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WFEO GENERAL ASSEMBLY
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SAFEGUARDING HUMANKIND'S HERITAGE, THE GREAT CHALLENGE FOR ENGINEERS
The World Federation of Engineering Organizations

A New Way of Conceiving and Dealing with Environmental Control of Process Plants by Real-Time Monitoring by Soft Sensors

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Who we are

ARPAT
Agenzia regionale per la protezione ambientale della Toscana
www.arpat.toscana.it

Sistema Nazionale per la Protezione dell'Ambiente

Established in 1996, our main aim is to protect and improve the environment of Tuscany region.

We have several offices and more than 650 employees across the Region.

We belong to SNPA, the National Environmental Protection System.

What we do

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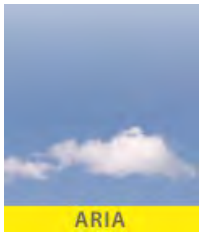
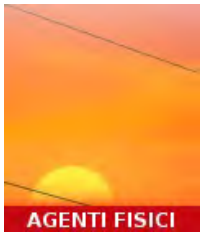
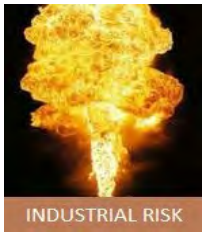
a) monitoring of the various environmental components:

- air (air quality, stack emissions),
- water (wastewater, bathwater, freshwater and groundwater),
- soil and subsoil,
- sound level,
- major risk establishments;







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b) technical – scientific support to other public bodies to issue environmental permits;

c) environmental data collection and processing, diffusion of information and management of Regional Information System for the Environment;

d) environmental inspections;

e) COMAH/Seveso major risk inspections

… (and so on)

Environmental Inspections in EU Policy and Legislation Framework

Collect information
Identify gaps in compliance with permit conditions

Environmental inspections include (1):

- ✓ on-site visits,
- ✓ monitoring achievement of Environmental Quality Standards, (Emission Limits ELVs control based on EQSs)
- ✓ consideration of environmental audit reports and statements,
- ✓ consideration and verification of any self-monitoring,
- ✓ assessing the activities and operations carried out at the controlled installation,
- ✓ checking the premises, the relevant equipments and the adequacy of the environmental management at the site,
- ✓ checking the relevant records kept by the operators of controlled installations

(1) Recommendation of the European Parliament and of the Council providing for minimum criteria for environmental inspections in the Member States (2001/331/EC)

Environmental inspections: PROs and CONs

Stakeholders

PUBLIC AUTHORITY IN CHARGE OF CONTROL

ARPAT

MONITORING CAMPAIGN
SAMPLING – ANALYSIS

PROs

- Should assess direct compliance with ELV (gaseous effluents, waste water, ecc.)

CONs

- Representative Sample
- Analytical method selection (and use)
- Staff qualification
- Use and maintenance (calibration) of instrumentation
- Related costs

Do point-by-point data guarantee compliance with ELV between campaigns?

Main problems

1) The environmental control of industrial installations based on the Command & Control strategy implies high costs for national governments and companies and operative difficulties in sampling and analyzing.

2) If not inserted in a wider context, the environmental point-by-point data give an incomplete representation of the impact of businesses.

Can we do something better?

Can we do something better?

A possible solution

A methodology for remote plant monitoring is proposed, which is based on:

1. the preliminary study of the process,
2. the reconciliation of the data used in the first principle equations,
3. specific models for real-time estimates of environmental critical parameters.

Phys - Math models

We use models of various complexity:
- statistical inference or governing equation-based models,
- CFDs,
- ANNs,
- fuzzy logic,
- expert systems,
- hybrid models.

CoSyMo System

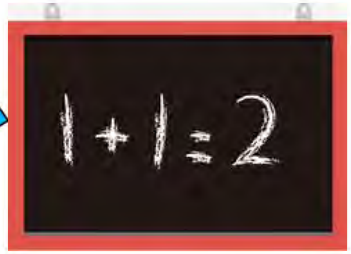
ARPAT

ARPAT data & modeling center

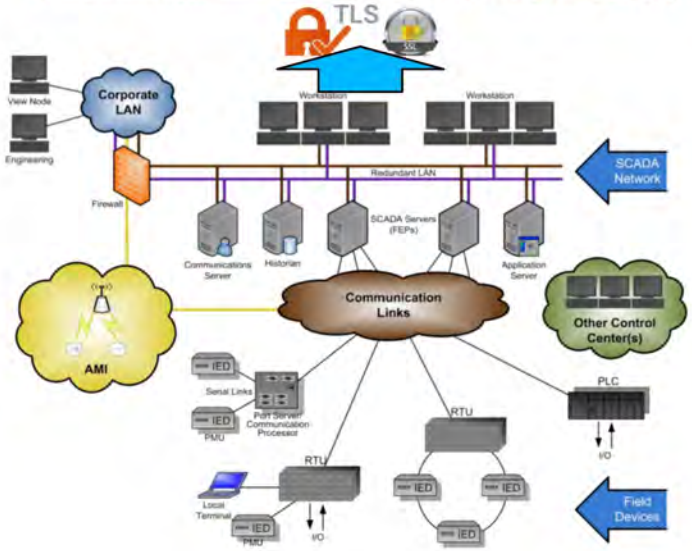
Encrypted data transfer (Transport Layer Security)

start

Chemical plant



On-line env-estimates



DCS & Corporate LAN

CoSyMo System

On-line data retrieving

Gross Error Identification

Data reconciliation

Mathematical tools - models

Environmental parameters estimate

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Data reconciliation

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Environmental parameters estimate

Monitoring Industrial Processes in real time

On-line calculations detect potentially critical anomalies and allow adoption of corrective actions in favor of the environment and the companies

In this way, they could comply with authorization limits and prescriptions moment-by-moment and achieve a better corporate image.

Soft Sensors for Monitoring and Control of Industrial Processes

The expected pro is a better control efficiency that becomes preventive and continuous and gives more credibility and transparency to the overall control system.

The benefits are both for the public and the companies.

Soft Sensors for Monitoring and Control of Industrial Processes

The biggest pros are related to medium-large establishments (such as waste-incinerators or crude oil refineries) that sometimes meet difficulties in gaining public acceptance

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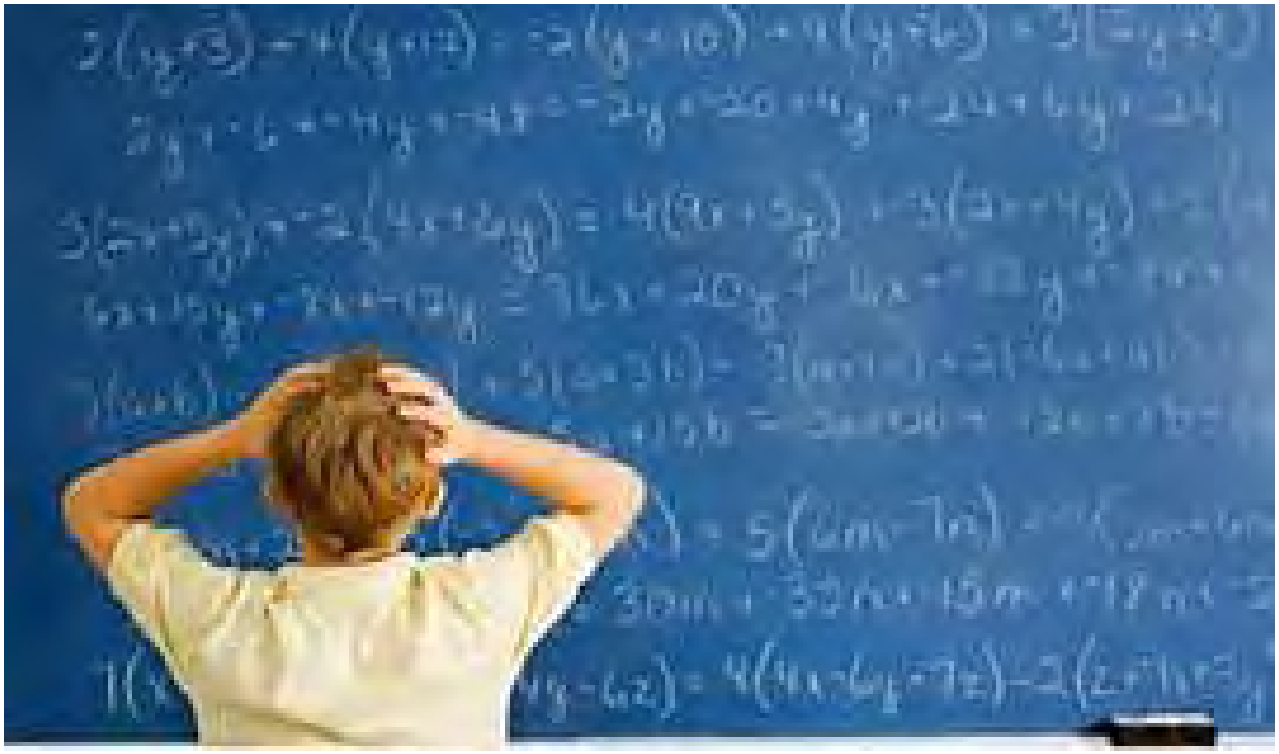
Soft Sensors for Monitoring and Control of Industrial Processes

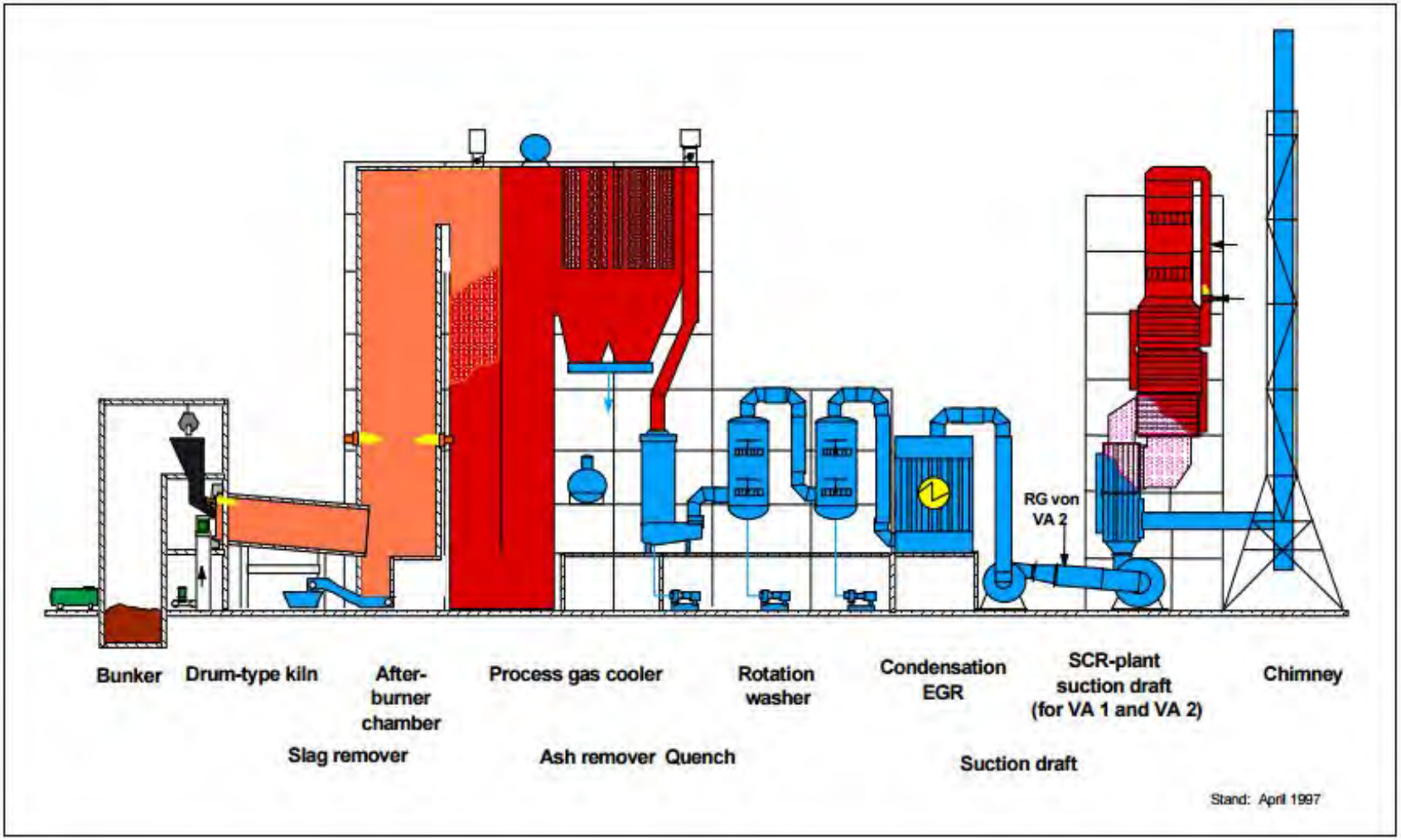


Methodology requires hard work for design, development and calibration of models, data analysis, cyber-security requirements, and training.

Soft Sensors for Monitoring and Control of Industrial Processes

Nevertheless, it could reduce by 20% costs incurred by the control body and the companies.

Case-study


RG von VA 2
Bunker
Drum-type kiln
After-burner chamber
Process gas cooler
Rotation washer
Condensation EGR
SCR-plant suction draft (for VA 1 and VA 2)
Chimney
Slag remover
Ash remover
Quench
Suction draft
Stand: April 1997

Case-study

A MWI (Municipal waste incinerator) in accordance with WTF (Waste Framework) Directive could be classified as energy recovery plant if:

$$R1 = f(\ldots, Ew, \ldots.) > 0{,}6$$

R1 = Energy Recovery Efficiency Factor

Ew = annual energy contained in the waste calculated using the net calorific value of the waste (GJ/year)

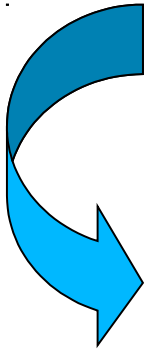
Ew factor plays an important role and LHV determination is the variable of greater uncertainty for undifferentiated urban waste

Case-study

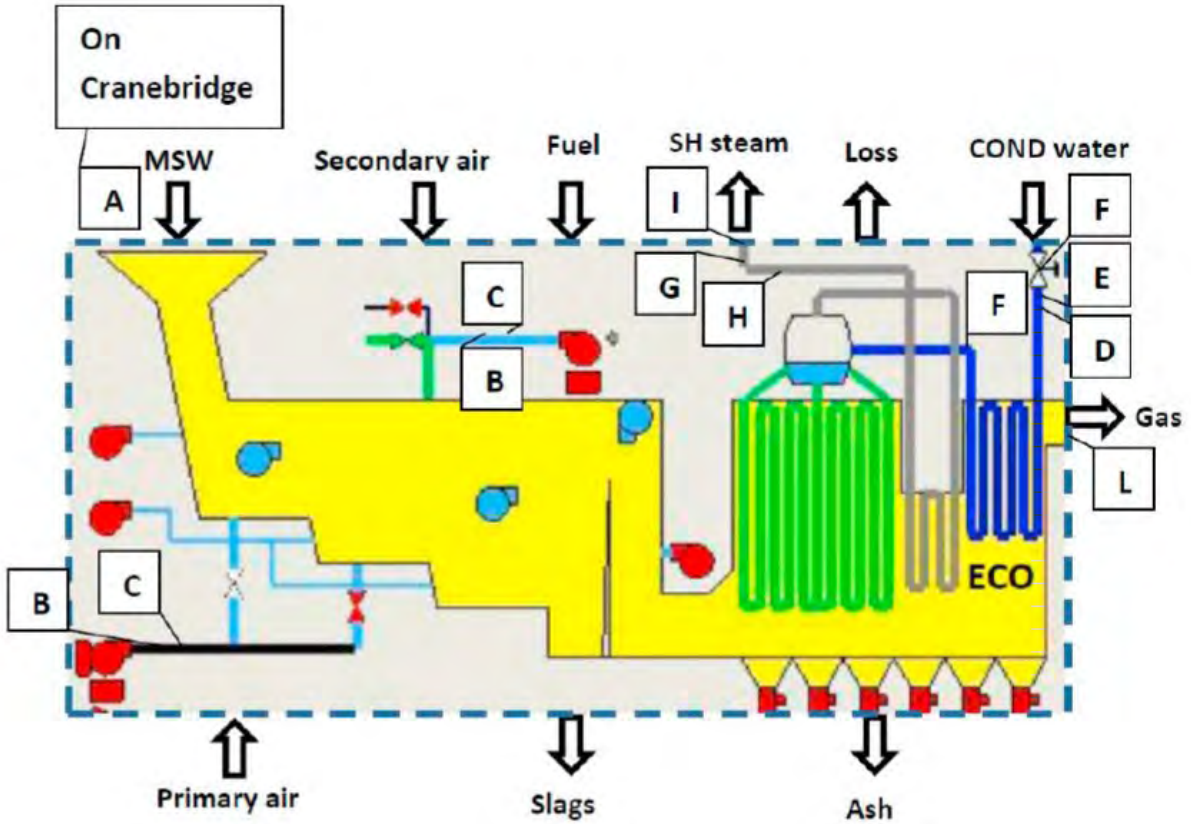
2 ways for the quantification of LHV parameter

Discontinuous Direct Sampling over time

Continuos Indirect estimation



EC guidelines
Selected Method for MWI Plants due to:
•high variance of the waste quality over the time
•not cheap semi-continuous sampling and analysis procedure.

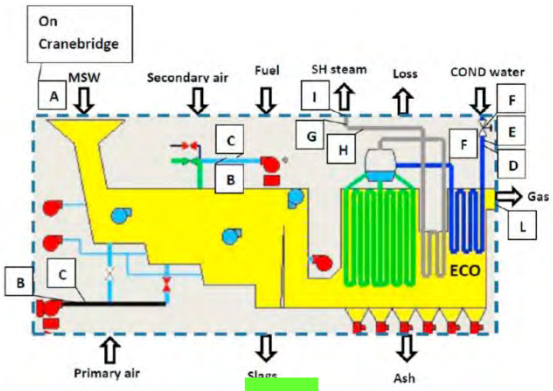


Most reliable method for LHV estimation is oven+boiler mass and energy balance eqs.

We ought to identify:

•the reference system limits based on the actual plant configuration;

•Plant data (continuously measured data, estimated and literature data, discontinuous data measurement).



in the case of low sensitivity of the overall model with respect to some variables

DISCONTINUOUS DATA

ESTIMATED DATA

Samplying PROCEDURE

CONTINUOUS MEASURED DATA

DCS

MASS AND ENERGY BALANCE SOFTWARE MODEL

MANUAL CALIBRATION MANAGEMENT PROCEDURE
Measurement System Maintenance Procedure

CONTINUOUS LHV, R1 DATA

Continuos LHV, R1 Data

MESE DI GENNAIO 2016

Anno-Mese-Giorno-Turno	PCI (kcal/kg)	Quantitativo in forno di rifiuto (kg)	Energia dal rifiuto (kcal)
1601011	1875.7737	45453.00	85259541.99
1601012	1709,9846	50951,00	87125425,35
1601013	2054,0066	42203,00	86685240,54
1601021	1747,4927	48289,00	84384674,99
1601022	1787,2455	45484,00	81291074,32
1601023	1.635.853	48980,00	80124079,94
1601031	1.648.038	50449.00	83141869.06
1601032	1.908.592	42654,00	81409083,17
1601033	1623,0115	49172,00	79806721,48
1601041	1653,7039	46870,00	77509101,79
1601042	1792,2087	47794,00	85656822,61
1601043	1750,2054	48517,00	84914715,39
1601051	1484.4948	52849.00	78454065.69
1601052	2149,0034	39696,00	85306838,97
1601053	1389,5033	59442,00	82594855,16
1601061	1578,5952	49020,00	77382736,70
1601062	1.564.374	51175,00	80056839,45
1601063	1.299.142	60993,00	79238568,01
1601071	1588.3701	49691.00	78927698.64
1601072	1826,6461	47625,00	86994020,51
1601073	1439,4598	55938,00	80520502,29
1601081	1731,5038	52658,00	91177527,10
1601082	1853,8019	50050,00	92782785,10
1601083	1.599.552	51303,00	82061816,26
1601091	1898,2139	42562.00	80791780,01
1601092	1971,5767	43990,00	86729659,03
1601093	1724,0743	52032,00	89707033,98
1601101	1.796.277	48780,00	87622392,06
1601102	1786,3558	47631,00	85085913,11
1601103	1987,7478	46596,00	92621096,49

R1 evaluation through Integration of data on an annual basis

Model Uncertainty Evaluation (ΔR1)

$R1+\Delta R1 > 0,6$? Check

For the year 2016, the calculated value of R1 turned out to be equal to 0.619 ± 0.013 (limit value = 0.6).

Advantages for the Company

The Company will acquire:

a) a better knowledge through the activity on data reconciliation and model development,

b) a safe return in terms of image with a consequent better inclusion in the territory and…

c) an increase in the transparency of Controls

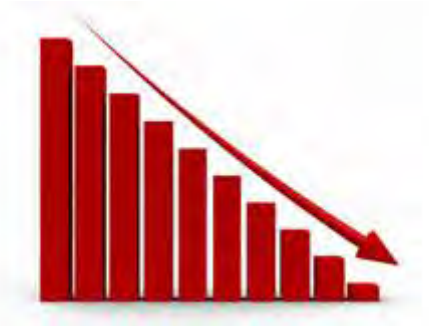
Advantages for the Company…

The Company is challenged to improve its performance and its transparency over time, also in relation to the public and the stakeholders.

On the other hand, the Company could avail itself of the data certified by the environmental authority that could be more reliably valued by the public.

Advantages for the Company…

The number of scheduled controls with the presence of the institutional staff in establishment could be strongly reduced.

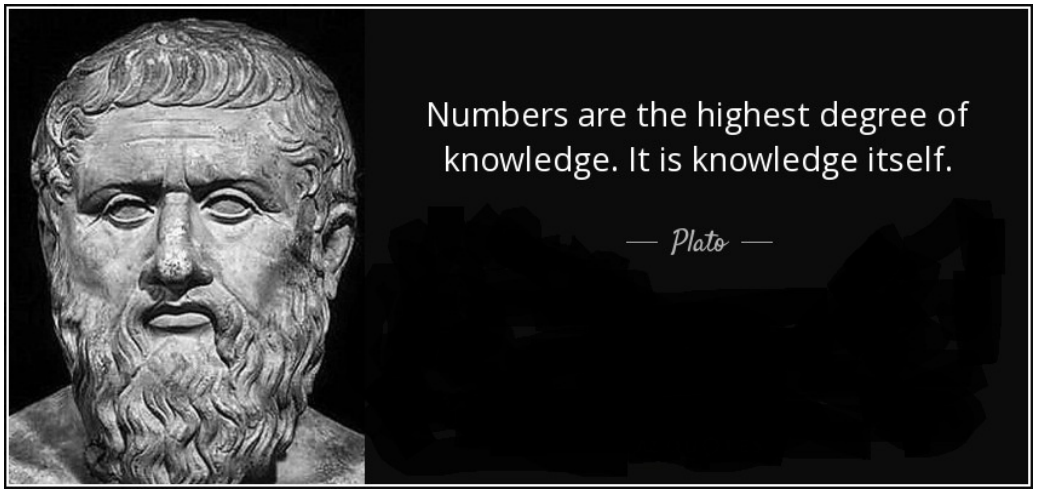


Advantages for the Company

The greatest advantages will be for establishments that find it difficult to be accepted by the public such as incinerators of waste, refineries, plants with combustion equipments and other chemical plants.

Advantages for the Public…

On the other hand, the public will improve the degree of knowledge on the actual impact of the establishment and be certain of the veracity of the data.



Advantages for the Public…

The new proposed control scheme carries out a continuous monitoring of potential impacts on the environment, minimizing costs for the community.

In conclusion

This methodology:

- ✓ overcomes the Command and Control strategy;
- ✓ could be the new challenge of environmental control both control Bodies and Companies might strive for;
- ✓ could be a suitable tool to build a better environment and ensure a sustainable development in the future.


děkuji
tack!
谢谢
salamat
Gracias
Tak
KIITOS
Toda
köszönöm
dankon
mahalo
Thank you!
Merci
благодаря
teşekür ederim!
Danke
dziękuję
sukriya
תודה
Grazie
terima kasih
Dank U
спасибо
ευχαριστώ
ありがとう
tahh