CEMS software



## 3.5 Categories of CEMS, data acquisition and communication systems

Systems installed on site can be complex in that there may be a large number of emission points being monitored by CEMS and depending on the process there may be multiple components measured by each of the CEMS. In addition there may be redundant (backup) CEMS for each unit. All of this adds to the amount of data generated and the complexity. Consequently there is a large amount of information that needs to be collected to ensure that the emission data collected and reviewed via telemonitoring is valid and assessed correctly.

Figure 3-7 shows an example of a possible set up of CEMS and associated communication devices.

Figure 3-7 Possible set up of CEMS and associated communication devices


Key: (1) Samples taken and sensors; (2) CEMS shelter with analytical assets; (3)Servers room hosting data and connection with internet; (4) Control room and offices to visualise data

*Source: Ricardo elaboration for illustration purposes using a Google Earth image*

We have identified the large number of possible arrangements, configurations and designs that are in place for CEMS, data acquisition and communication systems offered by the suppliers and used by operators and regulators:

- Type A: simple system (at site) that sends information from one CEMS (based in one router or DAHS with limited data treatment);
- Type B: complex system (at site) with a CEMS with multiple components integrated into data handling systems. Collects data from CEMS only;
- Type C: complex system (at site) with multiple CEMS monitoring multiple components. Collects data from CEMS and plant control systems;
- Type D: complex system (at site) capability to collect data but with regulator intervention capability (e.g. to undertake calibration) rather than pure data collection;
- Type E: the approaches/systems used to connect the CEMS to the regulator;
- Type F: IT system at regulator/authority that stores, processes, visualises and analyses data.

Table 3-1 provides an overview of each type.

Table 3-1 Overview of each category

| Type | Main components | Connection Approach[1,2] | | Common users | Comment |
|---|---|---|---|---|---|
| | | EU | Non-EU[3] | | |
| A | Router | 1 | 3 | Smaller industrial sites (e.g. from food, drink or animal by-products) | Information is sent live or sent periodically (monthly) |
| B | Router+ onsite Server+ firewall (block connection with DCS) | 1 | 3 | Small Medium Combustion plants, | Information is sent live or sent periodically (monthly) |
| C | Router+ onsite Server+ firewall (block connection with DCS) | 1,3 | 3 | Combustion plants, Incineration, Chemical sites, O&G refineries | Authorities can pull data from a DAHS/server where information is hosted |
| D | Router+ onsite Server+ firewall (block connection with DCS)+ direct connection with CEMS | 1 | 3,4 | Combustion plants, Incineration, Chemical sites, O&G refineries | Enables authorities to: check calibration of CEMS, collect raw emission process monitoring and wider actions |
| E | Connectivity | 3 | 3,4 | All applications for telemonitoring | Where real-time telemonitoring has been implemented internet/based or direct connections have been utilised. These utilise communication protocols such as Modbus and profibus. |
| F | Personal computers and/or server to host larger data quantities | 1 | 3,4 | Competent authority to host data received from the industrial installations | Hosted on cloud or server based systems. Utilises database packages such as SQL and Oracle to enable collection, verification and processing of the data.<br>Packages are available that have collected data from 4000+ sites. |

[1] Approaches as described in section 3.3

[2.] Majority approach used

[3] Countries where telemonitoring adopted – Malaysia, Korea, India, China

### 3.5.1 Type A: Simple System – Single CEMS

The infrastructure for a site with one CEMS measuring one pollutant (e.g. PM) and collecting supporting information is relatively simple. PM monitors used in these scenarios have a data acquisition and handling system as part of the measurement system. An example is PCME QAL 991 which can have up to sixteen sensors linked to a central controller using RS485. This can then be networked and the data collected remotely.

### 3.5.2 Type B: Complex System – a CEMS and Multiple Components

A CEMS system that is measuring multiple components and collecting data into a DAHS or server, but is independent of the plant DCS. An example of such a system and arrangement would be a small combustion plant involving a boiler measuring CO, NOX, and O2 using a multiple component CEMS designed for power plant (e.g. SICK PowerCEMS50) as the CEMS which has analogue and digital (Modbus) outputs to enable connection to plant DCS and a DAHS. The data are collected into a DAHS which generates reporting as required by the regulator. A direct connection can be made to the analyser or the DAHS to enable telemonitoring. This is utilised where there a number of units where the data are required to be viewed centrally.

### 3.5.3 Type C: Multiple CEMS and Components

Data are collected by a DAHS from multiple CEMS taking measurements at a number of units. Signals are sent and received from the plant's DCS. This is a typrical scenario at an IED waste incineration plant. In addition, outputs from the CEMS are used to control abatement systems such as $NO_X$ and acid gas control. The measurements in this scenario result in a number of signals. However there are also IED requirements that mean that signals from the CEMS are used. One is to stop the process via a series of interlocks, for example waste feed is prevented when there is a CEMS issue. Process operating parameters also need to be collected to enable reporting periods to be confirmed. For incineration these would include plant start up and shut-down times as currently these periods are excluded from reporting. The data collected is used in various places around the plant e.g. the control room, by the environmental manager, and by the shift manager.

Consequently, the network that is constructed is complex involving different connections to a number of different components:

- CEMS to plant DCS connection. Some systems use additional outputs from the CEMS which can be either analogue or digital. These provide signals directly to the plant DCS which are isolated from the CEMS. These can include measured concentrations and CEMS status. Analogue signals may need to be converted to digital signals depending on the plant DCS.
- CEMS to DAHS. These connections use set output channels from the CEMS and can also be analogue or digital. The DAHS collects and stores data and information from the CEMS and plant. This data are used to undertake calculations to enable reporting as required.
- CEMS to Regulator. Where telemonitoring is implemented with remote control to carry out calibration checking of CEMS, the connection may be:
  - made directly to the CEMS; or
  - to the DAHS providing the functionality is available; or
  - using an alternative independent datalogging system.

### 3.5.4 Type D: Complex system incorporating connection to plant DCS

This configuration involves collecting data from several CEMS, each monitoring a different emission release point. An example are refineries where are there are a large number of different processes each of which is to be monitored (e.g. boiler plant, process heaters, fluid catalytic cracking units and sulphur recovery units), and may have different requirements for CEMS measurements. Data from each CEMS is collected locally into DAHS, which is then linked into a plant area control system and central environmental management. Two cases have been identified regarding the capability to collect data from CEMS and initiating calibration checks:

- Case 1 - Using the installed CEMS capabilities;
- Case 2 - Installing an independent system.

Case 1 – CEMS provided by ABB, SICK, ENVEA and others utilise modern communication protocols to communicate within the CEMS and to connect to external systems such as DAHS and plant control systems. This is also used to control CEMS activities such as calibration checks. These can be critical for the operation of the CEMS and are threfore automated. This capability can also be triggered externally via connection to the analyser. An example of this is the ENVEA WEX system that enables this remote triggering of calibration.

Case 2 – This is the approach adopted in India in where a connection is made using a data logger utilising RS232/RS485/Modbus/Ascii protocols. GLens Clients provides secure encrypted data communication with a central server using open REST based API or MQTT based IoT protocols. The systems have the capability to integrate directly with CEMS.

In addition to the communication there is additional hardware infrastructure involving control valves to control calibration gases.

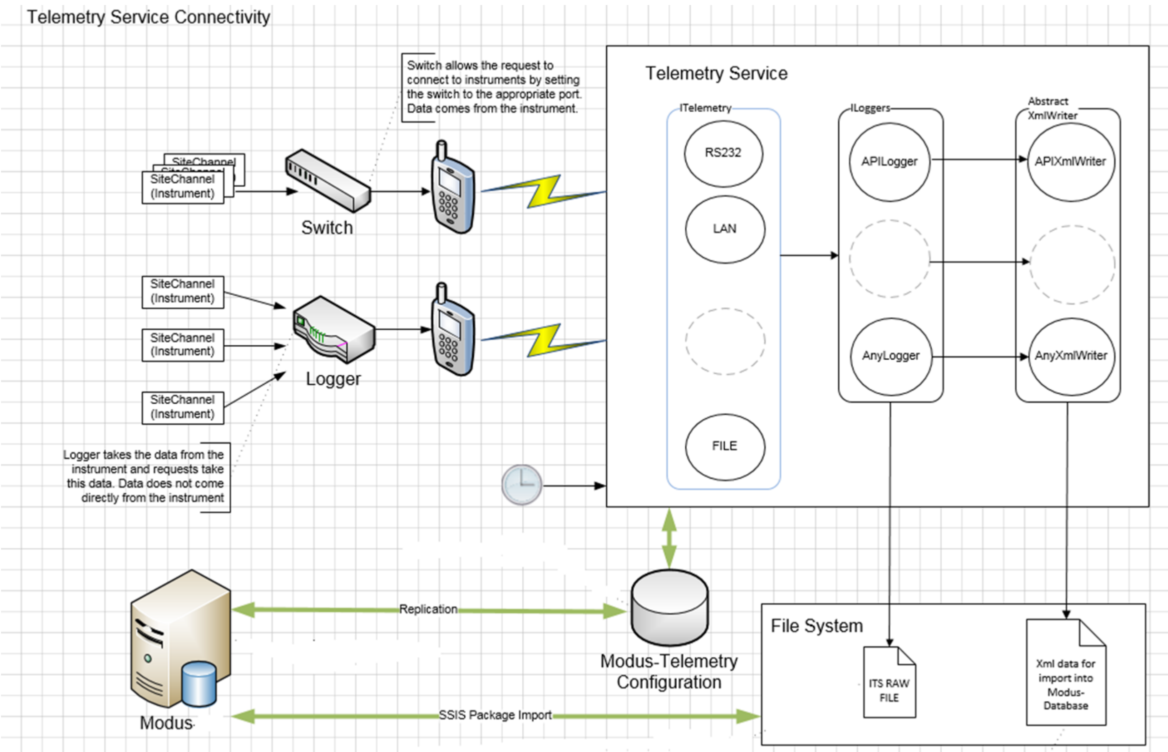
### 3.5.5 Type E: Connectivity

The different configurations for the communication with CEMS and their integration into plant/processes include the following:

1. Analogue interface from the CEMS;
2. Digital interface such as Modbus, profi-bus from the CEMS;
3. Analogue connection to a DAHS;
4. An Application Programming Interface (API) connection;
5. DAHS to plant DCS; Modbus, RS232, RS485, Ethernet, Profi bus – DP, OPC, PI ( SDK and OPC), Analogue (420mA) Retransmission. And Digital (voltage free contacts).

Figure 3-8 shows the typical connectivity to a DAHS or switch/server to enable telemonitoring.

Figure 3-8 Types of connectivity employed




Source: Own compilation

All regulators using telemonitoring have defined how the connection between the site/process systems and the regulatory data collection system should be made. This is usually the responsibility of the operator and supplier to ensure that when CEMS are installed the correct connectivity is in place so the regulator network can communicate with the system. Defining a specification for the interface ensures that there is a uniform connection to all systems rather than having to configure a connection for each CEMS or individual analyser.

Most operators who collect data solely into DCS do not allow or have the facility to provide external access to CEMS data; in addition they usually have anxieties around IT security. Data security is critical and the installation and operation of firewalls is needed to protect against unauthorised access. The data volumes depend on which levels of connectivity are to be achieved and on how many operators/sites are required to be incorporated into the telemonitoring scheme.

### 3.5.6 Category F: IT system

There are two approaches that have been adopted in regulatory telemonitoring solutions; these are cloud-based and server-based solutions. The server-based solution requires a physical presence in a location at the installation (i.e. a system of servers). A cloud-based system has no physical on-site structure. This also eliminates the need for hardware installation and maintenance, data storage and back-ups that would require management at the location. Typical software/hardware systems are described in section 3.3.

## 3.6 Certifications and standards

Countries that have adopted telemonitoring as a requirement at national level rather than on a regional basis, as was mainly found in the EU, have all implemented this as a requirement in national leglislation. Implementation has generally been focused on large environmentally high risk processes Telemonitoring is not considered in isolation as it is recognised that all aspects of the measurement are critical to the quality of input data to a telemonitoring database.

Requirements are placed on operators to meet specified standards, including the use of accepted reference standards, specification/quality of equipment and QA/QC procedures, communication systems, collection of data and its processing and data security.

The following sections summarise standards for CEMS andDAHS.

### 3.6.1 CEMS

There are international standards, European standards and national standards (USEPA, China and Japan) for monitoring that are considered as reference methods. When implemented correctly these ensure the provision of data of sufficent quality to confirm compliance or non-complaince against legislative and permit requirements. These standards include both the use of CEMS and periodic measurements.

A requirement for CEMS under the IED is the certification and approval of both CEMS and DAHS. This meets the requirements of standards EN14181 quality level 1 (QAL1) and EN15267 parts 1-4 (Performance test procedure and specification). In Germany, there is the UBA/TÜV scheme and, in the UK, MCERTs. EN standards that relate specifically to CEMS are:

- EN 14181- Stationary source emissions. Quality assurance of automated measuring systems.
- EN 15267-1:2009 Air quality. Certification of automated measuring systems. General principles.
- EN 15267-2:2009 Air quality. Certification of automated measuring systems. Initial assessment of the AMS manufacturer's quality management system and post certification surveillance for the manufacturing process.
- EN 15267-3:2007 Air quality. Certification of automated measuring systems. Performance criteria and test procedures for automated measuring systems for monitoring emissions from stationary source.
- EN 15267-4:2017 Air quality. Certification of automated measuring systems. Performance criteria and test procedures for automated measuring systems for periodic measurements of emissions from stationary sources.
- EN 15259:2007 - Air quality. Measurement of stationary source emissions. Requirements for measurement sections and sites and for the measurement objective, plan and report.

The QAL 1 certifcation/approval gives confidence to operators and regulators that a CEMS is capable of providing data that meets regulatory requirements of uncertainty and can be used to demonstrate compliance with legislation.

Outside the EU there are a number of approvals and certification schemes. These include GOST (Russia), KTL (Korea), CNEMC (China) and JMOE (Japan).

Countries where there were no CEMS standards in place prior to the implementation of telemonitoring, such as India and Malaysia, reviewed CEMS practices around the world looking at what could be considered “best practice” and then selected approaches that met their objectives.

India has adopted EN 14181 for CEMs and EN 15259 for the selection and verification of sampling position and reporting. This means in practice that there is a requirement to use certified/approved CEMS. However there are a number of CEMS suppliers in India that do not have certification/approval via any of the schemes around the world. Consequently they are developing their own certification scheme. As an interim step, the USEPA relative accuracy test Audit (RATA) has been adopted to verifiy installation of non-certified/approved CEMS.

In Malaysia, EN 14181 has been adopted for CEMS QA/QC together with USEPA sampling methods as the reference methdods. This was due to the fact that USEPA methods had already been in use for periodic monitoring.

### 3.6.2 DAHS

The following EN Standard is for the specification of data acquisition and handling systems:

- EN 17255-1:2019 Stationary source emissions - Data acquisition and handling systems - Part 1: Specification of requirements for the handling and reporting of data and performance specification.
- EN 17255-2: 2020 Stationary source emissions - Data acquisition and handling systems - Part 2: Specification of requirements on data acquisition and handling systems.
- EN 17255-3 Stationary source emissions —Data acquisition and handling systems —Part 3: Specification of requirements for the performance test of data acquisition and handling systems.
- EN 17255-4 Stationary source emissions —Data acquisition and handling systems — Part 4: Specification of requirements for the installation and on-going quality assurance and quality control of data acquisition and handling systems.

Within the EU, certification and approval schemes run by UBA/TÜV constrain certification/ approval testing in accordance with requirements of these standards.

Both the UBA/TÜV scheme and the UK’s MCERTS evaluate the DAHS for the collection of data from CEMS. Under the TÜV scheme these are approved as ‘Evaluating systems’ and certified under MCERTS as Environmental Data Management Software requirements for Environmental and Continuous Emissions Monitoring reporting systems.

The systems approved under the TÜV scheme are listed in Table 3-2. All reference the capability of remote monitoring. Digital transfer is using digital signal formats such as Modbus and Profibus.

Table 3-2 TÜV approved Evaluation Systems

| Manufacturer | Product(s) | Components |
|---|---|---|
| ABB Automation GmbH | CEM DAS<br>CEM DAS SE | Evaluation system, remote data transmission,digital data transfer via Modbus |
| DURAG GmbH | D-EMS 2000 | Evaluation system, remote data transmission,digital data transfer via Profibus/ Modbus |
| | D-EMS 2020<br>D-EMS 2020 CS | Evaluation system, remote data transmission, digital data transfer via Profibus/Modbus |

| Manufacturer | Product(s) | Components |
| --- | --- | --- |
| ITBK Ingenieurgesellschaft für Umweltschutz mbH | EMI3000+ | Evaluation system, remote data transmission |
| SICK AG | MEAC 300 (MEAC 2012) | Evaluation system, remote data transmission, digital data transfer via Modbus |
| Siempelkamp NIS Ingenieurgesellschaft mbH | UmweltOffice<br>UmweltOffice sE | Evaluation system, remote data transmission, digital data transfer via Modbus |

In the MCERTS schemes, these packages are certified as Environmental data management software. The systems listed are not certified specifically as having the capability for remote transmission. However, the majority list the capability to export data in real time to third parties therefore have the capability to communicate with a telemonitoring package.

### 3.6.3 Telemonitoring Regulatory Specification Requirements

Although there are specific standards for the interface between CEMS, DAHS and a telemonitoring system, we found that, where telemonitoring has been implemented, interfaces and enabling software have been clearly defined. Regulators make it the responsibility of the operators and CEMS suppliers to install systems that meet requirements and must be able to connect to the regulator's telemonitoring systems.

For example, the Scottish Environment Protection Agency have written in permits for waste incineration plants that any new or replacement CEMS must have the capability to connect to a telemonitoring system. This has resulted in new CEMS being installed with connections available specifically for this task but as of 2020 these have not yet been utilised on any plants.

Installed CEMS can be retrofitted with systems/components that allow telemonitoring. An example of this is the approach used in India where to comply with requriements and enable remote calibration checks an independent system is fitted. Additional ouptuts can be installed into the CEMS to enable connection. These outputs can provide digital outputs using Modbus, Profibus or other protocols that can be used. In addition DAHS used to collect CEMS data can be connected via telemonitoring using the communication protocols previously mentioned. Retrofitting of telemonitoring is possible but would involve the assessment of the installed system to develop an suitable approach

# 4 Analysis of decision drivers for implementing telemonitoring systems

This section provides a summary of drivers to implement telemonitoring. Principally these relate to reducing costs, providing benefits, or addressing challenges in implementation of IED requirements, or equivalent in non-EU countries.

The literature research and the consultation done in this assignment have captured information on the drivers to justify resources for these communication systems. Section 2 of this document provided the drivers per country or region; this section provides a horizontal analysis of the drivers.

## 4.1 Costs

### 4.1.1 Cost for the industrial operator

This section refers to costs of implementing systems across the categories A to E mentioned in the previous section.

There is a wide range of system designs to deliver data sharing functionalities. Reporting requirements can have a significant effect on the design of a data acquisition and reporting system, and the reporting frequency and averaging time for the monitoring results can impact capacity and cost. Costs for the industrial operator are driven by the degree of complexity selected by authorities. It is very rare to find operators expending resources beyond the compulsory requirements.

Regarding the **investment cost**, our sources indicate that:

- There are simple design options with low-cost implementation
- The communication device is frequently included in the scope of the CEMS offer request. This normally entails a very large budget (e.g. EUR 200,000) while the communication device cost is very small in comparison (ranging from EUR 500 to 8,000).
- When the online data sharing request came from a local or regional authority, the requirements have been simplified. This has led to simpler and cheaper solutions. In Asia, where the requirement was driven by national initiatives, the standardised solutions were more sophisticated with more functionalities.

Proprietary software typically comes from the CEMS (or DCS) vendor. This software manages data and produces quality assured reports for use by plant personnel and regulatory authorities. Examples of software functions include:

- Allowing the operator to interface with the CEMS;
- Averaging data, calculating emissions estimates, and creating reports;
- Providing electronic and hard copies of logs and reports;
- Interfacing with other computer systems.

**Regarding the operating cost for installations:** Operators' costs per stack or per monitoring activity may differ among sites, due to several factors: nature of parameters, economies of scale, sampling frequencies[56]. Here again, the maintenance cost for the telemonitoring devices are very small compared to ongoing costs for CEMS maintenance or calibration. One operator has answered in the interview that they have had to date not a single complaint, issue or incident regarding the communication device.

### 4.1.2 Cost for the authority

This section refers to costs of implementing systems from category F mentioned in section 3.5.

**Investment cost**: authorities seek a low investment cost to host and analyse the emission data. Most authorities use a server to host data and normal computers to operate the system. One authority

[56] JRC Reference Report on Monitoring of Emissions to Air and Water from IED Installations, 2018. Available at: https://eippcb.jrc.ec.europa.eu/sites/default/files/2019-12/ROM_2018_08_20.pdf

(Madrid region) reported that their single server had sufficient capacity to host data from all the 18 sites that had to report online.

Sources of investment/initial cost for authorities include staff hours of personnel to develop procedures, protocols and other start-up related tasks as follows:

- Defining guidelines and protocols to support CEMS implementation including selecting equipment, the installation of the equipment, operation and maintenance.
- Developing a mechanism for periodic performance audits.
- Procedures, norms or instructions to deal with performance evaluation and calibration,.
- Building capacity of testing labs, regulators and manufacturers and development of a system and protocol for empanelment of capable labs.
- Designing training on equipment, calibration, data transfer for regional and central regulators.
- Standardising the reporting procedure (e.g. releasing national guidelines or forcing communication protocols selection).

A number of authorities reported that they have analysed data with standard computer spreadsheet packages, with or without bespoke visual-basic based spreadsheets.

**Operating cost:** The annual cost to run online data sharing has been indicated to be small, with most authorities reporting only staff time as operating costs. Sources of operating costs for authorities include:

- Data validation: conversions, eliminating outliers or other than normal operating conditions. Authorities with no sophisticated software reported that the workload was larger than anticipated and required significant staff time to clean, standardise and validate the data, with one region reported to have outsourced the analysis of data for a contract value of (EUR 15,000/year).
- Assessing compliance of plant operator
- Assessing compliance with audits
- Providing training and guidance

## 4.2 Benefits

### 4.2.1 Benefits for the industrial operator

The use of telemonitoring systems deliver several benefits for operators, including:

- To ensure timely detection of emission limit exceedances.
- To improve the quality of reporting.
- To increase transparency related to investigating sources of emissions during high pollution / local air quality incidents.
- To reduce inspection workloads.

### 4.2.2 Benefits for the authority

The use of telemonitoring systems deliver several benefits for regulators, including:

- To support assessment of ELV compliance: the systems offer a faster and more robust approach to verify that emissions are below ELVs.
- To deter non-compliance. CEMS can be an important documentation of compliance at a time of increasing public concern about air pollution.
- To provide a more accurate record of emissions in real time which is relevant as emissions may vary (for instance by fuel type, quality, operating processes).
- To support air quality incident investigations. Those that pull or acquire data periodically (monthly) have reported that they can request data immediately to conduct these investigations.
- To supporting the response to and management of public complaints.
- To reduce inspection workloads.
- Linking of information to air quality networks.
- To harmonise with reporting to e.g. PRTR, EU ETS.

- To determine the annual fee on emission which is proportional to quantities emitted.
- To develop strategies for future measures for reducing emissions.

## 4.3 Challenges

### 4.3.1 Challenges for operators

Challenges for operators include:

- Operators complain about how heterogenous communication requirements are from one region to another within a country. Guidelines at EU or national level to standardise requirements could reduce the costs of dealing with different requirements.
- Ambiguity in regulations for what the applicable CEMS requirements are and hence which monitoring approaches are acceptable.
- Having to develop a detailed quality assurance plan before actual operating experience with the monitoring equipment is obtained.
- Installing redundant (backup) monitoring devices for all or some monitoring parameters or installing CEMS that cannot achieve the minimum data availability requirement (in this latter case the source owner or operator should use alternate monitoring procedures).
- Operators not having sufficiently qualified staff to maintain analysers through QAL3 checks and reporting.

To avoid these challenges, a preliminary monitoring plan is required by a number of regulators such as the US EPA, the Malaysian DOE and the South Korean DOE. These authorities then agree approaches, systems to be installed and plans of operations.

### 4.3.2 Challenges for authorities

These are generic issues faced by competent authorities regarding online data reporting:

- An absence of guidelines and protocols on technology selection, installation, operation and maintenance;
- Absence of quality assurance, verification or a mechanism for compliance checking; the need to set up a separate certification agency for certifying devices as well as a dedicated facility for performance evaluation and calibration for CEMS (like in Germany);
- Lack of accredited agencies/laboratories for CEMS including communication protocols.

#### 4.3.2.1 Legal issues

No region has revealed major legal hurdles on the implementation of these services. Most regions in Europe are not making installations' emission data publicly available.

#### 4.3.2.2 Workload

Some authorities have reported larger workloads than initially expected for this telemonitoting tasks to request only the data that will end up being assessed. The majority of authorities reported that the significant workload is the major challenge to implement this initiative.

#### 4.3.2.3 Skills and capabilities

Policy officers in industrial regulations are in general expected to be sufficiently skilled to perform data cleaning and data analysis tasks. Some have reported the need to have basic training or have delegated tasks (data analysis, cleaning or conversion) to contractors.

Some challenges for authorities associated with initial phases of development include:

- lack of required knowledge and skill among stakeholder groups;
- need for capacity building of regulators on CEMs;

Table 4-1 describes the benefits and challenges identified during the interviews for this project.

Table 4-1 **Hardware, software, costs, benefits and challenges reported by selected stakeholders**

| Stakeholder | Hardware | Software | Capex | Opex | Opex description | Benefits | Challenges |
|---|---|---|---|---|---|---|---|
| **Industrial operators/vendors** | | | | | | | |
| **CEMS vendor** | More complex hardware to send data from several CEMS. Firewall is always in between communication/storage device and key site IT | N/A | >EUR 8,000 | > 500 EUR /year | The operating cost of the communication device is negligible once the supplier solves the common start up flaws. Maintenance only. | **The telemonitoring system can operate with all CEMS.** Public access to information as a response to environmental problem | None reported by clients |
| **Hardware vendor 1** | More complex system to send data from several CEMs or site server after validation | N/A | EUR 2,000 | N/A | N/A | N/A | N/A |
| **Hardware vendor 2** | Simple system to send data from one CEM (or site server)<br>A more complex system to send data from several CEMs (or site server)<br>Complex system where authorities can pull data directly or calibrate CEMs | No software in place: data analysed with simpler tools such as Access/Excel/other.<br>Sophisticated software that deliver end results ready to use (maintained/customised by service provider)<br>Software license that requires extensive training of officials to use and exploit functionalities | <2,000 EUR | <500 EUR/y | Connectivity costs | Public access to information as a response to environmental problem | **Some Telemonitoring systems cannot operate with all CEMS**<br>Otherwise, no burden as industrial operators have been trained and it works well. |

| Stakeholder | Hardware | Software | Capex | Opex | Opex description | Benefits | Challenges |
|---|---|---|---|---|---|---|---|
| **LCP industrial operator 1** | Complex system to send data from DCS after validation. | Sophisticated software that delivers end results ready to use (maintained by service provider) | <EUR 8,000 | > 5,000 EUR /year | No info | Public access to information as a response to environmental problem | Connectivity problems<br>Different formats within different administrations<br>Different criteria when communicating data<br>Training required |
| **LCP industrial operator 2** | Complex system to send data from DCS after validation. | Sophisticated software that delivers end results ready to use (maintained by service provider) | <EUR 8,000 | > 5,000 EUR /year | No info | Public access to information as a response to environmental problem | Connectivity problems<br>Different formats within different administrations<br>Different criteria when communicating data<br>Training required |
| **Competent authorities** | | | | | | | |
| **Austria** | Standard PC/server at competent authorities' premises | The Software licence is from AIT, it collects data and prepares them in graphs and data columns as HHA (half hourly mean). Data are analysed by officer with simpler tools such as Excel to get Statistic data | >EUR 8,000 | >EUR 5,000/ year | Annual flat rate Uwedat Software, Annual Licence Database,<br>Annual flat rate server, personal costs<br>Staff costs | Helps to deal with complaints from citizens. It shows the existence of a high level in monitoring and will promote confidence in the competent authorities. | Training required |

| Stakeholder | Hardware | Software | Capex | Opex | Opex description | Benefits | Challenges |
|---|---|---|---|---|---|---|---|
| **Croatia** | Standard PC/server at competent authorities' premises | Sophisticated software that deliver end results ready to use | >EUR 8,000 | >EUR 500/ year | System maintenance Technical support Customer support Education | **FTP, FTPS and SFTPT connection used – compatible with all CEMS** To check compliance Feedback to update ELVs Public access to information Deterring effect for non-compliance | More workload and training needs; Problem with the specification or measurement range, so some data (xml) does not flow properly. There is lack of resources and skills within the authority. |
| **Germany** | Standard PC/server at competent authorities' premises | Sophisticated software that deliver end results ready to use | <EUR 2,000 | None | All operational costs are borne by the industrial installation. | Higher quality of industrial emission data sets Faster decision-making process | Sites afraid/not willing to share data |
| **Italy** | Standard PC/server at competent authorities' premises | Sophisticated software that deliver end results ready to use | 20,000-30,000 EUR for hardware and software | >500 EUR | Staff costs for 2 people hired to overlook telemonitoring from the authority full time. | Higher quality of industrial emission data sets Faster decision making process Lower workload for inspections | Higher overall workload and training needs |
| **Spain (Madrid)** | Standard PC/server at competent authorities' premises | Analysis performed in VBA Excel | None | <EUR 15,000/ year | Sub-contractor to analyse data | Higher quality of industrial emission data sets | More workload More skills required (training) Legal issues |

| Stakeholder | Hardware | Software | Capex | Opex | Opex description | Benefits | Challenges |
|---|---|---|---|---|---|---|---|
| **Spain (Andalucía)** | Standard PC/server at competent authorities' premises | Data are analysed by officer with simpler tools such as Access/Excel/other | Between EUR 50,000 and EUR 60,000 data acquisition systems | None (used to be EUR 2,000/ year) | The cost was reduced after transferring to FTP protocol. Only cost now is man-hours and maintenance. | Higher quality of industrial emission data sets<br>Faster decision-making process<br>Precise information source to investigate root cause of air quality data deviations (regardless of having citizens' complaints) | More workload<br>More training required<br>Sites afraid/not willing to share data<br>Variety in data and limit values causes difficulties for their treatment.<br>Receiving heterogenous data. |
| **Spain (Galicia)** | Standard PC/server at competent authorities' premises. | Data are analysed by officer with simpler tools such as Access/Excel/other. | None | EUR 500 | Staff costs - these task as just one small % of the IED officer time | Faster decision-making process.<br>Lower workload for inspection or compliance checks | Large workload on data preparation, tidying and data conversion.<br>Many subtle matters, details to solve and deal with prior to data analysis. |
| **Spain (Madrid)** | Standard PC/server at competent authorities' premises | Data are analysed by officer with simpler tools such as Access/Excel/other | None | >EUR 500/ year | Not specified | Higher quality of industrial emission data sets | More workload<br>More skills required (training)<br>Legal issues |

| Stakeholder | Hardware | Software | Capex | Opex | Opex description | Benefits | Challenges |
|---|---|---|---|---|---|---|---|
| **France** | Standard PC/server at competent authorities' premises | Sophisticated software that deliver end results ready to use | >EUR 8,000 | >EUR 500/year | Customers support, platform hosting, minor development (minor updates) | Higher quality of industrial emission data sets<br>Faster decision-making process<br>Lower workload for inspection or compliance checks | More skills required (training)<br>Legal issues<br>Handling and management of the complexity of such a global tool |
| **China** | Advanced PC to analyse and process data | Sophisticated software that deliver end results ready to use<br>Software licence that requires extensive training of officials to use and exploit functionalities | RMB[57] 50,000 and RMB 300,000 (EUR 6,000 to EUR 40,000) for software, hardware and data certification | >EUR 500/year | The Chinese Government has a dedicated department that is in charge of data processing. | Higher quality of industrial emission data sets<br>Faster decision-making process | More skills required (training) |
| **South Korea** | Advanced PC to analyse and process data | Sophisticated software that deliver end results ready to use | >EUR 8,000 | >EUR 500/ year | Not specified | Higher quality of industrial emission data sets<br>Faster decision-making process | More workload<br>Legal issues |

[57] Where RMB is the Chinese renminbi

| Stakeholder | Hardware | Software | Capex | Opex | Opex description | Benefits | Challenges |
|---|---|---|---|---|---|---|---|
| **India** | Standard PC/server at competent authorities' premises | Sophisticated software that deliver end results ready to use | Between EUR 2,000 and EUR 8,000 | >EUR 500/ year | Staff costs, annual Maintenance contract Charges for server | To check compliance<br>Higher quality of industrial emission data sets to work<br>Decision making in air quality<br>Public access to information, increased awareness, of public and litigations | More workload for competent authorities'<br>Management of large data volume;<br>Plausibility control of data, calibration of system, assessment of uncertainty<br>Selection of right monitoring technology |
| **USA** | Standard PC/server at competent authorities' premises<br>A service was hired to store data elsewhere (e.g data processed on Cloud) | Sophisticated software that deliver end results ready to use | >EUR 8,000 | >EUR 500/year | Collecting data and disseminating them to the public including communications to facilities, data refresh, code modifications to accommodate annual changes specific to new chemicals, data fields, covered sectors, data quality checks, guidance development, and outreach to data users. | Higher quality of industrial emission data sets | None |

Source: Information gathered in stakeholder consultation

# 5 Overview of continuous monitoring requirements under the IED

This section analyses the continuous monitoring requirements under the IED (including BATCs) for emissions to air and water. We have reviewed the continuous monitoring requirements set out in the BREFs taking two basic steps:

(1) Review and register monitoring requirements per BREF;

(2) Register of assumptions required to carry out the estimation.

**Step 1. Review and register of requirements per BREF**

We have reviewed the BAT requirements from all BREFs in the EIPPCB series. We have done the analysis on the monitoring related BATCs from adopted BREFs under the IED and those reviewed under the previous IPPC Directive. Those BREFs reviewed under IPPC do not have systematic monitoring requirements and may suffer some changes when reviewed under IED. We have identified the number of pollutants or parameters such as COD per emission stream with continuous monitoring requirements specified in the BATCs. We have considered continuous emissions monitoring to air and to water.

For some of the IED activities there is no relevant adopted BREF. These include asbestos manufacturing, landfill sites or $CO_2$ capturing installations.

Regarding the emissions sources, we have also investigated the amount of channelled sources per plant that had continuous monitoring requirements. For example, in an LCP, emission sources with continuous monitoring requirements are (1) the flue gases stream emitting to air and (2) emission to water from air abatement device (such as wet scrubber). This information on sources can be useful to estimate the number of CEMs and or communication devices required. In a best-case scenario, one communication device might be able to report online emission data from many emission sources (or CEMS).

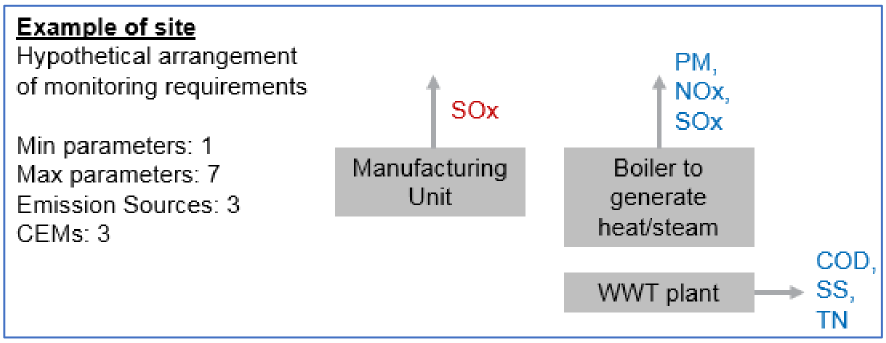
Table 5-1 describes the terminology used to derive and estimate impacts of IED related online monitoring.

Table 5-1 Terminology used in this estimation

| Term used | Description |
|---|---|
| **Maximum parameters** | The total maximum number of pollutants that are required to be monitored continuously in a worst case scenario for a given industrial process. The BATCs offer certain flexibility or conditions to impose continuous measurements. |
| **Minimum parameters** | The total minimum number of parameters (pollutants) that are required to be monitored continuously in worst case scenario for a given industrial process. |
| **Number of emission sources** | Number of different channelled emission sources per process that require at least one pollutant or parameter to be continuously monitored. |
| **Number of CEMS** | Number of continuous emission monitoring packages. This may include various shelters depending on the number of parameters. We have assumed that each CEMS will be able to monitor one channelled source (regardless of having one or many parameters to monitor). |
| **Number of connectivity devices** | Number of interconnections with the authorities. We have done a sensitivity analysis to cover different arrangements and the uncertainty of assumptions. |

Figure 5-1 provides an hypothetical example of monitoring requirements. In this example the BAT Conclusions require continuous monitoring of SOx emissions to air from manufacturing units (red font) but allow flexibility for other parameters (blue font).

Figure 5-1 Hypothetical example on monitoring requirements




The results of reviewing the BATCs for monitoring requirements are shown below. Table 5-2 summarises the number of parameters that must be measured continuously in each industrial activity according to the BATCs in its corresponding BREF. The data presented here correspond to the requirements **per plant**. In section 6 of this study, we describe our assumptions and verifications on the number of plants per installation for each industrial sector listed below.

Table 5-2 Online monitoring requirements per BREF

| BREF abbreviation (Sector) | Process | Maximum parameters | Minimum parameters | # sources/plant |
|---|---|---|---|---|
| LCP | Coal Boilers | 14 | 10 | 2 |
| LCP | Biomass Boilers | 15 | 10 | 2 |
| LCP | Natural Gas Boilers | 10 | 10 | 2 |
| LCP | Natural Gas engines | 10 | 10 | 2 |
| LCP | Natural gas turbines | 10 | 10 | 2 |
| LCP | Other gas fuel boilers | 13 | 10 | 2 |
| LCP | Liquid fuel boilers | 13 | 10 | 2 |
| LCP | Liquid fuel engines | 13 | 10 | 2 |
| LCP | Liquid fuel turbines | 13 | 10 | 2 |
| LCP | Co-incineration | 15 | 10 | 2 |
| LCP | IGCC | 10 | 10 | 2 |
| LCP | Average LCP | 15 | 10 | 2 |
| LVOCs | Organic chemicals | 20 | 10 | 4 |
| WGC | Organic chemicals | 20 | 10 | 4 |
| WI | incineration of waste | 20 | 19 | 3 |
| CLM | Cement | 13 | 9 | 1 |
| CLM | Lime | 13 | 5 | 1 |
| CLM | Magnesium | 13 | 5 | 1 |
| I&S | Integrated I&S (old) route | 12 | 5 | 5 |
| I&S | Coke ovens | 0 | 0 | 0 |
| I&S | Sintering | 3 | 3 | 1 |
| I&S | Electric arc furnaces | 6 | 5 | 2 |
| GLS | all processes | 6 | 2 | 2 |

| BREF abbreviation (Sector) | Process | Maximum parameters | Minimum parameters | # sources/plant |
|---|---|---|---|---|
| REF | Integrated unit | 30 | 10 | 4 |
| NFM | any metal | 20 | 5 | 5 |
| NFM | Producing carbon or electrographite | 0 | 0 | 0 |
| CAK | all processes | 2 | 2 | 2 |
| TAN | all processes | 2 | 1 | 1 |
| STS | Streams with > 10 Kg C/h | 1 | 1 | 1 |
| P&P | Various | 14 | 14 | 4 |
| SF | Various | 0 | 0 | 0 |
| STM | Various | 0 | 0 | 0 |
| OFC | Various | 5 | 2 | 1 |
| LVIC-S | Various | 0 | 0 | 0 |
| LVIC-AAF | Various | 0 | 0 | 0 |
| STS | Various | 1 | 1 | 1 |
| TXT | Various | 0 | 0 | 0 |
| WT | Various | 0 | 0 | 0 |
| IRPP | Various | 0 | 0 | 0 |
| FMP | Various | 0 | 0 | 0 |
| FDM | Various | 0 | 0 | 0 |
| IRPP | Various | 0 | 0 | 0 |
| WBP | Various | 0 | 0 | 0 |

**Step 2. Outline assumptions used in estimates.**

Several assumptions had to be made in order to develop comprehensive estimates of implementing telemonitoring for those IED activities with continuous monitoring requirements in the BATC. These assumptions are:

1. The monitoring requirement of a BREF reviewed under IPPC will remain similar after being reviewed under the IED.
2. Each CEMS can cover all monitoring needs (i.e. several parameters) from one emission source (assumption verified with equipment vendors).
3. Assuming a worst-case scenario to estimate the number of communication devices. Some industrial installations occupy very large sites (e.g. a refinery with associated seaport). One IT communication system per CEMS was assumed for this estimation while in some sites one communication device can be used for several CEMS. Sensitivity analysis is used to show the impact of using different assumptions here.
4. The number of installations per industrial activity in the EU remains similar to data validated in year 2015. Sensitivity analysis shows the impact of using different assumptions for this factor.
5. Regional and national legislation (for online data reporting requirements) have not been taken into account to forecast online data reporting sites. Regional or national authorities are already setting online reporting requirements prior to any EU initiative. These authorities are also requesting industrial operators provide data for online reporting for parameters not monitored continuously but which are relevant (e.g. for odour incident investigations).

# 6 Estimated impact of the implementation of telemonitoring for the IED

This section estimates the number of communication devices needed in the EU to tele-report emission data to authorities. The installations covered by the IED are assumed to purchase (or retrofit) CEMS to meet monitoring requirements regardless of data sharing requirements.

Some of these sites have had requests in the past to provide online emission data from their regional or local authorities. Nevertheless, this estimation refers only to the communication devices required if the EU was to include a requirement of online emission data reporting (for those pollutants that are being already continuously monitored). This forecast is based on the number of CEMS required for installations covered by the IED based on monitoring requirements in the BATC (see previous section).

The estimation has been done first for a base case scenario and completed with a sensitivity analysis to show the impact of different assumptions. The following steps have been used:

**Step 1. Estimate the number of EU installations for each relevant sector.**
The main source of information is the project completed in 2018 for the Commission by Ricardo: “Industrial Emissions Policy Country Profiles”[58].

Of the activities included in these profiles, there were three manufacturing processes that had multiple monitoring requirements such that we had to further disaggregate the number of installations for these processes. This disaggregation has relied on data from the BREFs to estimate the number of installations for:

- Chlor-alkali manufacturing installations (CAK) from the inorganic chemicals sector.
- Zinc oxide manufacturing sites from the inorganic chemicals sector.
- Sulphuric acid plants from the inorganic chemical sector.
- Wood based panels (WBP) manufacturing installations from the pulp, paper and board sector.

**Step 2. Estimate the number of plants per installation.**
In several industrial sectors (such as combustion plants or organic chemicals) it is quite common to have more than one manufacturing plant inside the installation. This is done to share utilities (steam, cooling water) and services like maintenance leading to business efficiencies. Table 6-1 Example of industrial sector with several plants per installationsprovides some examples of the number of plants per installation for selected IED sectors.

Table 6-1 Example of industrial sector with several plants per installations

| Most populated sectors | Assumed number of plants per installation |
|---|---|
| Large combustion plants | 3 |
| Manufacture of ceramics | 2 |
| Treatment and processing of food | 2 |
| Large volume organic chemicals | 3 |

Spot sample verification has been carried out for three of the sectors with large numbers of installations (LCP, LVOC and WI) to support the assumed numbers of plants per installation. The verification has been through reviewing individual installation permits where online data sharing is part of the permit requirements. Figure 6-1 shows an example of these verifications to prove assumptions were correct: an LCP installation in Andalucía with three main emission sources for air emissions (three combustion plants).

[58] https://circabc.europa.eu/sd/a/9b71b5da-996b-4de7-8130-86dc05f78812/Country%20Profiles%20Methodology%20Paper.pdf

Figure 6-1 Partial view of permit requiring online data reporting

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**ANEXO IV – PLAN DE VIGILANCIA Y CONTROL**

**1. ATMÓSFERA**

**Monitorización**. Se deberá instalar en cada uno de los focos P1G1, P2G1 y P3G1, procedentes de las calderas de los grupos 1, 2 y 3, un sistema de medida en continuo automático de los siguientes contaminantes y parámetros: partículas, dióxido de azufre, óxidos de nitrógeno, monóxido de carbono, contenido de oxígeno, temperatura, presión y caudal, de acuerdo con lo estipulado en la condición 2.4. de las resoluciones por las que se formulan las declaraciones de impacto ambiental de cada una de las fases de esta instalación.

Para los sistemas de medición en continuo antes mencionados se tendrá en cuenta lo regulado en el Decreto 503/2004, de 13 de octubre, por el que se regulan determinados aspectos para la aplicación de los Impuestos sobre emisión de gases a la atmósfera y sobre vertidos a las aguas litorales.

La calibración del sistema será realizado internamente por el personal de mantenimiento de la propia instalación con una periodicidad mensual.

### Step 3. Estimate the number of online communication devices

Based on the BATC requirements, we have combined those requirements with information on the number of installations and plants (step 1 and 2 above to conclude the estimation). For each industrial activity we have multiplied the number of installations with the number of plants per installation and the number of emission sources per plant.

***Total Connectivity devices*** = *Total number of installations in EU* X *Plants/installation* X *Emission sources/plant*

Table 6-2 provides the outcome of the estimation at EU level for each industrial sector taking into account the steps described above. It shows a base case scenario. The base case scenario is conservative, leading to a very high number of devices: assuming that one communication device is required per emission source has a high impact on the final figure shown in Table 6-2.

Table 6-2 Estimation of required number of communication devices in EU (RAG legend in footnote)

| BREF | Number of installations | Plants per installation | Maximum parameters (total EU) | Minimum parameters (total EU) | Emission sources (total EU) | CEMS (total EU) | Connectivity (total EU) |
|---|---|---|---|---|---|---|---|
| Energy | 2,802 | | | | | | |
| LCP | 2,543 | 3 | 114,435 | 76,290 | 15,258 | 15,258 | 2,543 |
| REF | 212 | 1 | 6,360 | 2,120 | 848 | 848 | 212 |
| I&S | 36 | 1 | 0 | 0 | 0 | 0 | 0 |
| Gasification | 11 | 1 | 110 | 110 | 22 | 22 | 11 |
| Metals | 5,504 | | | | | | |
| I&S | 36 | 2 | 216 | 216 | 72 | 72 | 36 |
| I&S | 256 | 2 | 6,144 | 2,560 | 2,560 | 2,560 | 256 |
| FMP (D1) | 208 | 2 | 0 | 0 | 0 | 0 | 0 |
| SF | 25 | 2 | 0 | 0 | 0 | 0 | 25 |
| FMP | 383 | 2 | 0 | 0 | 0 | 0 | 0 |
| SF | 611 | 2 | 0 | 0 | 0 | 0 | 611 |
| NFM | 174 | 2 | 6,960 | 1,740 | 1,740 | 1,740 | 174 |
| NFM/SF | 904 | 2 | 36,160 | 9,040 | 9,040 | 9,040 | 904 |

| BREF | Number of installations | Plants per installation | Maximum parameters (total EU) | Minimum parameters (total EU) | Emission sources (total EU) | CEMS (total EU) | Connectivity (total EU) |
|---|---|---|---|---|---|---|---|
| STM | 2,907 | 2 | 0 | 0 | 0 | 0 | 0 |
| Minerals | 2,573 | | | | | | |
| CLM | 523 | 1 | 6,799 | 4,707 | 523 | 523 | 523 |
| Asbestos | 1 | 1 | 0 | 0 | 0 | 0 | 0 |
| GLS (1) | 376 | 1 | 2,256 | 752 | 752 | 752 | 376 |
| GLS(2) | 74 | 1 | 444 | 148 | 148 | 148 | 74 |
| CER | 1,599 | 3 | 0 | 0 | 0 | 0 | 0 |
| Chemicals | 4,629 | | | | | | |
| CWW/LVOC/POL/ | 2,843 | 4 | 170,580 | 85,290 | 34,116 | 34,116 | 2,843 |
| LVIC-S | 25 | 2 | 50 | 50 | 50 | 50 | 25 |
| CAK | - | 2 | 0 | 0 | 0 | 0 | 0 |
| LVIC-AAF | 60 | 2 | 120 | 120 | 120 | 120 | 60 |
| OFC | 107 | 2 | 1,070 | 428 | 214 | 214 | 107 |
| OFC | 505 | 3 | 7,575 | 3,030 | 1,515 | 1,515 | 505 |
| OFC | 80 | 2 | 800 | 320 | 160 | 160 | 80 |
| Waste | 7,303 | | | | | | |
| WT(3) | 2,711 | 3 | 0 | 0 | 0 | 0 | 0 |
| WI | 439 | 3 | 26,340 | 25,023 | 3,951 | 3,951 | 439 |
| WT(4) | 935 | 2 | 0 | 0 | 0 | 0 | 0 |
| Landfills | 3,218 | 1 | 0 | 0 | 0 | 0 | 0 |
| Other | 24,593 | 1 | | | | | |
| P&P(5) | 221 | 1 | 3,094 | 3,094 | 884 | 884 | 221 |
| P&P(6) | 630 | 1 | 8,820 | 8,820 | 2,520 | 2,520 | 630 |
| WBP | 40 | 2 | 0 | 0 | 0 | 0 | 0 |
| TXT | 328 | 3 | 0 | 0 | 0 | 0 | 0 |
| TAN | 39 | 2 | 156 | 78 | 78 | 78 | 39 |
| SA | 846 | 1 | 0 | 0 | 0 | 0 | 0 |
| FDM | 1,847 | 2 | 0 | 0 | 0 | 0 | 0 |
| FDM | 622 | 1 | 0 | 0 | 0 | 0 | 0 |
| SA | 413 | 1 | 0 | 0 | 0 | 0 | 0 |
| IRPP(7) | 10,276 | 1 | 0 | 0 | 0 | 0 | 0 |
| IRPP(8) | 8,236 | 1 | 0 | 0 | 0 | 0 | 0 |
| STS | 1,098 | 3 | 3,294 | 3,294 | 3,294 | 3,294 | 1,098 |
| NFM | 37 | 1 | 0 | 0 | 0 | 0 | 0 |
| CCS | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Totals | 47,404 | - | 401,783 | 227,230 | 77,865 | 77,865 | 11,792 |

*Colour code: (Green) well covered by IED BREF; (Yellow) Draft version of IED BREF; (Orange) Covered by IPPC BREF; (Red) Not covered by IED BREF;*

A sensitivity analysis has been carried out to assess the impact of the main assumptions and most relevant inputs for this estimation. The results are shown in Table 6-4 and Table 6-4.These are the key drivers:

- The number of communicating devices (connectivity in section 3 of this document) is a key input. If plants inside one installation are closed to each other (e.g. less than 2 km away) the use of a single communication device for online emission data reporting for all plants in the installation is the most probable and efficient solution. This has a high impact in the final number of devices potentially needed in EU for all plants with continuous monitoring required by BATC.

Table 6-3 Impact of devices required per emission source on the final result

| All sectors | Base case: one communication device per emission source | Intermediate case: one communication device per plant | Extreme case: one communication device per site |
|---|---|---|---|
| Communication devices needed in EU | 77,865 | 27,693 | 11,792 |

- The number of plants per industrial installation also has a clear impact in the outcome of this estimation. Plants per installation was initially based on expert judgement. We have also done validations with a limited set of permits in the most populated sectors that have verified the base case. Table 6-4 presents alternative estimates for the number of plants per installation. We have changed the assumed value for most populated sectors such as LCPs. There is a significant impact on the overall number of devices that would be required in the EU, but the order of magnitude remains the same.

Table 6-4 Impact of plants per installation in the final result

| Most populated sectors | Fewer plants (plants/installation) | Base case (plants/installation) | More plants (plants/installation) |
|---|---|---|---|
| Large combustion plants | 2 | 3 | 4 |
| Manufacture of ceramics | 1 | 2 | 3 |
| Treatment and processing of food | 1 | 2 | 3 |
| Large volume organic chemicals | 2 | 3 | 4 |
| Communication devices needed in EU | 61,407 | 77,865 | 94,323 |

**Step 4. Estimate cost to connect each CEMS to its competent authority**

We have described in previous sections of this document that there are many options to provide the online emission data to the authorities. The hardware architecture setup varies widely from one installation to another depending on the required functionalities. There is also a range of levels of sophistication among installed systems. For this reason we have considered it useful to include here two different options to reflect this variety of solutions being used. The options considered in this cost estimation are:

- Simplest communication device: this corresponds to categories A to E (see section 3): the order of magnitude of investment cost is EUR 1,000/installation.
- Complex communication set up: this corresponds to categories A to E (see section): the order of magnitude of investment cost is EUR 8,000/installation.This is a more sophisticated device with wider set of functionalities.

The investigation found that higher investment efforts to btain more sophisticated systems may also lead to lower operating cost for authorities (e.g. software that delivers final products with sophisticated visualisation on analysis).

Regarding how investment cost varies from new CEMS to existing (available) CEMS: there isn't a significant investment cost difference for these communication devices between new or existing CEMS. Majority of CEMS would communicate with site IT architecture regardless of having to share emission data online. For example, the emission data collected by CEMS will be sent to a server, distributed control system (DCS) or a manufacturing engineer's computer.

**Step 5. Estimate the overall EU costs to implement online reporting at all installations conducting continuous monitoring**

Table 6-5 summarises the overall cost of imposing online emission data reporting for the EU for emissions that are already been monitored continuously. To note however, as identified in this report, that there are already many EU regions (authorities) imposing these features for several IED installations. Table 6-5 also considers that a share of existing plants may be already delivering online reporting.

We are proposing here different scenarios (or cases in the table) to have a better understanding of overall cost of this approach. The base case is presented on top row: assumes that no single site in EU is already doing online reporting. The following two cases assume a different share of installations already doing online reporting. The last row shows a pilot test for a smaller sector (waste incineration).

Table 6-5 Investment cost required to establish online reporting in EU

| Case | Number of installations | Number of devices in EU | Cost (Simplest communication device) (EUR millions) | Cost (Complex communication device) (EUR millions) |
|---|---|---|---|---|
| All IED sites (assumes no site is online sharing already) | 11,792 | 27,693 | 27.7 | 221.5 |
| All IED (assuming 10% sharing already) | 10,613 | 24,924 | 24.9 | 199.4 |
| All IED (assuming 30% sharing already) | 8,254 | 19,385 | 19.4 | 155.1 |
| Small pilot on incineration sector (WI) | 439 | 1,317 | 1.3 | 10.5 |

# 7 Conclusions

### Different telemonitoring approaches have been identified, with degrees of complexity

This report has showed that different telemonitoring approaches are used in the considered countries, with more advanced approaches being typically applied in the non-EU countries assessed. The technical capabilities of the technology required under each approach have been described in the report. The different approaches to connectivity have been grouped as follows:

- **Approach 1 – Periodic manual submission of data (examples identified in Croatia, Spain).** This approach is based on the operator manually sharing data with competent authority to demonstrate compliance requirements. Compliance data are sent to the regulator by the operator at defined intervals via e-mail in a defined format.
- **Approach 2 – Periodic automatic submission of data (examples identified in USA, Spain, Italy).** As Approach 1, but the data are sent directly to the regulator via an internet connection. However, the information is shared automatically. Using defined format for inclusion into a database which is done by the regulator.
- **Approach 3 – Nearly real-time automatic submission of data (examples identified in China, Austria, Germany).** This approach also collects CEMS operation status by collecting status flags. The system includes provision for a regulator to monitor individual CEMS real-time (for example in response to system or compliance alarm) and may provide (limited) regulatory access to CEMS functions.
- **Approach 4 – Real-time automatic submission of data (examples identified in India, South Korea and Malaysia).** Fully automated real-time data collection with access to CEMS Collection of real time or as close to real time data as possible. Also has the capability to access CEMS functions independently of the operator (for example to undertake calibration checks on a system by injecting calibration gas). Plant operation data are also collected.

The study has shown that there are no significant differences between telemonitoring applied for emissions to air and water.

### Several drivers for implementing different telemonitoring approaches have been identified, related to costs, benefits and challenges

The key reported drivers and benefits from telemonitoring include:

- Faster processing of citizens' complaints and better confidence in competent authorities authorities;
- Faster identification of exceedances of emission limit values;
- Easier process in the revision of emission limit values;
- Public access to information;
- Deterring effect for non-compliance;
- Higher quality of industrial emission datasets;

The investment costs of the communication device used for telemonitoring is small compared to the overall CEMS cost (e.g. EUR 500 - 8,000 out of EUR 200,000). The investment costs for the competent authority are smaller, and relate to capacity building by developing guidelines, standard procedures and reporting formats. The operational costs for both authorities and operators varies on case-to-case basis but predominantly relates to data processing and analysis.

The key challenges for both operators and competent authorities related to the absence of guidelines and protocols on technology selection, installation, operation and maintenance, quality assurance, verification or a mechanism for compliance checking and the lack of accredited agencies/laboratories for CEMS including communication protocols.

In terms of the data transmission approaches, the key benefits of automatic data transmission (approaches 2-4 above) are that it ensures no delays in data, and prevents the operator from manually editing the data prior to submission. Furthermore, it helps identify emission limit value exceedances quickly; for example with auto-generated messages sent by the systems to the competent authority and operator. However, the consultation showed that in some instances (e.g. Croatia) the competent authorities preferred to transfer the responsibilities for data validation and accounting for uncertainties to operators, in which case edited data are submitted manually.

With respect to data analysis, three key data analysis options were identified:

- **Option 1 – Manual analysis of data in Excel/VBA;**
- **Option 2 – Application of software that delivers ready to use results;**
- **Option 3 – Hybrid between the two,** i.e. application of software that delivers ready to use results and additional statistical analysis performed in Excel.

The benefits of option 1 are that it requires no investments on the part of the competent authority, and the operational costs are only linked to staff or sub-contractor costs for these responsible for the data analysis in Excel. Key reported drawbacks of option 1 include differences in the reporting formats used by different installations, problems with data management of large data sets which leads to a necessity to reduce the data points, and overall more time required for data analysis. It is noteworthy that some investment costs may still be incurred by the competent authority and/or the operator for the data acquisition system.

The benefits of option 2 is that it reduces the required time for data analysis and it reduces the potential for human error. Furthermore, the use of a software allows larger data sets to be processed which is more suitable for continuous monitoring. Finally, if the same software is applied across installations, data formats and outputs should be homogenous. Key drawbacks include that training is required for those in charge of using the software. Furthermore, investment costs are required for purchasing the software licence, and operational costs are associated with software maintenance and staff time. The costs and benefits for option 3 are similar, with the operational costs likely to be slightly higher due to the additional time for data analysis.

In terms of the required technology on the competent authority premises, the consultation revealed that a standard PC is sufficient to receive tele-reported data. In the cases of Korea and China, it was reported that advanced PCs are also used but the advantages of this approach were not clearly stated.

### We have estimated the possible costs of implementing telemonitoring to those installations already required to carry out continuous monitoring

Regarding the application of telemonitoring in the context of the Industrial Emissions Directive 2010/75/EU, we have estimated the number of communication (reporting) devices required in EU. The estimate is based on the requirements for continuous monitoring in the Best Available Techniques Conclusions, and ranges between 11,000 and 77,000 communication devices required in the EU. The lowest value assumes that only one communication device is required per industrial site. Other key assumptions include the number of plants per installation in each sector.

The possible costs of implementing telemonitoring to those installations already required to carry out continuous monitoring are estimated to be an investment cost ranging from € 27 - 221 million. The lower end of this range represents implementing one simple reporting device in each installation, and the upper end represents implementing the most sophisticated solution with enhanced functionalities.

### On the basis of the report findings, we recommend that:

- It is crucial to develop detailed guidelines about the implementation and intended usage of telemonitoring. This can cover the technology selection, reporting formats, data trasmission frequency and quality assurance to minimise the challenges for operators and competent authorities when setting up telemonitoring;
- Automatic telemonitoring delivers better quality datasets and is preferable, unless data validation is required by the operator. The costs of automatic connection device are small when compared to the overall CEMS cost.
- Data analysis could be performed in both Excel and in purchased software, with both approaches being associated with certain costs and benefits. The sizes and formats of datasets should be a key consideration in selecting the data analysis method.

# A1 Annex 1 Stakeholder consultation questionnaire

Enclosed as a standalone file.

# A2 Annex 2 Information received in the stakeholder consultation

Enclosed as a standalone file.

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