European Network on New Sensing Technologies for Air Pollution Control and Environmental Sustainability - *EuNetAir*

COST Action TD1105

Focus Group Meeting on

Innovation on Environmental Sensor Technologies

Siemens AG - Corporate Technology
Munich, Germany, 29 April 2015

Action Start date: 01/07/2012 - **Action End date**: 30/06/2016 - **Year 3**: 2014-15 (***Ongoing Action***)

PLAN for a REPORT

INNOVATION on ENVIRONMENTAL SENSOR TECHNOLOGIES

Michele Penza

Function in the Action: Action Chair

ENEA - Brindisi, Italy

COST is supported by the EU Framework Programme

ESF provides the COST Office through a European Commission contract

FOCUS GROUP MEETING: MUNICH, Germany

organized and hosted by SIEMENS AG

AGENDA	
29 April 2015 - Wednesday	
09:30 - 16:00	***REGISTRATION***
10:00 - 10:10	**Welcome Address**
10:10 - 11:30	**Session 1: Oral Presentations**
11:30 - 12:00	*Coffee Break*
12:00 - 13:00	**Session 2: Oral Presentations**
13:00 - 14:30	*Lunch*
14:30 - 16:30	**Session 3: Discussion on Methodology and Preliminary Drafting of Report on Innovation**
16:30	*Closure of Meeting*



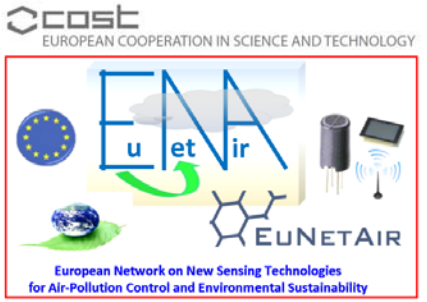
COST Action TD1105 *EuNetAir*: FOCUS GROUP MEETING

Innovation on Environmental Sensor Technologies

- **Welcome Address from COST Action TD1105 EuNetAir**
- Dr. Michele Penza, Action Chair

  ENEA, Technical Unit for Materials Technologies, Brindisi (Italy)

Outline



- **Focus Group Innovation:**
  - ✓ *Scientific context for Air Quality Control*
  - ✓ AQ Sensors *addressed by the Action*
- **Setup of the FG for Report Innovation:**

✓ *Objectives and Scope*

- **Report *Innovation on Environmental Sensor Technologies***
  - ✓ *Definitions and Further Processing*
- **Future Plans and Challenges:** *Expected Impact*
- **Concluding Remarks**

COST Action TD1105 *EuNetAir:* FGM on Sensor Innovation

Statistics of Focus Group Meeting at Munich (29 Apr 2015):	
e-COST Registered Participants / Total Participants:	15 / 15
Sessions: Focus Group Meeting	3
Involved Teams:	13
Participants from Universities:	7 (47.0%)
Participants from Research Centers:	4 (26.5%)
Participants from Companies:	4 (26.5%)
Reimbursed Participants:	13
COST Countries involved in Focus Group Meeting: *Austria, Denmark, Germany, Greece, Italy, Portugal, Spain, Sweden, Turkey, United Kingdom*	10
Gender Balance in Focus Group Meeting:	1 F (6.5%) 14 M (93.5%)
Early Stage Researchers (ESRs):	1 (6.5%)

COST Action TD1105 *EuNetAir*: FGM INNOVATION on

New Sensing Technologies for Air-Pollution Monitoring

COST Action TD1105 *EuNetAir*: FOCUS GROUP MEETING

Innovation on Environmental Sensor Technologies

AIM and OBJECTIVES of FGM at Munich

- **Scope of Meeting**:

Start the process in the definition and writing of a **REPORT** ***Innovation on Environmental Sensor Technologies*** as important deliverable of the COST Action TD1105 (see ***Memorandum of Understanding - MoU. Recommendations on AQC***)

- **Deadline for Report:**

May 2016 (End time of *EuNetAir*, maybe Action Extension to be requested to *COST Association* till *December 2016*. MCM at Linkoping, 5 June 2015, for final decision on Action Extension)

- **By-products:** ***Joint-Publication(s)*** on sensors innovation in archival journals and/or magazines

How to manage REPORT on Innovation (1/5)

- **Who involve**:

MC and WG Members (*Voluntary and mentioned authors*)

- **Which topics/contents:**

Political, Economic and Technical Framework; EU AQ Regulation; EU Research and Innovation; Best Practices in AQ; Standards/Protocols; National Activities; Conclusions/Recommendations; References; List of Authors
(**Marco Alvisi** will present a detailed and open *Table of Contents* for Report ***Innovation on Environmental Sensor Technologies***).
Suggestions to improve are highly welcomed !

How to manage REPORT on Innovation (2/5)

- **How work**:
  - **Filling the Executive Summary and ToC at Munich, TODAY !**
  - **Filling the *Agreed Forms* by MC/WG Members and replied to** (***Michele Penza*** - *michele.penza@enea.it*; ***Marco Alvisi*** - *marco.alvisi@enea.it*; ***Annamaria Demarinis*** - *annamaria.demarinis@uniba.it*)
  - **Merging of the Filled Forms in a single Report** by *Annamaria Demarinis*
  - **Progress Report Monitoring** at each next *EuNetAir* meeting (2015-2016) by *Marco Alvisi*
  - **Final Review and Validation of Report** *by Action MC (May 2016)*

COST Action TD1105 *EuNetAir*: FOCUS GROUP MEETING

Innovation on Environmental Sensor Technologies

How to manage REPORT on Innovation (3/5)

- **Where circulate**:
  - **COST Association**
  - **EC: DG R&I; DG ENV; other EC Directorates**
  - **European Environment Agency (EEA)**
  - **National Environmental Agencies**
  - **WHO Europe**
  - **AQUILA - Network of Air Quality National Reference Laboratories to fulfil EU Directive Ambient Air 2008/50/EC**
  - **CEN / TC264:** *Air Quality - Performance evaluation of sensors for the determination of concentrations of gaseous pollutants and particulate matter in ambient air* (*chaired by Dr. Michel Gerboles. Candidate Observer: Michele Penza*)
  - **ESSC - European Sensor System Cluster**

by Action Chair on behalf of Action MC

How to manage REPORT on Innovation (4/5)

- **What interlink**:
  - **Position Paper ESSC - European Sensor Systems Cluster**

Chairman: Michele Penza; WG Indoor AQ Sensors Leader: Andreas Schuetze; Coach: Rudolf Frycek; Observer: Hans-Hartmann Pedersen, EC DG R&I Officer

  - **NGAM Roadmap for Next Generation of Air Monitoring**

by US Environmental Protection Agency (EPA). Contact Points: Dr. Tim Watkins and Dr. Viens Mattheus (http://epa.gov/research/airscience/docs/roadmap-20130308.pdf)

  - **Trillion Sensors Summit**

by Janusz Bryzek (http://www.tsensorssummit.org)

COST Action TD1105 *EuNetAir*: FOCUS GROUP MEETING

Innovation on Environmental Sensor Technologies

REPORT on Innovation (5/5)

- **Upcoming Related Events**:
  - **Kick-off Meeting ESSC - European Sensor Systems Cluster**

19 May 2015 - Nurnberg Convention Center, NCC West, Nurnberg (Germany)
at the **SENSOR+TEST Fair**
Some Speakers: Michele Penza, Andreas Schuetze, other ESSC SC Members

  - **EuroNanoForum 2015 Conference**

10 - 12 June 2015 - Radisson Blu Hotel, Riga (Latvia)
organized by EC DG R&I under auspices of the LV Presidency of the EU Council
Invited Speaker: Michele Penza

  - **EMRS Spring Meeting 2016 Symposium**

2 - 6 May 2016 - Lille Grand Palace, Lille (France)
Functional Materials for Environmental Sensors and Energy Systems
Symposium Organizers: Michele Penza, Anita Lloyd Spetz,
Albert Romano-Rodgriguez, Meyya Meyyappan

Year 3: Scientific Planning of *EuNetAir* (1/3)

Meetings/Workshops/Training Schools planned **for upcoming year** (**Year 3: 1 July 2014 - 30 June 2015**):

- **WG1-WG4 Meeting** on *New Sensing Technologies for Air-Pollution Monitoring and Start of the Air Quality Joint-Exercise Intercomparison* at IDAD - University of Aveiro, Aveiro (**Portugal**), 13 - 15 Oct. 2014.

- The **3rd International Workshop of the COST Action TD1105** on *New Trends and Challenges on Air Quality Control* at University of Latvia, Riga (**Latvia**), 26 - 27 March 2015.

- The **Action 3rd International Training School** on *Atmospheric Aerosol Physics, Measurements and Sampling* at Hyytiala Station of the University of Helsinki, Helsinki (**Finland**), 2 - 8 May 2015.

Year 3: Scientific Planning of *EuNetAir* (2/3)

MC/WG Meetings planned **for the upcoming year**

(**Year 3: 1 July 2014 - 30 June 2015**):

- **3rd SCIENTIFIC MEETING: WGs Meeting and 6th MC Meeting on Indoor Air Quality Monitoring** at Bahcesehir University and GEBZE Institute of Technology, Istanbul (**Turkey**), 3 - 5 Dec. 2014.

- **4th SCIENTIFIC MEETING: WGs Meeting and 7th MC Meeting on Outdoor Air Quality Monitoring** at Linkoping University, Linkoping (**Sweden**), 3 - 5 June 2015.

- **Special Session EuNetAir / Core-Group Meeting** to **EUROSENSORS 2014**, Brescia (**Italy**), 7 - 10 September 2014.

- **Special Session EuNetAir / Smart Cities Sensors** to **IEEE SENSORS 2014**, Valencia (**Spain**), 2 - 5 November 2014.

Year 3: Scientific Planning of *EuNetAir* (3/3)

MC/WG Meetings planned **for the upcoming year**

(**Year 3: 1 July 2014 - 30 June 2015**):

- ***EuNetAir* FOCUS GROUP: Data Analysis of Aveiro Air Quality Sensors Intercomparison** hosted at WHO Collaborating Centre for Air Quality Management and Air Pollution Control - Federal Environment Agency, Berlin (**Germany**), 17 April 2015. Expected Persons: 10.

- ***EuNetAir* FOCUS GROUP: Innovation on Environmental Sensor Technologies** hosted by Siemens AG, Munich (**Germany**), 29 Apr 2015 Expected Persons: 10.

- ***EuNetAir* FOCUS GROUP: ISOEN 2015 - International Symposium on Olfaction and Electronic Noses**, Dijon (**France**), 28 June - 1 July 2015. Expected Persons: 5 (3 Speakers + 2 Flash Presenters).

SELECTED EXAMPLES OF AQC SENSOR APPLICATIONS

EXAMPLES OF SENSORS DEMONSTRATION IN EU CITIES

London: Heathrow Airport, UK

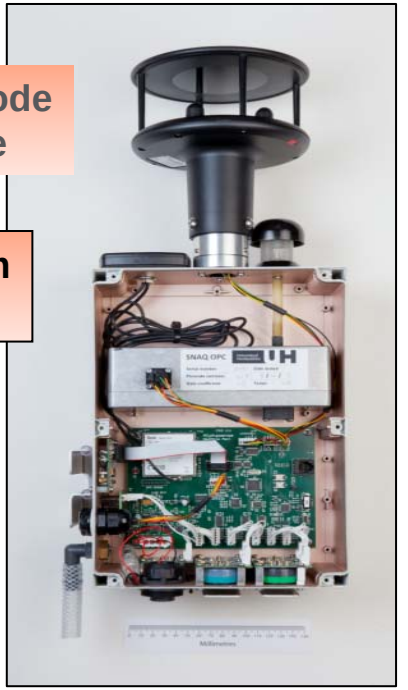
SNAQ-Heathrow project: Wireless Sensors Network

Courtesy by Rod Jones (Cambridge University) and Alphasense Ltd

- **~ 36 sensor nodes located in and around the airport**
- **Web: http://www.snaq.org/**

SNAQ sensor node by Cambridge

~49 x 22 x 16 cm
~2.8 kg



UNIVERSITY OF CAMBRIDGE

University of Hertfordshire

alphasense THE SENSOR TECHNOLOGY COMPANY

MANCHESTER 1824

Heathrow

BRITISH AIRWAYS

NPL National Physical Laboratory

Imperial College London

Cambridge Environmental Research Consultants
Environmental Software and Services

EXAMPLES OF SENSORS DEMONSTRATION IN EU CITIES

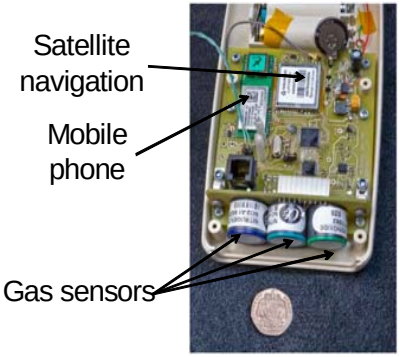
City: Cambridge, UK

MESSAGE project: Wireless Sensors Network

Courtesy by Rod Jones (Cambridge University) and Alphasense Ltd

50 Sensor-Nodes for air quality monitoring in the Cambridge city

Sensor units components



400 gm (incl. batteries)

UNIVERSITY OF CAMBRIDGE

Lisbon
13-14 November 2009

message

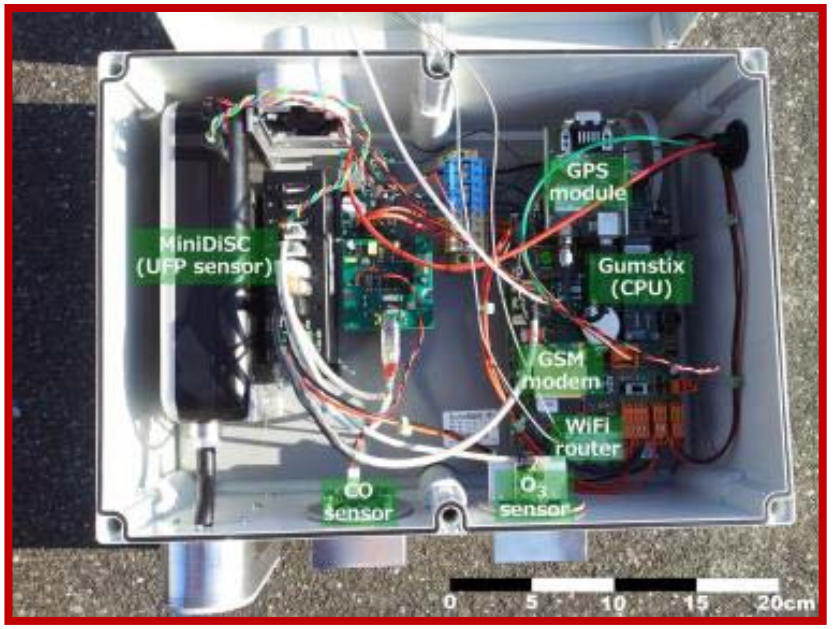
EXAMPLES OF SENSORS DEMONSTRATION IN EU CITIES

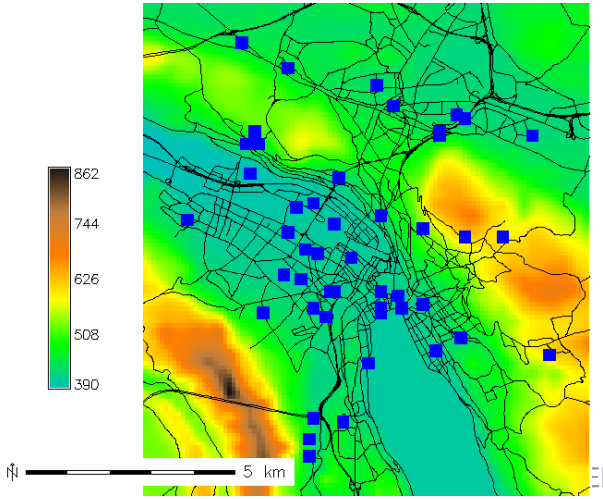
City: Lausanne and Zurich, Switzerland

OpenSense project: Wireless Fixed/Mobile Sensors Network

Courtesy by Karl Aberer (EPFL) and OpenSense Consortium

At least 6 Tramways with AQ sensors in Zurich





Sensor Node for Air Quality Monitoring: CO, NO_x, O_3, UFP, etc.

EXAMPLES OF SENSORS DEMONSTRATION IN EU CITIES

City: Oslo, Norway

CITI-Sense project: Participatory Sensing Network

Courtesy by Nuria Castell, Alena Bartonova (NILU) and CITISense Consortium

Sensing the city with bicycles: *measure where the people cycle*

EXAMPLES OF SENSORS DEMONSTRATION IN EU CITIES

City: Oslo, Norway

CITI-Sense project: Participatory Sensing Network

Courtesy by Nuria Castell, Alena Bartonova (NILU) and CITISense Consortium

Sensing the city with people: *measure where the people walk*

NO_2+O_3

AQ

Temp

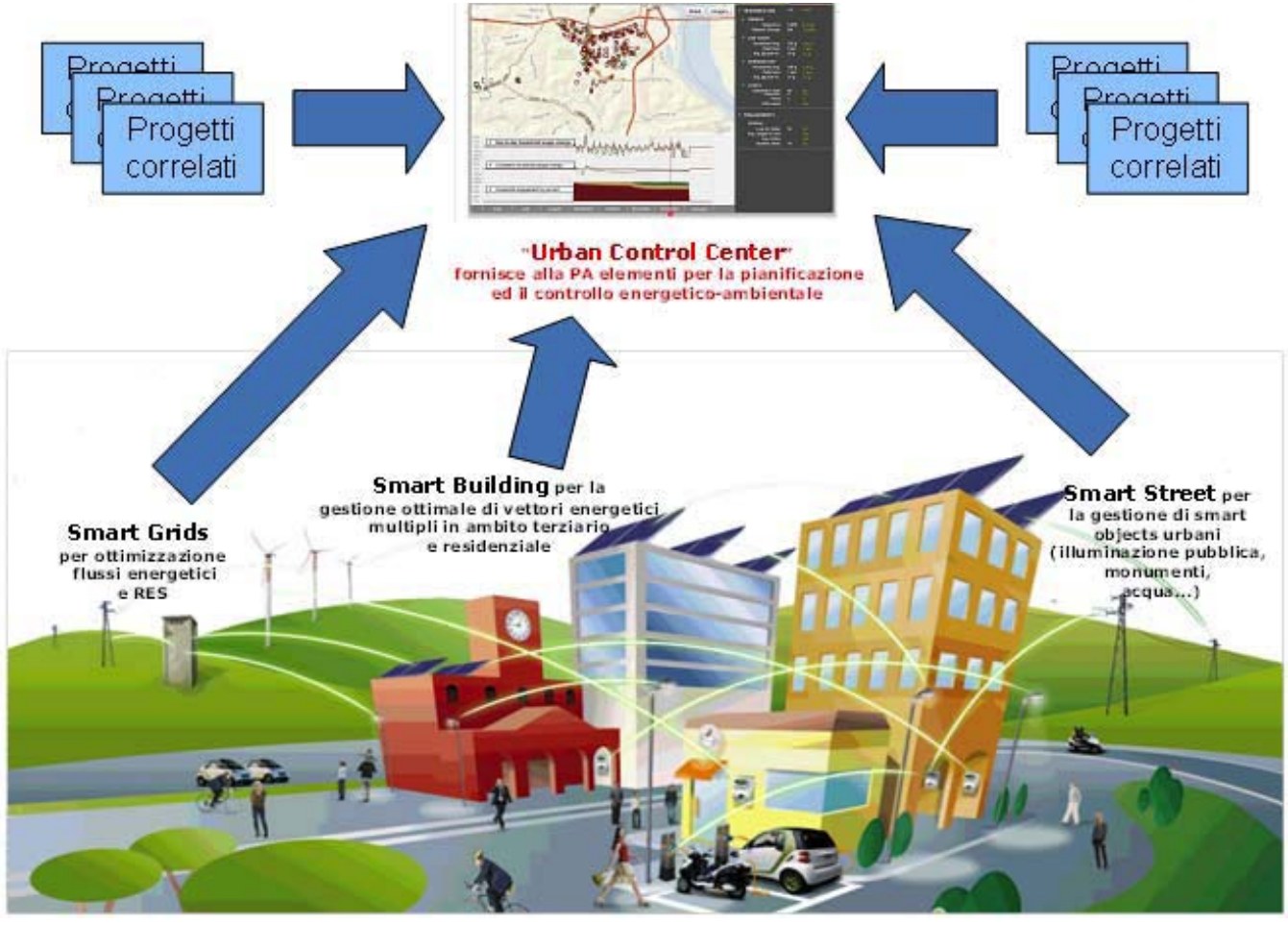
UV

EXAMPLES OF SENSORS DEMONSTRATION IN EU CITIES

City: Bari, Italy - RES-NOVAE national IT project:

Networks, Buildings, Streets for New Challenges towards Environment and Energy

Courtesy by RES-NOVAE Consortium

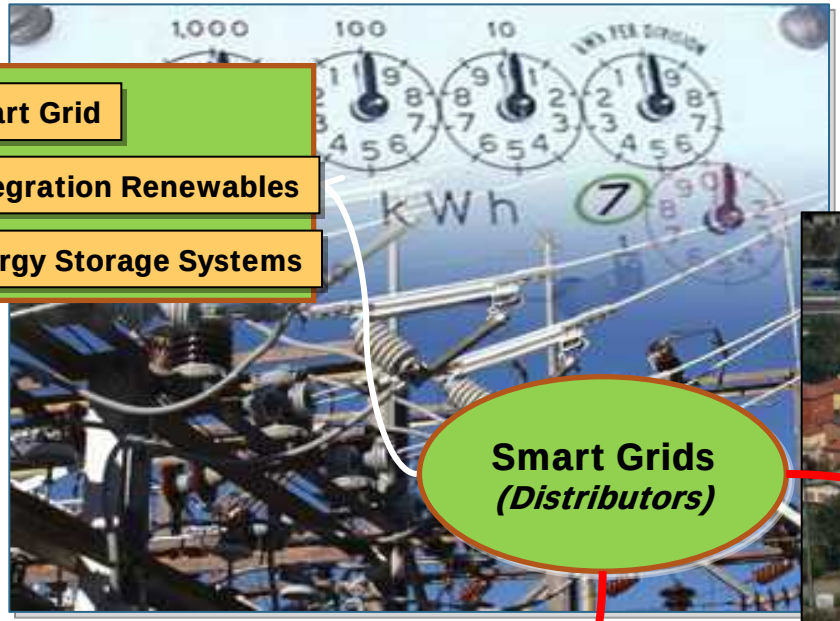


Demonstration an integrated solution for urban context with distributed Energy functionalities (smart grids), management of buildings network, management of streets and real-time environmental monitoring in City are cooperative.

IT NATIONAL PROJECT *RES-NOVAE*: APPLICATIONS SCENARIO

Smart City Bari

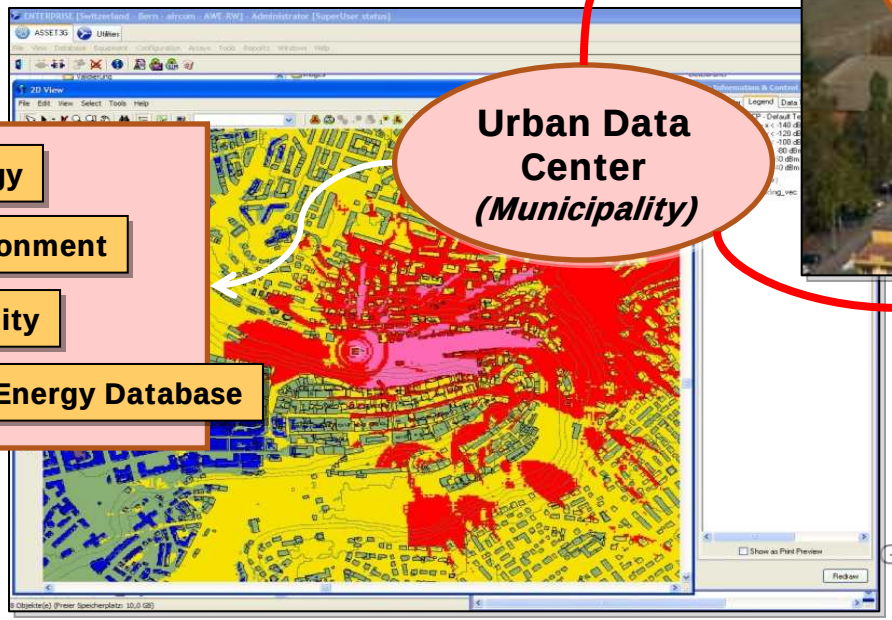
- Smart Grid
- Integration Renewables
- Energy Storage Systems



Smart Grids *(Distributors)*

Smart District *(Aggregators)*

- Urban Renewables ed Ecobuildings
- Building Diagnostics & Control
- Active Demand Management



Urban Data Center *(Municipality)*

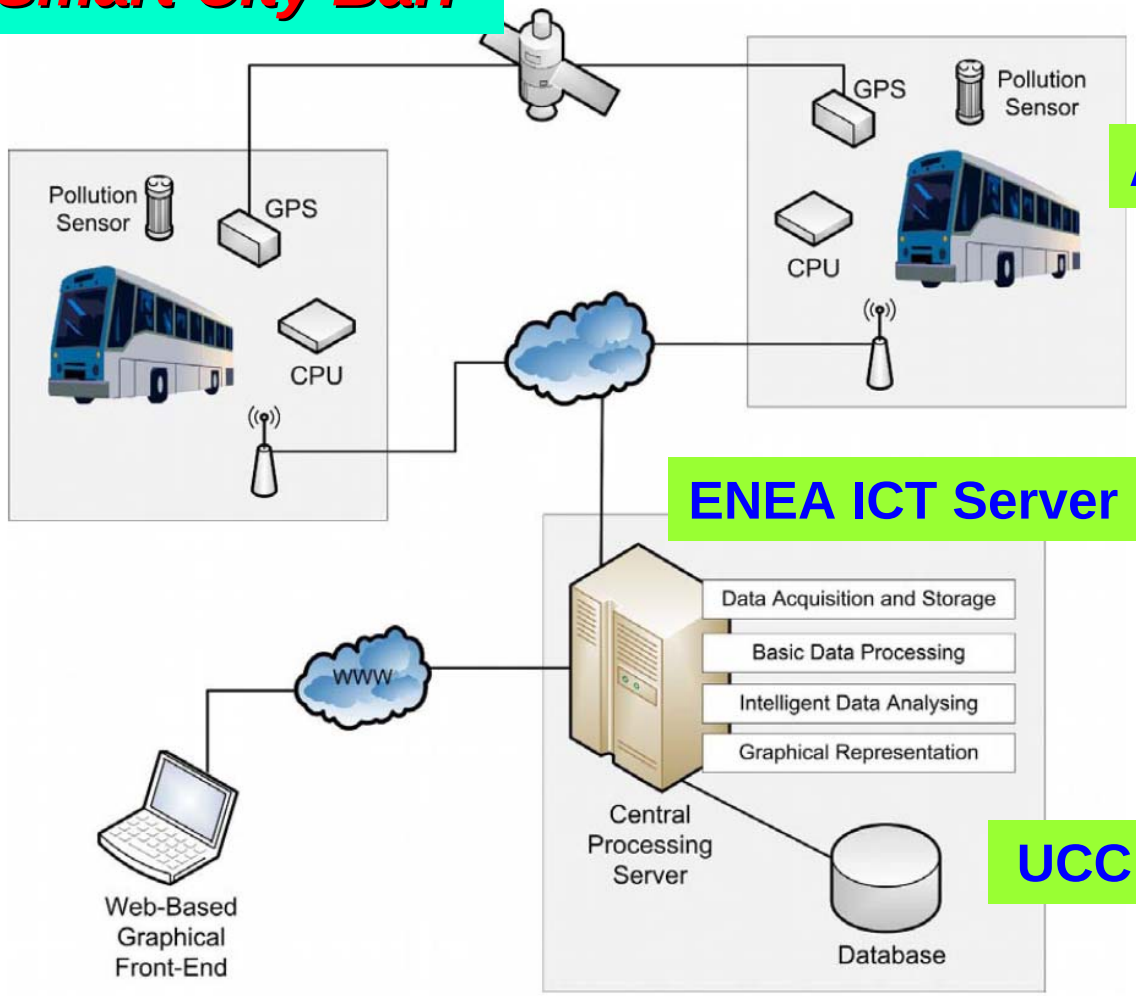
- Energy
- Environment
- Mobility
- City-Energy Database

- Smart Street Control
- Public Light control
- Smart Urban Objects

IT NATIONAL PROJECT *RES-NOVAE*: OUTDOOR APPLICATIONS

Real-Word Scenario for Sensor Technology Demonstration:
AQ ENEA Sensors Mobile Node mounted on public bus (AMTAB) in Bari (Italy).
Urban Control Center (UCC) collects ENV/ENE/OTH data from City.

Smart City Bari



AMTAB Public Buses

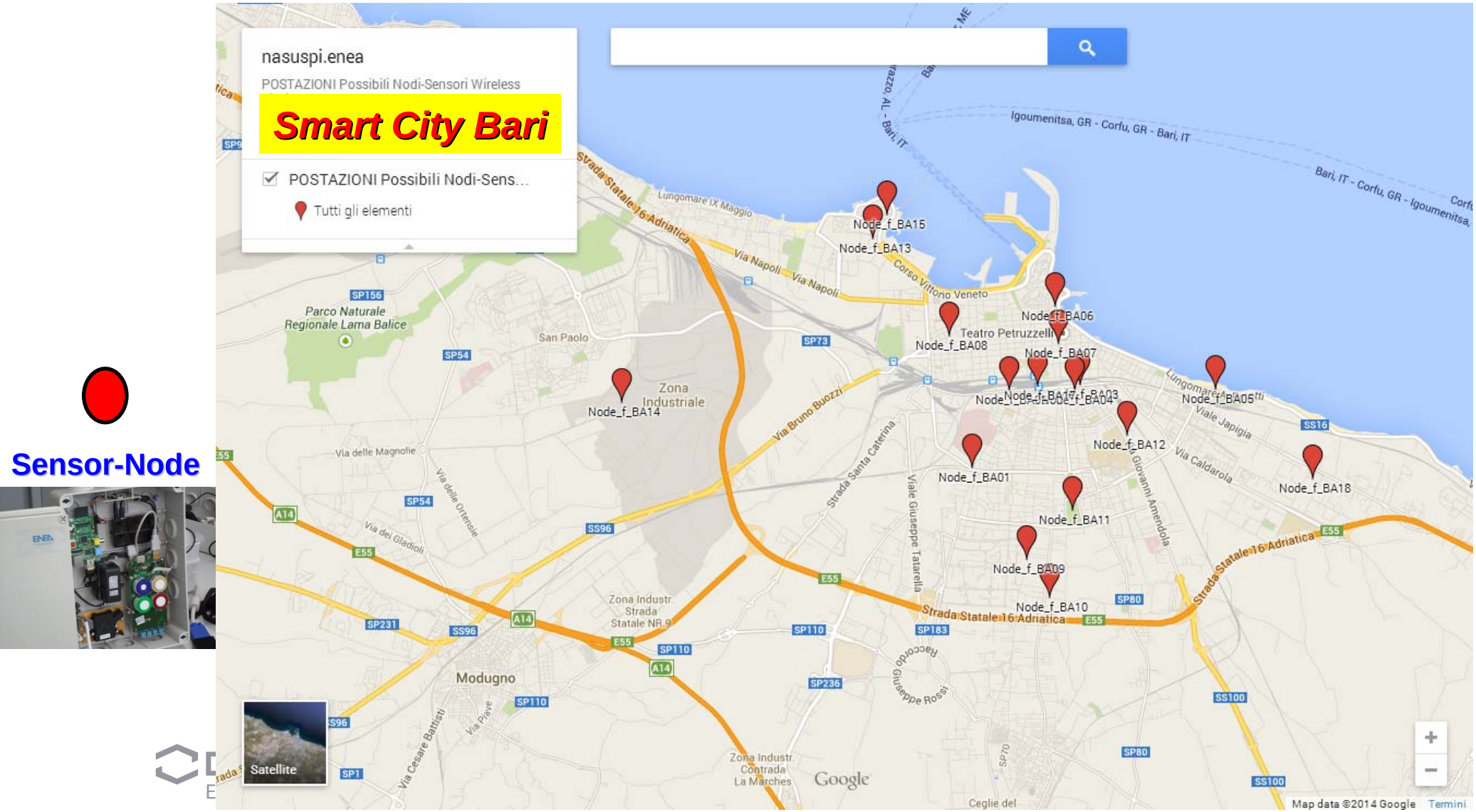
ENEA Mobile Sensor Node for Air Quality Monitoring: CO, NO_x, O_3, SO_2, CO_2, PM10, T, RH

ENEA ICT Server

UCC by IBM Italia

IT NATIONAL PROJECT *RES-NOVAE*: OUTDOOR APPLICATIONS

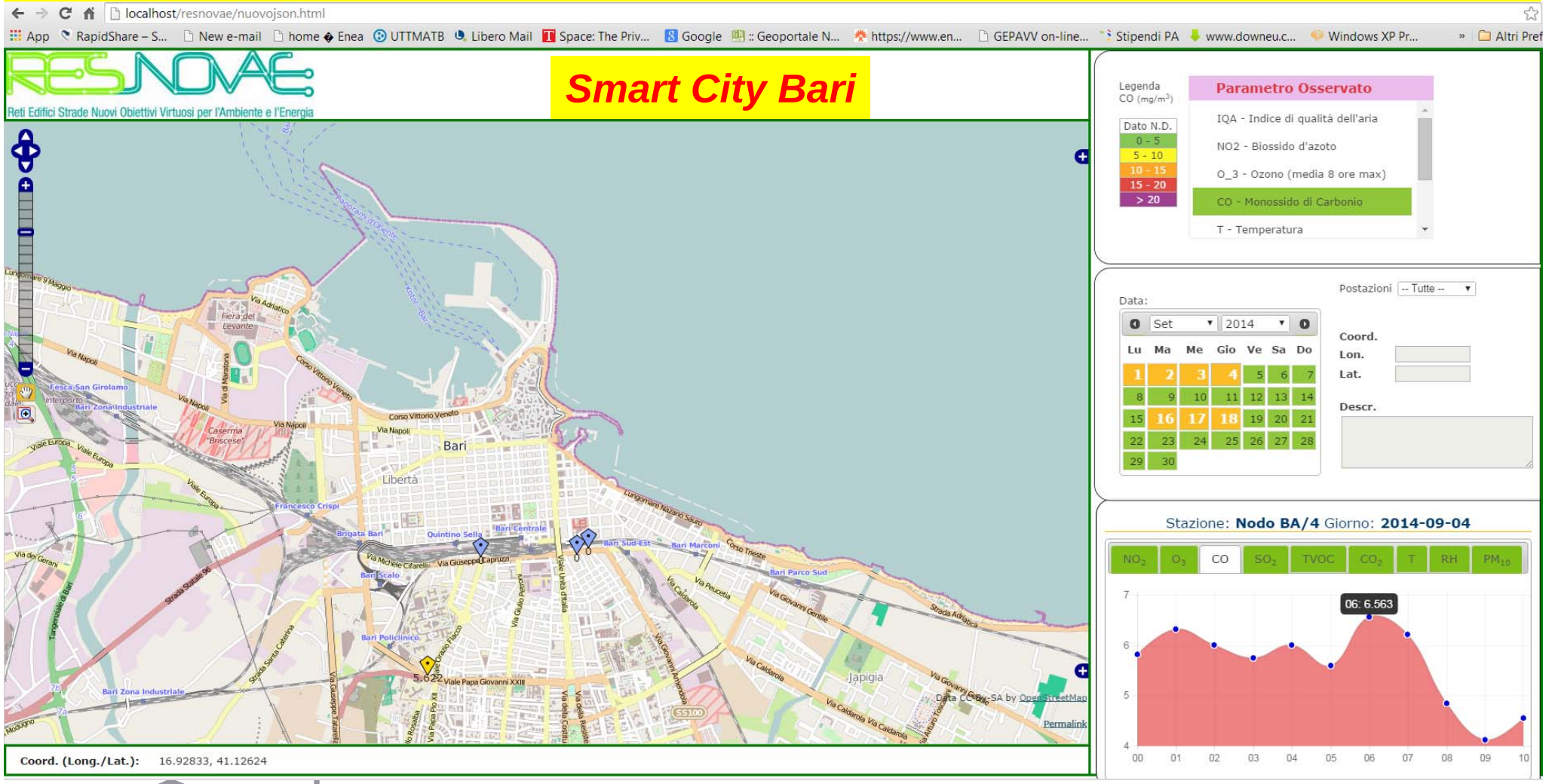
AQ ENEA Sensor Stationary Nodes Network distributed in Bari (Italy)
Urban Control Center (UCC) collects data from City.



Sensor-Node

IT NATIONAL PROJECT *RES-NOVAE*: OUTDOOR APPLICATIONS

AQ ENEA Sensor Stationary Nodes Network distributed in Bari (Italy)
Urban Control Center (UCC), hosted by ENEA server, senses *real-time* City



Air Quality Index (AQI): *Simple Provision of Real-Time Data*

AQI for each Pollutant:

$$AQI = \frac{CurrentPollutionLevel}{PollutionStandardLevel} * 100$$

EU Air Quality Directive 2008/50/EC

Pollutant	Limit Standard Level
NO_x	100 ppb (200 μg/m³) 200 ppb (400 μg/m³)
CO	8 ppm (10 mg/m³)
SO_2	130 ppb (350 μg/m³) 190 ppb (500 μg/m³)
O_3	120 μg/m³ (90 ppb)
PM_{10}	50 μg/m³
$PM_{2.5}$	25 μg/m³
BTEX	5 μg/m³
PAH (BaP)	1 ng/m³

Air Quality Index (AQI): *Categories & Risk for Health*

US EPA AQIs Classification

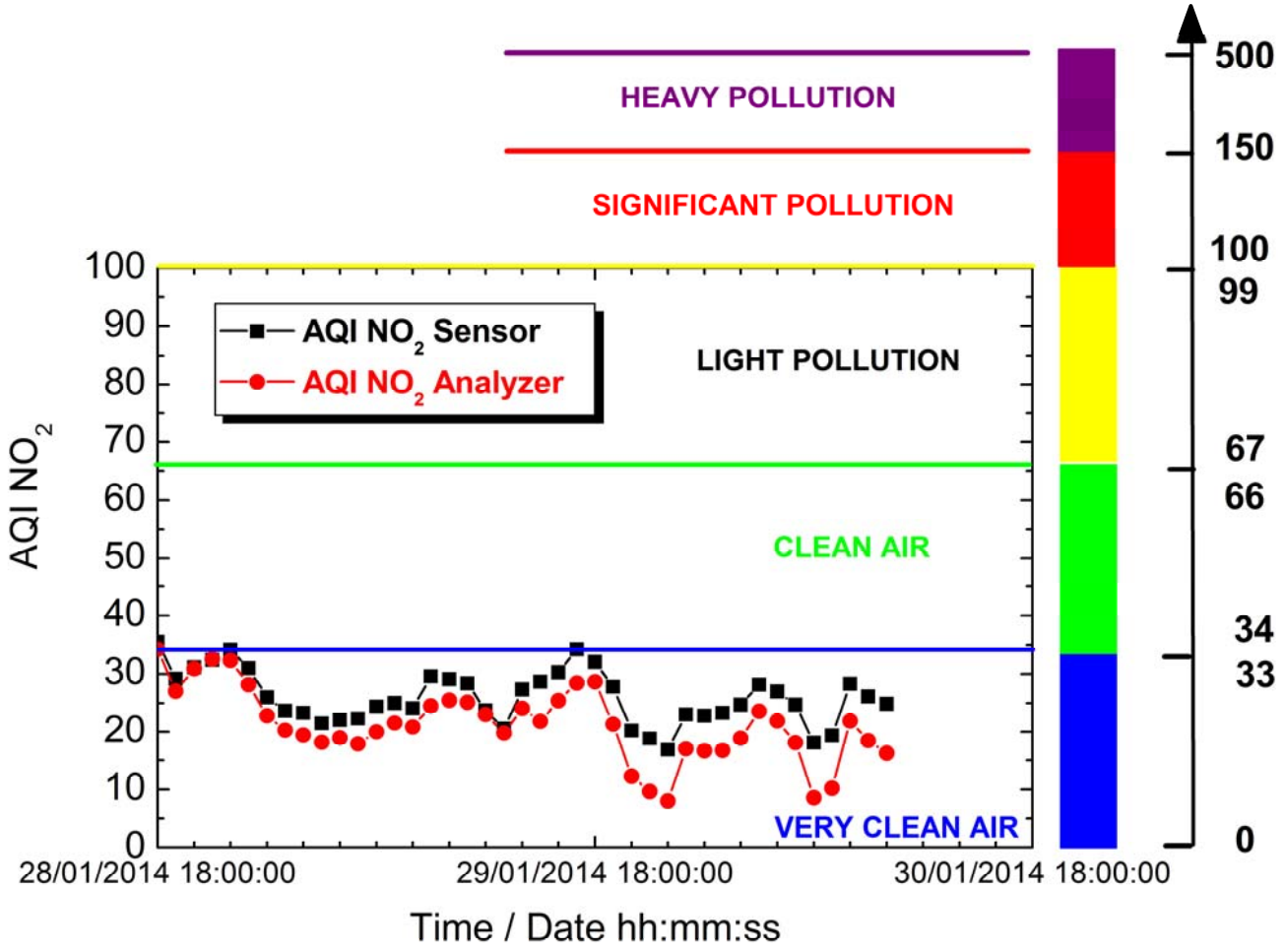
AQI Values	Levels of Health Concern	Colours
When AQI is in this range	*…. air quality conditions are:*	*… as symbolized by this colour:*
0 to 33	**VERY CLEAN AIR - *Excellent***	**BLUE**
34 to 66	**CLEAN AIR - *Good***	**GREEN**
67 to 99	**LIGHT POLLUTION - *Moderate***	**YELLOW**
100 to 150	**SIGNIFICANT POLLUTION - *Bad***	**RED**
> 150	**HEAVY POLLUTION - *Worse***	**PURPLE**

Air Quality Index (AQI): *Sensors versus Analyzers*

NO_2 detection at an air quality station (*JRC-IES, Ispra*) and related AQI by sensor and analyzer for general public

Very Good Correlation

O_3 interference with NO_2 exists !

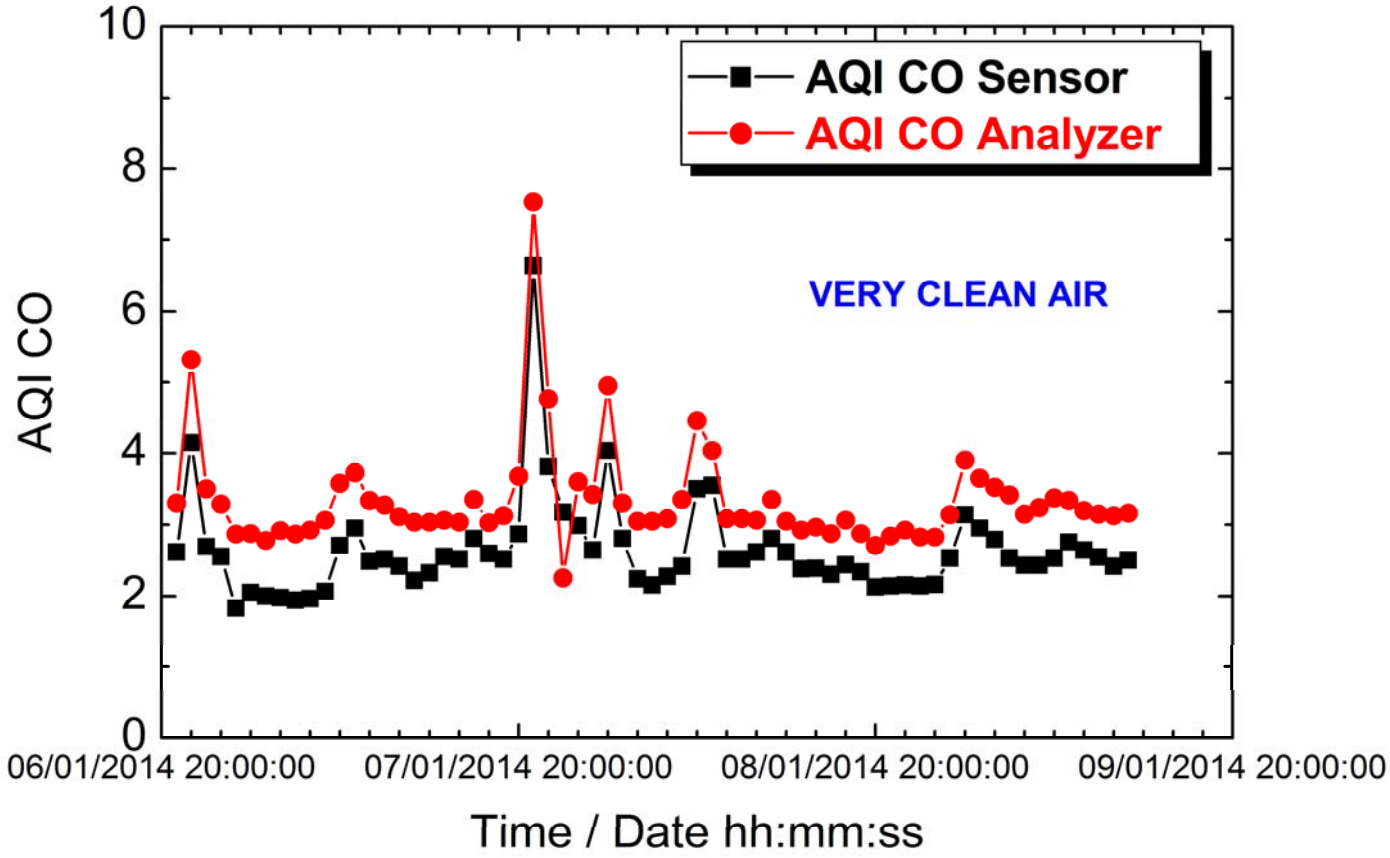


Air Quality Index (AQI): *Sensors versus Analyzers*

CO detection at an air quality station (*ARPA-Puglia, Brindisi*) and related AQI by sensor and analyzer for general public

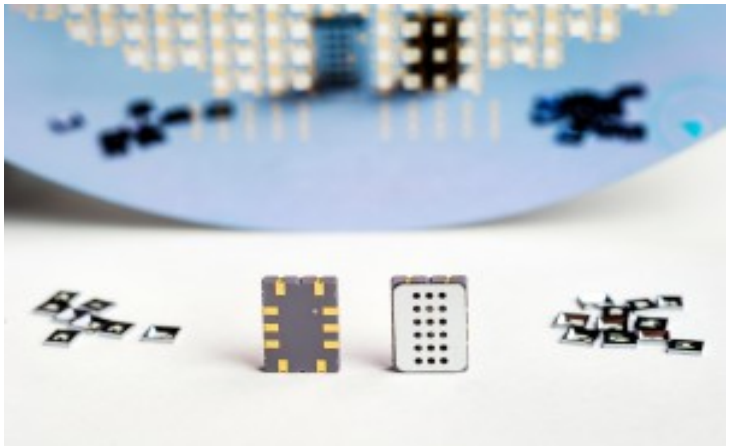
Very Good Correlation

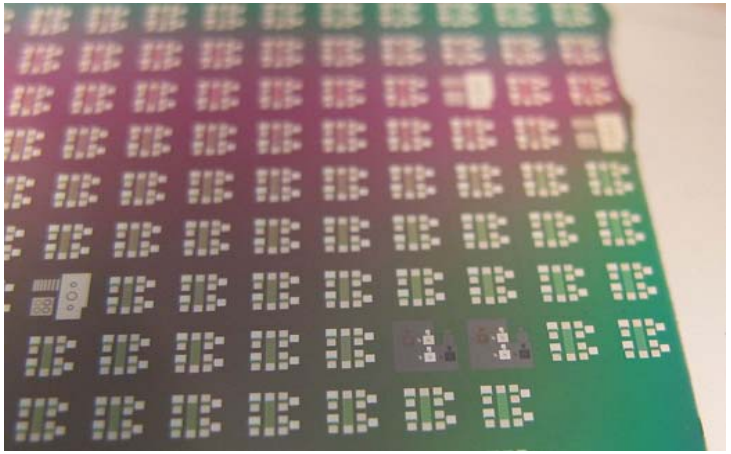
Minor interference with other pollutants exists !



SENSIndoor sensor technologies

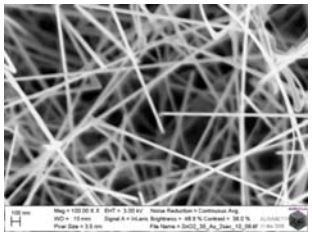
- **Sensor technologies**
  - **MOS - Metal oxide semiconductor** (*SGX Sensortech, USAAR-LMT*)
- well known for high sensitivity and robustness @ low-cost
- MEMS technology for mass production and low power consumption
  - **GasFET - Gas-sensitive Field Effect Transistors** (*LiU, SenSiC*)
- complementary technology (polarity ⇔ reaction)
- SiC technology for chemical robustness
- and high operating temperatures



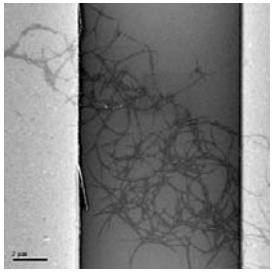


SENSIndoor FP7 project presentation by Saarland University (Coordinator: Prof. A. Schuetze)

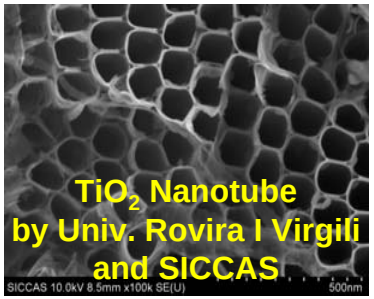
Selected Examples of Gas Sensors and Sensor Systems

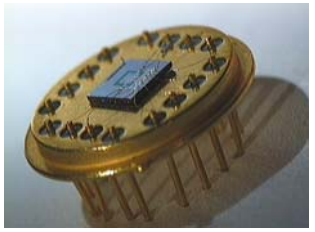


Metal oxide (SnO_2) Nanowires nets by Univ. of Brescia



Carbon Nanotubes by Ames NASA

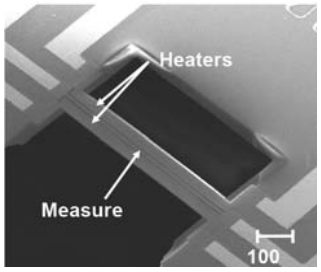




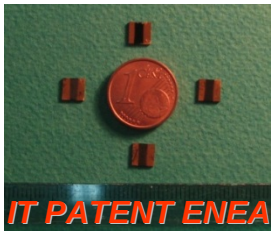
GasFET by EPFL, CH

UNITEC srl, ETL3000
multi-component outdoor air quality monitor

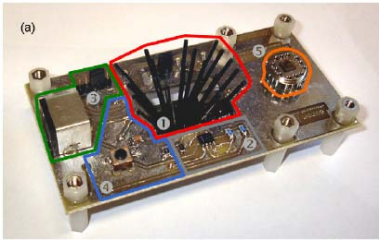
AEROQUAL, AQM 60
Air Quality Sensors Station



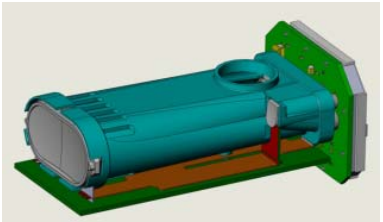
Cantilever Sensor by DTU, DK



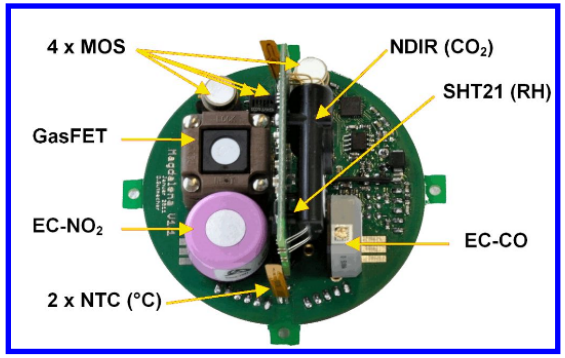
Carbon Nanotube Gas Sensors



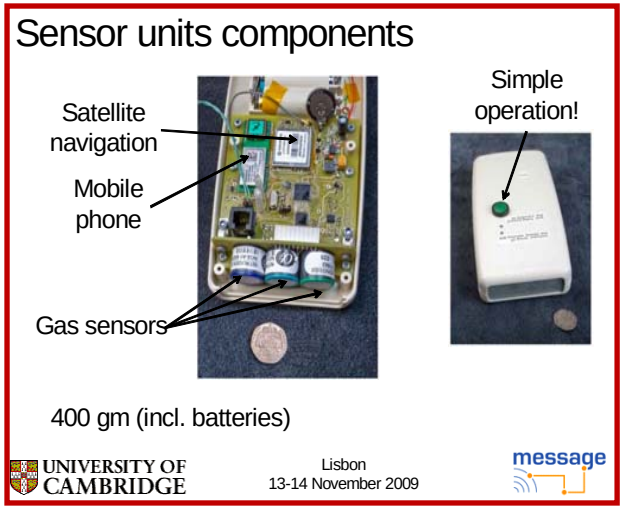
Autonomous Gas Sensor System by IREC and Univ. of Barcelona



SenseAir SA,
Low-Cost NDIR Sensor Platform for sub-ppm Gas Detection



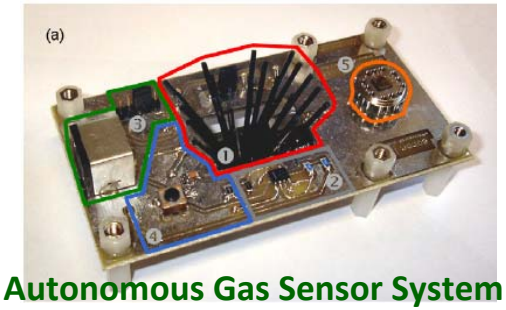
Research Platform for Fire Gas Detection by Siemens AG



Octocopter - the first platform by *Max Planck Institute for Biogeochemistry, Jena, Germany* tested a measurement sensor package for air quality

cost
EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

EuNetAir INNOVATION on AIR QUALITY MONITORING



Autonomous Gas Sensor System
by IREC and Univ. of Barcelona

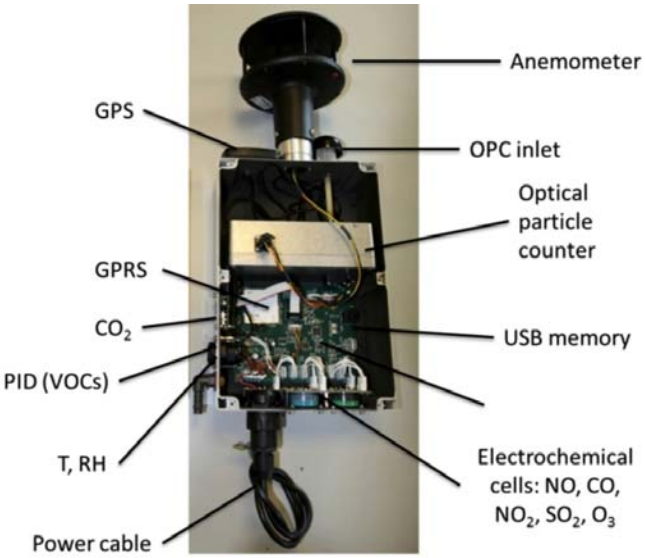
23 cm

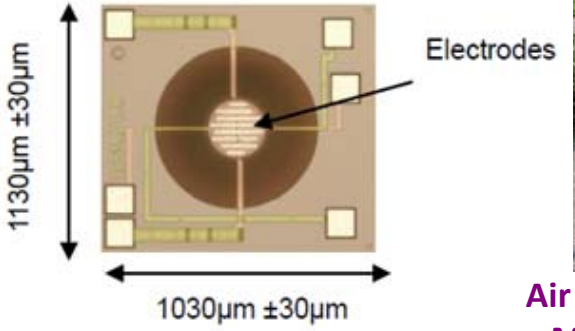
30 cm

AIRBOX Sensor System
by ENEA, Italy

Wireless sensor network for air-quality monitoring
around Heathrow airport
by University of Cambridge and Alphasense Ltd, UK

AQC Gas Sensor
by CCS, UK



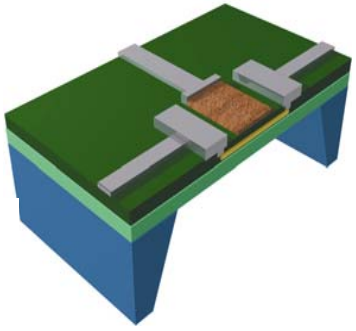


Miniaturized CMOS Sensor
by CCMOS Sensors Ltd and Warwick University

Air Quality Bike (Aeroflex) for
Mobile AQ Measurements
by VITO, Belgium

Smoke Detector
SIEMENS, Germany

E5000 IAQ
Probe/Controller,
NanoSense, France



SGX-Sensortech MOX Gas Sensors
for Automotive AQ Measurements
by SGX-Sensortech, Switzerland

A low-cost modular sensor platform
combining IR spectrometry and
MOX gas sensors for IAQ
monitoring (CO_2, VOC) and medical
applications
by 3S GmbH and Saarland
University, Germany

NDIR Gas Sensors (CO_2)
by SenseAir, Sweden

PRIORITIES & ROADMAP

- What do we want to provide on the long-term in relation to **routine monitoring** and **public information** ?
- **Micro-sensors should not substitute but supplement routine monitoring devices**
- **Future routine networks** may look very different from today and **include low-cost and accurate sensors** ?
- The **green routes through the city** or access to information about **air-pollution load** at specific local address **might be future goals**
- **Pervasive low-cost microsensors for indoor energy efficiency should be a must for future green-buildings**

COST Action TD1105 *EuNetAir:*

SOME INPUTS for FUTURE RESEARCH in AQC

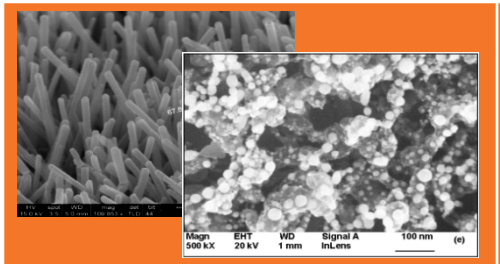
- **Wearable Sensors to Monitor Air-Pollution Personal Exposure**
- **Mobile Sensing (Smartphones, Tablets, Watches)**
- **Fixed Sensor Nodes in Urban Wireless Networks**
- **Mobile Sensor Nodes on Public Transports (Buses, Trams, etc.)**
- ***Sensing City* (bikes, city guardians, citizens, etc.)**
- **Indoor Energy Efficiency Sensors (VOCs, Formaldehyde, etc)**
- **Sensors for Greenhouse Gases Monitoring (CO_2, CH_4, N_2O, etc.)**
- **Sensors for Odour Monitoring**
- **Sensors for PM Detection at Low-Cost**

Expected Impact by Action TD1105

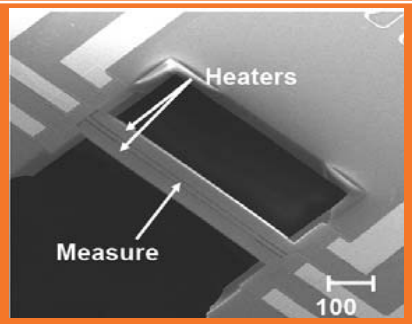
- **European Leadership on AQC Science & Technology**
- **Development of Green-Economy**
- **Support to Sustainable Development**
- **Support to Monitoring System of Clean Air for Europe**
- **Fostering Research & Innovation on New Sensing Technologies for Environmental Monitoring**

COST Action EuNetAir: CHALLENGES

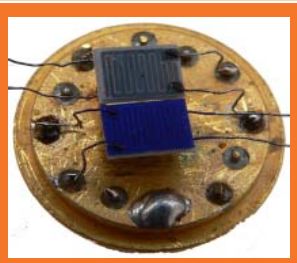
MATERIALS & GAS SENSORS



MOX by UNIBS IREC UB SICCAS
CNT by ENEA NASA URV CSIRO



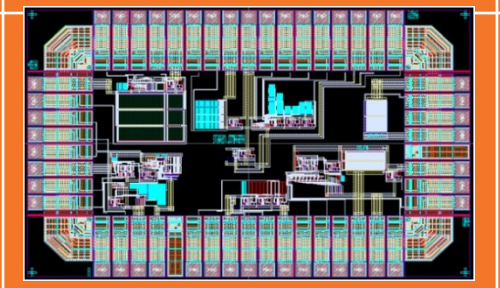
Cantilever Sensor by DTU, DK



Phtalocyanine Gas Sensors
by CNRS UBP-LASMEA, FR

AQC SENSORS & SYSTEMS

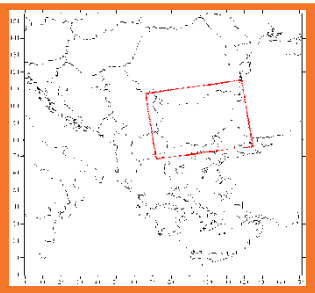
GasFET by EPFL, Switzerland



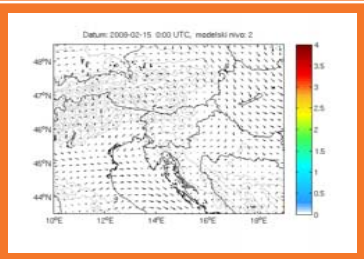
ASIC Circuit: CMOS SOI
by WARWICK & CCMOS Ltd, UK

WIRELESS SENSORS NETWORK
by ISI, Greece

AQ MODELLING



CMAQ Calculations
by NIMH, BG

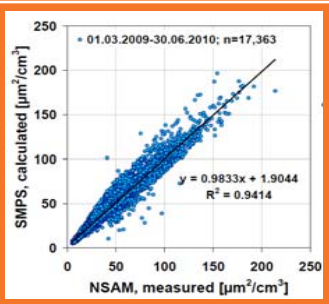


AQ Modelling dispersion in
meteorological mesoscale by
University of Ljubljana, SL

Chemical Weather Forecasting
and Information System
by Hungarian Meteo Service

STANDARDS & PROTOCOLS

Dynamic Olfactometry (EN
13725/2003) by Univ. of Bari and
Lenviros srl, IT



Particle Surface Area
Measurements by IUTA eV, DE

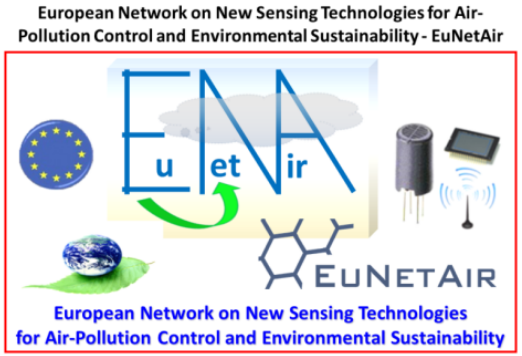
?

HARMONISATION:
Definition of protocols and
standards for gas sensing
measurements and gas sensors

CONCLUSIONS

The COST Action TD1105 *EuNetAir* is proposed to solve problems in the area of:

- **Air Quality Control**
- **Environmental Sustainability**
- **Indoor/Outdoor Energy Efficiency**
- **Climate Change Monitoring**
- **Health Effects of Air-Pollution**



Contact Details

CSO Approval: 01 Dec. 2011

Kick-off Meeting: 16 May 2012

Start of Grant: 01 July 2012

End of Grant: 30 June 2016

www.cost.eunetair.it

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CEASED from 30 Sept 2014

http://www.cost.eu/domains_actions/essem/Actions/TD1105

ACKNOWLEDGEMENTS

Munich, Germany, 29 April 2015

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EuNetAir
European Network on New Sensing Technologies
for Air-Pollution Control and Environmental Sustainability

THANK YOU VERY MUCH FOR YOUR KIND ATTENTION !

SIEMENS

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