QUINTO **CONVEGNO NAZIONALE** SUL **PARTICOLATO ATMOSFERICO**

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# VECA: an integrated approach to prevent aerosol corrosion in data centers

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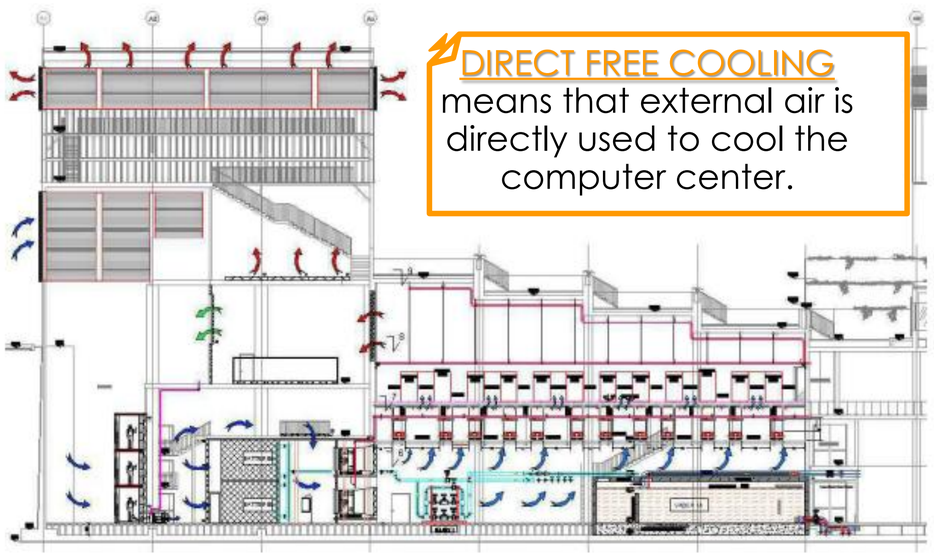
✓**OBJECT OF THE STUDY: DATA CENTER (5200 m² of computers) characterized by a DIRECT FREE COOLING DESIGN**



DIRECT FREE COOLING means that external air is directly used to cool the computer center.

Energy saving depends on external climatic conditions but it can reach values as high as ~50% compared to other cooling techniques (indirect or using common conditioning systems)

**BUT…**

**…Aerosol** that comes into the computer center during the **DIRECT FREE COOLING can damage** the computers due to their:
- **Chemical effects (**corrosion…**)**
- **Mechanical effect (**prevented the dissipation of heat…**)**
- **Electrical effects (**arc effect…**)**

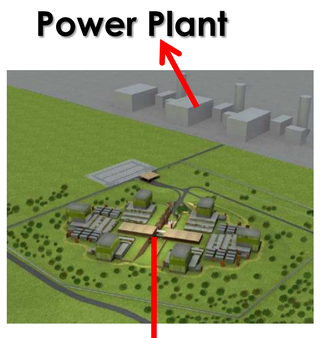
**THUS…** international technical committee (**ASHRAE**) have given the limits on: **aerosol number concentration (**in function of size: ISO8 standard**), temperature (**15-32°C**) and relative humidity (**20-80%**)** to prevent aerosol contamination and **aerosol hygroscopicity**… thermodynamic limits have to be adapted to the aerosol hygroscopic properties of the air entering in the system.

ASHRAE
American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
**ASHRAE Technical Committee 9.9**

| ISO CLASS | Maximum Number of Particles in Air (particles in each cubic meter equal to or greater than the specified size) | | | | | |
|---|---|---|---|---|---|---|
| | Particle size | | | | | |
| | > 0.1 µm | > 0.2 µm | > 0.3 µm | > 0.5 µm | > 1 µm | > 5 µm |
| Class 1 | 10 | 2 | | | | |
| Class 2 | 100 | 24 | 10 | 4 | | |
| Class 3 | 1000 | 237 | 102 | 35 | 8 | |
| Class 4 | 10,000 | 2,370 | 1,020 | 352 | 83 | |
| Class 5 | 100,000 | 23,700 | 10,200 | 3,520 | 832 | 29 |
| Class 6 | 1,000,000 | 237,000 | 102,000 | 35,200 | 8,320 | 293 |
| Class 7 | | | | 352,000 | 83,200 | 2,930 |
| Class 8 | | | | 3,520,000 | 832,000 | 29,300 |
| Class 9 | | | | | 8,320,000 | 293,000 |

Note: Uncertainties related to the measurements process require that data with no more than three (3) significant figures be used in determining the classification level.

✓ **SAMPLING SITE: SANNAZARO DE' BURGONDI** (PAVIA) in the middle of the **Po Valley, Italy near one of the largest power-plants of Italy**


✓ **ANALYSIS:** PTFE filters extracted in ultra-pure water by ultrasonic bath and analyzed by IC (Dionex® ICS90 and ICS2000 coupled system).

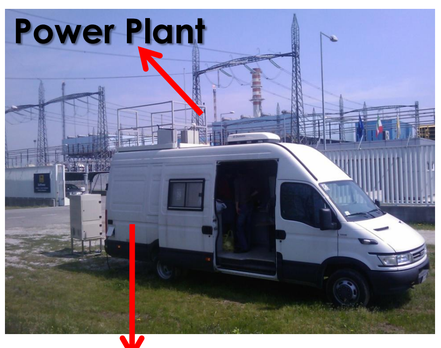
**water soluble inorganic ions**
$Na^+$, $NH_4^+$, $K^+$, $Mg^{2+}$, $Ca^{2+}$, $F^-$, $Cl^-$, $NO_3^-$, $PO_4^{3-}$, $SO_4^{2-}$

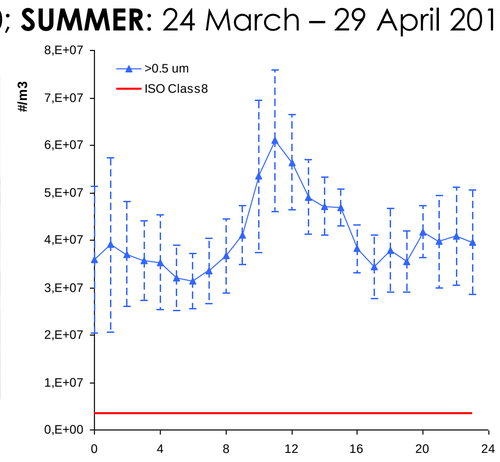
+

**mono-/dicarboxylic acids**
acetic, propionic, formic, glutarric, succinic, malonic, maleic, oxalic acids

✓ **SAMPLING CAMPAIGN: $PM_{0.4}$ + $PM_1$ + $PM_{2.5}$ + OPC-Tandem System ($OPC_{"dry"}$+$OPC_{"wet"}$) + Meteo Parameters**

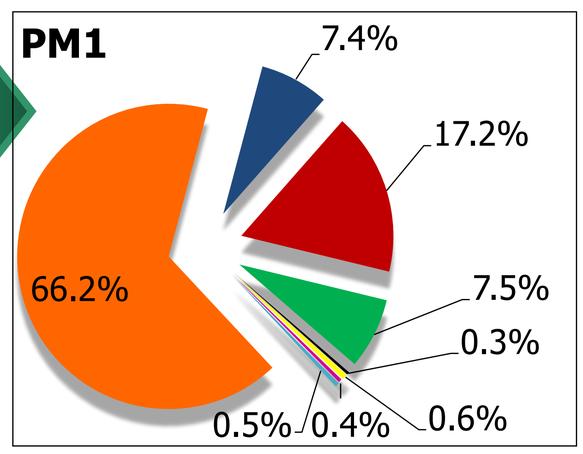
**SPRING**: 10 June – 2 July 2010; **SUMMER**: 24 March – 29 April 2010

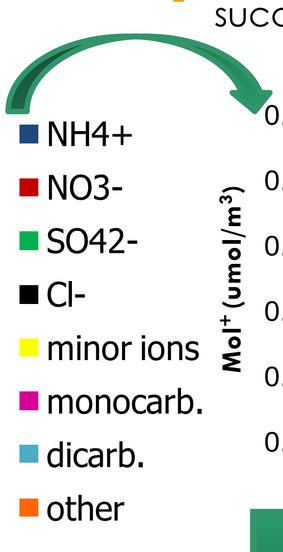


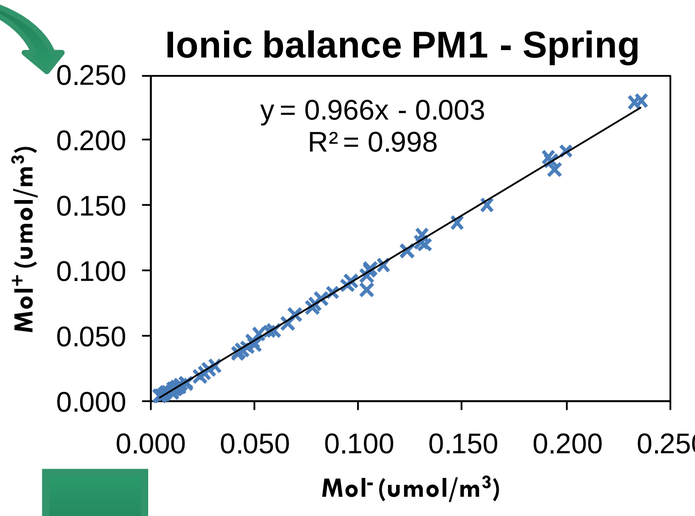




**High Pollution levels** (aerosol concentrations above ISO8 standards) need for an **aerosol chemico-physical characterization**…

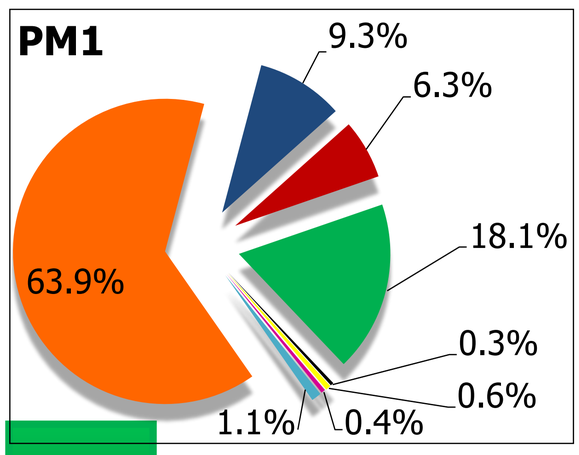
## SPRING



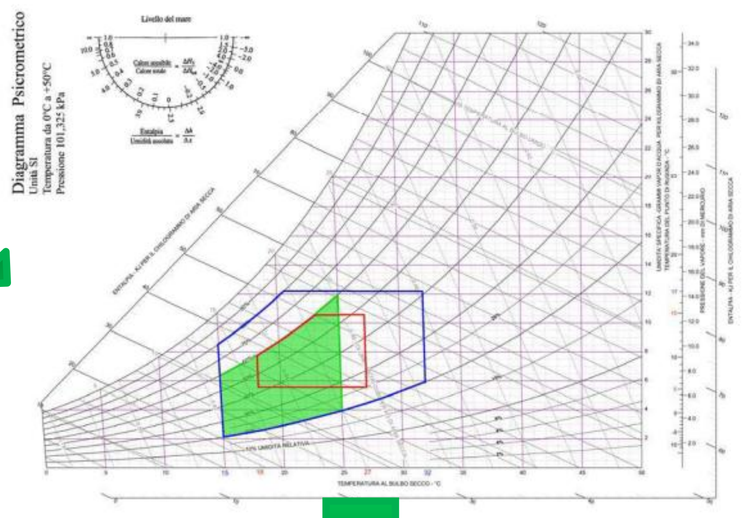

## SUMMER



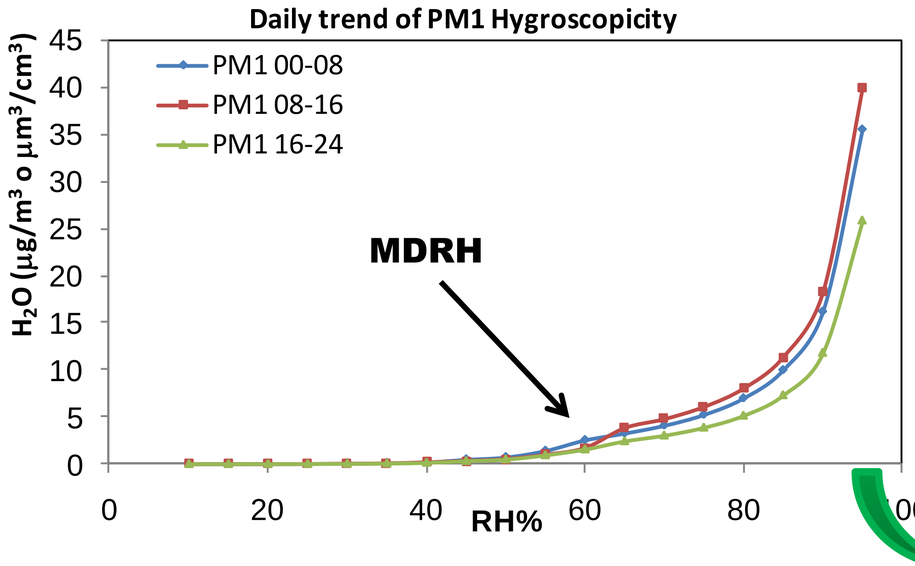

Very similar pattern of ionic balance for both the seasons and all the PMx: $R^2$ very high (**$R^2 \geq 0.96$**); slope very close to 1 (**slope ≥ 0.85**). The neutrality condition of aerosol prevent the computer damage due to acidity.
However is very important to assess the aerosol hygroscopicity to prevent any corrosion problem due to the overcoming of the Mutual Deliquescence Relative Humidity (*MDRH*) of aerosol.

✓ **AEROSOL HYGROSCOPICITY: Aerosol Inorganic Model (E-AIM)**, an aerosol **thermodynamic model** that can simulate aerosol water content, free acidity (free $H^+$), and activities of ionic species in aqueous aerosols and the solid- and liquid-phase compositions (Clegg et al., 1998; http://www.aim.env.uea.ac.uk/aim/aim.php)

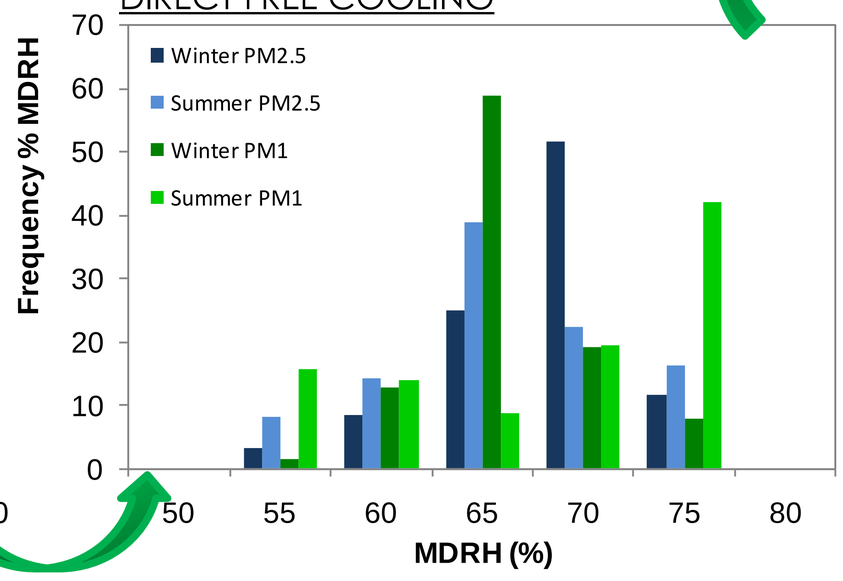
| | SPRING | | SUMMER | |
|---|---|---|---|---|
| | T (°C) | RH % | T (°C) | RH % |
| **PM2.5** | 12±5 | 72±19 | 21±5 | 72±17 |
| **PM1** | 12±4 | 72±18 | 23±5 | 69±15 |
| **PM0.4** | 12±1 | 77±9 | 26±1 | 61±3 |




**AEROSOL CHEMISTRY + THERMODYNAMIC CONDITIONS**




**Frequency distribution of MDRH + external air thermodynamic condition** allow to find the best thermodynamic range (the green one in the psychrometric table) to use the DIRECT FREE COOLING




## CONCLUSION

The study of **aerosol Hygroscopicity** coupled with aerosol concentration and thermodynamic studies allowed to find the best conditions to use a **DIRECT FREE COOLING** in a computer center.

This approach allowed to design a **cooling system able to save up to 60% of energy** compared to classical conditioning systems.