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Quality management for building performance

Το Ευρωπαικό έργο QUANTUM: Εργαλεία και υπηρεσιες για τη διαχείριση της κτιριακής απόδοσης

Building Green Open Space 2019

Metropolitan Expo, 20/10/2019, Athens

THE PROJECT

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Quality management for building performance - improving energy performance by life cycle quality management

Acronym: QUANTUM
Project number : 680529

European Commission
Horizon 2020

01|16 - 12|19

International Consortium
14 Partners
11 Countries

quality management, active functional specifications, energy performance, comfort

PARTNERS

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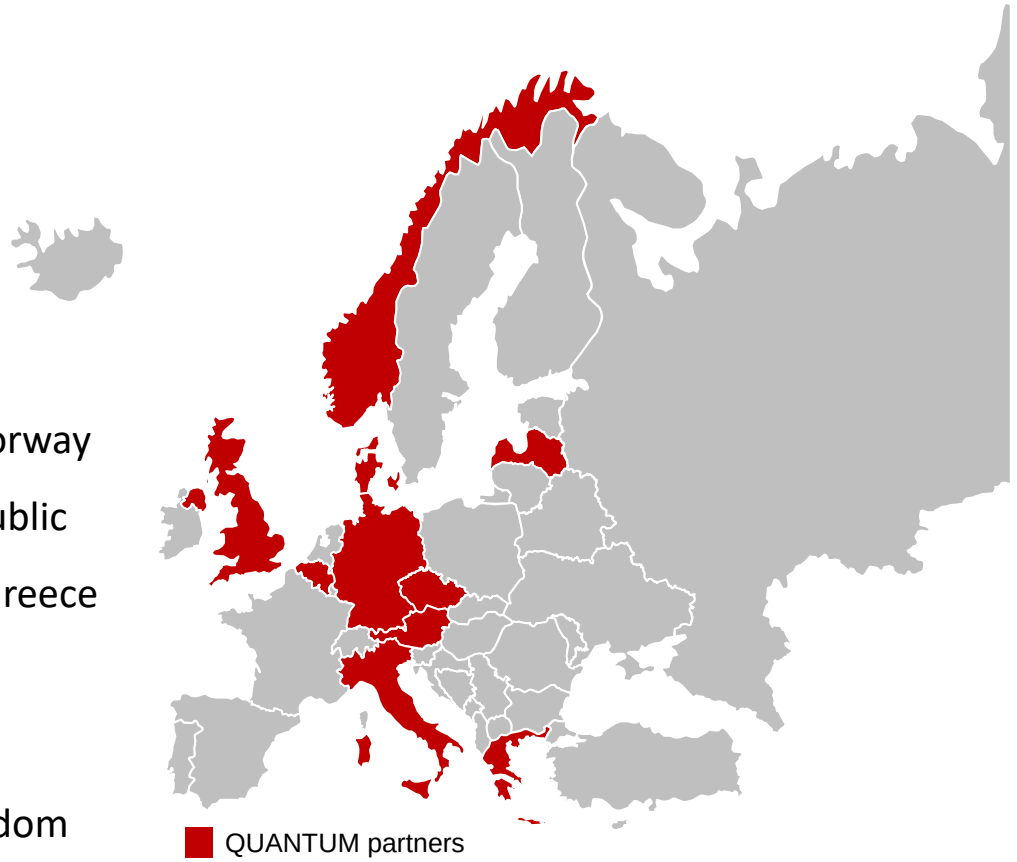
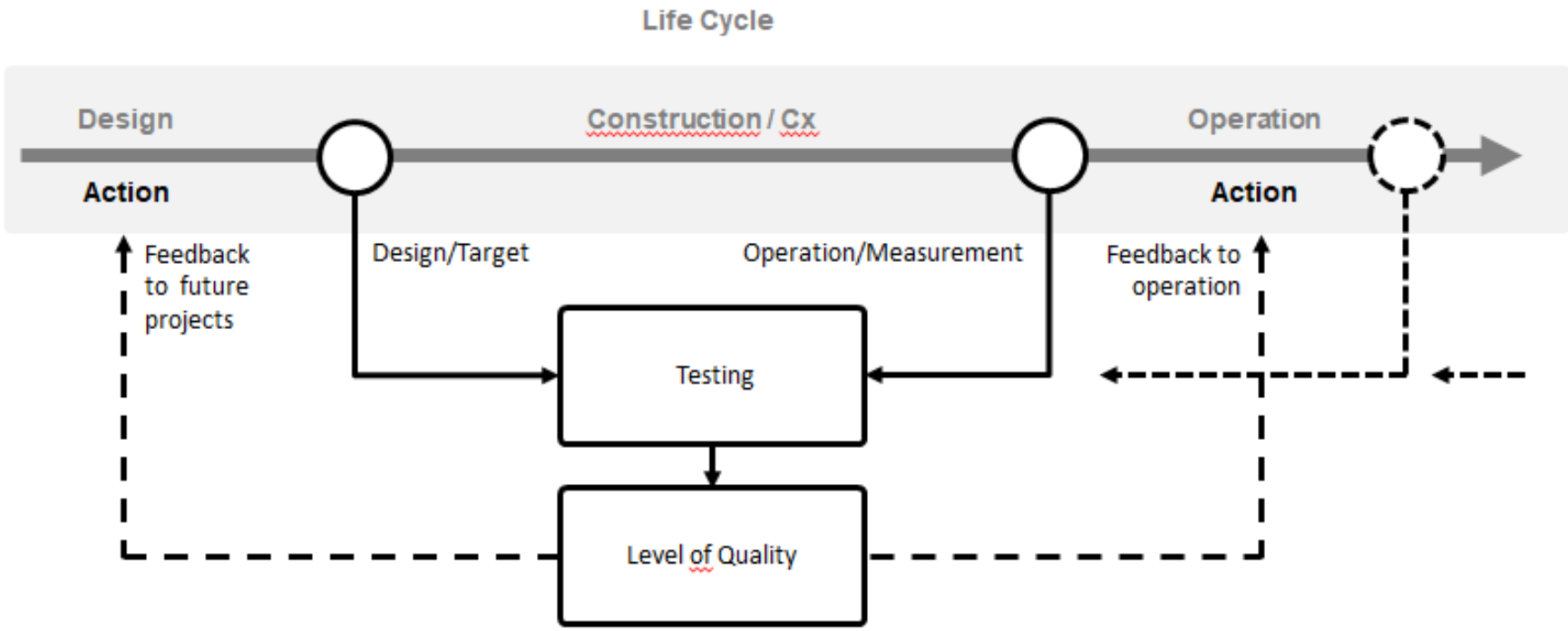
1. Technische Universitaet Braunschweig, Germany (Coordinator)
2. Factor 4 BVBA, Belgium
3. ENESA a.s., Czech Republic
4. E7 Energie Markt Analyse, Austria
5. COWI A/S, Denmark
6. SYNAVISION GMBH, Germany
7. Norges Teknisknaturvitenskapelige Universitet, Norway
8. Ceske Vysoke Uceni Technicke v Praze, Czech Republic
9. Ethniko Kai Kapodistriako Panepistimio Athinon, Greece
10. REHVA, Netherlands
11. EKODOMA, Latvia
12. Building Research Establishment LTD, United Kingdom
13. Energy Team spa, Italy
14. eERG Group - Politecnico di Milano, Italy



Introducing quality management into buildings



Regular design & Construction process

Quality Management

THE QUANTUM TOOLS

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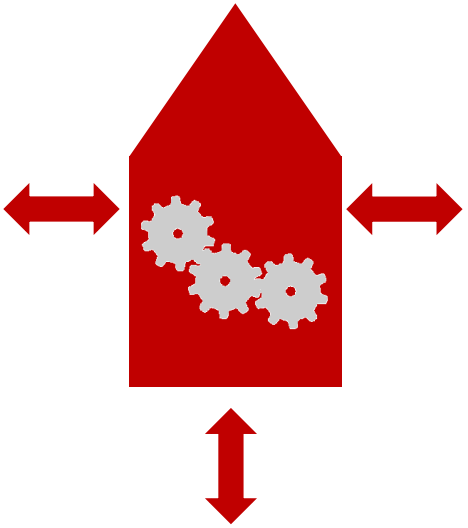
- Tool for functional specifications of Building Services
- Link between the description of individual BMS functions and an automated statistical analysis and evaluation of the corresponding operation data
- Clear metrics for system performance



COMFORTMETER
ONLINE COMFORT SURVEY TOOL

- Web based survey tool
- Questions related to different comfort, productivity and user related aspects
- Cost-effective, reliable and clear insight in the comfort performance of the building

NG-9 Next Generation Power Analyzer

- Application on electrical energy low cost sub-metering
- Development of energy management indicators
- Detection of unexpected energy consumption
- Real-time local analysis

THE QUANTUM TOOLS

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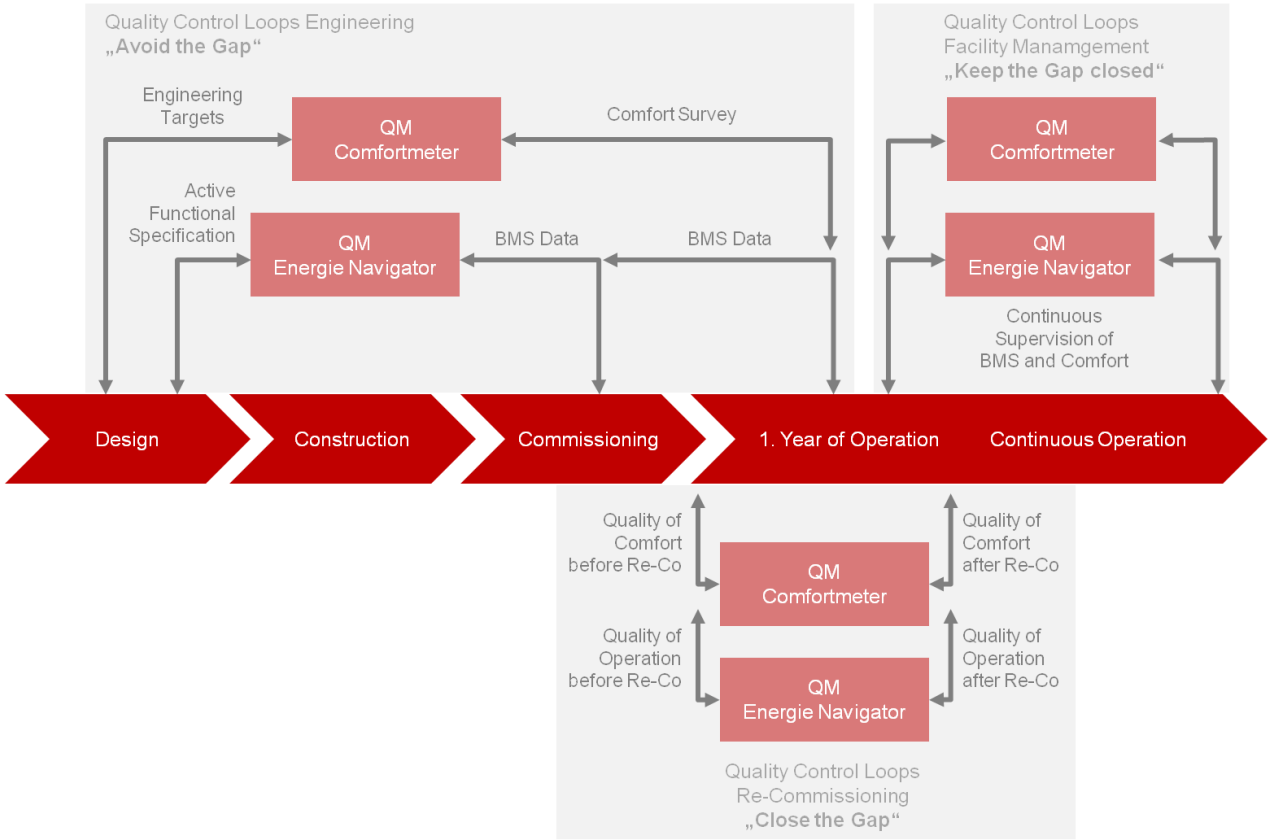
- Development of services and tools supporting QM in the design, construction, commissioning and operation phase
- Implementation of tools to a set of European buildings
- Dissemination about the advantages of comprehensive QM systems for the building industry
- At least 10% reduction in energy consumption
- Proof cost effective multiplication



WORK PLAN

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WP1 - Design of the quality management platform

WP2 - Development and validation of tools

WP3 - Services for quality management

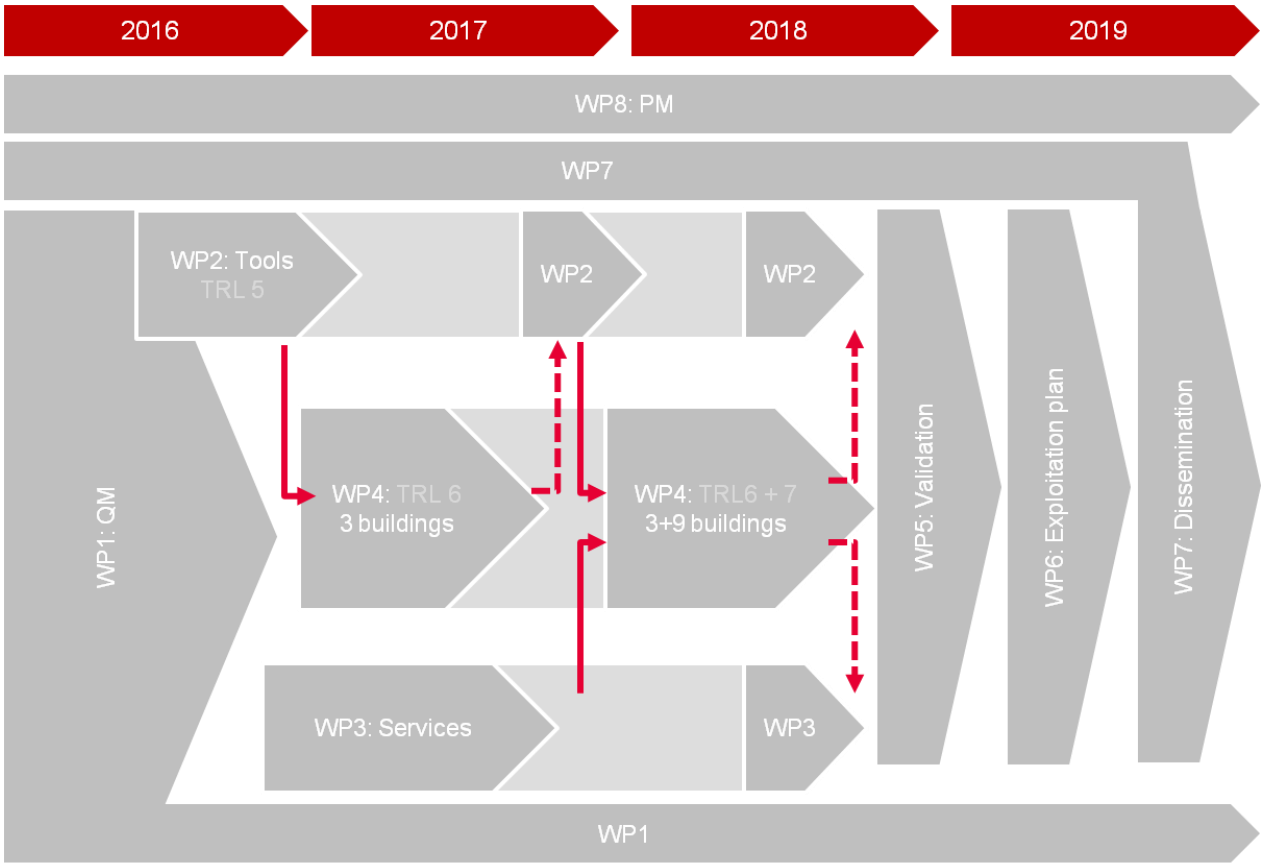
WP4 - Demonstration on buildings

WP5 - Overall evaluation and feedback

WP6 - Exploitation and business plans

WP7 - Dissemination

WP8 - Project management



Minimizing the gap

- Despite a proper planning there is a big gap between designed and achieved performance of building services. This is often caused by errors or malfunctions in the building automation and control level.
- Regularly these problems negatively affect energy demand, room comfort, persistence of system components etc.
- The following three tools aim to overcome this challenge. These tools are:
  - Performance Test Bench
  - NG-9
  - Comfortmeter

Performance Test Bench: a cloud computing software

The **Performance Test Bench** is a **cloud-computing based Software** for planning, commissioning and technical monitoring for holistically and sustainably Quality Management of the Building Automation.

With the digital **Performance Test Bench Tool** (PTB, previously called Energie Navigator) the **Building Management System functions can be checked and controlled**, using the so-called “active functional descriptions” that entail evaluation routines for system-specific performance indicators

The evaluation of the Building Automation system is carried out a) in newly constructed buildings or b) in already established ones. Therefore **PTB can be used either for a single optimization or to process quality control loops at all phases of the construction** and checks whether the system functions as planned or not and identifies actual optimization potentials.

Performance Test Bench: a cloud computing software

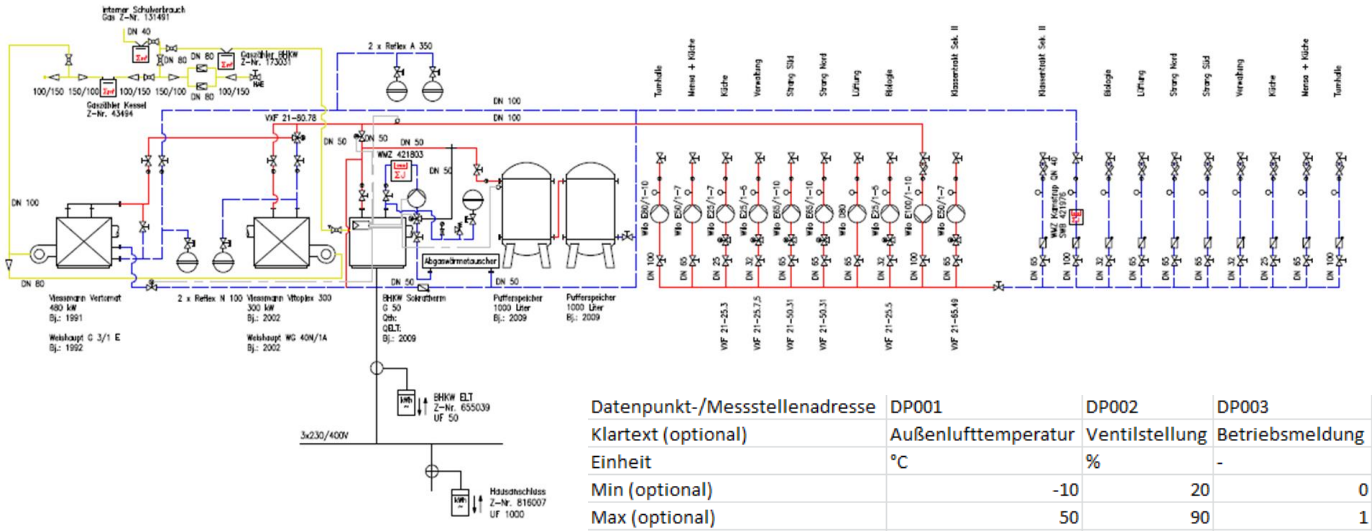
synavision

Digitaler Prüfstand

Requirements for applications in buildings

Check & Optimization of a Building can be achieved in **less than 4 weeks**

The **hydraulic scheme** of the building automation is needed as a first input to specify a data-point list within the PTB. Then the required data points are defined. The measured values are extracted from the building automation system and placed e. g. as a CSV-file in the tool.



Datenpunkt-/Messstellenadresse	DP001	DP002	DP003
Klartext (optional)	Außenlufttemperatur	Ventilstellung	Betriebsmeldung
Einheit	°C	%	-
Min (optional)	-10	20	0
Max (optional)	50	90	1
01.01.2014 00:00	5,3	0	0
01.01.2014 00:15	6,5	0	1
01.01.2014 00:30	7,2	25	1
01.01.2014 00:45	7,3	37	1
01.01.2014 01:00	7,5	52	0
01.01.2014 01:15	8,4	100	1
01.01.2014 01:30	9,3	87	1

NG-9: A 3 channel mono/three phases

The NG-9 is an electrical ***energy meter tool***. It is an **innovative** instrument because it is able to **measure up to 9 loads present** on a single phase, 3 three phases loads or a mix of mono/three phases loads.

The NG-9, compared to traditional methods of measurement of the absorbed current has interchangeable Rogowski Coils or Split Current Sensors with a range of 1-8000 Amps. With these methods of measurement, **during the installation** of the measuring instruments, **there is not necessity of plant shutdown**.

This obviously is an appreciable **advantage** in all scenarios **where power interruption has to be avoided**. In synthesis, **installation and configuration takes few minutes**.

NG-9 costs like any other multi-function device but it has higher initial features. Thanks to its small dimensions, it's possible an easy installation within the case of a panel. The color display with settable character size allows a quick consultation

Different fields of **applications**: offices, warehouses, retail centres, small and large factories, data centres and many more.

Different final **users**: Energy Managers, Maintenance and Production Managers, Energy Consulting Companies, ESCo, Energy Certifications (Diagnose, Audit).

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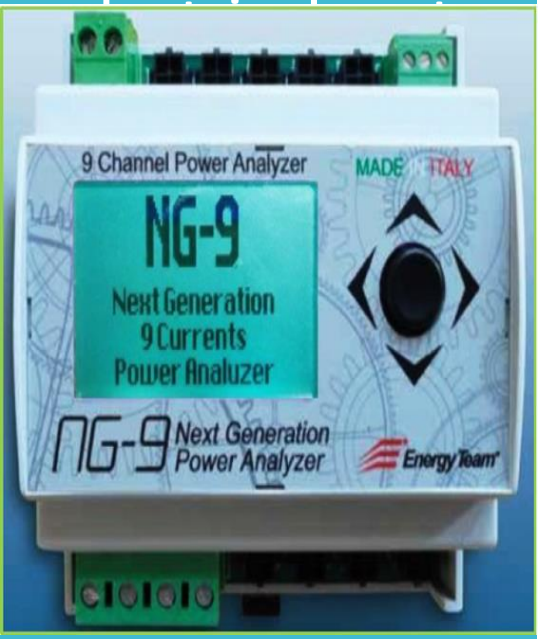
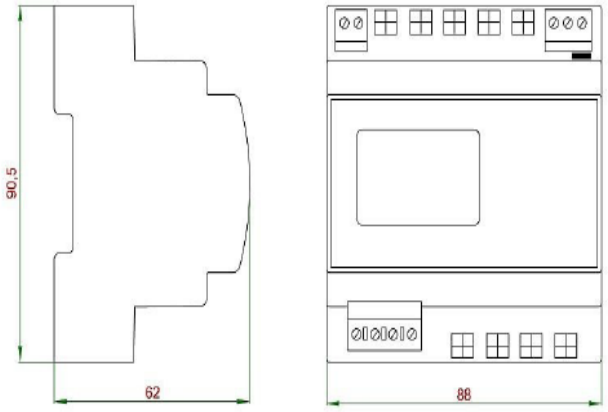
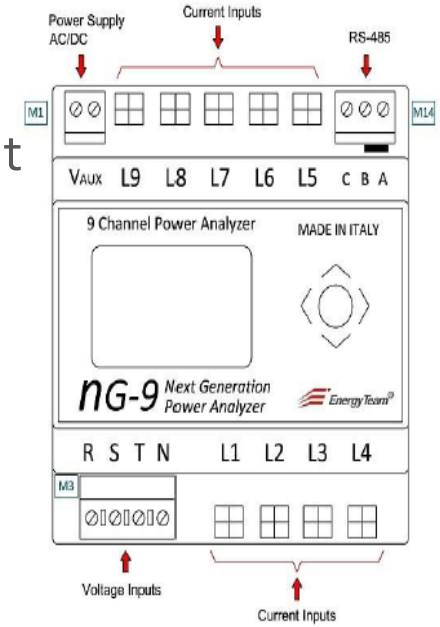
NG-9: A 3 channel mono/three phases





INPUTS / OUTPUTS CLAMPS AND CABLE SECTIONS



M1: **Power Supply** – Maximum cable section: ø 2 mm^2 (16 AWG)

M3: **Inputs Voltage** - Maximum cable section: ø 2.5 mm^2 (14 AWG)

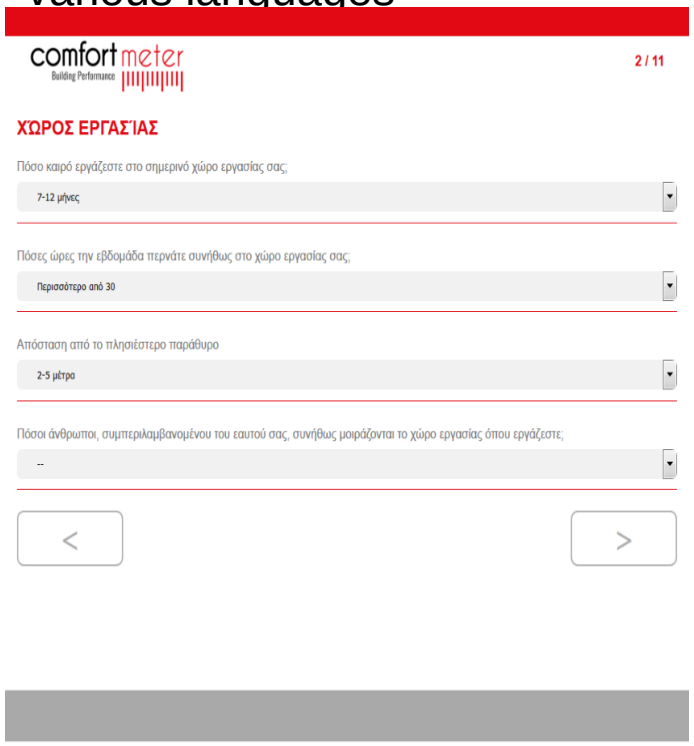
M14 : **RS-485** - Maximum cable section: ø 0.75 mm^2 (18 AWG) *Belden 9841*

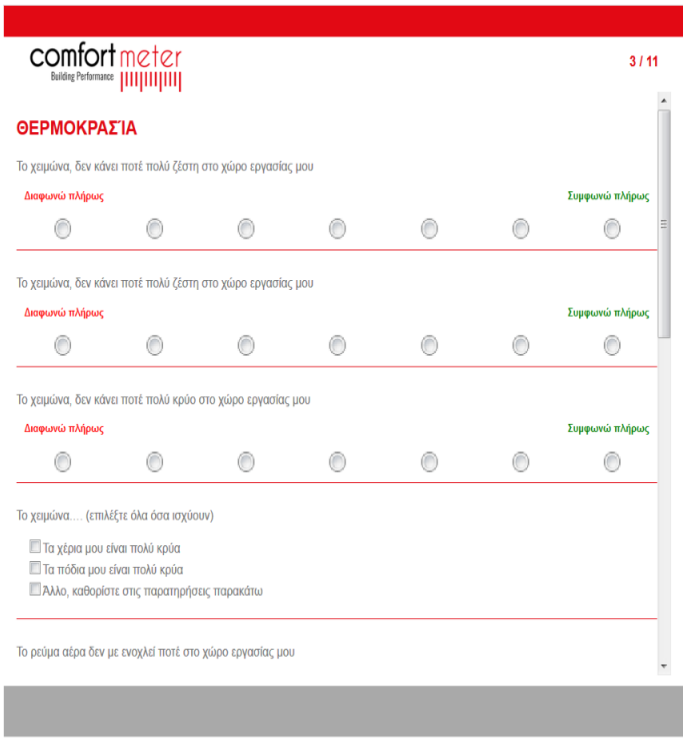
TECHNICAL FEATURES

Measurements on Network 50/60HZ	Unit of measure
Voltage	Vac
Active Power	W
Reactive Power	VAr
Apparent Power	VA
Three-phase equivalent current	A
Line current	A
Cosφ	
Power Factor	
Active Energy delivered	Wh
Active Energy absorbed	Wh
Reactive Inductive Energy	VArh
Reactive Capacitive Energy	VArh
Frequency	Hz
Accuracy	Class 0,5
Power Supply	**Unit of measure**
Voltage	Vac: 90÷250V, Vdc: 24÷120V
Frequency	Hz: 50÷60
Consumption	AC: 1,5VA max, DC: 1,5W max
General	**Unit of measure**
Voltage Inputs. Nr. Channels: 3	Maximum working voltage: 430 V peak, phase-neutral 300 Vac phase-neutral 520 Vac phase-phase
Current Inputs. Nr. Channels: 3	A (on display)
Protection Degree	IP20
Weight	gr. 95 (without external sensors)
Maximum dimensions: L x H x W	mm 88 x 90,5 x 62 (5 mod. DIN) T35 DIN rail mounting.
Working temperature	-5 °C ÷ +60 °C
Relative humidity	95% without condensation
Display	Graphic display 128x64 pixel, with multicolor desktop RGB LED.
Keyboard	5 functions selector button
Communication Interface	RS-485 ModBus RTU, maximum bit rate selectable: 115200 bps.

Comfortmeter: A web based survey tool for the physical comfort

- The Comfortmeter is a **web based survey tool** that provides essential management information to improve the physical comfort in an office building. Available in various languages





- As a Comfortmeter client you receive a reliable insight in the comfort situation of your buildings via a **clear-cut comfort report**. The report informs you in detail whether there are major comfort problems in the building and if so, in which building zones they occur and which aspects are concerned (e.g. too hot or too cold in winter).

Comfortmeter: A web based survey tool for the physical comfort

comfort meter
Building Performance

- The Comfortmeter exists out of 3 modules:
- A module for the survey and building data (building information data)
- A module for the survey of comfort and user data (the actual survey)
- A data processing and reporting module
  - The report contains essential management information that will help you to:
  - Evaluate the effectiveness of building service providers
  - Justify facility expenditures to management
  - Assess the effectiveness of improvements
  - Stay aware of the occupants' perceptions of the building
  - Enhance the communication between management, facility operators and building occupants

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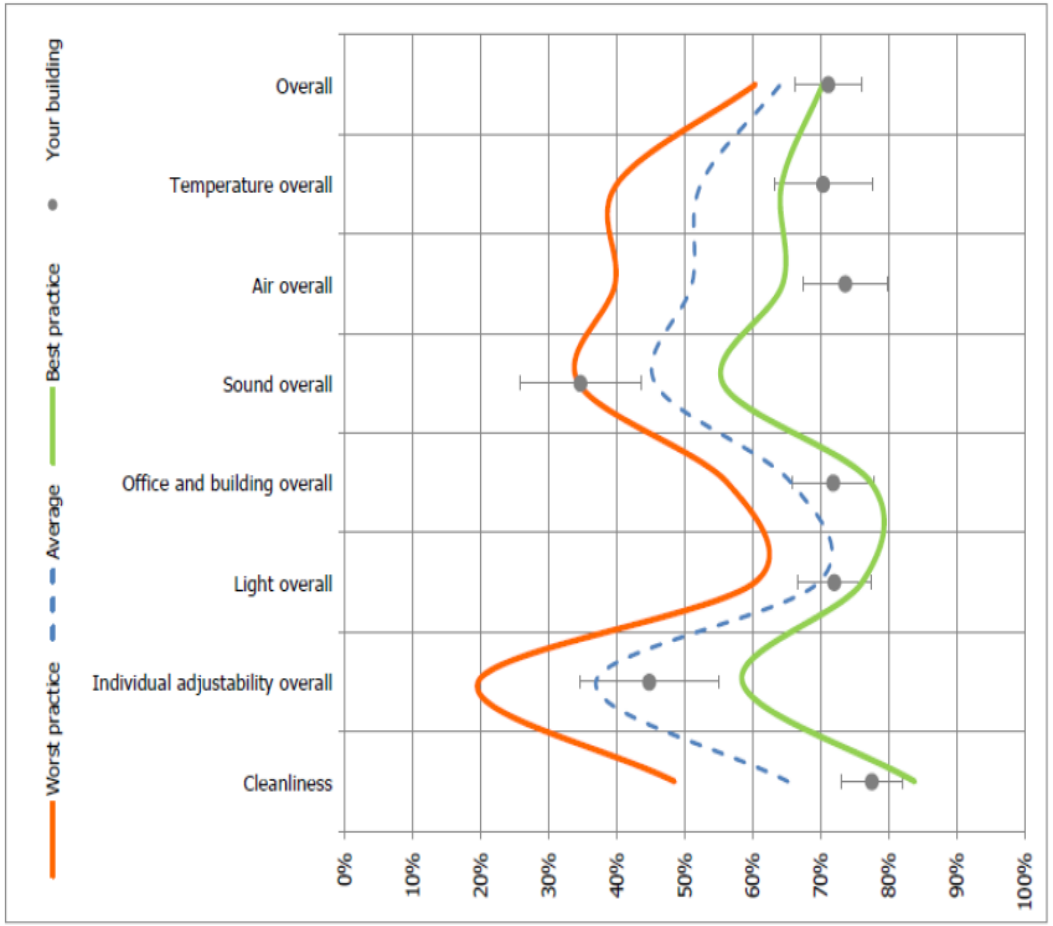
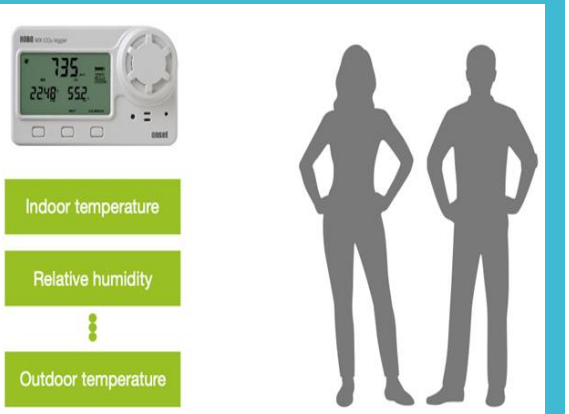
Comfortmeter: A web based survey tool for the physical comfort

comfort meter
Building Performance



- Scientific studies prove that physical comfort has a significant effect on employee productivity and job satisfaction. This means that the Comfortmeter **report contains crucial information** that will help you **to increase job satisfaction and productivity**.

The CM Experiment

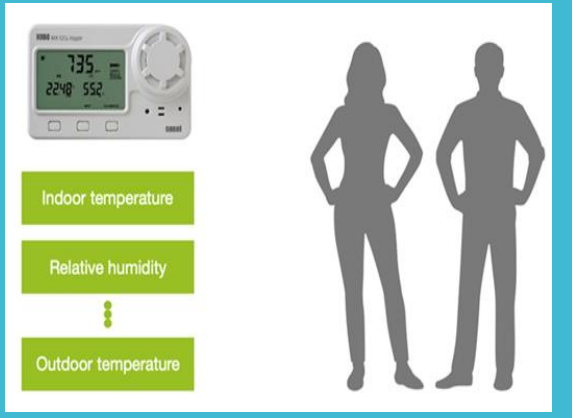


The Comfortmeter aims at using people as sensors to sense the overall quality of the office environment. Its advantage is that it considers the direct response of people about the perception they have about the perceived indoor environment and space. However, it doesn't account for any physical parameter that describes microclimate to which people are exposed.

In order to bridge the gap between the above-mentioned features, **an experiment was set to investigated and search for any relationship between people perceived thermal comfort and physical variables describing the indoor and outdoor thermal environments.**

Relationships will be investigated for example using a correlation analysis between the actual measurements and perceived thermal comfort and, possibly, they may provide operational information on how to optimize the behavior of the buildings.

The CM Experiment



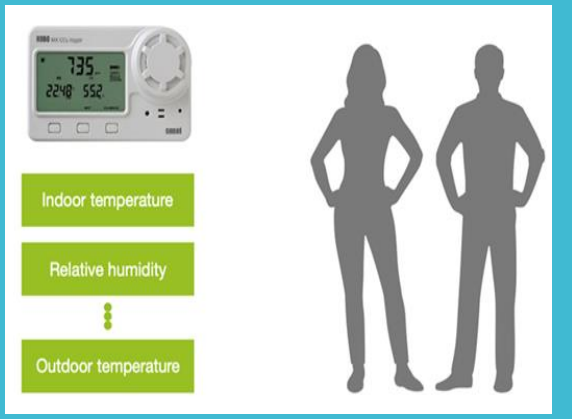
Following partners are taking part in the experiment:

- Norges Teknisk-Naturvitenskapelige Universitet (NTNU)
- Technische Universitat Braunschweig (IGS)
- Politecnico Di Milano (eERG-PoliMI)
- Ethniko Kai Kapodistriako Panepistimio Athinon (UOA)
- Eske Vysoke Uceni Technicke V Praze (CVUT)
- Factor 4 BVBA (Factor4)

The population of the experiment is employees working in project partners countries offices

It was decided to have at least four rooms per partner where indoor environmental data were collected and at least four people who are accommodated in the given offices and going to take part in the Comfortmeter surveys. Also, an experiment sample should contain at least 50% of non-energy expert in order to reduce a possible bias in the survey responses.

The CM Experiment



The experiment and data collection lasted one year. During this period, at least the following indoor and outdoor environmental variables have to be collected by measuring equipment:

- Indoor

1) (Dry-bulb) air temperature

2) Relative humidity or Dew-point temperature

- Outdoor

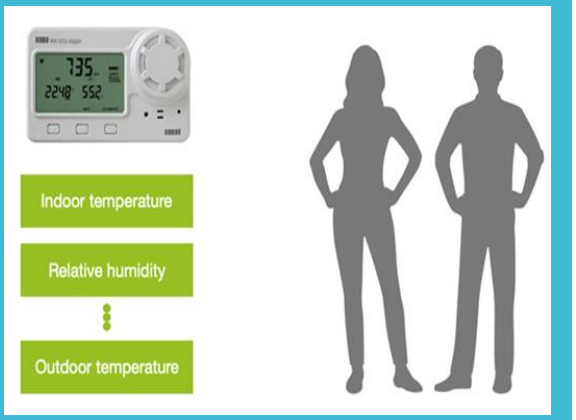
1) (Dry-bulb) air temperature

2) Relative humidity or Dew-point temperature

In parallel, 8 Comfortmeter surveys were scheduled with 1.5-month interval.

Each survey was sent by e-mail, and participants had 8 to 11 days to fill in their answers.

The CM Experiment in UoA : people & data



- Experiment started in 1st of March 2018 until 15th of October 2019
- Collection of field data in 5 offices
- 30 persons: 12 men and 18 women
- 9 surveys completed
- Indoor data measured every 15mins:
  - Air Temperature
  - Relative Humidity
  - CO_2
  - VOCs
- 6 Indoor Air Quality stations were deployed (photo)
- Outdoor data measured every 10 mins:
  - Solar Irradiance
  - Air Temperature
  - Relative Humidity
  - Wind speed
- Department of Physics meteorological station

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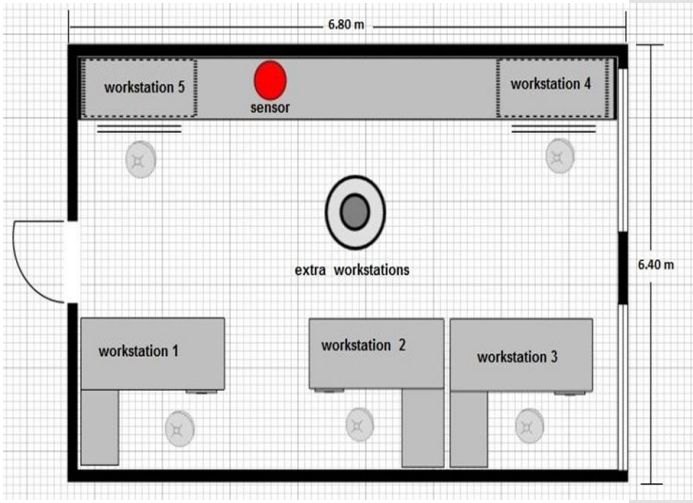
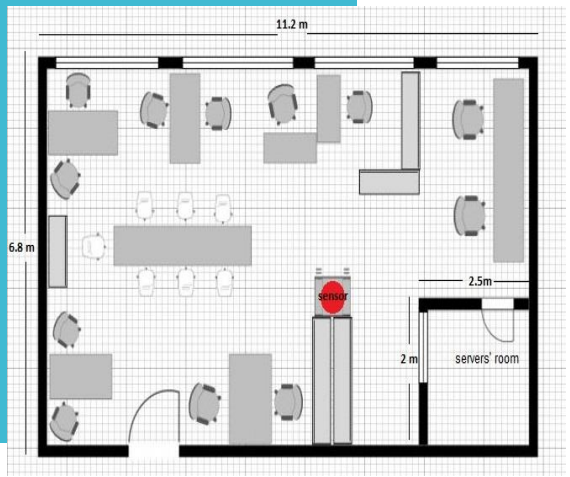
The CM Experiment in UoA : offices & sensor points

Office 1

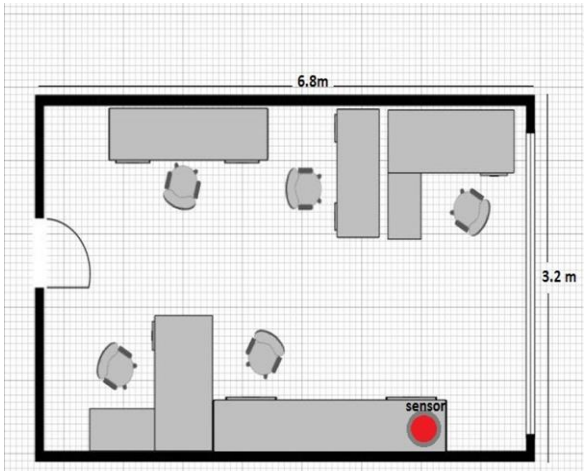
Office 2



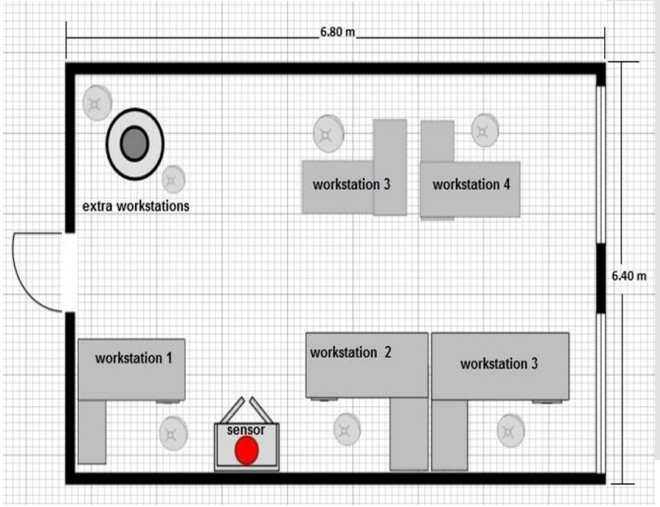
Office 3



Office 4



Office 5



The CM Experiment in UoA: Data Series

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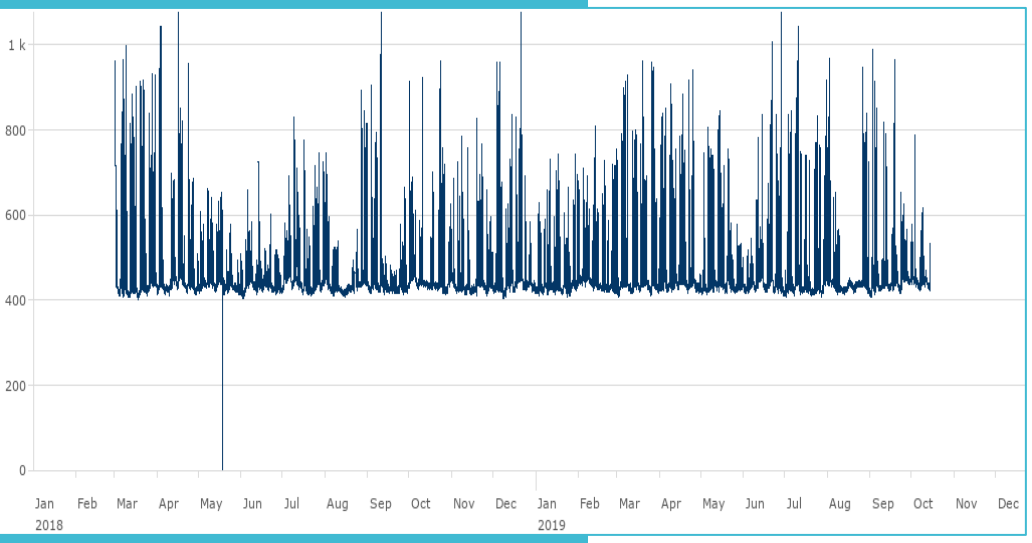
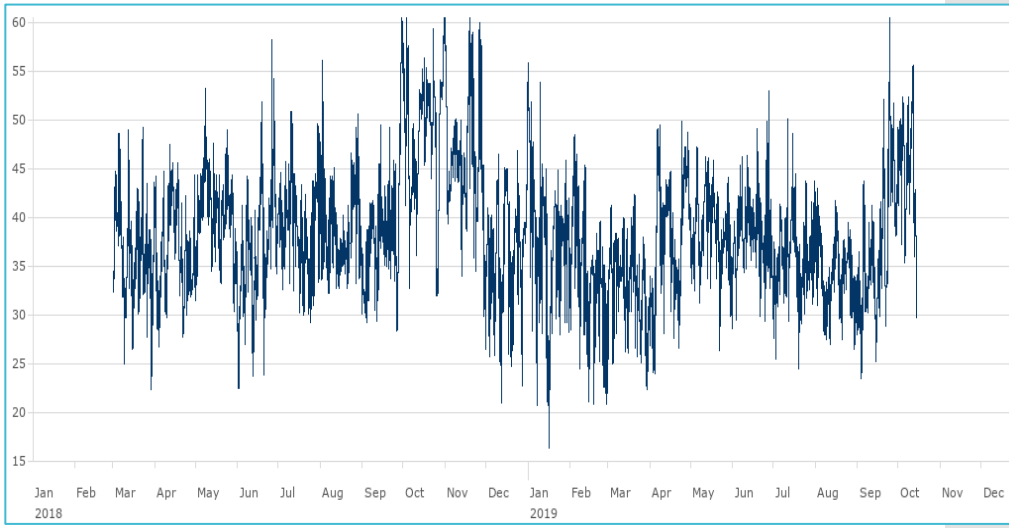
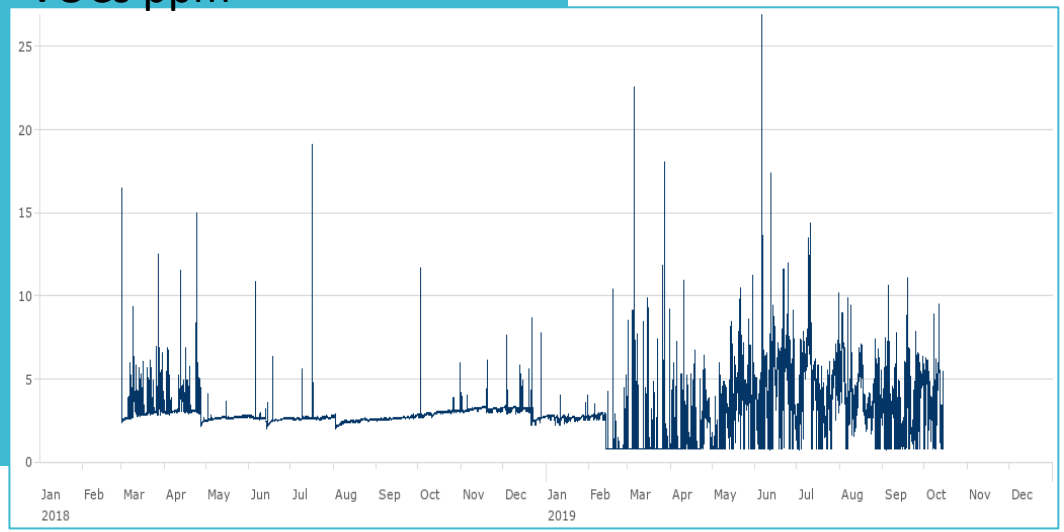
CO2 ppm



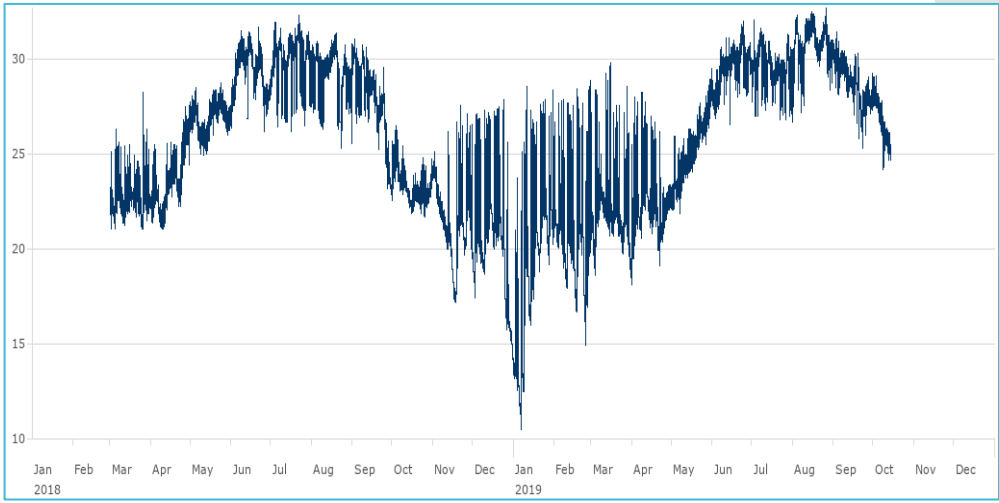
Humidity % RH



VOCs ppm



Temperature °C



Data collection from the offices as well as the online surveys lasted until 15 of October 2019 . Due to that the results are not fully assessed yet.

PILOT CASE STUDY:
DIMAND SA BUILDING IN ATHENS

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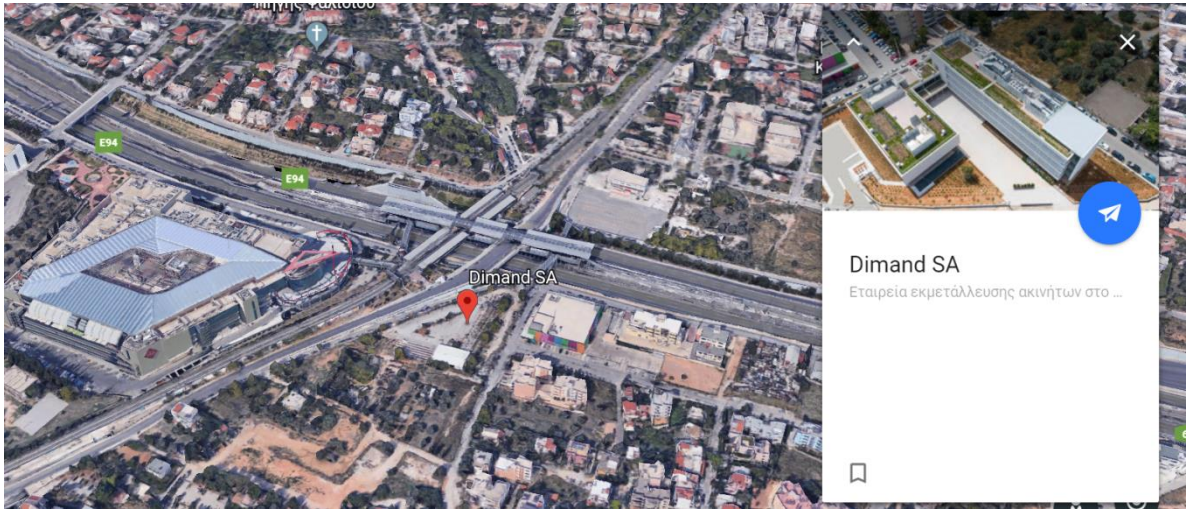
- Dimand is a real estate company located in Marousi, Greece

- Builging design with emphasis to sustainability
  - Green roof
  - Automated lighting systems
  - Central heating/cooling

- Located near Attiki Highway – Constant vehicle flow
- Northeast building orientation



PILOT CASE STUDY:
DIMAND SA BUILDING IN ATHENS

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For the purposes of **Quantum Project** (H2020 Grant agreement 680529)

- Measurements were undertaken from July 24th- August 5th , and September 15th 2019-ongoing
- 3 different scientific instruments were deployed and monitored (IAQ, SWEMA Thermal Comfort, HAZ-SCANNER 6000)
- Main target was to assess the thermal conditions and the air quality in the company's offices
- Monitor the outdoor air quality
- Export indexes to determine the thermal comfort
- Compare results with measurements undertaken at the Department of Physics offices

Experimental procedure - Experimental equipment

Thermal comfort	SWEMA Thermal Environment	• Temperature (°C) • Relative humidity (%) • Radiant temperature (°C) • Wind speed (m/s) • PMV • PPD	Every 5 minutes	
Indoor Air Quality	IAQ Tongdy sensors	• Temperature (°C) • Relative humidity (%) • Carbon dioxide (ppm) • TVOCs (ppm)	Every 15 minutes	
Outdoor conditions	HAZ SCANNER Model HIM 6000	• Temperature (°C) • Relative humidity (%) • CO_2 • CO • NO • NO_2 • PM_{10} • $PM_{2.5}$ • Relative humidity • TVOCs • Wind Speed • Wind direction	Every 10 minutes	

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DIMAND SA BUILDING IN ATHENS

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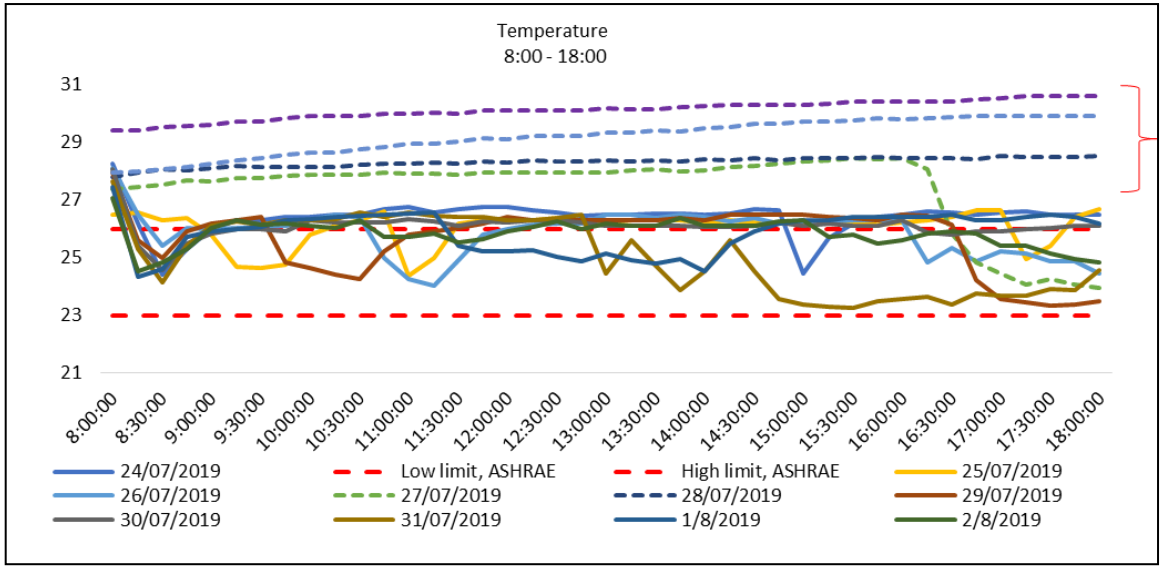
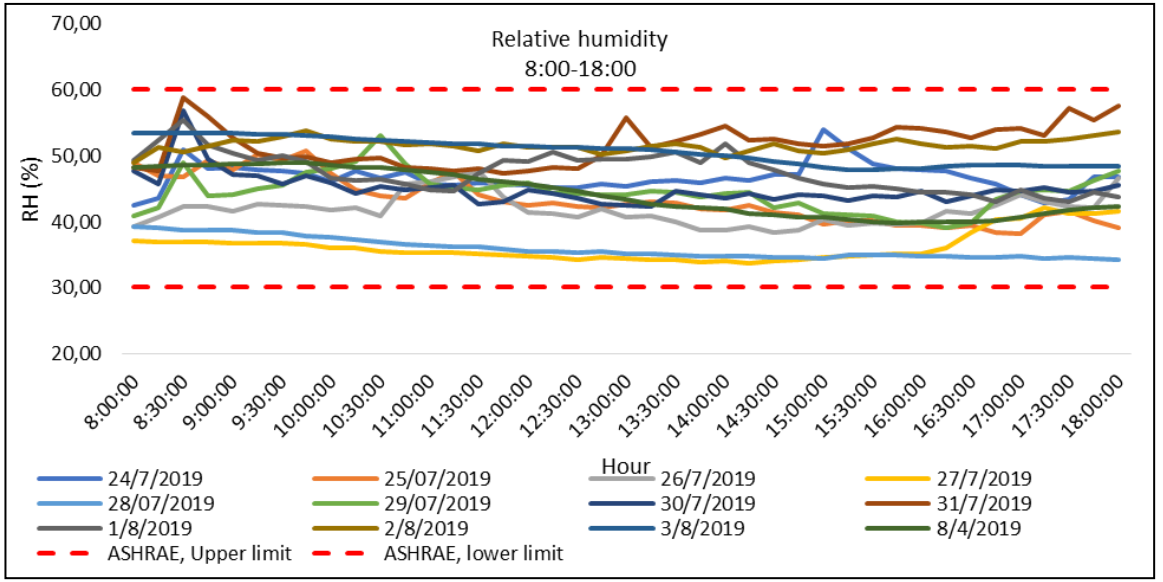


weekend



Thermal conditions

- During office hours, temperature was mostly within the ASHRAE limits
  - Max=26°C, Min=23°C
- Temperature decreases after 8:00 – A/C activation
- Most cases that surpassed the limits, during working hours, was by a small margin (~0.5°C)
- Almost 100% of the cases during the weekends were above the respective limit
- Humidity was bellow the limits as set by ASHRAE – Average : 44,5%
- During weekends, humidity levels are mostly stable
- Fluctuations are observed mainly due to the opening of windows, especially after 17:00

PILOT CASE STUDY:
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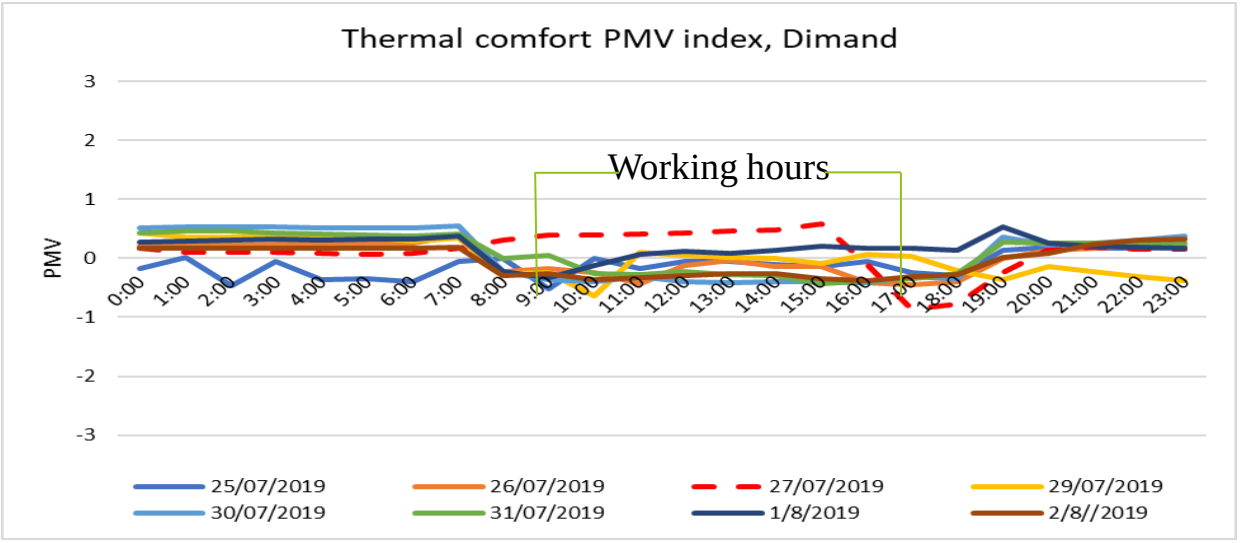

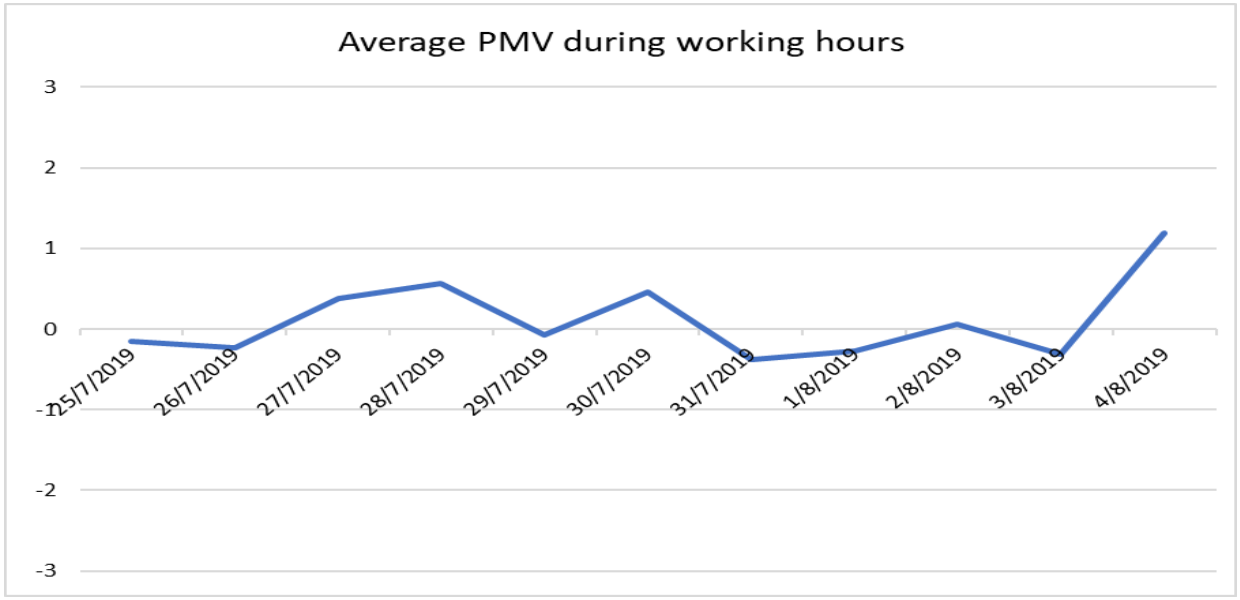

- **PMV** index predicts how a large group of persons would respond on the thermal conditions – Range:-3 (cold) to +3 (hot), *ANSI/ASHRAE*
- For the calculation of PMV the appropriate metabolic rate and clothing factor were chosen
- **PMV** index is in the range of the respective limits
- Higher **PMV** values (Max=2.11) were observed mainly on weekends
- During working hours, the **PMV** values were close to 0 - Average **PMV** was 0,11
- Indication of **optimal** thermal conditions

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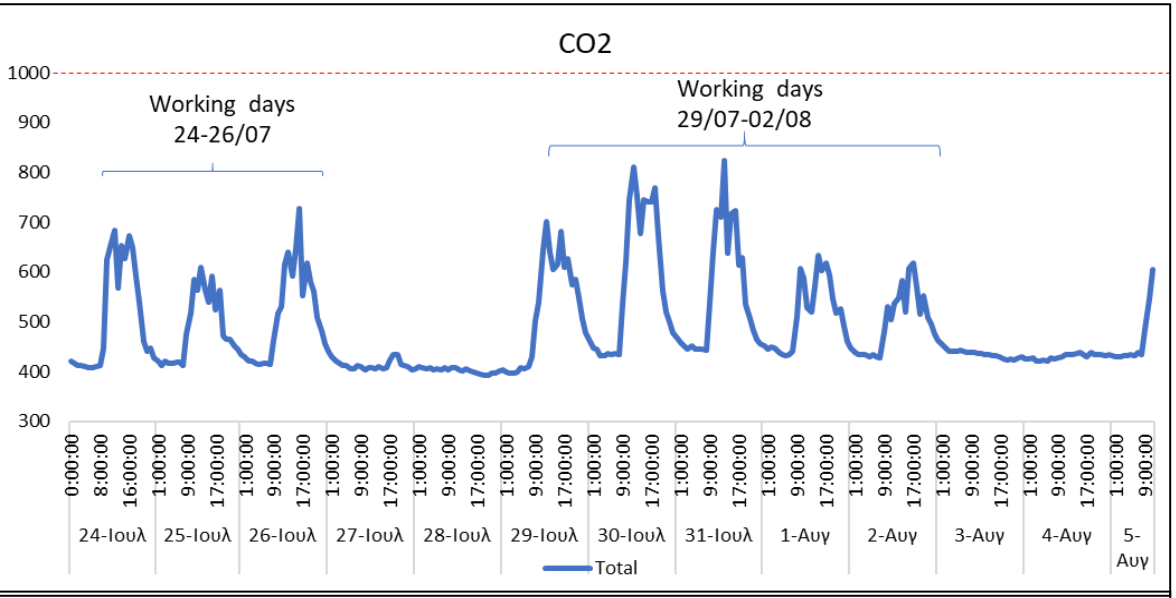

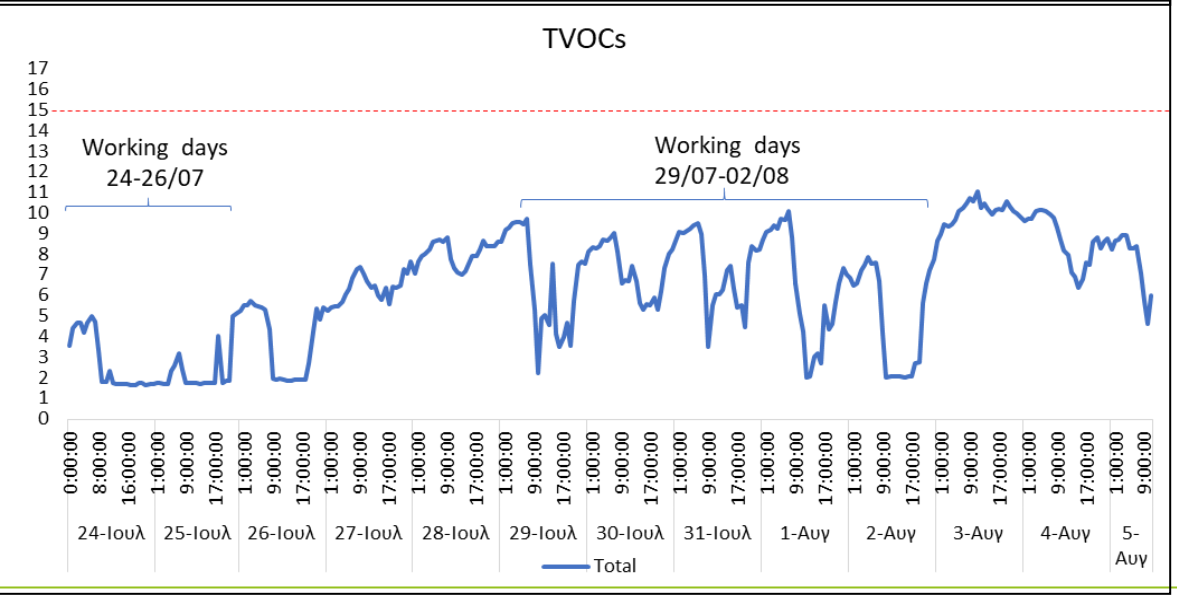

INDOOR AIR QUALITY

- **Carbon dioxide – CO_2**

  - ❖Carbon dioxide levels are within the ASHRAE limits, <1000 ppm
  - ❖Higher concentrations during working hours – anthropogenic source
  - ❖During weekends the CO_2 concentration reaches almost 400 ppm

- **Total Volatile Organic Compounds (TVOCs)**

  - ❖All TVOCs' cases were bellow the manufacturer's tolerance limits (<15ppm)
  - ❖Main sources are cleaning material used after working hours

Overall air quality within the limits – Indication of a good ventilation system during working hours

PILOT CASE STUDY: DIMAND SA BUILDING IN ATHENS

HELLENIC REPUBLIC
National and Kapodistrian University of Athens
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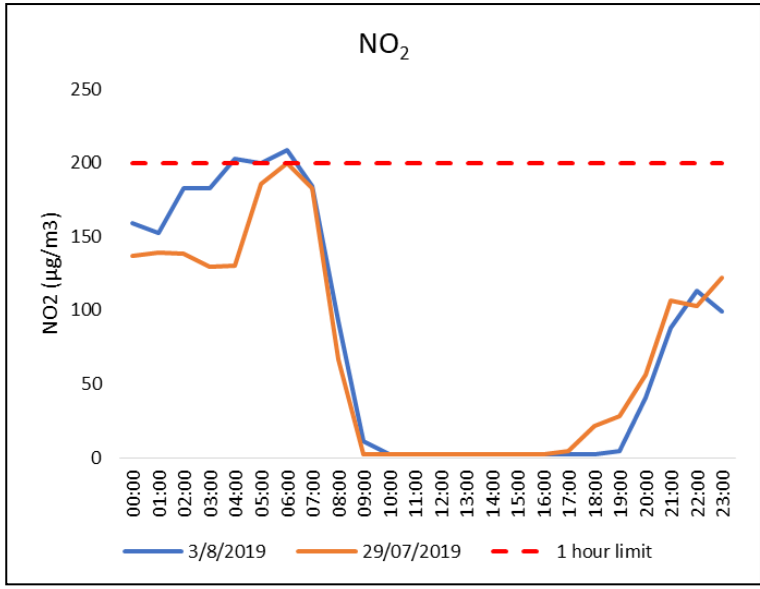
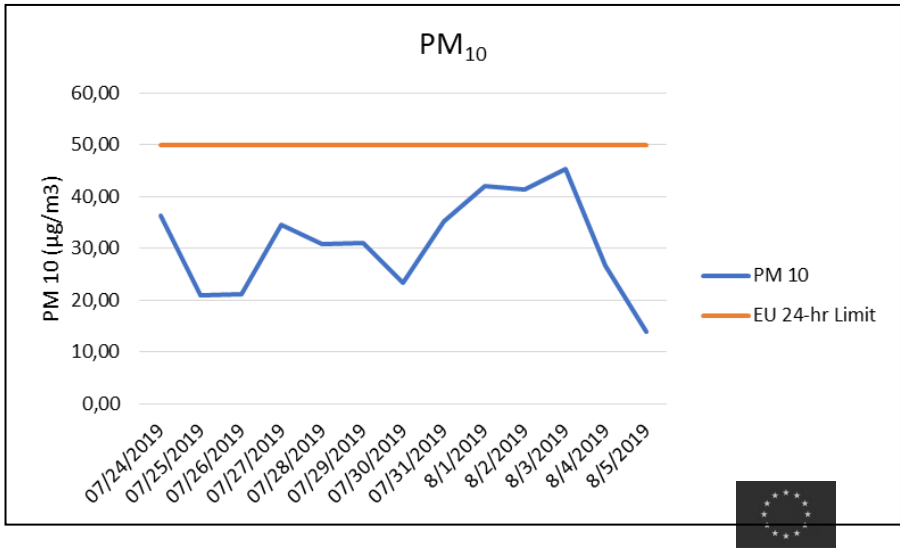
OUTDOOR CONDITIONS

Dimand, 24/07 – 05/08									
	PM_{10} (µg/m3)	$PM_{2.5}$ (µg/m3)	CO_2 (ppm)	CO (ppm)	NO (ppb)	NO_2 (µg/m3)	TVOCs (ppb)	Relative Humidity (%)	Temperature (°C)
Mean	31,64	23,07	358,07	0,23	18,62	66,07	14,86	44,73	27,51
Std. Deviation	36,53	31,54	10,47	0,13	23,01	62,14	13,57	12,87	3,28
Maximum	241,00	237,00	402,00	0,81	118,00	227,50	58,00	76,00	36,00
Minimum	2,00	1,00	330,00	<0.01	1,00	2,50	<0.01	14,00	20,00



- High temperatures were recorded, reaching up to 36°C, with a daily mean average bellow 30°C
- The mean values of the pollutants were bellow the respective limits
- There were some cases for NO_2 that surpassed the EU hour limit of 200 µg/m^3
- PM_{10} values were bellow the EU's 50 µg/m^3 daily limit



Conclusions

✓In overall the thermal conditions and the air quality in Dimand's offices, during working hours, were satisfactory

✓Cases that were out of limits were observed – Not during working hours

✓The temperature levels during working hours and the PMV values are within the respective limits

✓Thermal comfort conditions are the optimum according to ASHRAE's scale

✓The same occurs for the outdoor measurements - Some cases out of limits

✓The air quality is not affected significantly by Attiki highway

✓The measurements are currently ongoing

Thank you for your attention

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