

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

COST Action TD1105

## EMRS 2016 Spring Meeting - Symposium X

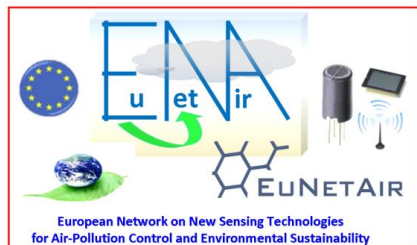
*Functional Materials for Environmental Sensors and Energy Systems*

Lille Grand Palais, Lille, France, 2 - 6 May 2016

Action Start date: 01/07/2012 - Action End date: 15/11/2016 - Year 4: 2015-16 (*Extended Action*)

## *COST Action TD1105: Overview and Plans*

 **cost**  
EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY



**Michele Penza**

Action Chair

**ENEA - Brindisi, Italy**



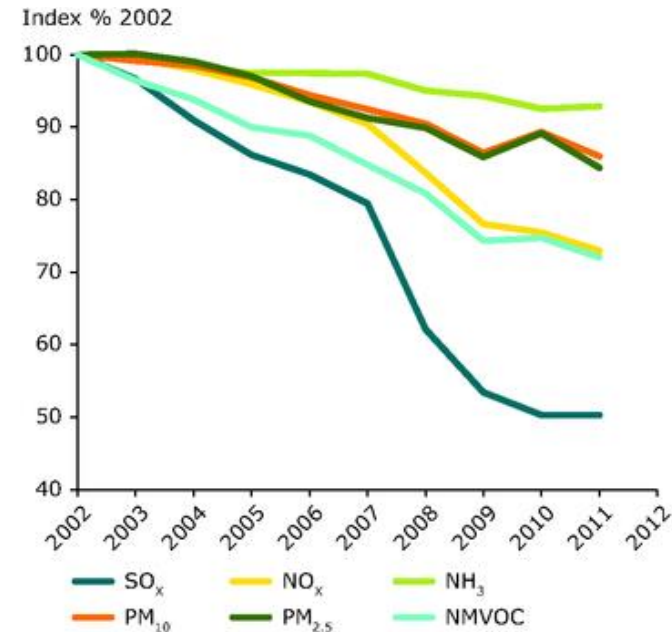
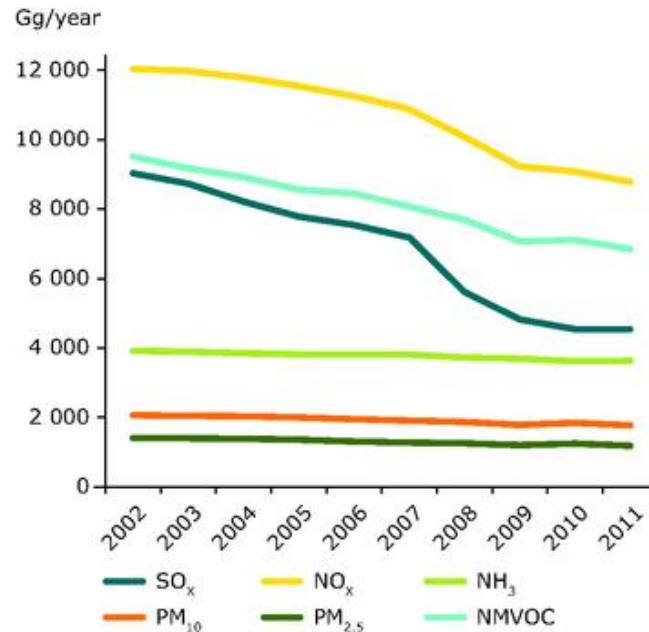
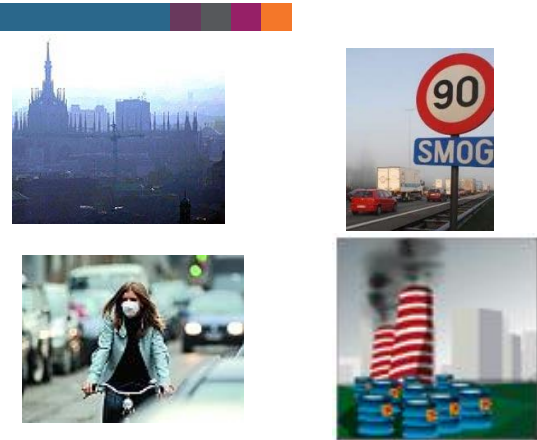
# Outline



- **Background / Problem Statement:**
  - ✓ *Scientific context*
  - ✓ *Challenges addressed by the Action*
- **MoU Action's Objectives: *Main and Secondary***
- **Action Research Directions:**
  - ✓ *Methodology and Innovation*
- **Working Groups**
- **Results versus Objectives: *Significant Highlights***
- **Future Plans and Challenges: *Expected Impact***
- **Concluding Remarks**

# Scientific context: Air Quality Control (2/3)

European Environment Agency, EEA Report 9/2013

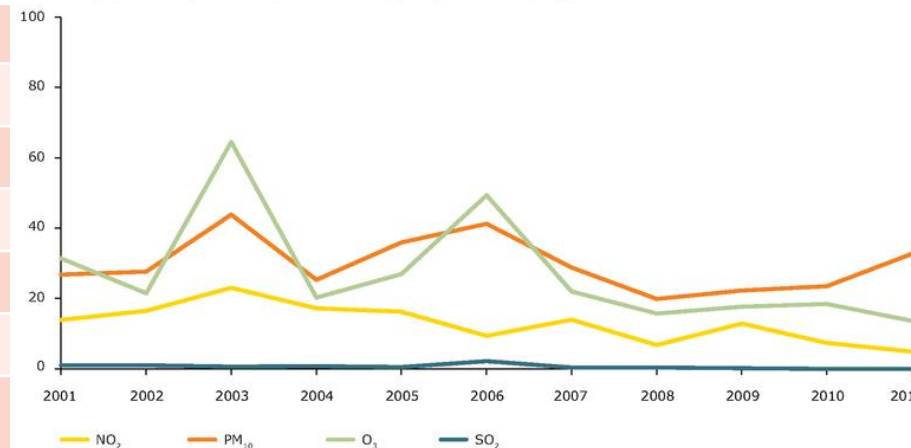


## Some Environmental Emergencies:

- 1930 - Meuse Valley (Belgium)
- 1952 - Great London Smog (UK)
- 1954 - Los Angeles (USA)
- 1984 - Bhopal (India)
- 2005 - Teheran (Iran)
- 2006 - Hong Kong
- 2008, 2015 - Shanghai, Peking, CN
- 2012 - Taranto (Italy)

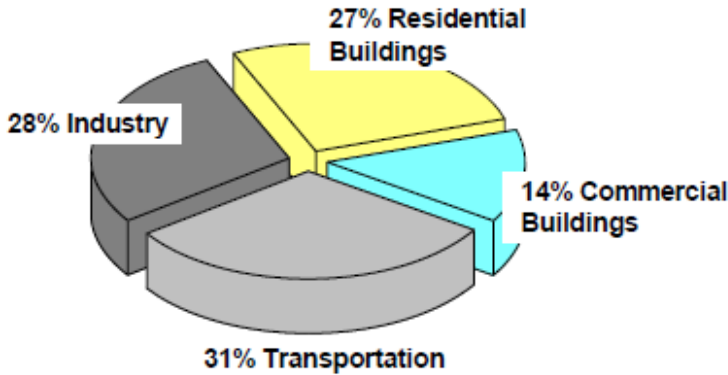
Pollutant	Limit Level
NO <sub>x</sub>	100, 200 ppb
CO	8 ppm
SO <sub>2</sub>	130, 190 ppb
O <sub>3</sub>	120 µg/m <sup>3</sup>
PM <sub>10</sub>	50 µg/m <sup>3</sup>
BTEX	6 µg/m <sup>3</sup>
PAH (BaP)	1 ng/m <sup>3</sup>
PM <sub>2.5</sub>	25 µg/m <sup>3</sup>

% of urban population exposed to air pollution exceeding acceptable EU air quality standard



**AMBIENT AIR QUALITY  
EU DIRECTIVE 2008/50/EC  
and Daughters**

# Scientific context: Indoor/Outdoor Energy Efficiency (3/3)



Primary energy consumption in the EU<sup>1</sup>

<sup>1</sup> O. Seppanen,

11<sup>th</sup> Conference on Indoor Air Quality  
2008, Copenhagen, Denmark

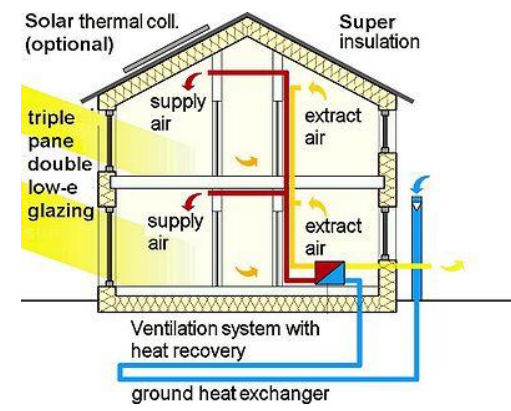
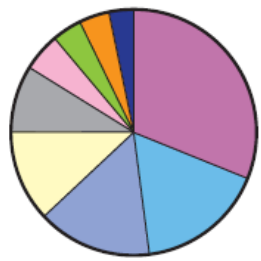
41% Primary Energy consumed in Buildings:

- 2/3 in Residential Buildings
- 1/3 in Commercial Buildings

**Energy Performance of Buildings EU Directive**  
**EPBD 2010/31/EC**

Figure 2 – Total Energy Consumption by End Use  
Adapted from E Source, 2006

- Ventilation 4%
- Refrigeration 3%
- Space Heating 31%
- Water Heating 17%
- Cooling 15%
- Lighting 12%
- Other 9%
- Cooking 5%
- Office Equipment 4%



Source: Environmental Protection Agency's National Action Plan for Energy Efficiency Sector Collaborative on Energy Efficiency Hotel Energy Use Profile

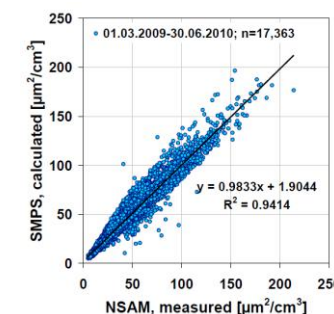
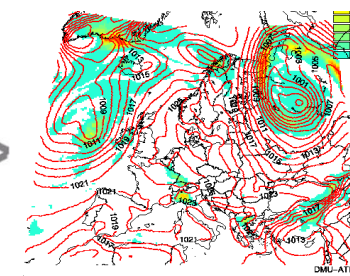
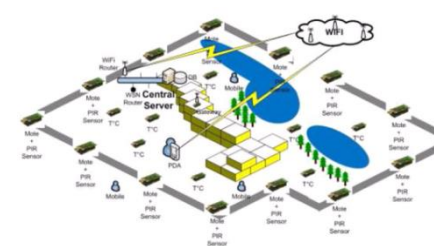
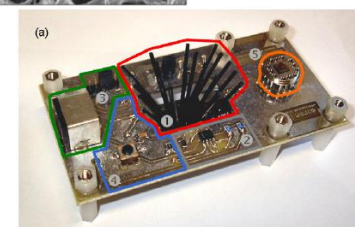
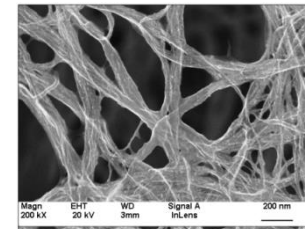
## IAQ by WORLD HEALTH ORGANIZATION

Indoor Air		Typical Substances		Cure	
Contamination Source	Emission Source	VOCs	Others		
• Human Being	• Breath	Acetone, Ethanol, Isoprene		demand controlled ventilation	
		CO <sub>2</sub>			
	• Skin Respiration & Transpiration	Humidity			
		Nonanal, Decanal, α-Pinene			
	• Flatus	Methane, Hydrogen			
	• Cosmetics	Limonene, Eucalyptol			
	• Household Supplies	• Combustion (Engines, Appliances, Tobacco Smoke)	Alcohols, Esters, Limonene		
			Unburnt Hydrocarbons		
		CO			
		CO <sub>2</sub>			
Humidity					
• Building Material • Furniture • Office Equipment • Consumer Products	• Paints, Adhesives, Solvents, Carpets	Formaldehyde, Alkanes, Alcohols, Aldehydes, Ketones, Siloxanes		permanent 5-10% ventilation	
		Toluene, Xylene, Decane			
	• PVC • Printers, Copiers, Computers	Benzene, Styrene, Phenole			

Table 1 – Typical Indoor Air Contaminants (VOCs and others)

# Challenges addressed by Action TD1105 (1/1)

- **Nanomaterials for AQC sensors**
- **Low-cost Gas Sensors**
- **Low-power Sensor-Systems**
- **Wireless Technology (*Environmental Sensors Network*)**
- **Air Quality Modelling**
- **Environmental Measurements**
- **Standards and Protocols**



# Action's Objectives (1/1)

## MoU Main Objectives of COST Action TD1105:

- To establish a *Pan-European multidisciplinary R&D platform* on new sensing paradigm for Air Quality Control (AQC) contributing to sustainable development, green-economy and social welfare.
- To create *collaborative research teams* in the ERA on the new sensing technologies for AQC in an integrated approach to avoid fragmentation of the research efforts.
- To train *Early Stage Researchers (ESRs)* and new young scientists in the field for supporting competitiveness of European industry by qualified human potential.
- To promote *gender balance* and involvement of ESRs in AQC.
- To disseminate *R&D results on AQC* towards *industry community* and policy makers as well as general public and high schools.

# COST Action TD1105 *EuNetAir*: Working Groups (1/5)

[www.cost.eunetair.it](http://www.cost.eunetair.it)



**WG1:**  
Sensor Materials  
&  
Nanotechnologies

**WG2:**  
Sensors, Devices  
& Systems for AQC

**WG4:**  
Protocols &  
Standardisation  
Methods

**WG3:**  
Env. Measurements  
&  
Air Pollution Modelling

**INTERDISCIPLINARY  
SPECIAL INTEREST GROUPS**

## MANAGEMENT COMMITTEE:

### CORE-GROUP & STEERING COMMITTEE

- *Editorial Board*
- *Dissemination*
- *Training Schools*
- *Gender Balance*
- *Early Stage Researchers (ESR)*
- *Short-Term Scientific Mission (STSM)*
- *Intellectual Property Rights (IPR)*
- *Local Organizing Committee (LOC)*

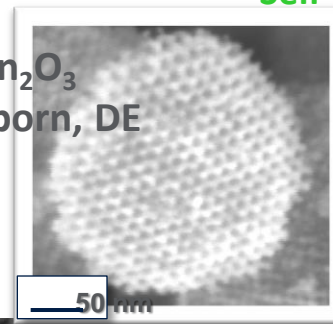
- **SIG 1:** *Network of Spin-offs*
- **SIG 2:** *Smart Sensors for Urban Air Monitoring in Cities*
- **SIG 3:** *Guidelines for Best Coupling Air Pollutant-Transducer*
- **SIG 4:** *Expert comments for the Revision of the Air Quality EU Directive*

**Action (2012-2016) Size:**

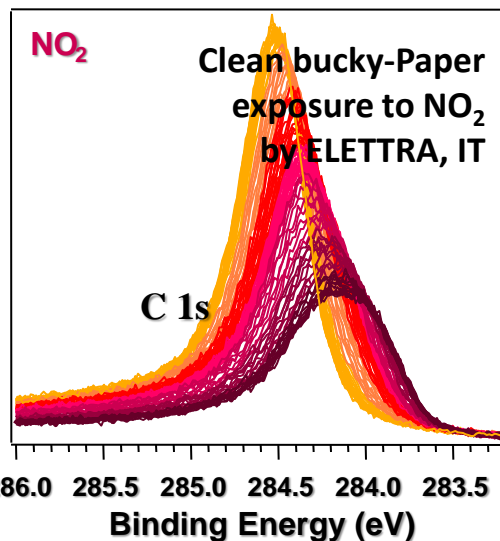
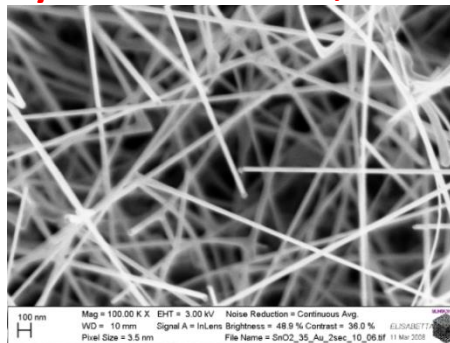
**200 Experts from 120 Teams - 31 Countries**

- **Sub-Working Group 1.1:**  
Metal oxides nanostructures for AQC gas sensors.
- **Sub-Working Group 1.2:**  
Carbon nanomaterials for AQC gas sensors.
- **Sub-Working Group 1.3:**  
Emerging sensor materials (organic/inorganic, hybrid, nanocomposites, polymers, functional, etc.).

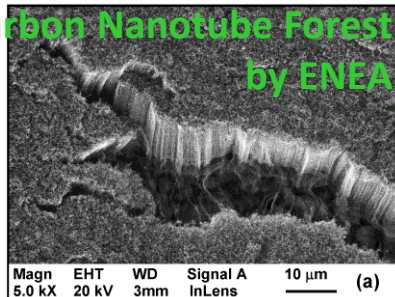
Mesoporous In<sub>2</sub>O<sub>3</sub>  
by Univ. of Paderborn, DE



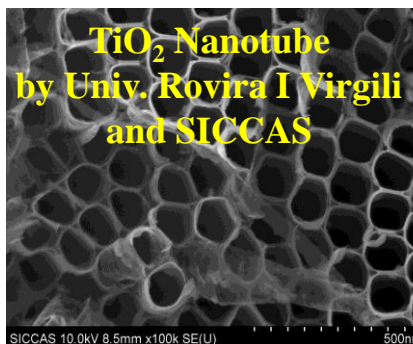
Metal oxide (SnO<sub>2</sub>)  
Nanowires nets  
by Univ. of Brescia, IT



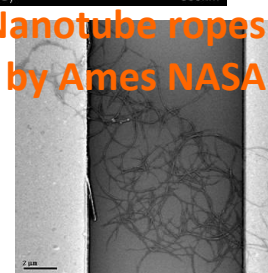
Carbon Nanotube Forest  
by ENEA



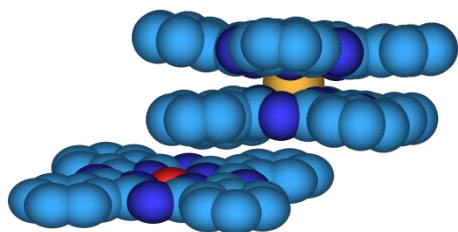
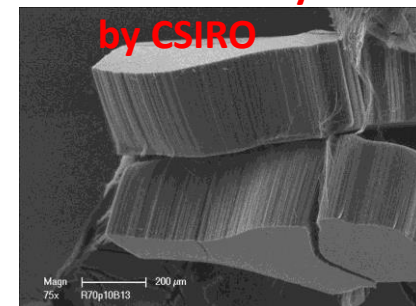
TiO<sub>2</sub> Nanotube  
by Univ. Rovira I Virgili  
and SICCAS



Carbon Nanotube ropes  
by Ames NASA

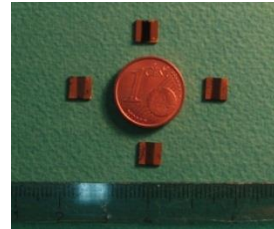


Carbon Nanotube yarns  
by CSIRO

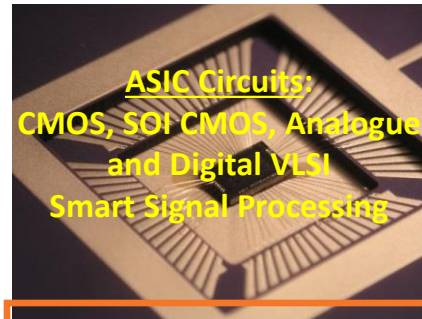


New molecular materials of polymer-macrocycles as transducers for polluting gas sensing by University of Bourgogne

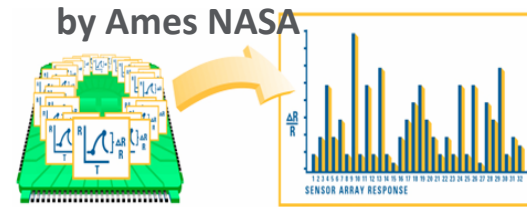




EnviroWatch mote by Newcastle University



Warwick University in collaboration with Cambridge University, EPFL, PennState.

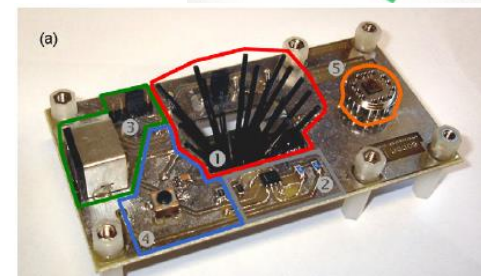


by Ames NASA  
Using pattern matching algorithms, the data is converted into a unique response pattern

A versatile platform for the efficient development of gas detection systems based on automatic device adaptation by University of Saarland.

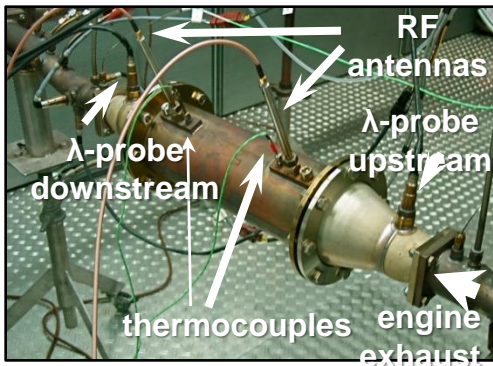


Low-ppb sensitivity for NO<sub>2</sub> GaN-based sensor concept



Autonomous Gas Sensor System by IREC and Univ. of Barcelona

- **Sub-Working Group 2.1:**  
Gas sensors and new transducers.
- **Sub-Working Group 2.2:**  
Portable gas sensor-systems.
- **Sub-Working Group 2.3:**  
Wireless technology and AQC sensors network.
- **Sub-Working Group 2.4:**  
Intelligence algorithms and distributed computing for networked AQC gas sensors.



Direct status measurement of automotive catalysts by radio-frequency technique by University of Bayreuth, DE.

## Sub-Working Group 3.1:

Environmental measurements at laboratory and in field air-quality stations.

## Sub-Working Group 3.2:

Air-quality modelling and chemical weather forecasting.

## Sub-Working Group 3.3:

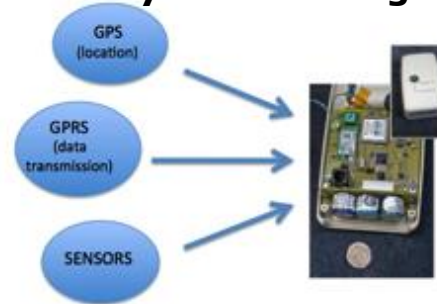
Harmonisation of environmental measurements.

by Aristotle University, EL

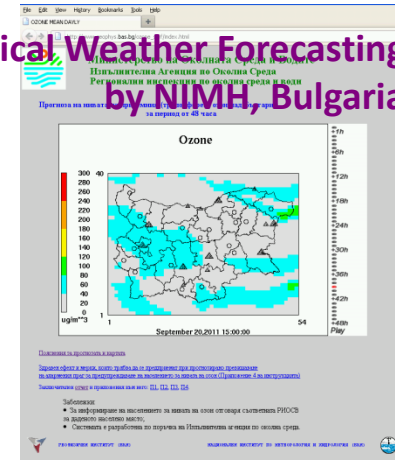


**AirMerge system for Chemical Weather Models**

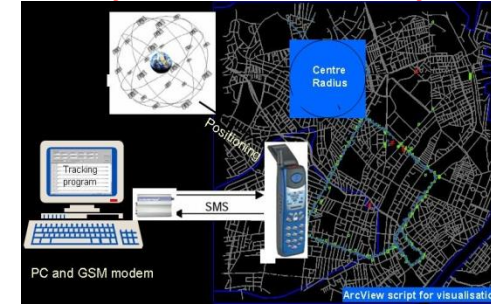
Mobile and static sensor network configurations by University of Cambridge.



## Chemical Weather Forecasting by NIMH, Bulgaria



## AQ Modeling: Tracking routes by Aarhus University, DK



Environmental measurements of PM and air pollution by CSIC, ES



AQ monitoring station by ARPA-PUGLIA, IT



AQ monitoring station by Aarhus University, DK



AQ monitoring station by Lithuanian EPA

# TD1105 *EuNetAir* **WG4**: Protocols and Standardisation Methods (5/5)

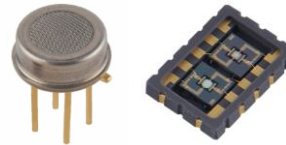
*WG4 Chair: Prof. Ingrid Bryntse, SenseAir AB, Sweden*

- **Sub-Working Group 4.1**:  
Protocols, standards and methods for AQC by analyzers/instruments (no-sensors) technologies.
- **Sub-Working Group 4.2**:  
Protocols, standards and methods for AQC by sensors (no-analyzers) technologies.
- **Sub-Working Group 4.3**:  
Benchmarking of new products and market of commercial AQC sensors.

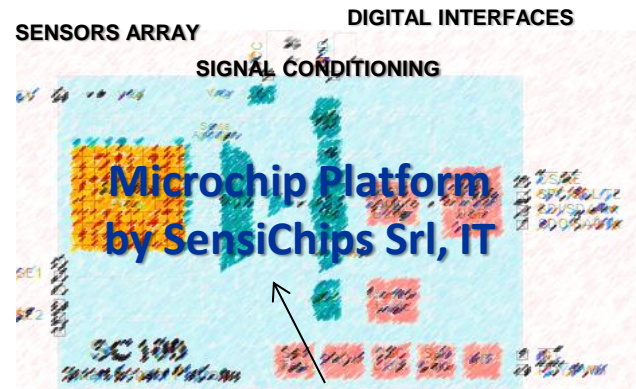
European Directive 2008/50/EC: Ambient Air Quality  
EU standard EN 13725/2003: Dynamic Olfactometry

Protocols and Standardised Methods for Gas Sensors  
Guidelines of Best Transducers applied to specific gases

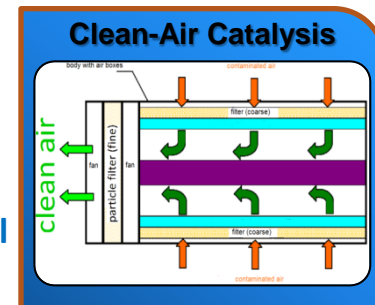
Dynamic olfactometry EN13725  
by Univ. of Liege, Odometric SA,  
Univ. of Bari, Lenviros srl.



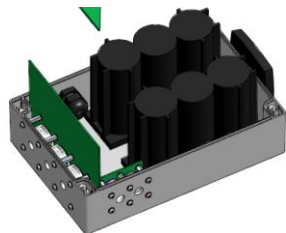
**Packaged Sensors**  
by E2V, CH



New precision multi-parametric analytical tool



Becker Gruppe, DE



**Battery-Powered Sensors by Alphasense Ltd, UK**



**CO<sub>2</sub> IR sensor for alarm System by SenseAir AB, Sweden**

# COST Action TD1105 EuNetAir: **Action Parties (31)**

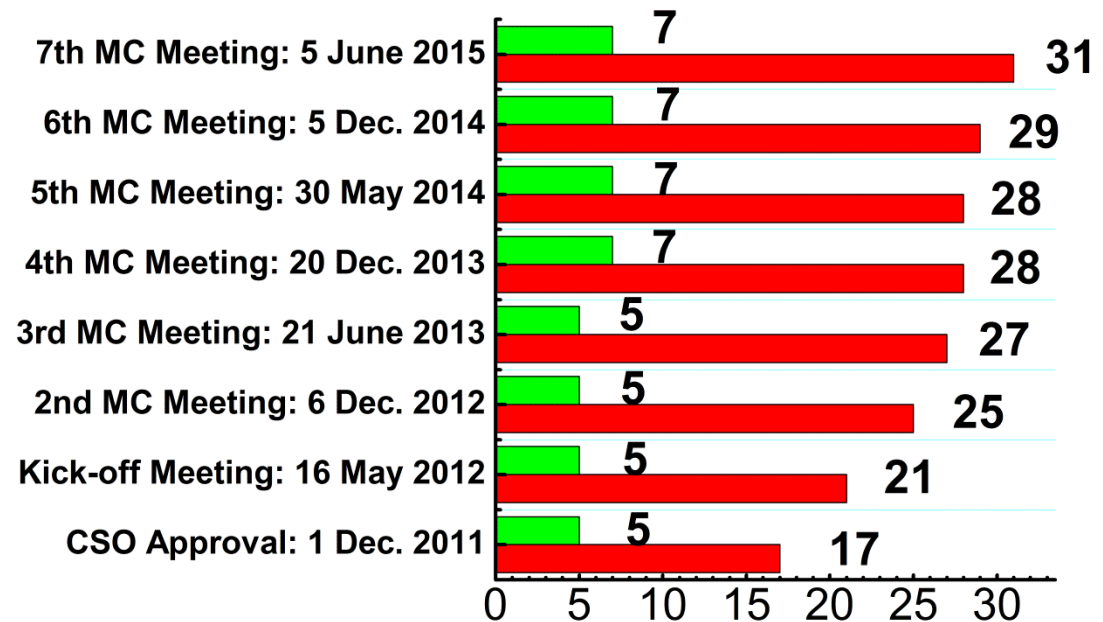
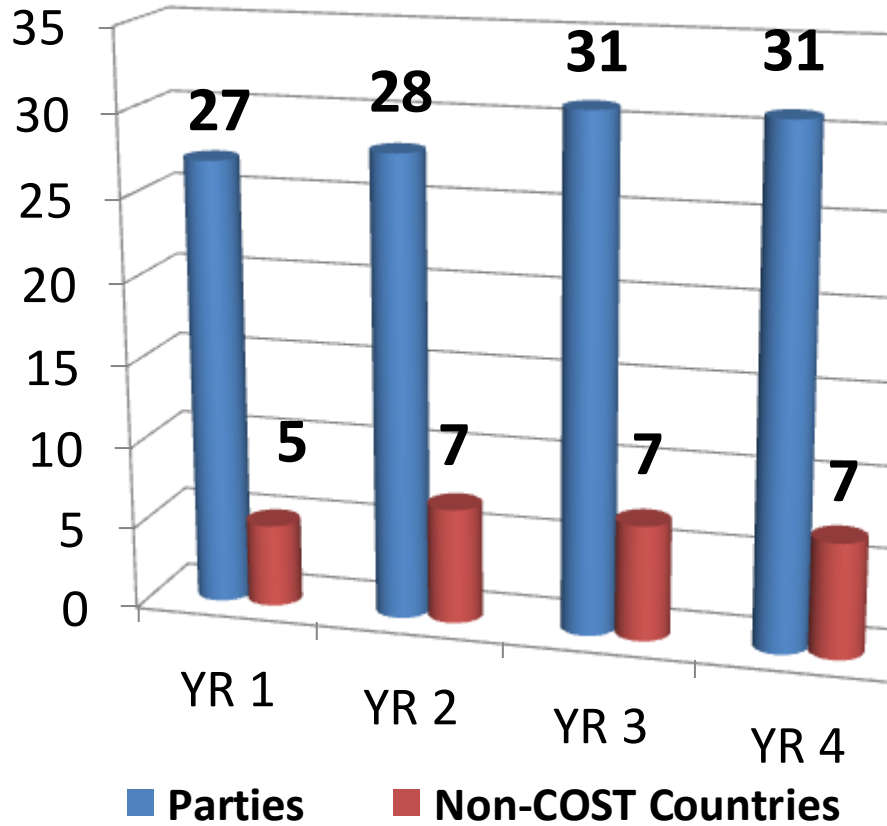
## Grant Holder:

Eurice GmbH, Saarbrücken, Germany

## *GH Scientific Representatives:*

Corinna Hahn, MC Member

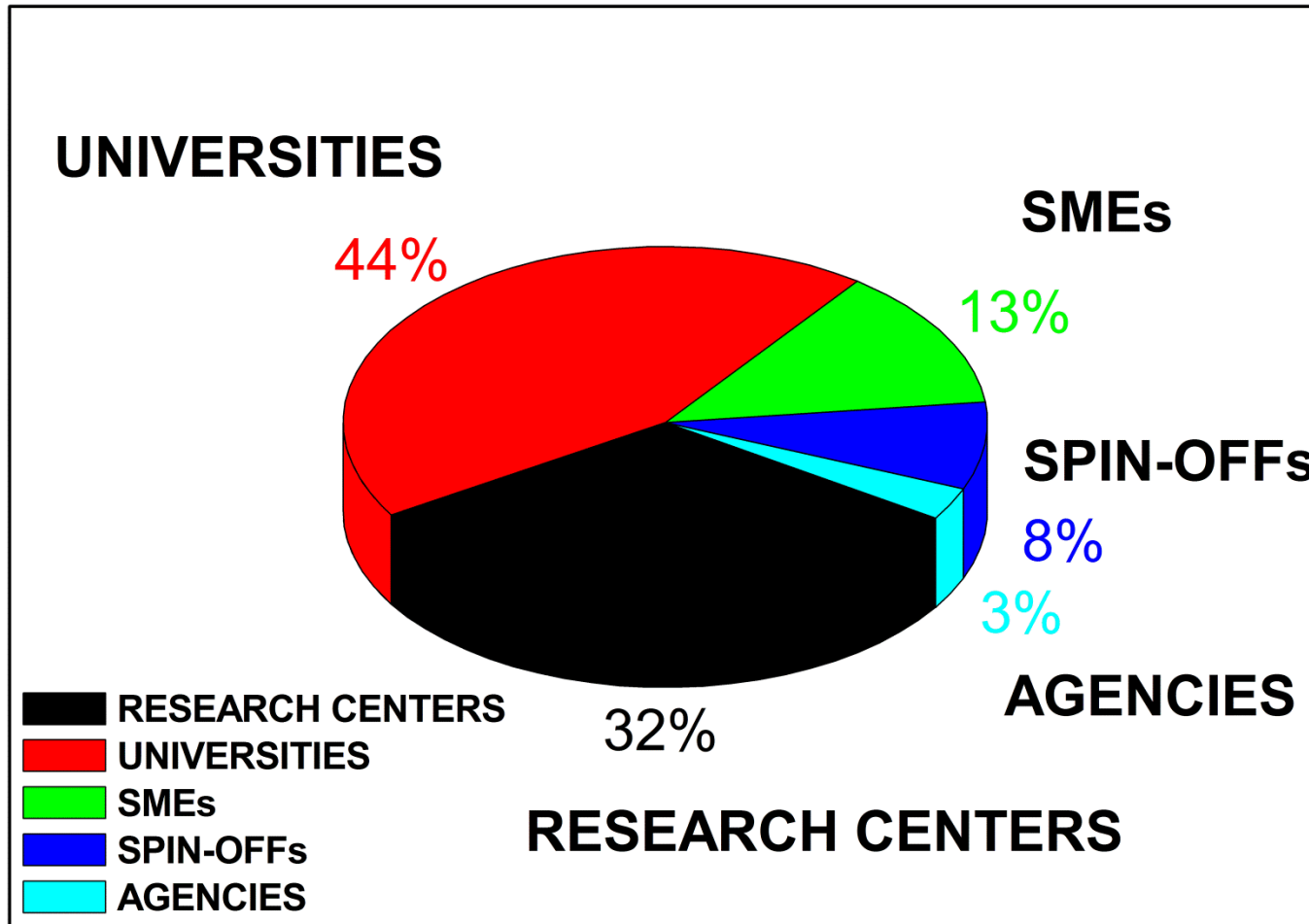
Juliane Rossbach, MC Substitute



**Non-COST Countries: NNC + IPC**

# Action Participation Statistics

**EuNetAir COST PARTNERSHIP** May 2016



**COST Parties: 31**  
**COST Organizations: 123**  
**UNIVERSITIES: 55**  
**RESEARCH CENTERS: 39**  
**SMEs: 16**  
**SPIN-OFFs: 9**  
**AGENCIES: 4**

31 COST Countries (Parties) have already signed Memorandum of Understanding (MoU)

**PARTIES: 31**

**already accepted MoU**

Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Latvia, Luxembourg, The Former Yugoslav Republic of Macedonia, Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom



# COST Action TD1105 *EuNetAir*:

## 7 Non-COST Countries and 8 Non-COST Institutions

**Non-COST Countries:**  
Australia, Canada, China,  
Morocco, Russia, Ukraine,  
USA

**Non-COST Institutions:**  
CSIRO (Australia);  
University of Waterloo  
(Canada); Chinese Academy  
of Sciences, Shanghai  
Institute of Ceramics  
(China); University of  
Agadir IBN Zohr (Morocco);  
National Research Center  
Kurchatov Institute  
(Russia); O.M. Marzeiev  
Institute for Hygiene and  
Medical Ecology of  
Academy of Science of  
Ukraine (Ukraine); Southern  
Illinois University  
Carbondale, NASA Ames  
Research Center (USA).

### Non-COST *EuNetAir* PARTICIPANTS

The map displays the following participants:

- USA - United States:** Ames Research Center, NASA Ames Nano Research Center Center for Nanotechnology, Southern Illinois University Carbondale, Department of Physics.
- CA - Canada:** University of Waterloo, Systems Design Engineering.
- RU - Russian Federation:** National Research Center Kurchatov Institute, Institute of Applied Chemical Physics.
- Ukraine:** O.M. Marzeiev Institute, Academy of Sciences of Ukraine.
- China:** Chinese Academy of Sciences, Shanghai Institute of Ceramics.
- Morocco:** University of Agadir IBN Zohr.
- Australia:** CSIRO, Materials Science and Engineering.

**NNC - Near Neighbour Countries**  
**IPC - International Partner Countries**

# External Experts involved from International Organizations

International Organization	External Expert	Action Event
<b>JRC - IES, Ispra</b>	<i>Michele Gerboles</i>	<ul style="list-style-type: none"> <li>Rome, 3-5 Dec. 2012</li> <li>Barcelona, 20 June 2013</li> <li>Brescia, 10 Sept. 2014</li> <li>Linkoping, 3-5 June 2015</li> <li>Vienna, 25-26 February 2016</li> </ul>
<b>AQUILA Network</b>	<i>Annette Borowiak</i>	<ul style="list-style-type: none"> <li>Duisburg, 4-6 March 2013</li> </ul>
<b>European Environment Agency (EEA)</b>	<i>Valentin Foltescu</i> <i>Cristina Guerreiro (NILU)</i>	<ul style="list-style-type: none"> <li>Copenhagen, 3-4 Oct. 2013</li> <li>Vienna, 25-26 February 2016</li> </ul>
<b>US Environment Protection Agency (EPA)</b>	<i>Tim Watkins</i>	<ul style="list-style-type: none"> <li>Cambridge, 18-20 Dec. 2013</li> </ul>
<b>UNECE</b>	<i>Wenche Aas (NILU)</i>	<ul style="list-style-type: none"> <li>Copenhagen, 3-4 Oct. 2013</li> </ul>
<b>WHO Europe</b>	<i>Michal Krzyzanowski</i> <i>(Former Head WHO Europe Office)</i>	<ul style="list-style-type: none"> <li>Riga, 26-27 March 2015</li> </ul>
<b>MIT, USA</b>	<i>Marguerite Nyhan</i>	<ul style="list-style-type: none"> <li>Istanbul, 3-5 Dec. 2014</li> </ul>
<b>NASA Ames Research Center</b>	<i>Meyya Meyyappan</i> <i>Jing Li</i>	<ul style="list-style-type: none"> <li>Rome, 3-5 Dec. 2012</li> <li>Lille, 26-30 May 2014</li> </ul>
<b>CSIRO, Australia</b>	<i>Philip J. Martin</i>	<ul style="list-style-type: none"> <li>Barcelona, 20 June 2013</li> </ul>
<b>QUT, Australia</b>	<i>Zorane Ristovski</i>	<ul style="list-style-type: none"> <li>Belgrade, 13-14 Oct. 2015</li> </ul>



## Country

## MC Members (58): Male (69%) - Female (31%)

Austria	Dr. Anton KOCK
Belgium	Dr Jan THEUNIS; Dr Anne-Claude ROMAIN
Bulgaria	Dr Dimiter SYRAKOV; Dr Ivan NEDKOV
Croatia	Dr. Irena CIGLENECKI-JUSIC; Prof. Vedran BILAS
Czech Republic	Dr. Vera KURKOVA; Dr. Zdenek ZELINGER
Denmark	Prof. Ole HERTEL
Estonia	Prof. Raivo Jaaniso
Finland	Prof. Kaarle HAMERI; Prof. Jyrki LAPPALAINEN
France	Prof. Marcel BOUVET; Prof. Jerome BRUNET
Germany	Prof. Andreas SCHUETZE; Dr Corinna HAHN
Greece	Prof. George PAPAPOULOS; Prof. Kostas KARATZAS
Hungary	Ms Krisztina LABANCZ; Dr Zita FERENCZI
Iceland	Dr Arngrimur THORLACIUS
Ireland	Dr. Francesco PILLA; Prof. John WENGER
Israel	Dr. Liad ORTAR; Prof. Hossam HAICK
Italy	Dr. Michele PENZA; Prof. G. SBERVEGLIERI; Dr. G. DE GENNARO
Latvia	Dr. Iveta STEINBERGA; Dr. Gita SAKALE
Luxembourg	Dr. Arno GUTLEB
Macedonia Rep.	Dr. Igor ATASANOV; Dr. Ljupcho GROZDANOVSKI
Netherlands	Dr Sywert BRONGERSMA; Dr. Ernie WEIJERS
Norway	Dr Nuria CASTELL BALAGUER; Dr. Philipp SCHENEIDER
Poland	Dr Monika KWOKA; Prof. Janislaw GAWRONSKI
Portugal	Prof. Bernadete RIBEIRO; Prof. Carlos BORREGO
Romania	Dr Marcel IONICA; Dr Roxana Mioara PITICESCU
Serbia	Dr. Anka CVETKOVIC; Dr. Milena JOVASEVIC-STOJANOVIC
Slovenia	Dr Grisa MOCNIK; Dr Rahela ZABKAR
Spain	Prof. Juan Ramon MORANTE; Prof. Eduard LLOBET VALERO
Sweden	Prof. Anita LLOYD SPETZ; Prof. Ingrid BRYNTSE
Switzerland	Dr Danick BRIAND; Dr. Nicolas MOSER
United Kingdom	Dr John SAFFELL; Prof. Roderic JONES
Turkey	Prof. Zafer ZIYA OZTURK; Prof. Mehmet Fatih DANISMAN

**Kick-off Meeting  
Brussels  
16 May 2012**

**MANAGEMENT  
COMMITTEE**

**MC Chair:** Michele Penza, ENEA, IT

**MC Vice Chair:** Anita Lloyd Spetz, Linkoping University, SE

**Grant Holder:** Eurice GmbH, Saarbrucken, DE

## Country

## MC Substitutes (33)

Austria	Dr Stefan DEFREGGER
Belgium	Dr Julien DELVA
Czech Republic	Dr. Roman NERUDA
Denmark	Dr. Lise Lotte SORENSEN
Finland	Prof. Jorma KESKINEN
France	Dr Jean SUISSE; Prof. Alain PAULY Dr. Daniela SCHONAUER-KAMIN
Germany	Dr. Thomas KUHMBUSCH Dr. Juliane ROSSBACH
Greece	Prof. George KIRIKIADIS Dr. Christos KOULAMAS
Hungary	Prof. Zoltan HORVATH
Italy	Dr. Roberto SIMMARANO Dr. Marco ALVISI; Dr. Saverio DE VITO
Macedonia Rep.	Dr. Beti ANGELEVSKA
Netherlands	Dr. Rene OTJES
Poland	Prof. Jacek SZUBER
Portugal	Dr. Joao Paulo TEIXEIRA Dr. Ana Margarida COSTA
Romania	Dr. Cristina RUSTI; Dr. Marcel Adrian IONICA
Slovenia	Prof. Andrej DOBNIKAR
Spain	Prof. Albert ROMANO-RODRIGUEZ Dr. Jordi LLOSA
Sweden	Dr Mike ANDERSSON; Dr. Marina VOINOVA
Switzerland	Dr Christoph HUEGLIN
Turkey	Prof. Necmettin KILINC
UK	Prof. Julian GARDNER Dr Robin NORTH; Prof. Florin UDREA

# Year 4: Scientific Planning of *EuNetAir* (1/2)

Meetings/Workshops/Training Schools planned for upcoming year  
(Year 4: 1 July 2015 - 15 May 2016): EXTENSION: 15 Nov. 2016

- **WG1-WG4 Meeting** on *Air Quality Monitoring and Calibration: Horizons in Sensing Technologies, Methods and Modelling - Start of the 2<sup>nd</sup> EuNetAir Air Quality Joint-Exercise Intercomparison* organized by the VINCA Institute, Belgrade (**Serbia**), 13 - 14 Oct. 2015. Local organizer: Dr. Milena Jovasevic-Stojanovic, VINCA and Anka Cvetkovic, Public Health Institute of Belgrade
- The **4<sup>th</sup> International Workshop of the COST Action TD1105** on *Innovations and Challenges for Air Quality Control Sensors* at FFG (National AT COST Office), Wien (**Austria**), 25 - 26 February 2016. Local organizer: Dr. Anton Kock, MCL
- The **Action 4<sup>th</sup> International Training School** on *Modelling, Methods and Technologies for Air Quality Control* at Emdrup Campus in Copenhagen, by Aarhus University (**Denmark**), 19 - 22 April 2016.  
Local Organizer: Prof. Ole Hertel, Aarhus University. Trainees: 20. Trainers: 8.  
Deadline for Trainees Application: 10 March 2016

# Year 4: Scientific Planning of *EuNetAir* (2/2)

MC/WG Meetings planned for the upcoming year

(Year 4: 1 July 2015 - 15 May 2016): EXTENSION: 15 Nov. 2016

- **5<sup>th</sup> SCIENTIFIC MEETING: WGs Meeting and 8<sup>th</sup> MC Meeting on New Sensing Technologies for Indoor Air Pollution Monitoring and Environmental Measurements** at Bulgarian Academy of Sciences, Sofia (**Bulgaria**), 16 - 18 Dec. 2015. Local organizers: Prof. Ivan Nedkov and Prof. Dimiter Syrakov, BAS

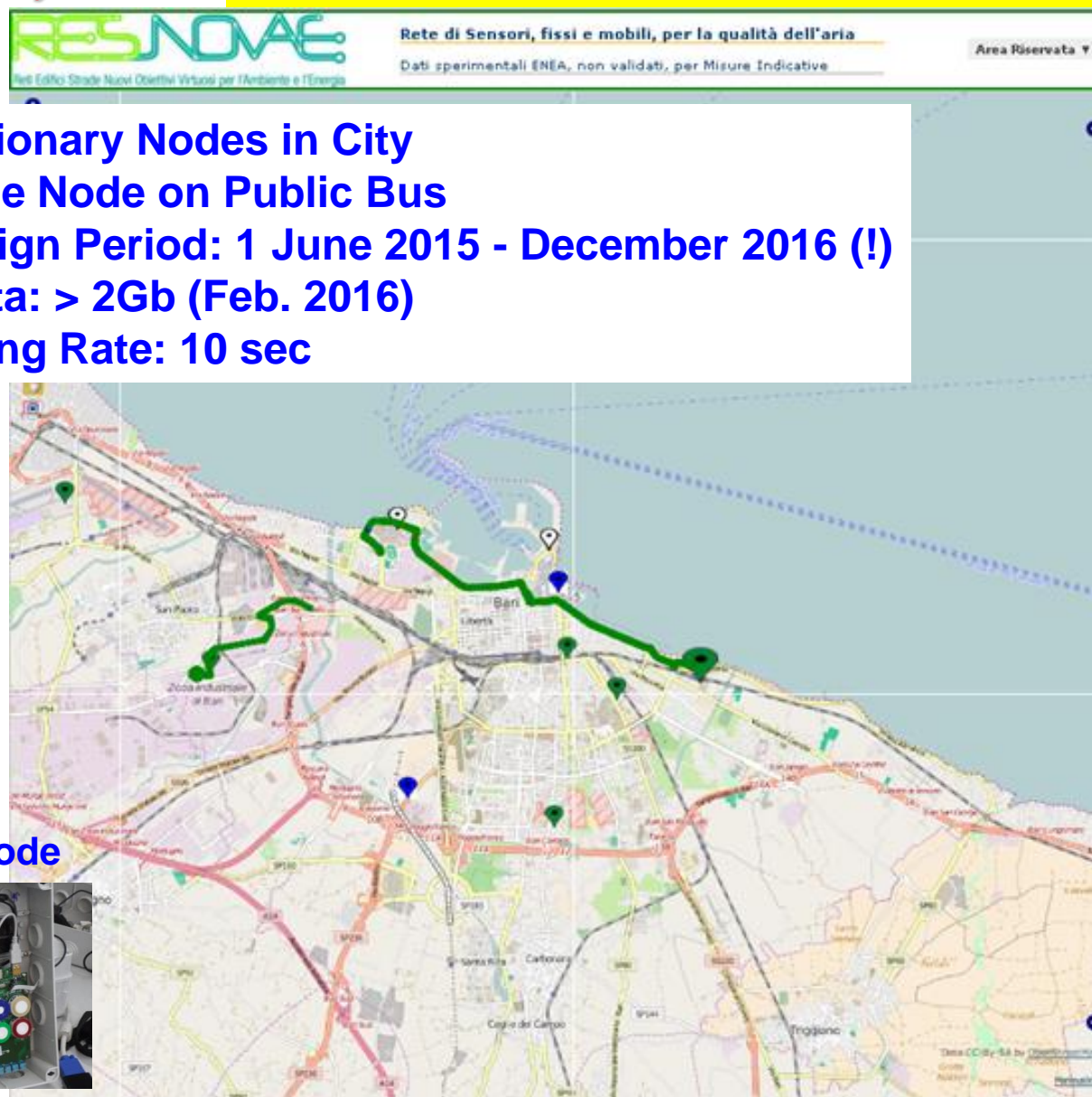
- **6<sup>th</sup> SCIENTIFIC MEETING: WGs Meeting and 9<sup>th</sup> MC Meeting on New Sensing Technologies for Outdoor Air Quality Monitoring** at Czech Academy of Sciences, Prague (**Czech Republic**), 5 - 7 October 2016. Local Organizers: Prof. Zdenek Zelinger, Dr. Vera Kurkova, Dr. Roman Neruda, CAS - FINAL MEETING

- **Special Session EuNetAir / Core-Group Meeting** to **EUROSENSORS 2015**, Freiburg (**Germany**), 6 - 10 September 2015

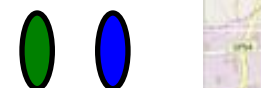
# IT NATIONAL PROJECT RES-NOVAE: OUTDOOR APPLICATIONS

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

## Smart City Bari



- 10 Stationary Nodes in City
- 1 Mobile Node on Public Bus
- Campaign Period: 1 June 2015 - December 2016 (!)
- Big Data: > 2Gb (Feb. 2016)
- Sampling Rate: 10 sec

  
AirBOX  
Sensor-Node



# IT NATIONAL PROJECT RES-NOVAE: OUTDOOR APPLICATIONS

Smart City Bari

## AQ ENEA Sensors Fixed Nodes Network distributed in Bari (Italy)



Centro Ricerche Brindisi

### ENEA Sensors Lab OpenVPN Status Monitor

N7: ON BUS



nea NasusPI - Connection up, pingable. 12 clients, 603847607 bytes in, 314525951 bytes out

[ 172.17.0.1 tun ]

Username / hostname	VPN IP Address	Remote IP Address	Port	Location	Recv	Sent	Connected Since	Last Ping	Time Online
<a href="#">nasuspi-5</a>	172.17.0.6	37.19.108.20	52428		73065	73872	23/02/2016 15:28:09	23/02/2016 15:28:16	3:01:40
<a href="#">nasuspi-8</a>	172.17.0.9	62.19.56.54	24059		16932314	8252487	14/02/2016 02:06:33	23/02/2016 18:26:23	9 days, 16:23:16
<a href="#">nasuspi-2</a>	172.17.0.3	62.19.60.187	50059		61118723	29838611	19/01/2016 15:31:29	23/02/2016 18:22:13	35 days, 2:58:20
<a href="#">nasuspi-12</a>	172.17.0.13	5.170.133.155	21548		3986071	2173688	22/02/2016 12:31:11	23/02/2016 18:26:45	1 day, 5:58:38
<a href="#">nasuspi-3</a>	172.17.0.4	5.170.159.213	49326		50720954	24762444	25/01/2016 14:59:28	23/02/2016 18:18:43	29 days, 3:30:21
<a href="#">nasuspi-13</a>	172.17.0.14	62.19.60.37	28028		10410773	4378176	19/02/2016 15:22:35	23/02/2016 18:19:49	4 days, 3:07:14
<a href="#">nasuspi-6</a>	172.17.0.7	5.170.100.125	44309		60155115	28671705	21/01/2016 09:35:05	23/02/2016 18:27:28	33 days, 8:54:44
<a href="#">airbox-one</a>	172.17.0.20	192.168.172.238	38932	RFC1918	2992201	3165714	18/02/2016 09:20:28	18/02/2016 09:20:28	5 days, 9:09:21
<a href="#">nasuspi-1</a>	172.17.0.2	62.19.59.82	13710		16883240	8246839	14/02/2016 02:05:49	23/02/2016 18:17:56	9 days, 16:24:00
<a href="#">nasuspi-9</a>	172.17.0.10	62.19.59.173	34552		9107149	4258171	18/02/2016 19:48:32	23/02/2016 18:26:32	4 days, 22:41:17
<a href="#">nasuspi-4</a>	172.17.0.5	62.19.57.93	34803		25405866	12317796	09/02/2016 06:27:37	23/02/2016 18:25:51	14 days, 12:02:12
<a href="#">nasuspi-10</a>	172.17.0.11	5.170.246.120	20180		17242918	8314106	14/02/2016 02:06:27	23/02/2016 18:18:10	9 days, 16:23:22

N1: ENEL

N2: ENEA

N3: PERONI

N4: AMTAB

N6: AIRPORT

N8: POLIBA

N9: COFELY

N10: City Office

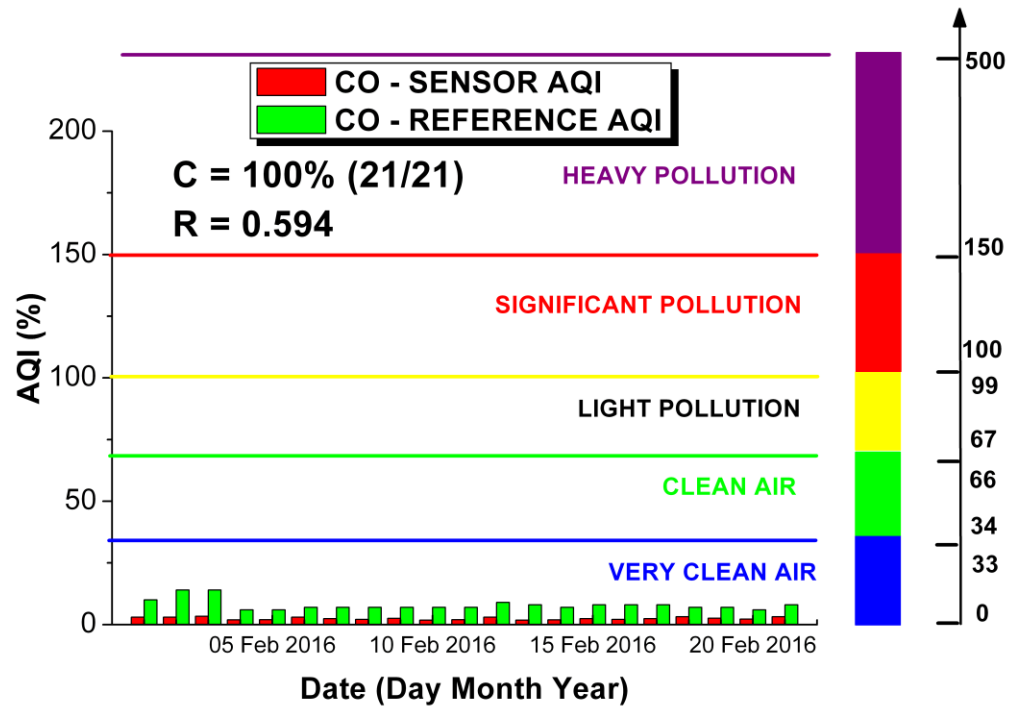
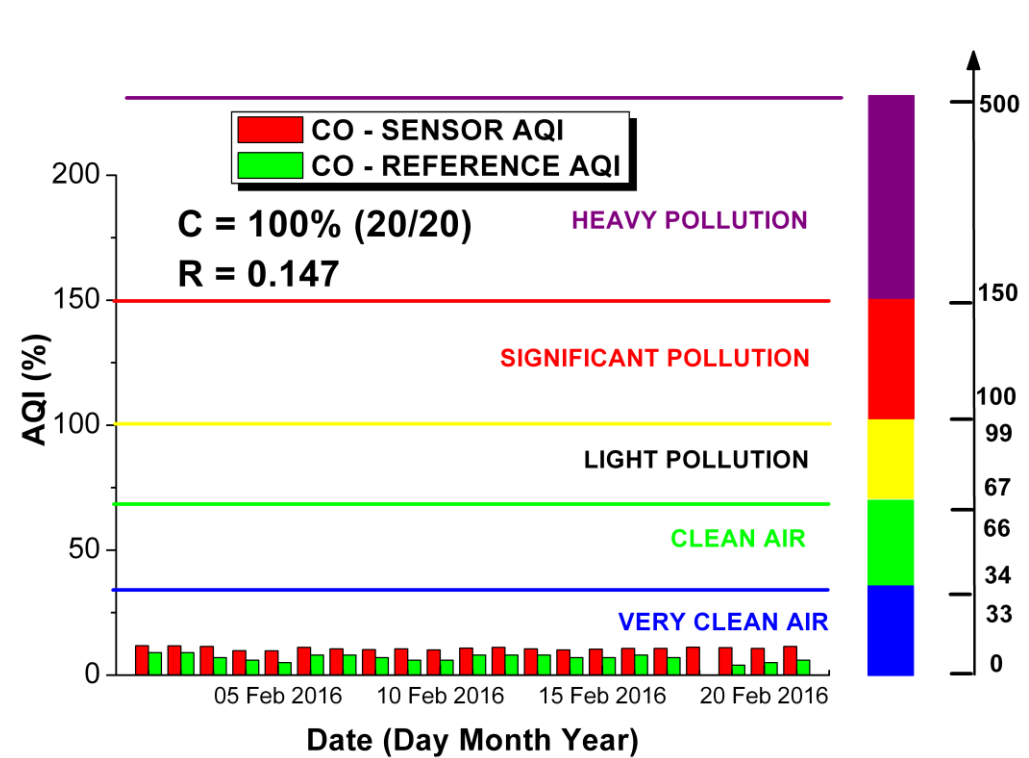
N12: FAIR

N13: PORT

# CITY SENSORS NETWORK: AQI from Nodes

**CO**  
**Node 2: ENEA**  
**AQI Sensor vs. AQI Reference**  
**1 - 21 February 2016**

**CO**  
**Node 6: Bari AIRPORT**  
**AQI Sensor vs. AQI Reference**  
**1 - 21 February 2016**



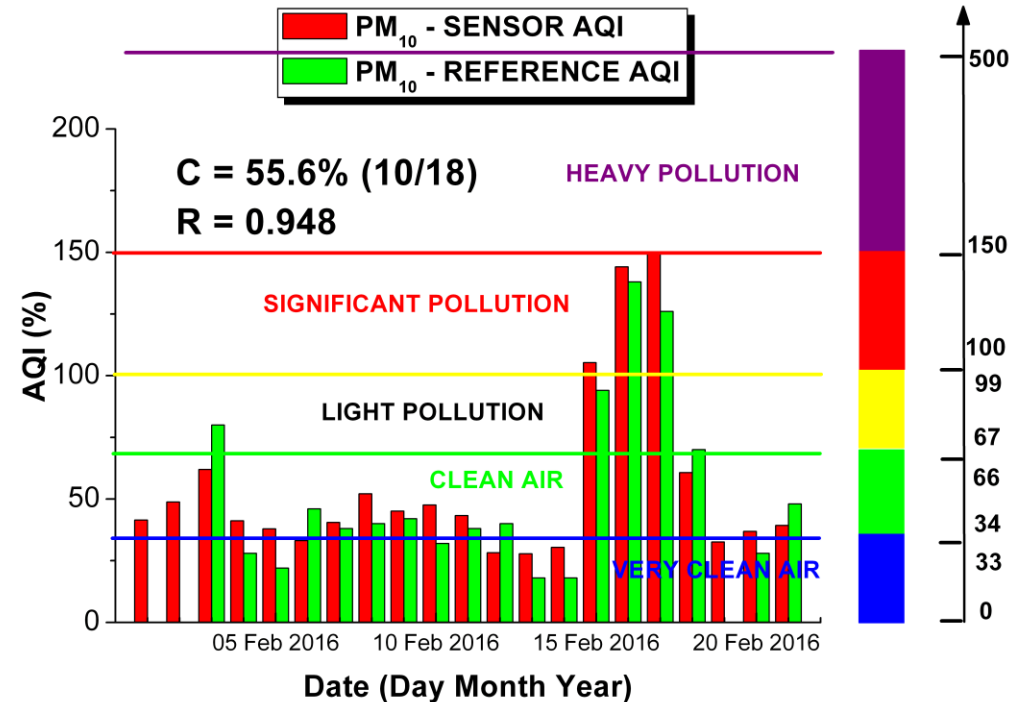
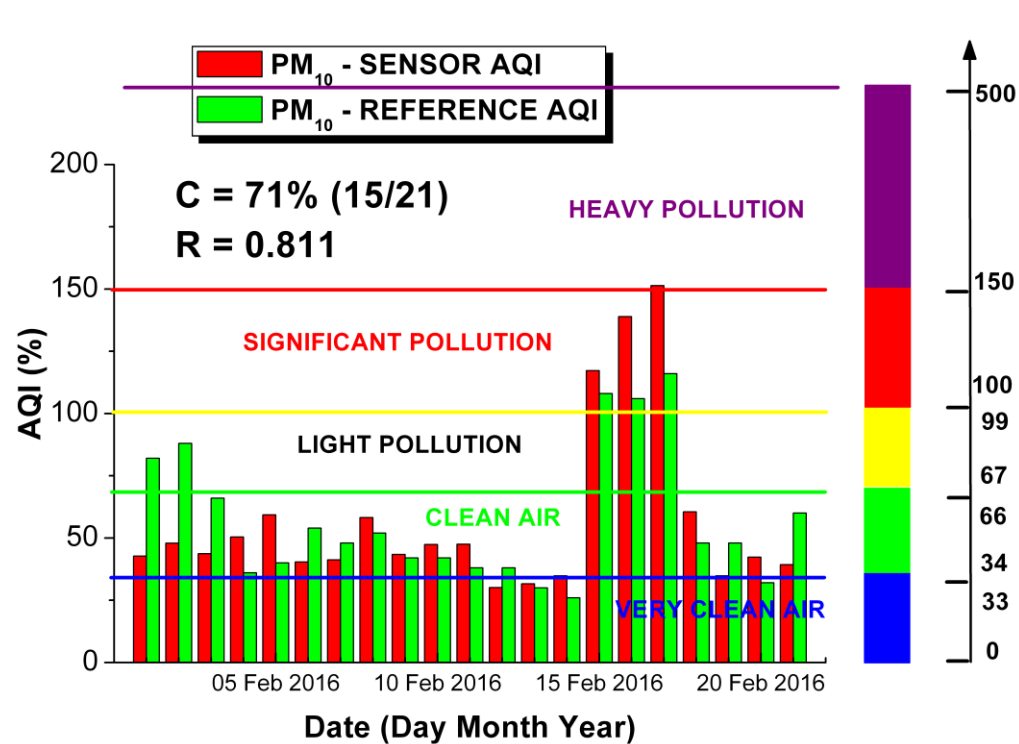
*R = Correlation Coefficient*  
*C = Classification Index*

**Courtesy by ENEA**

# CITY SENSORS NETWORK: AQI from Nodes

## PM<sub>10</sub> Node 2: ENEA AQI Sensor vs. AQI Reference 1 - 21 February 2016

## PM<sub>10</sub> Node 6: Bari AIRPORT AQI Sensor vs. AQI Reference 1 - 21 February 2016



*R = Correlation Coefficient*  
*C = Classification Index*

**Courtesy by ENEA**

# Aveiro Joint-Exercise Intercomparison & WG Meeting

13 - 27 October 2014: Starting Joint-Exercise (2 weeks duration)

14 - 15 October 2014: EuNetAir WG1-WG4 Meeting

**EuNetAir Air Quality Joint-Exercise Intercomparison 2014**

**Local Organizers: Prof. Carlos Borrego and Dr. Ana Margarida Costa (IDAD)**

**Air Quality Monitoring campaign at Aveiro (Portugal) city centre 2014**



Continuous measurements: CO, benzene, NO<sub>x</sub>, SO<sub>2</sub>, PM<sub>10</sub>, VOC

Temperature, humidity, wind velocity, wind direction, solar radiation, precipitation

**COST partners (15 teams joined from 12 COST Countries) installed their microsensors side-by-side to compare performance with referenced equipment in the Air-Quality Mobile Laboratory**



# COST Action TD1105 *EuNetAir: Aveiro* INTERCOMPARISON

*New Sensing Technologies and Modelling for Air-Pollution Monitoring*

CAMBRIDGE  
CMOS  
SENSORS



Cambridge, UK



Kjeller, NO



Delsbo, SE



Cambridge, UK

Eindhoven, NL



Saarbr., DE



SIEMENS

Warwickshire, UK



Mol, BE



Louvain, BE

Petten, NL



Munich, DE



Leoben, AT



Corcelles, CH



Aveiro, PT



Barcelona, ES



Brindisi, IT



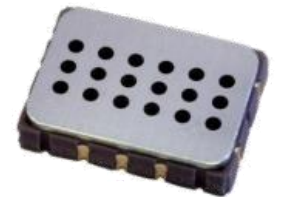
Thessaloniki, EL



# 1<sup>ST</sup> EuNetAir Air Quality Joint-Exercise Intercomparison

## • Micro-sensors typologies and monitored pollutants:

- Electrochemical sensors:
  - NO, NO<sub>2</sub>, CO, O<sub>3</sub>, SO<sub>2</sub>
- Optical sensors:
  - PM1, PM2.5, PM10
- Metal Oxide Semiconductor based sensors (MOS):
  - NO<sub>2</sub>, COV, CO, O<sub>3</sub>, SO<sub>2</sub>
- Non dispersive infrared technology sensors (NDIR):
  - CO<sub>2</sub>
- Photoionization detection sensors (PID):
  - COV<sub>t</sub>

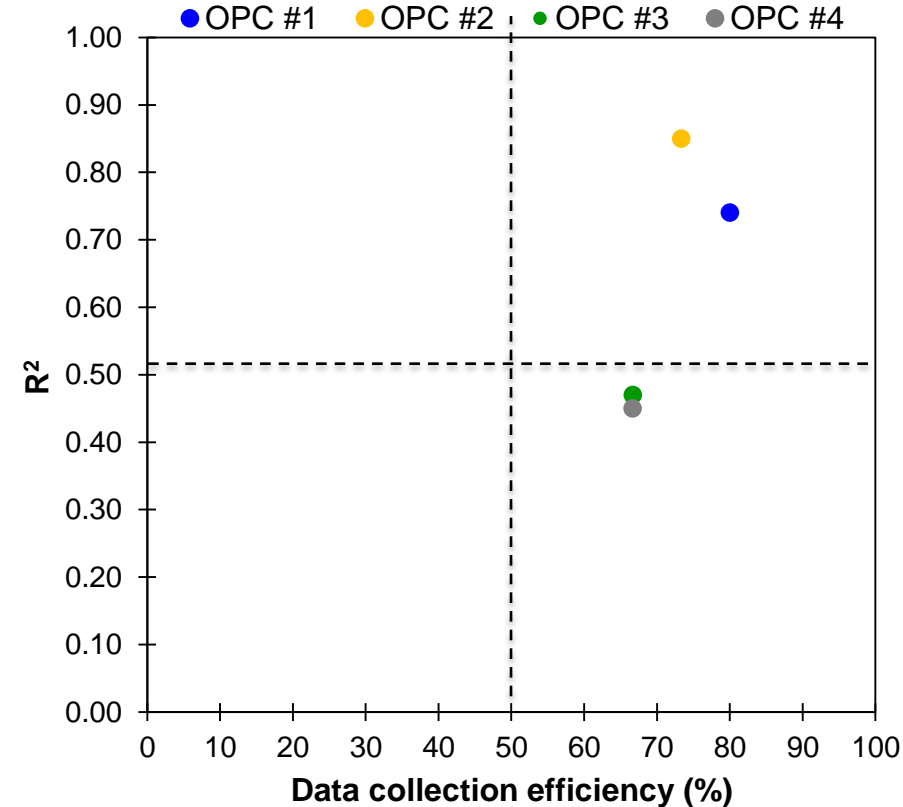
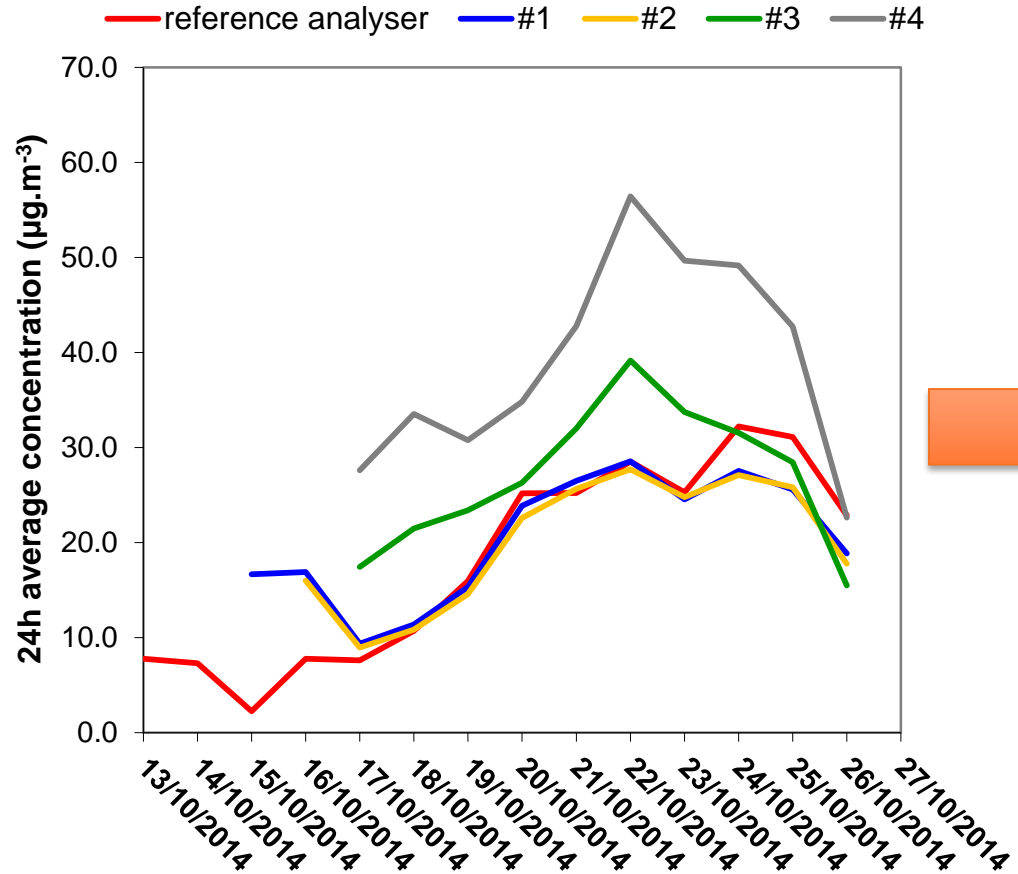


*Carlos Borrego, IDAD, Aveiro, Portugal*

# Assessment of micro-sensors vs. reference methods

Carlos Borrego, IDAD, Aveiro, Portugal

- **PM2.5:**



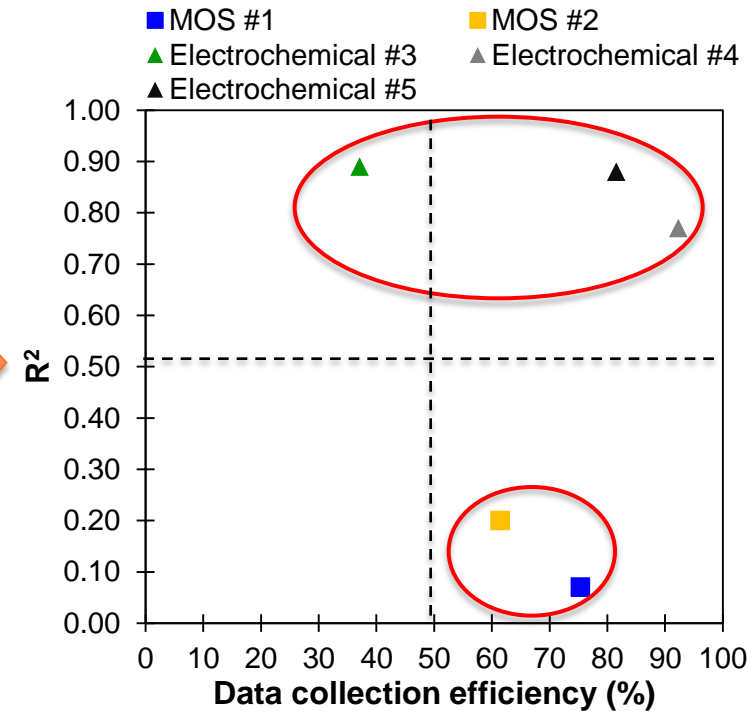
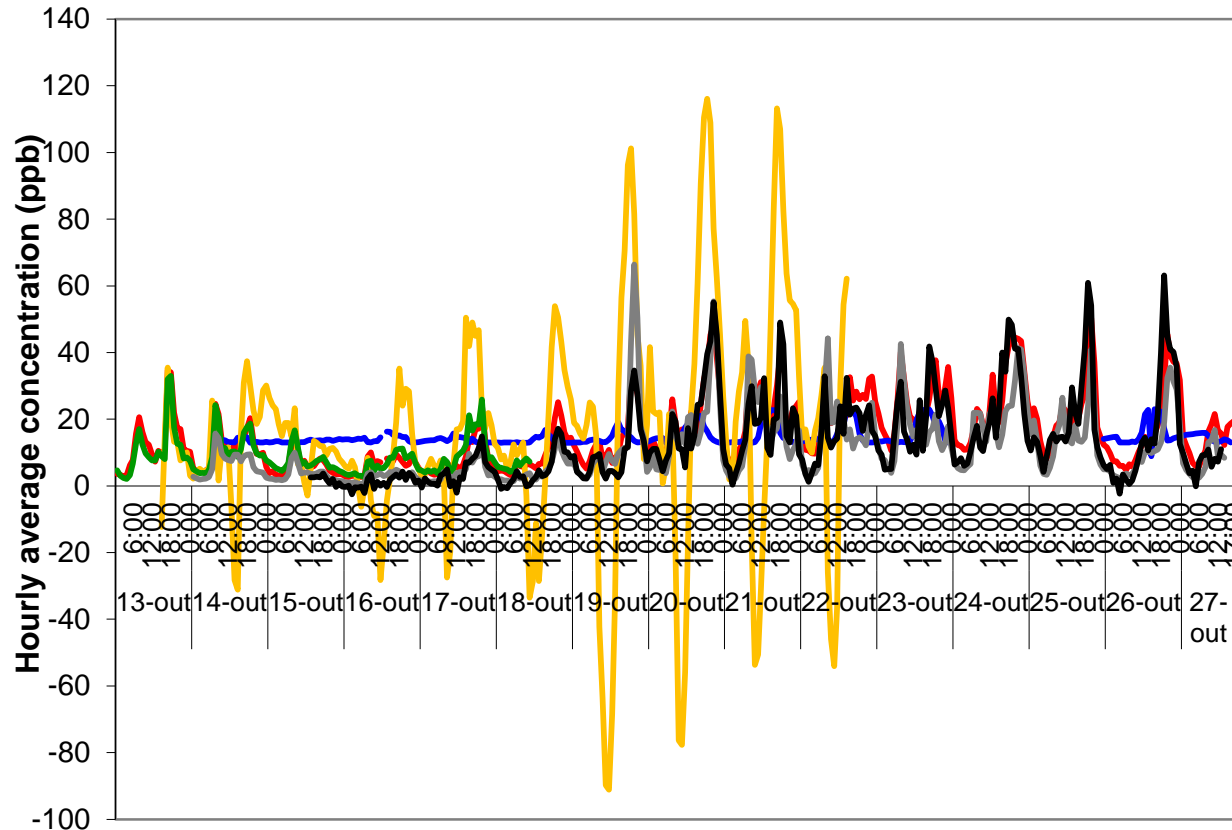
- The optical (OPC) sensors for PM2.5 presented correlations varying between 0.45-0.85 and data collection efficiencies in the range of 67-80%.

# Assessment of micro-sensors vs. reference methods

Carlos Borrego, IDAD, Aveiro, Portugal

- **NO<sub>2</sub>:**

— reference analyser — #1 — #2 — #3 — #4 — #5



- **Electrochemical sensors showed a greater correlation with the reference method and in most cases a higher efficiency collecting data than metal oxide semiconductor (MOS) sensors.**

# Open Questions of the Air Quality Sensors

- Lower Accuracy compared to Reference Methods
- Cross-sensitivity and low Selectivity
- Low Stability and Drift to be corrected periodically
- Calibration needs periodically (e.g., at least 1 calibration/month)
- Regular Maintenance of the in-field AQ sensor nodes
- Data Quality Objective (European Directive 2008/50/EC) to be addressed for ***Indicative Measurements*** by demonstration of the equivalence to use microsensors for AQ monitoring

# Advantages and Benefits of the Air Quality Sensors

- Low-cost for deployment in Cities at high spatial-temporal resolution
- Suitability for personal exposure studies
- Suitability for emission source information
- Outdoor monitoring of gases ( $\text{NO}_2/\text{NO}$ ,  $\text{O}_3$ ,  $\text{CO}$ ,  $\text{SO}_2$ ,  $\text{H}_2\text{S}$ , tVOCs,  $\text{CO}_2$ ,  $\text{NH}_3$ , etc.)
- Outdoor monitoring of particulate matter ( $\text{PM}_{10}$ ,  $\text{PM}_{2.5}$ ,  $\text{PM}_{1.0}$ , UFP)
- Indoor monitoring of gases ( $\text{CO}$ , VOCs, benzene, formaldehyde, naphthalene, toluene, etc.) and PM ( $\text{PM}_{10}$ ,  $\text{PM}_{2.5}$ ,  $\text{PM}_{1.0}$ )
- Combination of sensors with modelling for micro-scale analysis (1-2 mt resolution)

# OUTREACH ACTIVITIES from Action TD1105

## COST Action TD1105 - EuNetAir

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

Action website:

[www.cost.eunetair.it](http://www.cost.eunetair.it)

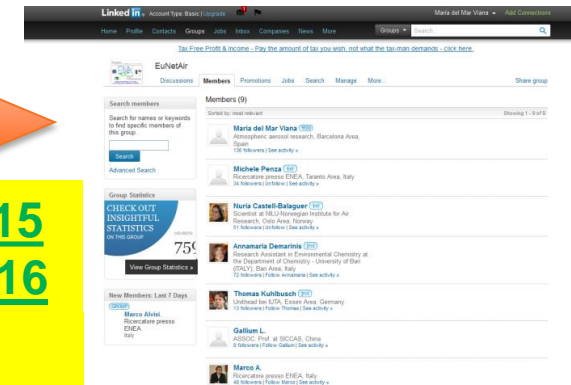
hosted by ENEA

**Dr. Marco Alvisi, Webmaster Coordinator**

**Sebastiano Dipinto, Valerio Pfister, Gianfranco Zingarelli, Webmaster Team**

Social Scientific ESRs Network (SSEN) by LinkedIn

Members: >80 - Moderators: M. Viana, M. Minguillon



4° CALL for Short Exchange Visits launched on September 2015  
Short Term Scientific Mission: **6 TO BE FUNDED** by 15 Nov. 2016

**Dr. Jan Theunis, STSM Coordinator EuNetAir**



**EuNetAir Newsletter**

COST Action TD1105 Iss. 1/Dec 2012

Opening Editorial

- Issue 1: published on Dec. 2012 ✓
- Issue 2: published on June 2013 ✓
- Issue 3: published on Dec. 2013 ✓
- Issue 4: published on June 2014 ✓
- Issue 5: published on Dec. 2014 ✓
- Issue 6: published on June 2015 ✓
- Issue 7: published on Dec. 2015 ✓

**Prof. Ralf Moos, Editor-in-Chief**

**Dr. Daniela Schonauer-Kamin, Editorial Board Manager**

# 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

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





# Contact Details



**CSO Approval:** 01 Dec. 2011  
**Kick-off Meeting:** 16 May 2012  
**Start of Grant:** 01 July 2012  
**End of Grant:** 15 Nov. 2016

[www.cost.eunetair.it](http://www.cost.eunetair.it)

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[michele.penza@enea.it](mailto:michele.penza@enea.it)

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[http://www.cost.eu/domains\\_actions/essem/Actions/TD1105](http://www.cost.eu/domains_actions/essem/Actions/TD1105)

**Top Story**   
▶ all stories

***TD1105 selected as Top-Story  
by COST Association***



**Taking charge of air quality control in Europe's smart, green cities**



A COST funded network of European spin-offs, SMEs, agencies, research centres and universities is working on developing cheaper and energy efficient sensors for air quality control in Europe's future smart cities.

▶ full story



**MATERIALS RESEARCH SOCIETY**

*Advancing materials. Improving the quality of life.*

## **Symposium PM4 at 2016 MRS Fall Meeting & Exhibit**

**Boston (USA), 27 November - 2 December 2016**

### ***Novel Materials, Fabrication Routes and Devices for Environmental Monitoring***

• **Symposium Organizers:** <http://www.mrs.org/fall2016>

- ✓ Michele Penza, ENEA, Italy
- ✓ Ruby Ghosh, Michigan State University, USA
- ✓ Albert Romano-Rodriguez, Barcelona University, Spain
- ✓ Meyya Meyyappan, NASA Ames Research Center, USA

• **Deadline for abstract submission: 16 June 2016**



2016 **MRS**<sup>®</sup>  
FALL MEETING & EXHIBIT  
November 27 – December 2, 2016 | Boston, Massachusetts

**CALL FOR PAPERS**

**Abstract Deadline: June 16, 2016**

REMINDER: In fairness to all potential authors,  
late abstracts will not be accepted.

[www.mrs.org/fall2016](http://www.mrs.org/fall2016)

Symposium PM4: Novel Materials, Fabrication Routes and Devices for Environmental Monitoring

# ACKNOWLEDGEMENTS

Lille, France, 2 - 6 May 2016



**THANK YOU VERY MUCH FOR YOUR KIND ATTENTION !**



**Symposium X:**

***Functional materials for environmental sensors and energy systems***

**Deadline for Proceedings BJNANO submission:**

**30 June 2016**

