The Growth of Automated and Predictive Monitoring Systems (SAM & PEMS)

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The 'Internet of Things'

WIRED

- Revolves around increased and smarter 'Machine to Machine' (M2M) communication

"…will create the most disruption as well as the most opportunity over the next five years."

- But its not just devices talking to like-devices & its not just talking about making machines "smart"

"The Internet of Things really comes together with the connection of sensors and machines."

- We are talking about SENSORS.

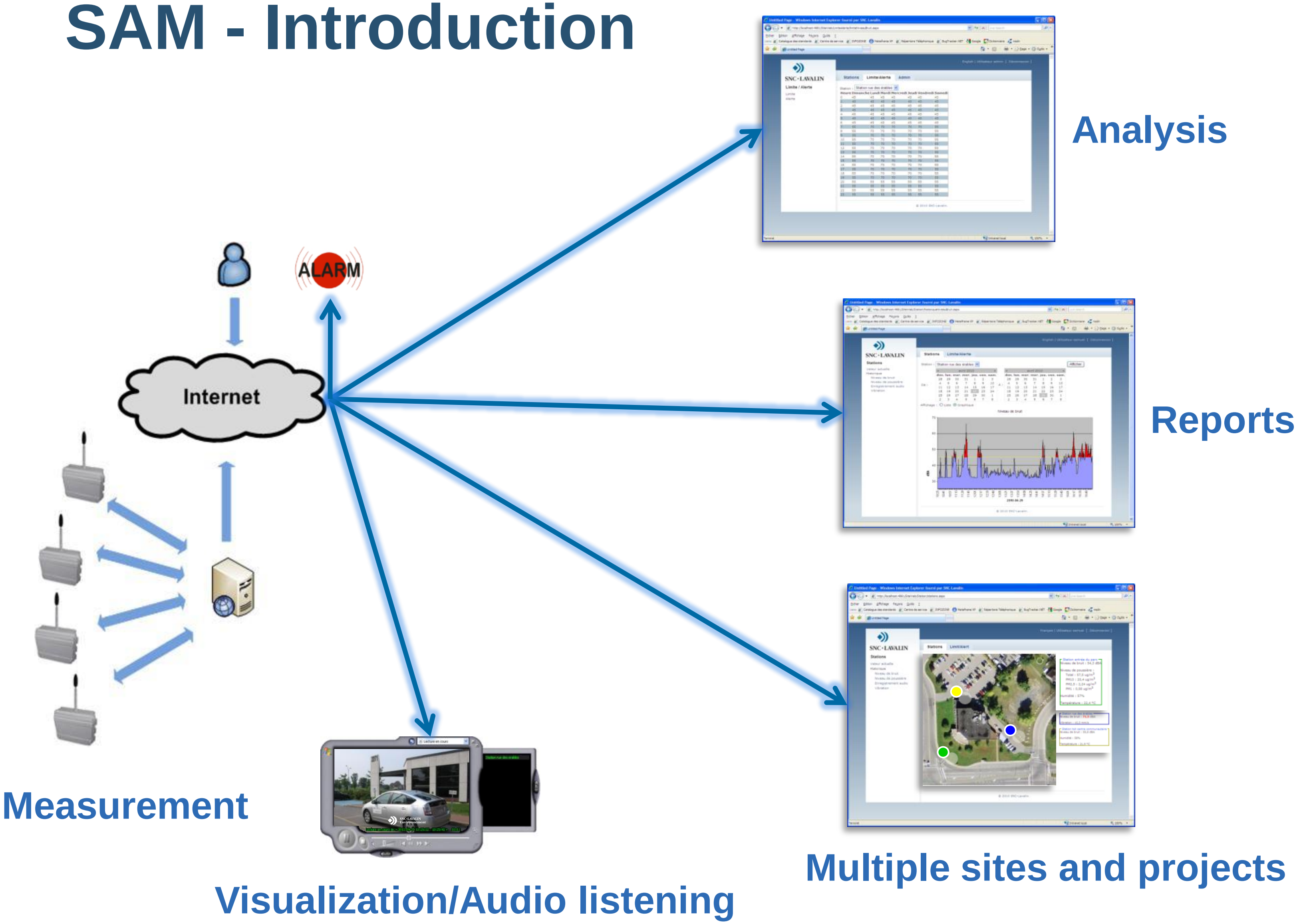
Paraphrased from Daniel Burrus, Burrus Research

Two such “Sensors”

SAM - Automated Monitoring System

PEMS – Predictive Emission Monitoring System

SAM - Introduction

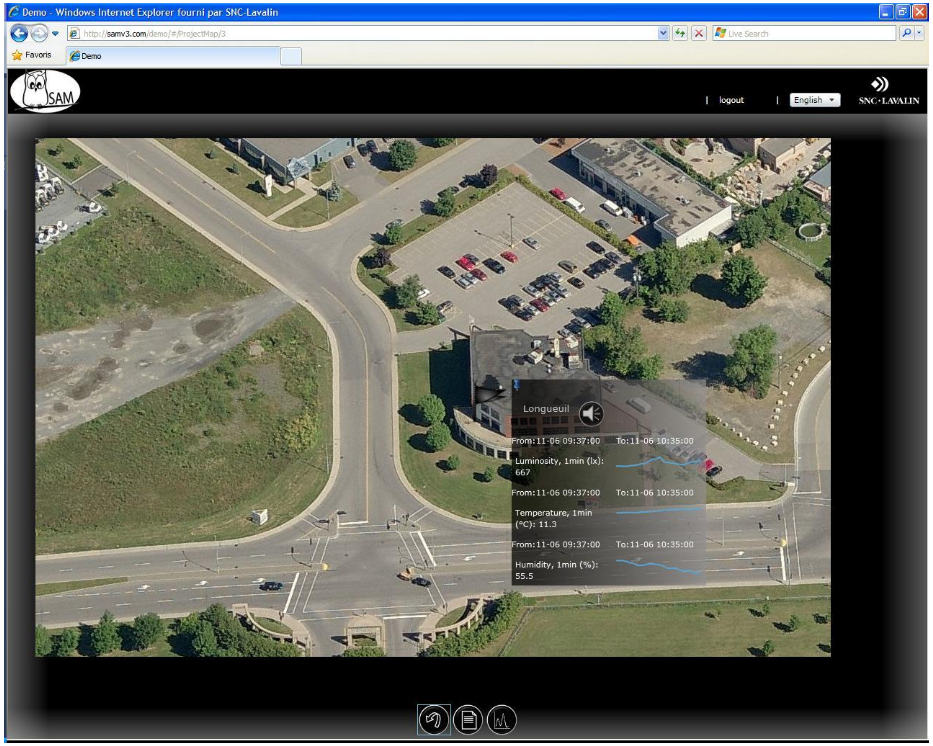


SAM – Multiple Measurement Devices

- **Versatile and modular architecture**
  - **Noise**
  - **Vibrations**
  - **Particulate matter**
  - **Pollutants (CO, SO_2, NO_x, O_3, COV, H_2S, etc.)**
  - **Traffic radar**
  - **Motorized camera**
  - **Water level/Flow rate**
  - **Electric power**
  - **Land slides (pressure, slope, stress, displacement, etc.)**

SAM – Real-time

- Real-time display
- Real-time analysis (preventing exceedences)
- Real-time alarms and notifications



SAM – Online

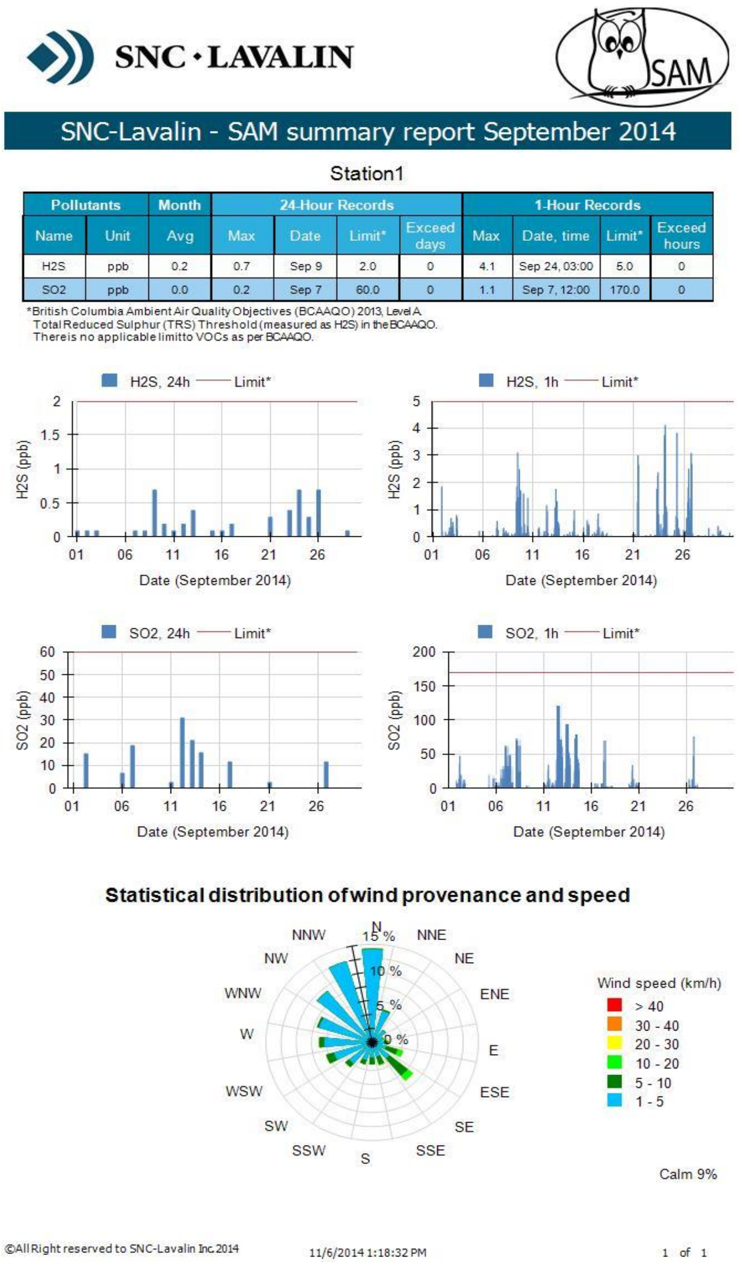
- **Exceedences of limits**
  - Measured or calculated exceedences
  - Alarms and notifications (e-mail, SMS, etc.)
  - Source identification (camera)
  - Annotations by the user
  - Data on exceedences including audio and video sequences

SAM – Multi-user

- **Customizable user rights**
  - Access (real-time, analysis, annotations)
  - Alarms and notifications

SAM – Reporting

- Advanced reporting
  - Custom reports
  - Dashboard



SNC·LAVALIN SAM

SNC-Lavalin - SAM summary report September 2014

Station1

Pollutants		Month	24-Hour Records				1-Hour Records			
Name	Unit	Avg	Max	Date	Limit*	Exceed days	Max	Date, time	Limit*	Exceed hours
H2S	ppb	0.2	0.7	Sep 9	2.0	0	4.1	Sep 24, 03:00	5.0	0
SO2	ppb	0.0	0.2	Sep 7	60.0	0	1.1	Sep 7, 12:00	170.0	0

*British Columbia Ambient Air Quality Objectives (BCAAQO) 2013, Level A.
Total Reduced Sulphur (TRS) Threshold (measured as H2S) in the BCAAQO.
There is no applicable limit to VOCs as per BCAAQO.

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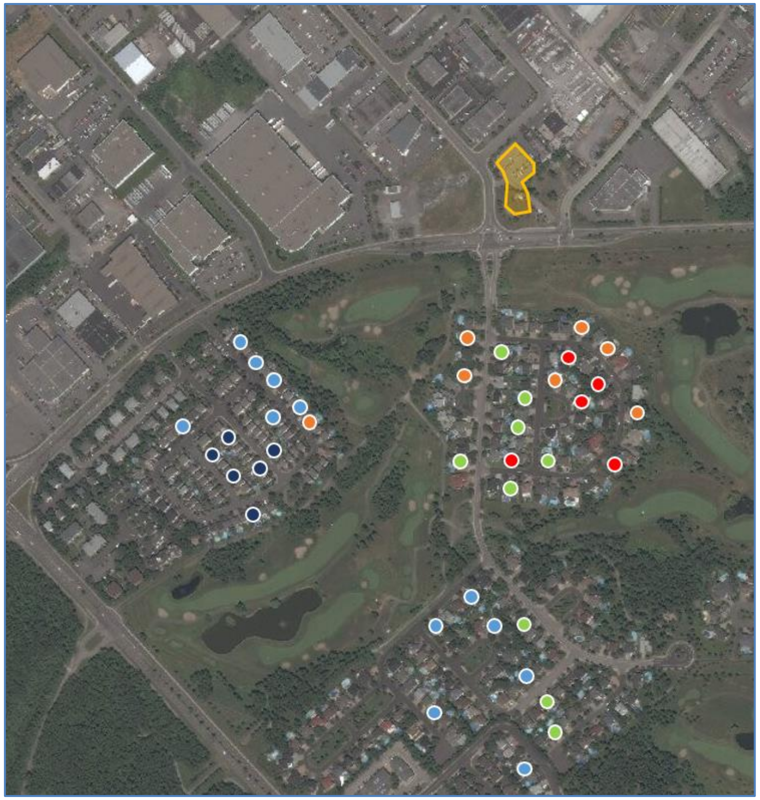
SAM – Correlations

- Source identification
  - Avoids exceedences caused by local activities
  - Automated

SAM – Complaints

- **Complaints management**
  - **Data input forms**
    - User and public
  - **Geolocation**
  - **Complaint categories**
  - **Analysis and reporting**
  - **Mapping**



WHAT IS PEMS?

Predictive Emission Monitoring System

Accurately *estimate* emissions through correlation between process parameters rather than by on-going direct *measurement*

WHY TALK ABOUT PEMS?

There are growing regulatory requirements for emission monitoring. We need to use stack tests, CEMS, etc.

CEMS takes a simple concept – direct measurement, and time has made it complicated and expensive

PEMS takes a complicated concept – prediction, and time is making it simpler.

To make it available for use in Alberta, PEMS needs more awareness and regulatory engagement now.

WHY TALK ABOUT PEMS?

In some cases PEMS can be simpler, cheaper and provide extra value for a company:

- CEMS can be labor intensive, expensive and difficult to manage (e.g., in Alberta with -40C and high wind, do you really want to climb that stack and change a filter?).
- PEMS may be used as a back-up system when there is a CEMS shut down.
- PEMS may confirm process operational parameters are kept within specification, and can provide better and more immediate diagnostic information

PREDICTIVE EMISSIONS MONITORING

Parametric (Up to Now)

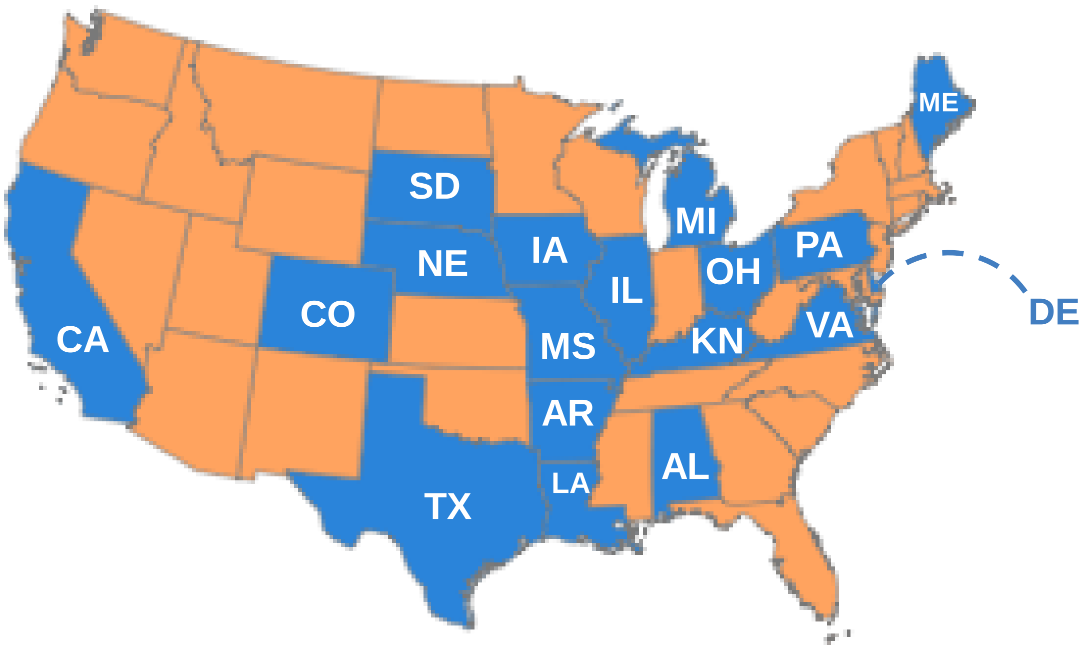
Monitoring of process parameters for comparison to (design) set points. Easy and simple. Can be used for steady state continuous operations (like a compressor facility). Predicted emissions can be set conservatively high.

Predictive (Emerging)

Use of process inputs along with **correlations and statistical** verifications to calculate an emission concentration. More sophisticated. Could be more expensive, but more accurate. Requires more expertise.

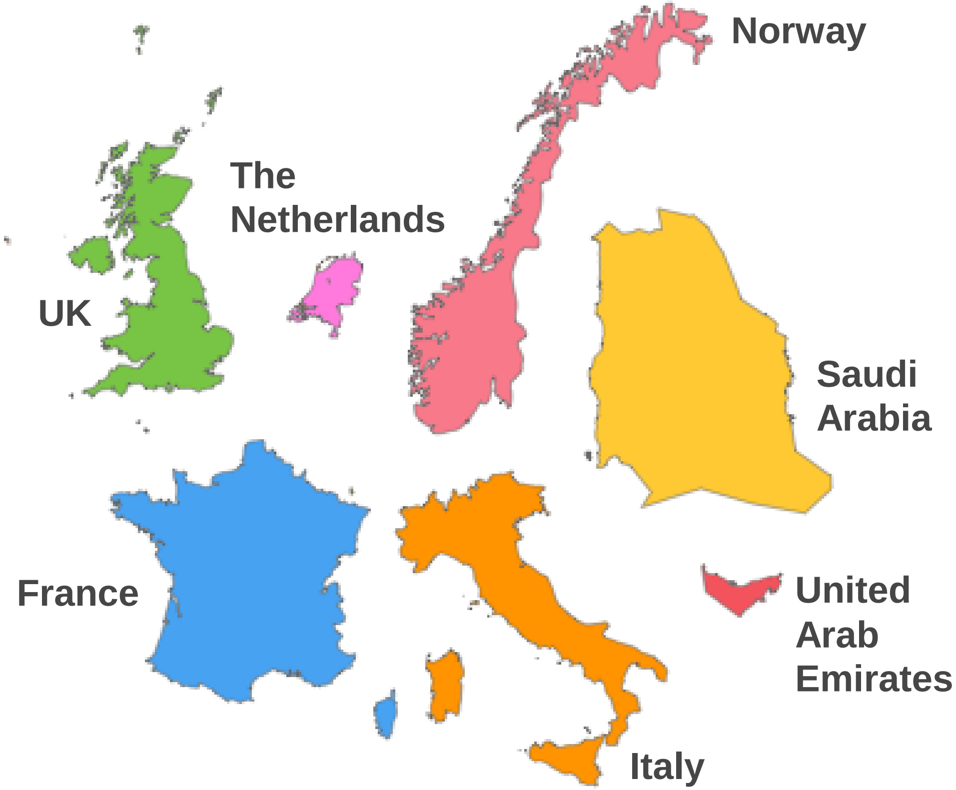
PEMS ACCEPTANCE

In the United States, where PEMS use is codified in EPA national and state-level guidelines, 18 states have approved the use of PEMS.



PEMS ACCEPTANCE

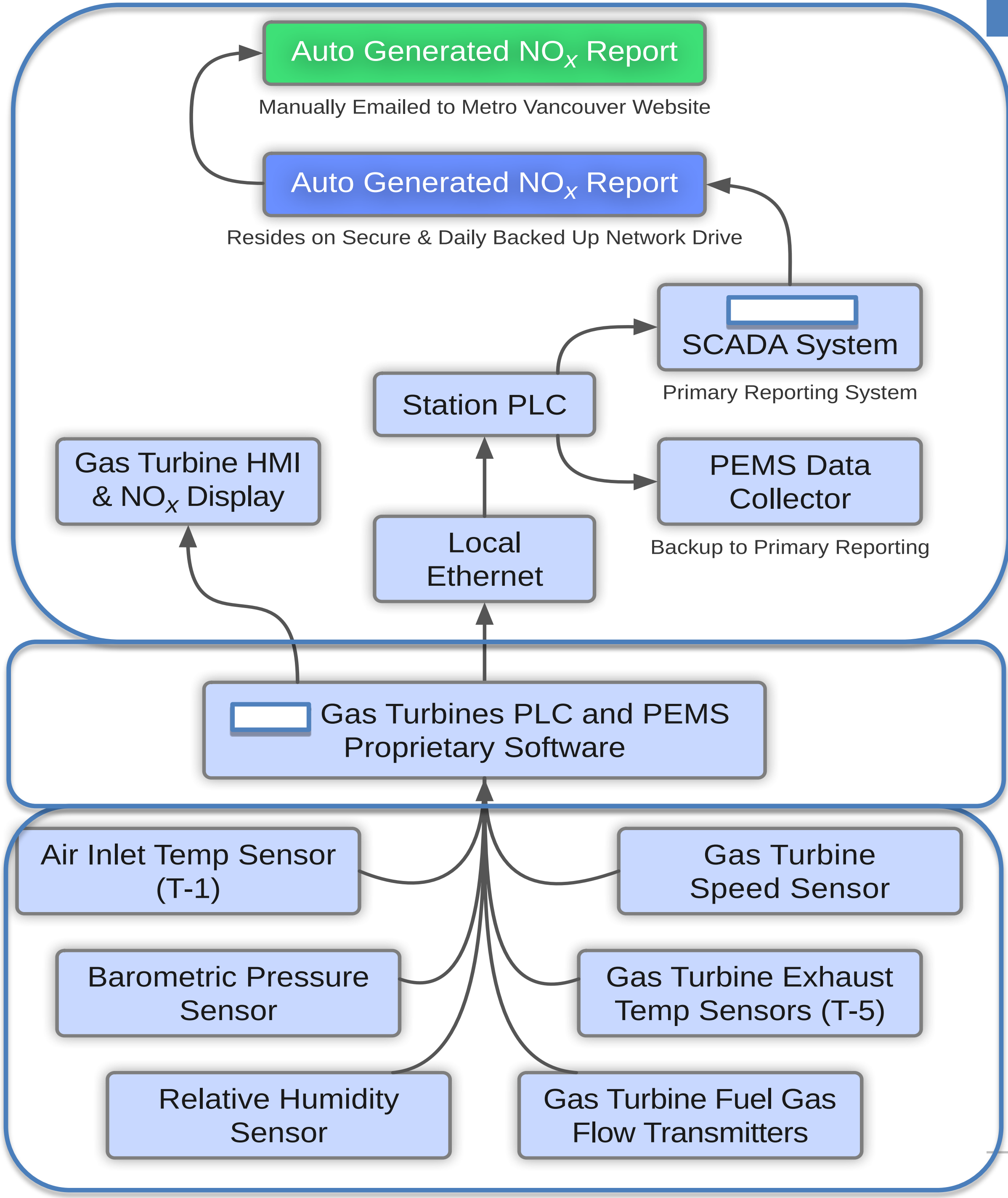
Aside from the USA, eight other countries have approved or are currently validating use of PEMS.



ISSUES DRIVING PEMS In REGULATION

- Increasing familiarity and comfort.
- Software and sensor integration developments.
- Need for monitoring of prolific use of IC technology (CEMS are unrealistic to keep online)
- The need to effectively address the relatively recent interest in trace organics, toxic compound and surrogate markers that might be more cost-effectively measured using PEMS technology.
- The acceptance by the public in several provinces of the use of computed instead measured emissions.

PEMS Schematic



OUTPUT (Emission Numbers)

CALCULATION

Such sensors are also normally part of the overall operating system, leading to quicker issue identification & resolution

PEMS METHOD: PARAMETRIC

A parametric system utilizes 1 – 6 key input parameters.

- The parameter is generally an operational parameter of the process or the Air Pollution Control Device (APCD) that is known to affect the emissions levels from the process or the control efficiency of the APCD (eg, temperature, pressure, or flow rate).
- It is a simple method and can be used in many simple cases like turbines, compressors, internal compression engines. Steady state operating conditions.
- Predicted emissions can be set as higher than real emissions.

PREDICTIVE ‘Learning” APPROACHES

Smart systems using statistical methods and & historical data:

- Rise of ***smarter***, ***faster*** and ***networked processing*** giving rise to “learning systems” which allow for more emission variation (e.g., from variable fuels)
- Algorithms inspired by biological neural networks (the central nervous systems of animals, in particular the brain). A neural network approach contains complexity by design.
- Multivariate analysis involves analysis techniques that incorporate multivariate statistical calculations.
- Statistical Hybrid PEMS is combining statistical methods and learning algorithms. E.g., can better predict startup and shutdown emissions accurately as long as the historical training dataset is ‘robust’.

TYPES OF CONTAMINANTS

The evolutionary process has resulted in robust PEMS with increasingly comprehensive parametric ability beyond basic gas speciation; hence, current contaminants of interest other than just NO_x are possible to predict. Some examples might include:

- Non-methane hydrocarbons (NMHCs)
- Hydrocarbons (HCs)
- Formaldehyde
- Carbon monoxide (CO)

UPTIME AND REDUNDANCY

Uptime can be maximized through:

- The implementation of a PEMS system with a robust software stack
- A system architecture that incorporates redundancy
- Storage of raw and processed data in a database within a local system that
  - Maximizes data redundancy
  - Minimize potential for data loss
- System backups can be tied into an existing system for disk backups
- Local or network backup continuously performed to increase redundancy of stored data

DATA BACKFILLING OPTIONS

Should the system be taken offline:

- Any gaps in the time series data could be processed at a later time
- The database table could be backfilled

This could be performed using a low-level function that:

- Scans the available data store
- Systematically identifies time-series gaps, and
- Triggers a reanalysis of emissions estimates for the missing period.

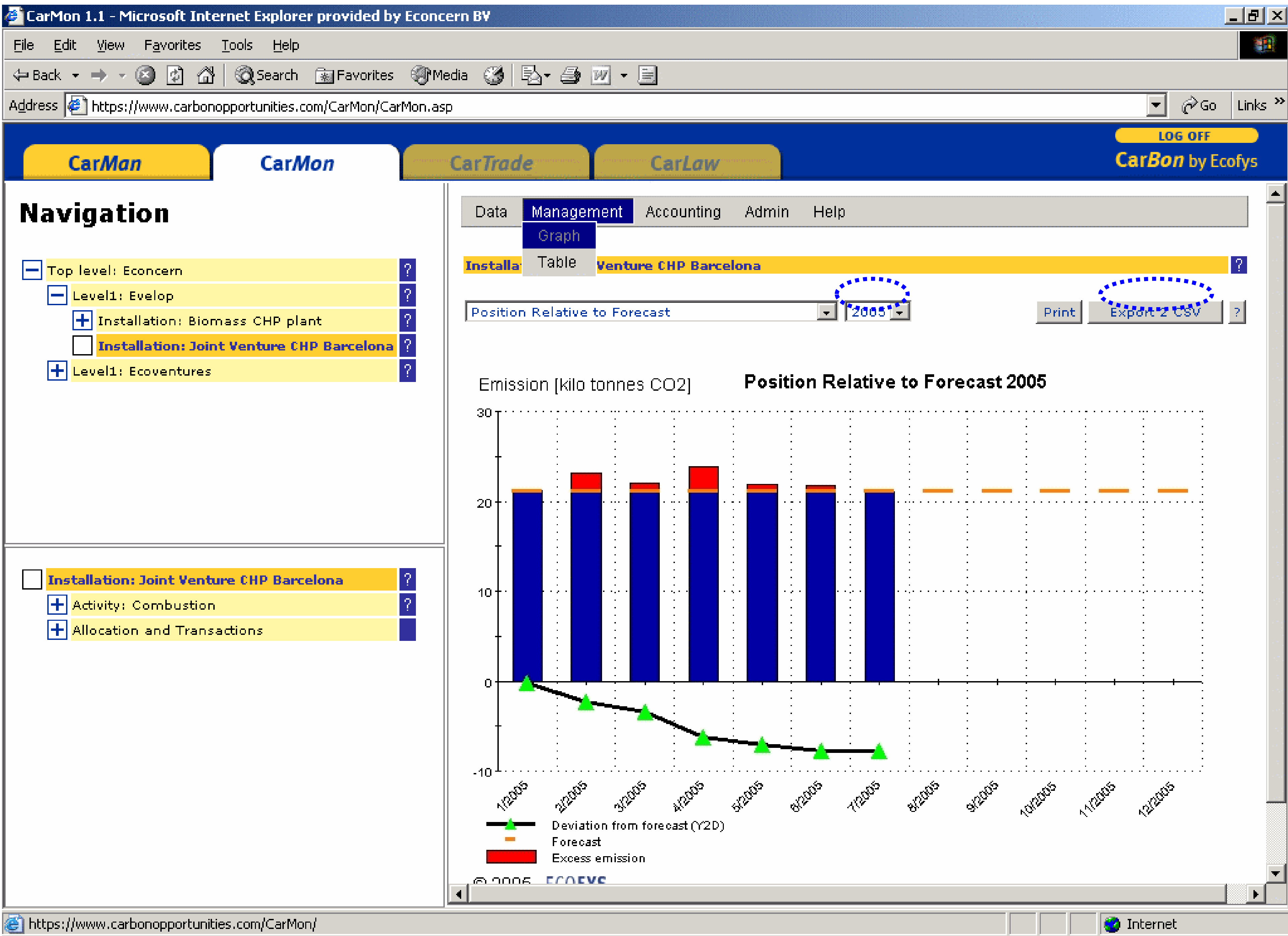
This backfilling can be done automatically or interactively, presenting data backfilling options to the user.

PEMS & CEMS COST PARALLELS

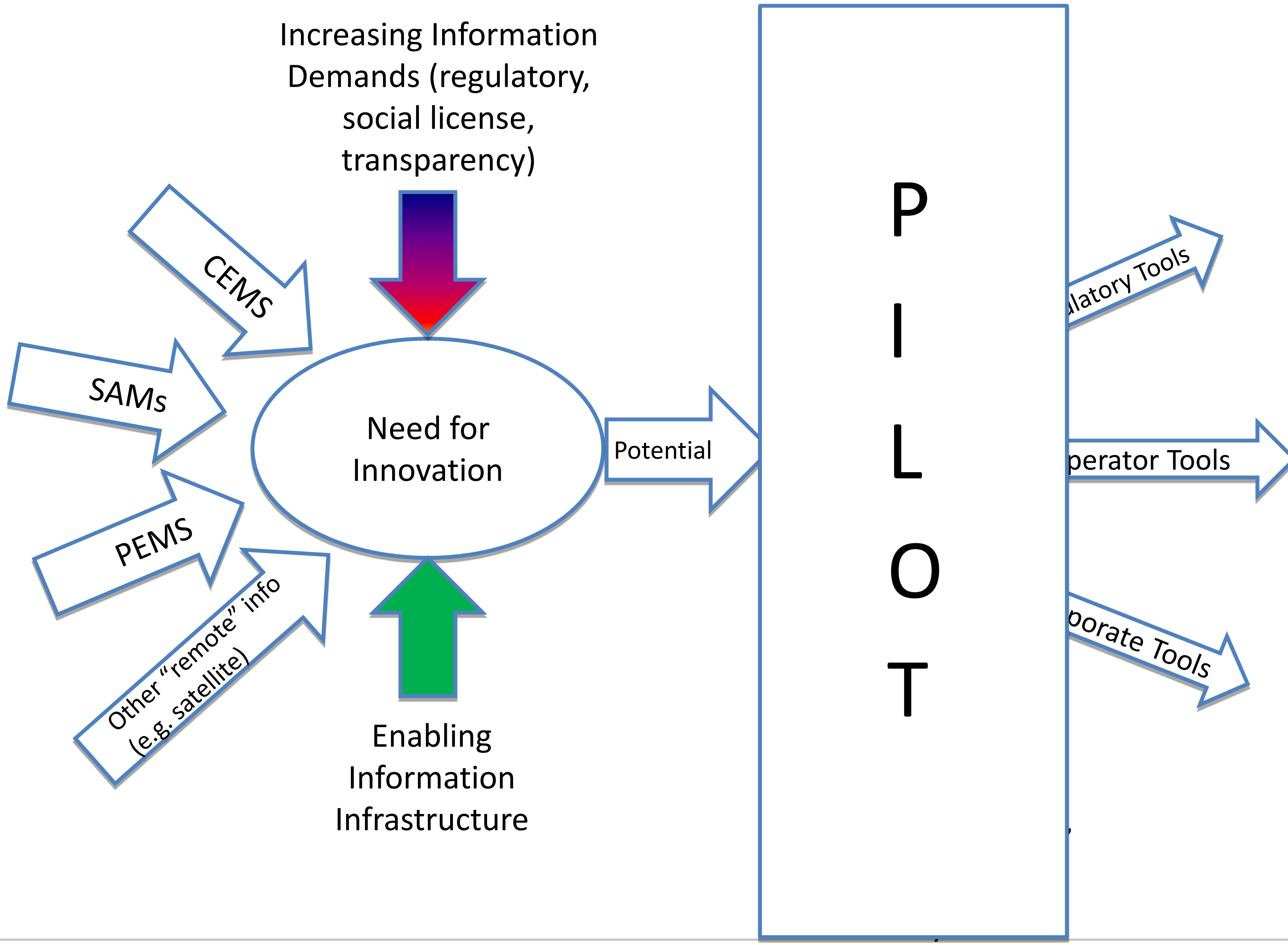
PEMS	Capital	1st Year	5 years	Capital	1st Year	5 years	CEMS
Front End Design and Specification	30,000	5,000	5,000	25,000	5,000	10,000	Front End Design and Specification
Installation	10,000	2,000	4,000	25,000	2,000	4,000	Installation
Input Analyzer/Computer	10,000	1,000	5,000	10,000	2,000	10,000	Probe
Database Back End	10,000	1,000	5,000	20,000	2,000	4,000	Cable Umbilical Connection to Stack
Developer Solutions	2,000	1,000	4,000	20,000	2,000	10,000	Conditioning System
Sensor Validation Procedures	INCL	INCL	INCL	10,000	2,000	10,000	Sample Header Distribution System
Reporting Modules	5,000	2,000	2,000	80,000	10,000	50,000	Analyzers: NO_x, SO_2, O_2, TOC
Dashboard System	5,000	2,000	5,000	20,000	2,000	10,000	H_2O Analyzer
Data Backfilling	5,000	1,000	5,000	5,000	1,000	2,000	Temperature Analyzer
QA/QC Processes	5,000	5,000	8,000	1,000	1,000	5,000	Other Analyzer Considerations
Calibration and Data Management	5,000	1,000	4,000	10,000	1,000	2,000	Volumetric Flow System
Data Report Generation Systems	5,000	5,000	5,000	3,000	6,000	18,000	Calibration Gases
Maintenance Systems	5,000	2,000	5,000	10,000	10,000	15,000	Data Report Generation Systems
QA/QC Systems	N/A	15,000	30,000	20,000	10,000	50,000	Maintenance Systems
Prescriptive Uptime	1,000	1,000	2,000	NA	15,000	30,000	QA/QC Systems
Training	5,000	2,000	8,000	5,000	2,000	8,000	Training
Subtotals	**103K**	46K	**97K**	**264K**	73K	**238K**	Subtotals
Capital + 5 Year Costs		**200K**			**502 K**		Capital + 5 Year Costs

Air & Carbon Monitoring Drivers

- Health Impacts in Challenged Airsheds
- Growing international focus on “Black Carbon” & VOCs (including methane)
- Increased public awareness and activism
- Increased corporate social responsibility (CSR)
- Federal AQMS (Driven by oil sands monitoring concerns)
- Permitting (e.g NEB, AENV, OGC, EA, BCE)
- Increased reporting/disclosure/due diligence requirements
- Increasing monitoring requirements (e.g. flaring, BLIERS)
- Real cost of carbon and impending regulation



CarMon 1.1 - Microsoft Internet Explorer provided by Econcern BV
File Edit View Favorites Tools Help
Back Search Favorites Media
Address https://www.carbonopportunities.com/CarMon/CarMon.asp
Go Links
LOG OFF
CarBon by Ecofys
CarMan
CarMon
CarTrade
CarLaw
Navigation
Top level: Econcern
Level1: Evelop
Installation: Biomass CHP plant
Installation: Joint Venture CHP Barcelona
Level1: Ecoventures
Installation: Joint Venture CHP Barcelona
Activity: Combustion
Allocation and Transactions
Data
Management
Accounting
Admin
Help
Graph
Table
Installa
Venture CHP Barcelona
Position Relative to Forecast
2005
Print
Export 2 CSV
Emission [kilo tonnes CO2]
Position Relative to Forecast 2005
30
20
10
0
-10
1/2005
2/2005
3/2005
4/2005
5/2005
6/2005
7/2005
8/2005
9/2005
10/2005
11/2005
12/2005
Deviation from forecast (Y2D)
Forecast
Excess emission
https://www.carbonopportunities.com/CarMon/
Internet


Increasing Information Demands (regulatory, social license, transparency)
CEMS
SAMs
PEMS
Other "remote" info (e.g. satellite)
Need for Innovation
Enabling Information Infrastructure
Potential
P I L O T
latory Tools
perator Tools
porate Tools

WE CARE
NOUS VEILLONS

WE CARE embodies SNC-Lavalin's key corporate values and beliefs. It is the cornerstone of everything we do as a company. **Health and safety, employees,** the **environment, communities and quality:** these values all influence the decisions we make every day. And importantly, they guide us in how we serve our clients and therefore affect how we are perceived by our external partners. **WE CARE** is integral to the way we perform on a daily basis. It is both a responsibility and a source of satisfaction and pride by providing such important standards to all we do.

WE CARE about the health and safety of our employees, of those who work under our care, and of the people our projects serve.

WE CARE about our employees, their personal growth, career development and general well-being.

WE CARE about the communities where we live and work and their sustainable development, and we commit to fulfilling our responsibilities as a global citizen.

WE CARE about the environment and about conducting our business in an environmentally responsible manner.

WE CARE about the quality of our work.