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Proposed Data Acquisition & Handling System for Pilot Emission Trading Scheme in India

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Abbreviations

CEMS	Continuous Emissions Monitoring System
CPCB	Central Pollution Control Board, India
DAHS	Data Acquisition and Handling System (Entire IT system to implement and support ETS regime)
DAS	Data Acquisition System
DRP	Data Correction Protocol
DVP	Data Validation Protocol
ETS	Emissions Trading Scheme
MoEF	Ministry of Environment and Forests, Government of India
PM	Particulate Matter
SOP	Standard Operating Procedure
SPCB	State Pollution Control Board (Boards working at various state levels within India)
SRM	Standard Reference Method

Introduction

Power, cement, chemical, textile and many other industries are indicators of a country's progress, however all these industries have adverse impact on environment. India like many other countries, has put in place a regulatory regime to control industrial emissions into air. However, in a developing country like India, industries face various challenges to follow this regime due to factors like lack of appropriate technology, paucity of resources, etc. On one hand regulatory regime mandates emissions limits, but there are no positive incentives for compliance and also for further reduction in emissions.

On this background, an Emission Trading Scheme (ETS) using Particulate Matter (PM) as marker pollutant is being planned in India. The Central Pollution Control Board (CPCB) and Ministry of Environment and Forest (MoEF), Government of India are spearheading this project and a pilot for the same is being rolled out in few states. ETS is based on Cap & Trade mechanism for total emissions in a given period for participating industries in an identified cluster.

Aggregating reliable, accurate and complete emission data from all participating industries was most crucial aspect in initial demonstration of ETS program. Thus an integrated aggregator platform to acquire, monitor, analyze, validate and benchmark emissions data across multiple plants had to be designed and built. The paper introduces such an aggregator platform or Data

Acquisition and Handling System (DAHS) designed for this project. The paper also discusses key challenges in such a system and approaches used to overcome the same.

ETS Overview

Emission Trading Scheme for Particulate Matter aims to establish an innovative market based regulatory instrument for stationary sources in designated industry clusters in India. ETS will follow a '**Cap and Trade**' mechanism based on total emission load (mass emissions) of PM measured over a period of time. In this the regulator sets the overall amount of emissions (a cap) for an industry cluster but does not decide exactly how much each industry source will emit. Industries and other polluters are not given fixed emission limits, but are free to decide for themselves within a reasonable upper limit. Each industry holds emission permits and can trade un-utilized permits with other industries in the cluster. Prices of the permit will be decided by the market. This is expected to give continuing incentive to industries to cut back pollution which will translate into better environment.

States of Maharashtra, Gujarat and Tamil Nadu are participating in the pilot. The pilot will be run in total of 1000 industries in identified clusters in these states. Design phase of ETS pilot was launched in March 2011 and spearheaded by a Technical Committee comprising of members of CPCB, participating SPCB and external experts. The author of this paper, Ms Sujata Tilak, was in this committee as an IT expert and contributed in defining framework for DAHS.

Design phase was successfully completed in November 2013. Pilot roll outs have started in the states of Maharashtra and Gujarat from January 2014 using an existing DAHS solution called PlantConnect AQMS which was customized for this purpose.

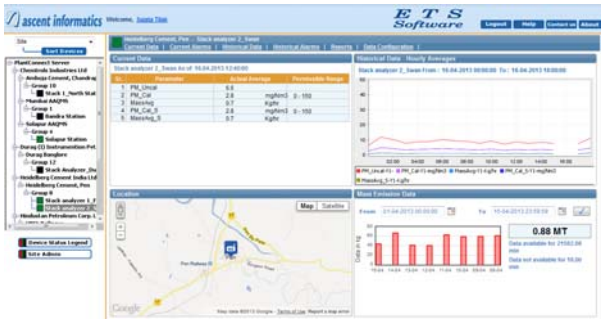

Fig 1 ETS Pilot Rollout – Screen shot of dashboard

Key challenges

Key challenges in designing and implementing a Data Acquisition and Handling System (DAHS) for the ETS project are -

1. Designing a robust, yet simple interface for receiving PM data from CEMS software of multiple vendors. This is critical to ensure maximum participation of hardware vendors and wide choice of CEMS hardware to industries.
2. Ensuring complete integrity, reliability and availability of data to establish credible trading system.
3. Enforcing and ensuring analyzer with appropriate technology for given stack.
4. Enforcing and ensuring timely maintenance and calibration of analyzers to ensure continued reliability and integrity of data.
5. Enforcing usage of appropriate calibration factors
6. Incorporation of corrections for load and process variations

7. Transparent system accessible to all stake holders like industries, regulators and vendors

Data Acquisition and Handling System

Basic Working

A continuous emission monitoring system (CEMS) for PM will be installed on each stack in participating industries. CEMS vendor will also install a data logger software on a computer that reads data from CEMS analyser. On same computer, a standard software provided by ETS Program will be installed. This is called ETS Bridge. The ETS Bridge will read data from CEMS vendor software in real time and send to DAHS Server via internet.

Components

Listed below are various hardware and software installed on each hardware

1. PM CEMS Device
    a. Firmware / software of CEMS vendor
2. Data Acquisition System (DAS) or computer in the industry
    a. CEMS vendor software
    b. ETS Bridge software
3. CPCB Server
    a. DAHS Server software
4. SPCB Servers
    a. DAHS Server software
5. Data Access Points
    a. Web portals for different stake holders

Architecture

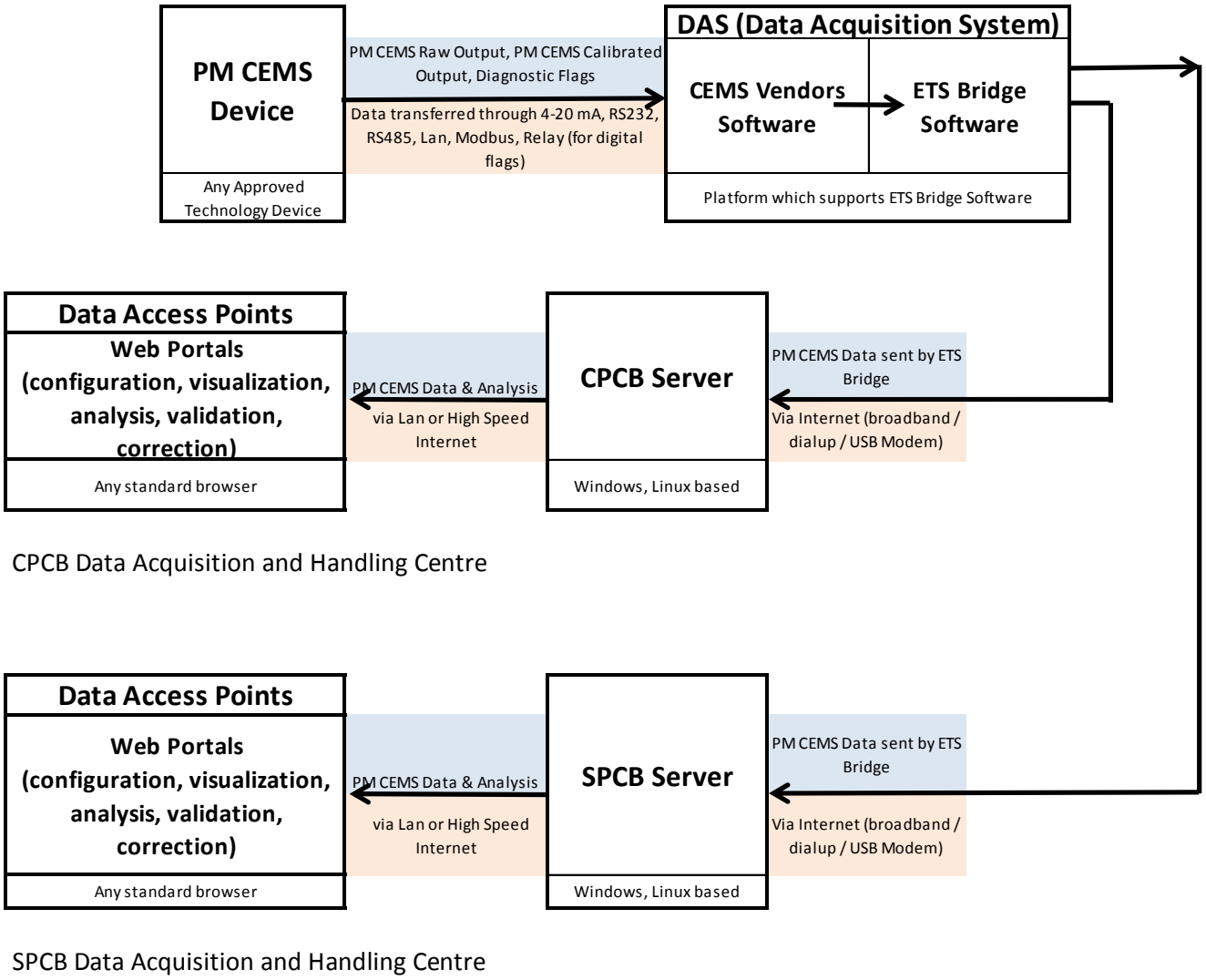

Fig. 2 DAHS Architecture

ETS Interface

A simple, yet robust interface called **ETS Interface,** is developed for data transfer between CEMS Vendor Software and ETS Bridge. It is a file based, yet real time interface. Apart from measurement data, it is also necessary to get information about device mode (sample, calibration etc.). Thus ETS Interface includes measurement data, diagnostic data, device mode, alarms, etc. One key differentiator of this interface is that it mandates vendor software to provide raw or un-calibrated data. This data is then converted to calibrated data by ETS Bridge using calibration factors received from ETS Server. This greatly improves data authenticity.

Any vendor who implements ETS Interface is eligible to sell analyzers to industries participating in the program. Already 8 to 10 vendors have released software implementing ETS Interface.

DAHS Functional areas

It is beyond scope of this paper to provide all details of various functional modules of DAHS. We are going to concentrate on those parts which have a bearing on providing accurate and reliable data for trading.

As mentioned in first section, ETS uses **'Cumulative Mass Emissions'** measured over a given period for trading and not emission concentration.

CEMS Installation and Registration

Following figure gives an overview of this workflow

Industry	State Pollution Control Board
1. PM CEMS Device & Flow meter Installation (as per the guidelines)	
2. DAS Setup	
3. CEMS Device Registration	SPCB checks the CEMS Device Registration form and sends the approval to the industry.
4. Configuration of CEMS Software	SPCB sends the Unique Composite ID and other configuration details to the industry
5. Installation and Functional Test Checklist	SPCB reviews the self-attested Installation and Functional Test Checklist submitted by industry
6. PM CEMS Ready for Calibration	SPCB tells industry if the PM CEMS is ready for calibration or not

Fig 3 CEMS Workflow

ETS program has published guidelines about appropriate analyser technology based on stack characteristics. Accordingly analyser can measure mass emissions directly or concentration. In case if the analyser is measuring concentration, then a volumetric flow meter must be installed on the stack to measure flow so that mass is calculated as concentration x flow.

Another aspect to be considered here is accuracy and compatibility of analysers using various technologies. Some field trials were conducted for this by installing analysers with 2 different technologies on same stack. Figure 4 shows test results of CEMS technology demonstrating long term accuracy and convergence of data over several days from these analysers.

Fig 4 Readings from 2 different technology CEMS

CEMS Calibration

The calibration is done by an approved Environmental Laboratory. The Standard Reference Method (SRM) for measuring and calibrating PM emissions is through Iso-Kinetic Sampling. Minimum 6 to maximum 9 points at different loads are required.

The calibration procedure involves regressing CEMS readings against manual sample measurements and estimating a linear equation of a line through the points. The line would take the form of –

$y = mx + c + \hat{e}$ where

y = SRM readings
x = un-calibrated CEMS readings
m (line slope) and c (offset) = calibration factors
ê = measure of how far each point is from the estimated line

Since ê is randomly distributed, the sum of these random errors would be expected to average out to zero, over a 12-month of compliance period. As ETS is interested in cumulative mass emissions, ê can be safely ignored and thus we get a linear equation $y = mx + c$.

User enters y and x readings obtained during calibration in DAHS Industry Portal. Server validates the calibration process and then calculates m and c. These are used by server to compute calibrated readings throughout using following equation –

$Y = mx + c$ where

Y = calibrated reading
x = un-calibrated CEMS reading
m and c = calibration factors

Thus ETS Server DOES NOT depend on calibrated readings of CEMS analyser, but uses own calculated readings.

Real time data collection

ETS Bridge reads data from ETS Interface file in real time as vendor software is writing to this file. Typically vendor software writes 1 row per minute. There are several values in a row like timestamp, un-calibrated data, calibrated data, flow (if applicable), temperature, pressure, analyser status, analyser alarms etc. ETS Bridge adds its own timestamp to indicate when a data

row was read. Ideally there should be maximum few seconds gap between the 2 timestamp values.

ETS Bridge stores this data locally in encrypted format and also sends to server where the data is processed and stored.

Data Validation and Data Replacement

ETS Program proposes to use a comprehensive automated Data Validation Protocol (DVP). This will include various checks to identify invalid / missing data. Following checks are proposed -

- Missing value checks – identify that values are missing
- Format checks
- Consistency checks – these include checks for negative values, duplicate data and range checks
- Constant value checks – check if a value is remaining constant for long periods of time
- Late data check – this is a special check to see if data was not received in real time by ETS Bridge. If data was received late in spite of ETS Bridge running properly at the industry at that particular time, there is a chance of data manipulation and it is dealt with as such.

Any data failing validation check(s) is appropriately flagged and then subjected to Data Replacement Protocols (DRP). The replacement protocol stringency varies according to quality and quantity of failures. The longer or higher the occurrences of failures, more stringent are the replacements.

Data Visualization and Reporting

Finally DAHS will provide extensive visualization, analysis and reporting features to various types of users via different web portals –

- Regulator Web Portal
- Industry Web Portal
- System Integration Portal for Vendors
- Public Website

Thus all users namely, regulators, industries, vendors and public will connect to same database, making it highly transparent and open system.

Overcoming the challenges

To sum up, let us revisit the key challenges listed above and see how DAHS will overcome these.

1. Designing a robust, yet simple interface for receiving PM data from CEMS software of multiple vendors. This is critical to ensure maximum participation of hardware vendors and wide choice of CEMS hardware to industries.

ETS Interface which is simple to implement, real time and secure

2. Ensuring complete integrity, reliability and availability of data to establish credible trading system.

Combination of ETS Interface, ETS Bridge, DVP and DRP

3. Enforcing and ensuring analyzer with appropriate technology for given stack.

Standard Operating Procedure (SOP) and guidelines for analyzer selection along with capacity building trainings for industries

4. Enforcing and ensuring timely maintenance and calibration of analyzers to ensure continued reliability and integrity of data.

Enforcement of periodic re-calibration as well as data driven re-calibration by DAHS Server

5. Enforcing usage of appropriate calibration factors

Calibration factors stored and used by server

6. Incorporation of corrections for load and process variations

Enforcing re-calibration if data goes beyond 120% of highest point used during calibration

7. Transparent system accessible to all stake holders like industries, regulators and vendors

Via various web portals

Conclusion

Success of this pilot ETS is expected to set the stage for more such initiatives in India as well as other countries. Willing participation of industries and hardware vendors is possible because of the policy to build trust through transparent systems. The DAHS presented in this paper is a cornerstone of this policy.

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Sujata has over 25 years of experience in software industry. An Instrumentation and Control engineer, Sujata is a recognized expert in Industrial Automation domain and a thought leader in convergence of Industrial Automation and Information Technology. Under her guidance, Ascent Informatics has built PlantConnect AQMS, a web-based air quality monitoring solution. Sujata worked on ETS project as an IT expert and has helped in successful field trials and pilot rollout.