COST Action TD1105

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

COST Action TD1105 Scientific Workplan

Action Core-Group: Working Groups and Sub-Working Groups Leaders		
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Working Groups Workplan Updating

This Action will achieve its scientific objectives through 4 inter-related Work-Packages identified in the Working Groups (WGs). These groups are responsible for carrying out the scientific tasks listed in the section D1 of Memorandum of Understanding (MoU). To this purpose the Action will be initially focused on the key-aspects in the development roadmap.
The **four WGs** will aim to activate the scientific debate and the consequent synergy on the listed topics:

- **WG1: Sensor materials and nanotechnology**
- **WG2: Sensors, devices and sensor-systems for AQC**
- **WG3: Environmental measurements and air-pollution modelling**
- **WG4: Protocols and standardisation methods**

Updating of the WG1 Workplan

Working Group 1: Sensor materials and nanotechnology

ROLE - TASK	NAME	COUNTRY
WG1-Leader (Coordinator) Sensor Materials and Nanotechnology	Prof. Juan Ramon Morante IREC	Spain
WG1 Vice-Chair Sensor Materials and Nanotechnology	Prof. Jyrki Lappalainen Oulu University	Finland
Sub-WG 1.1 Metal oxides nanostructrures for AQC gas sensors	Prof. George Kiriakidis FORTH	Greece
Sub-WG 1.2 Carbon nanomaterials for AQC gas sensors	Prof. Eduard Llobet Universitat Riviri I Virgili	Spain
Sub-WG 1.3 Emerging sensor materials (organic/inorganic, hybrid, nanocomposites, polymers, functional, etc.)	Prof. Marcel Bouvet Universitè de Bourgogne	France
MEMBERS WG1		

From Memorandum of Understanding

WG1: Sensor materials and nanotechnology

Gas sensors have been extensively used to detect and monitor a wide variety of volatile and other radical gases. In particular, gas sensors have a huge variety of applications such as environmental quality control, public safety issues, medical applications, automotive applications, air conditioning system setups in aircrafts, spacecrafts, vehicles, houses, etc. According to a recent industrial market report, in the USA the demand for sensors raised with an average annual growth rate (AAGR) of 4.6% from $6.1 billion in 2004 to $7.6 billion in 2009.

New classes of Nanostructured Materials are very promising for gas sensing: Semiconducting metal oxides (MOs), carbon-nanomaterials (i.e., carbon nanotubes, nanowalls, graphene, etc.), conducting polymers, nanocomposites. Semiconducting metal oxides (MOs) such as SnO_2, TiO_2, InO_x and ZnO are used for gas sensing applications due to the sensitivity of their electrical conductivity to the ambient gas composition, which arises from charge transfer interactions with reactive gases such as O_2, NO_x, CO, hydrocarbons (HC), volatile organic compounds (VOC) and ozone (O_3). Ozone is a strong multi-purpose oxidizing gas which plays a fundamental role to the formation of photo-chemical smog in urban polluted areas. It may also be met in a wide field of industrial and agriculture applications. Ozone, in concentrations over the 40 ppb threshold, is known to be harmful to the human body according to existing USA (FDA) and EU standards. Thus a big thrust, for the development of gas sensors, driven by the need to enhance radical gases, including ozone, and trace element detection limits for security and environmental reasons, emerged. The sensitivity and response time of MOs based ozone sensor films strongly depend on the porosity of the material type. In addition, the grain size of the polycrystalline MO film has also a noticeable effect on its gas sensing properties. However, the gas sensing mechanism of polycrystalline MOs films is partially understood and the effect of grain size on the gas sensitivity in the limit of grains requires further clarification.

In the present COST Action, the WP1 efforts will be on Sensor materials and nanotechnology including advances and recent trends to develop and utilize sensors fabricated mainly by MOs polycrystalline films utilizing among other, two of the most intensively studied techniques, i.e. Aerosol Spray Pyrolysis (ASP) and DC magnetron sputtering. The influence of the grain size

and the surface morphology from films obtained by the above different depositions techniques, achieving sensing responses of the order of a few parts per billion for gases such as ozone at room temperature, will be emphasized. Study of the sensitivity of MO films to additional harmful gases (NO_2, H_2 and vapors of acetone) will provide a guide for further material and device development either onto glass and Si or on flexible (PET/PEN substrates. Involving the successful application of flexible substrates may lead to simpler, faster and inexpensive fabrication techniques targeting novel roll-to-roll and printed processing applications with obvious advantages over conventional ceramic or silicon-based technologies. Sensor responses will be studied by applying conventional conductometric techniques or specific low to medium frequency Surface Acoustic Wave (SAW) devices which have shown high sensitivity towards electrical perturbations caused by the gas interaction at their active surface. Other advanced transducers (MEMS, NEMS, cantilevers, optical fibers, Field Effect Transistor (FET), electrochemical devices, etc.) will be studied as well.

Another important class of sensor materials to be considered in the research activities are carbon-based nanomaterials, including nanotubes, nanowalls, advanced nanostructures, nanoparticles. These nanomaterials can be synthesized by means of cost-effective methods with Chemical Vapor Deposition (CVD) technologies at single-wall or multi-wall format but not yet by controlled processing. These carbon-based nanomaterials are very sensitive to different air-pollutants even at room temperature for developing wireless gas-sensors at low-power consumption. Also, functionalizations with metal nanoclusters and surface-modifications of carbon nanomaterials are very challenging for addressing high sensitivity and broad selectivity.

WG1 Workplan Objectives will include:

- Protocols for synthesis of gas-sensitive nanomaterials;
- Protocols for synthesis of functionalized nanostructures for enhanced gas detection at part-per-billion (ppb) level, stability and selectivity;
- Report on nanomaterials characterization for AQC gas sensors;
- Protocols for integration of nanomaterials into micromachined devices and gas sensors;
- Protocols for development of gas nanosensors, microsensors and sensors-array.

WG1 Deliverables:

- Overview of the current state-of-the-art on gas sensor materials and advanced nanostructures;
- Recommendations for gas-sensitive nanomaterials priorities and strategies;
- Recommendations for nanotechnologies and nanomaterials management;
- Guidelines for an open framework on nanomaterials and new sensing technologies for AQC.

Current topics in the research related to the Action WG1 issues

*The **hot-issues** in the current research related to the Action WG1 topics with emphasis to the selected activities from Action WG1 members are described.*
WG1 parallel session at Rome Meeting (ENEA Headquarters, 4-6 December 2012) to collect inputs from members during WG1 discussions to address the current research.

Description of current research related to WG1 Issues

It was obvious from the eleven presentations given in work group WG1 meeting that implementation, combining and integration of the conventional sensor materials, such as various metal oxides and carbon based nanomaterials, in forms of different nanostructures including thin films, nanoparticles, nanowires, nanotubes, nanoneedles, and nanoporous structures offer huge potential to be exploited in gas sensor applications, and yet still not studied extensively. This also includes totally new perspectives among the more conventional approaches, as listed below:

- realization of metal-oxide MO_x sensor materials in nanostructured forms and utilization of subsequent increase of specific surface area and possible change in detection mechanisms
- utilization of CNMAT - Carbon Nano Materials and their functionalization, i.e. CNT and graphene, in combination of metal and MO_x nanoparticles, and integration of the materials on the transistor structures
- use of heterostructures and mixed phase materials as sensing elements in gas sensors including heterostructures of semiconductors and polymers in Schottky junctions, and mixed phase MO_x structures creating p-n-junctions
- development of low-cost mass-production fabrication methods, like ink-jet printing, with capability to utilize nanostructures sensor materials also on flexible substrates
- use of biomaterials, enzymes, and antibodies, for example, in combination of other materials in complex smart sensor systems

Priorities in the research and networking activities related to the Action WG1 issues

*The **PRIORITIES** in the current research related to the Action WG1 issues with emphasis to the selected activities from Action WG1 members are described.*
WG1 parallel session at Rome Meeting (ENEA Headquarters, 4-6 December 2012) to collect inputs from members during WG1 discussions to address the priorities.

Description of WG1 Priorities

The research directions as WG1 Priorities for Action TD1105 can be summarized as:

- Other materials: biomaterials, enzymes, antibodies, etc.
- Molecular, organic/inorganic materials:
  - ✓ Heterostructures of semiconductors and polymers, Schottky junctions
- Processing of low cost sensors on flexible substrates:
  - ✓ Printing techniques, inkjet printing, spin coating, droplet casting, etc.
  - ✓ Template assisted growth of nanostructures
- Chemical modifications in the surface of materials with tuned properties for selectivity and specific applications
- Combination of different approaches and methods and defining the state-of-art of the technologies available, for example, to realize smart sensor structures.

WG1 Priorities

- *Priority #1:* MO thin films, nanoparticles, nanowires, nanotubes, nanoneedles, nanoporous forms of materials like ZnO, SnO_2, WO_3, TiO_2, InO_x, NiO, and magnetic materials Fe_3O_4, doped dielectrics $BaSrTiO_3$, etc:
  - ✓ Doping of the materials to improve sensitivity and selectivity
  - ✓ Nanostructuring to increase specific surface area
  - ✓ Heterojunction effects of materials
  - ✓ Phenomena at the surface
- ✓ *Priority #2*: CNMAT - Carbon Nano MATerials and their functionalization, i.e. CNT, graphene:
  - ✓ Functionalization of CNMAT by metal and MO_x nanoparticles, chemical functionalization
  - ✓ Doping of graphene layers, integration of graphene on SiC devices
- ✓ *Priority #3*: Molecular, organic/inorganic materials:
  - ✓ Heterostructures of semiconductors and polymers, Schottky junctions
- ✓ *Priority #4*: Processing of low cost sensors on flexible substrates:
  - ✓ Printing techniques; inkjet printing, spin coating, droplet casting, etc.
  - ✓ Template assisted growth of nanostructures
- ✓ *Priority #5*: Other materials: biomaterials, enzymes, antibodies, etc.
- *Priority #6*: Chemical modifications of the materials with tuned properties to address selectivity and specific applications
- *Priority #7*: Combination of different approaches and defining the state-of-art of the technologies available, for example, to realize smart sensor structures.

Updating of the WG2 Workplan

Working Group 2: Sensors, devices and sensor-systems for AQC

ROLE - TASK	NAME	COUNTRY
WG2-Leader (Coordinator) Sensors, Devices and Systems for AQC	Prof. Andreas Schuetze Saarland University	Germany
WG2 Vice-Chair Sensors, Devices and Systems for AQC	Prof. Florin Udrea Cambridge CMOS Sensors Limited	UK
Sub-WG 2.1 Gas sensors and new transducers	Dr. Danick Briand EPFL	Switzerland
Sub-WG 2.2 Portable gas sensor-systems	Dr. Sywert Brongersma IMEC	Netherlands
Sub-WG 2.3 Wireless technology and AQC sensors network	Prof. George Papadopoulos ISI-ATHENA RIC	Greece
Sub-WG 2.4 Intelligent algorithms and distributed computing for networked AQC gas sensors	Prof. Julian Gardner University of Warwick	UK
MEMBERS WG2		

From Memorandum of Understanding

WG2: Sensors, devices and sensor-systems for AQC

The low-cost and ubiquitous measurement of air quality is essential for the health and well-being of EU citizens. Today air quality is generally monitored in the process industries, such as the petrochemical industry, or in city centres where pollution is an issue. The most common sensors are electrochemical for high concentrations of redox gases (oxygen, methane, etc.), optical for high concentrations of gases (CO_2, H_2) or metal oxide for low concentrations of toxic gases (CO, NH_3, NO_x). However, in the future we need to measure these gases at many more locations and at a much lower cost. The average price of a gas sensor today is €25 - and this does not include the interface circuitry, read-out electronics or packaging. This Actions aims to utilize pioneering research into low cost SOI CMOS based devices for low power gas and temperature sensing. Devices have been developed based on existing metal oxide materials and new on-chip nanomaterials such as nanowires and nanotubes to make low-cost, low-power devices at the full wafer level in a tungtsen CMOS process. The same patented technology is being used in IR gas sensors with a new SOI based product launched in June 2011 at the Sensor + Test Fair (Nurnberg). Further developments are needed to address the issues of AQC and in particular the reliability of the sensors, ultralow power consumption and wireless interfaces to control systems. Our approach is to look at thermally modulated polymer devices for low power detection of VOCs and to consider smarter interface circuitry. By smart design of CMOS devices, the Action hopes to initiate a new generation of devices for AQC systems.

The development of nanosensors and nanotransducers for portable gas sensor systems, miniaturised systems and microsystems will be addressed by:

- the implementation of full microsystem compatible technology for developing sensors based on the use of nanomaterials and their performances and characteristics with transducer principles controlled at the nanoscale level;

- the feasibility analysis of the implemented nanosensors considering response level, stability, selectivity and response times as well as their robustness as elements of heterogeneous integrated microsystems;
- the exploration of the power consumption requirements and capabilities range for the implemented nanosensors and elements for portable gas sensor systems and fully autonomous systems.

Moreover, zero emission buildings, related to high energy efficiency building concept, need to include air quality control inside the buildings and to give feedback on this information to have the most efficient management of the building from energy consumption and CO_2 emission point of views. Heating, ventilation and conditioned air need for supplying adequate comfort are determinants in the composition and specifications of air (e.g., humidity, temperature, CO, NO_x, CO_2, as well as some other targeted VOC's such as O_3 depending on the used technology). Likewise, the smart cities or green cities depend on information about the air quality. For security air quality must be easily monitored in industrial zones. Finally, in all of these cases, the use of fully autonomous systems for gas sensing becomes a challenge from a technology point of view as well as for budgetary reasons.

A wide possibility of transducers for AQC gas sensors will be studied and developed by the COST Action research-platform such as Micro-Electro-Mechanical-Systems (MEMS), Nano-Electro-Mechanical-Systems (NEMS), cantilevers, optical fibers, Field Effect Transistor (FET), electrochemical devices, chemoresistors, hybrid transducers, etc.

WG2 Workplan Objectives will include:

- Protocols for fabrication of gas sensors;
- Protocols for integration of nanostructures and nanomaterials into AQC gas sensors;
- Protocols for design and implementation of new transducers for AQC gas sensors;
- Report on device characterization for AQC gas sensors;
- Report/Protocols for integration of portable gas sensor-systems for AQC;
- Report on integrated intelligence of AQC gas sensors and distributed computing;
- Protocols for development of wireless sensors network for AQC;
- Report on IP Rights of gas nanosensors for AQC.

WG2 Deliverables:

- Overview of the current state-of-the-art on gas nanosensors;
- Recommendations for AQC gas sensors priorities and strategies;
- Recommendations for portable AQC gas sensor-systems management ;
- Recommendations for AQC wireless sensor networks management;
- Guidelines for an open framework on new sensing wireless technologies for AQC.

Current topics in the research related to the Action WG2 issues

*The **hot-issues** in the current research related to the Action WG2 topics with emphasis to the selected activities from Action WG2 members are described.*
WG2 parallel session at Rome Meeting (ENEA Headquarters, 4-6 December 2012) to collect inputs from members during WG2 discussions to address the current research.

Description of current research related to WG2 Issues

- Investigation of the integration effect of novel sensor element level materials and techniques on AQC sensor systems:
  - Closely linked to WG1 activities
- Study of sensor elements active control techniques on all levels:
  - Sensor module: enhanced electronics (i.e. for self-monitoring)
  - Sensor node: improved selectivity and stability via information correlation
  - Sensor network: enhanced reliability, auto-configuration/calibration

Priorities in the research and networking activities related to the Action WG2 issues

*The **PRIORITIES** in the current research related to the Action WG2 issues with emphasis to the selected activities from Action WG2 members are described.*
WG2 parallel session at Rome Meeting (ENEA Headquarters, 4-6 December 2012) to collect inputs from members during WG2 discussions to address the priorities.

Description of WG2 Priorities

As discussed in the WG2 meeting during the First Scientific Meeting of *EuNetAir* in Rome, the research in environmental monitoring should address various APPLICATIONS:

- Outdoor air quality monitoring (immission control):
  - ✓ Better information for citizens and awareness of pollution
- Indoor air quality monitoring (immission control):
  - ✓ Controlled ventilation due to monitoring of hazardous VOC
  - ✓ Reduced health hazards plus improved energy efficiency
- Outdoor monitoring of pollution sources (emission control):
  - ✓ Identification of sources and minimization of emissions
- Closed loop process control (industrial, transport, home use):
  - ✓ Minimization of emissions at source, active countermeasures

Taking these various application fields into account, the following research issues and priorities were identified for SENSOR TECHNOLOGIES. The ultimate goal of these activities should be to demonstrate the potential of micro/nano-sensor systems in the context of environmental sensing, e.g. complementarity to existing fixed stations for added resolution - both spatial and temporal. Research should include a rigorous assessment of the performance.

WG2 Priorities

- *Priority #1:* Versatile µ-transducers for integration of various nanomaterials:
  - ✓ Allow application specific adaptation and low cost
  - ✓ Low power! (down to µW for single nanowire)
- *Priority #2:* Dynamic operation of sensors to gain more than one signal from a single sensor for higher selectivity and stability as well as possible self-monitoring at the sensor module level:
  - ✓ Well known, but not yet standard: temperature cycling, EIS
  - ✓ New methods: RF, optical excitation (gas sensitive solar cell!), pulsed polarization, mass and dissipation in QCM
  - ✓ Modelling of interaction of sensing layer and gas/dust/aerosol
- *Priority #3:* Selective filters integrated in sensors or sensor modules
- *Priority #4:* Dosimeter approach: integrating sensor response
- *Priority #5:* Nanoparticle detection for dust and aerosols!
- *Priority #6:* Intelligent sensor modules for NO_x, ozone, NH_3, H_2S, SO_2, VOC:
  - ✓ Electronics combined with sensor elements
- *Priority #7:* Intelligent sensor nodes and (heterogeneous) networks:
  - ✓ Data pre-processing and processing (in node and/or in network: parallel and distributed computing)
  - ✓ Energy efficient communication

Updating of the WG3 Workplan

Working Group 3: Environmental measurements and air-pollution modelling

ROLE - TASK	NAME	COUNTRY
WG3-Leader (Coordinator) Environmental Measurements and Air-Pollution Modelling	Prof. Ole Hertel Aarhus University	Denmark
WG3 Vice-Chair Environmental Measurements and Air-Pollution Modelling	Prof. Kaarle Hameri University of Helsinki	Finland
Sub-WG 3.1 Environmental measurements at laboratory and in field air-quality stations	Dr. Nuria Castell-Balaguer NILU - Norwegian Institute for Air Research	Norway
Sub-WG 3.2 Air-quality modelling and chemical weather forecasting	Prof. Kostas Karatzas Aristotle University	Greece
Sub-WG 3.3 Harmonisation of environmental measurements	Dr. Ulrich Quass Institute of Energy and Environmental Technology (IUTA)	Germany
MEMBERS WG3		

From Memorandum of Understanding

WG3: Environmental measurements and air-pollution modelling

Environmental measurements of PM and air-pollution

Current urban air quality monitoring networks across Europe are based on reliable and state-of-the-art measuring technologies. However, the data produced by the different networks are in strong need of harmonisation, if comparability between European regions is to be achieved. Efforts should be made to improve measurement data quality, as well as to develop and test new low-cost technologies which will allow for their widespread use across Europe.

For most regulated pollutants a reference measurement method has been prescribed by European Directives, with standardized methods being currently available for SO_2, NO_2, NO_x, O_3, Pb, Cd, As, Ni, PM_{10}, $PM_{2.5}$, benzene, and CO. Reference method automatic analysers are available for gaseous pollutants CO, SO_2, NO_2/NO_x, benzene and O_3. The reference methods for all other regulated compounds are non-automated, manual methods (e.g., PM_{10}). In addition to the well-known reference methods for each of the pollutants above, new monitoring techniques are currently being developed based on alternative strategies, such as passive sampling by dosimetry, wireless sensor networks, portable samplers (as opposed to fixed-site monitoring stations), assessment of indoor environment air quality, or personal exposure sampling. These new strategies are mostly based on a new sensing paradigm focused on low-cost sensors for air quality control. In order to meet the needs of these new air quality monitoring approaches, new measurement and analytical techniques need to be developed and tested. In a second stage, the new instruments and sensors should be subject to inter-comparison exercises which will guarantee the comparability of their results with regard to the reference methods currently in force. Such instrument tests and inter-comparison exercises should be carried out on a European-scale in order to ensure the validity of the new air quality monitoring strategies in different European regions.

Air quality modeling

The Air Quality (AQ) is a key element for the well-being and quality of life of European citizens. According to the World Health Organization, air pollution severely affects the health of European citizens (WHO, 2000, 2004): between 2.5 and 11% of the total number of annual deaths are due to air pollution. There is increasing evidence for adverse effects of air pollution on both the respiratory and the cardiovascular system as a result of both acute and chronic exposure. In particular, a significant reduction of life expectancy by a year or more is assumed to be linked to long-term exposure to high air concentrations of particulate matter (PM). There is considerable concern about impaired and detrimental air quality conditions over many areas in Europe, especially in urbanized areas, in spite of about 30 years of legislation and emission reduction. Current legislation, e.g. the Ozone daughter directive 2002/3/EC (European Parliament, 2002), requires informing the public on AQ, assessing air pollutant concentrations throughout the whole territory of Member States and indicating exceedances of limit and target values, forecasting potential exceedances and assessing possible emergency measures to abate exceedances. For this purpose, modeling tools must be used in parallel to and together with air pollution measurements. Reliable air quality forecasts aim at the efficient control and protection of population exposure as well as possible emission abatement measures.

Air dispersion modeling has been an effective tool to assess the environmental impact of human activities on air quality already at the early planning stage. Environmental assessments during planning stage are required by the EU directive 85/337/EEC. Only models can give detailed information on the distribution of pollutants with high spatial and temporal resolution, while they allow the decision-makers to devise a range of scenarios, in which the various processes determining the environmental impact can be easily simulated and changed. Furthermore, the implementation of the European Union framework directive on air quality (2008/50/EC) and their daughter directives requires an extensive assessment of air quality in the EU member states. One of the required tools is air-quality models for assessing regional and urban air quality. There is a fundamental need for the all countries to build upon the experiences of each other according to the requirements in the framework directive, and to harmonize the development and use of models in several respects.

Lately, integrated air quality monitoring and forecast systems for a specific region was developed assimilating the ambient pollutant concentrations or any other air quality indexes delivered by in-situ networks of sensors and remote platforms (satellites, lidars etc.) on the base of up-to-science meteorological, emission and chemical transport models.

Such systems can be used in different modes:

- planning or “preparedness” mode - mainly for optimal distribution of the sensor’s networks;
- off-line or “recovery” mode - simulation of critical pollution episodes combining model output and measured data in the frame of different scenarios or long-term integration for Risk Assessment purposes;
- on-line or “operational (fast decision)” mode - forecast of pollution levels with or without assimilation of the measured concentrations;
- inverse mode - use of on-line measurements for determining of unknown sources of pollution. Usually special versions of dispersion models have been elaborated for this purpose.

Such systems are supposed to give operational response to the releases of harmful gases in the atmosphere (as a result of normal industrial activity or industrial accident) for specific

regions and they would be used for solving different tasks, mainly:

- perform accurate and reliable risk analysis and assessment for selected region or "hot spot";
- provide the local authorities (and the international community) with short-term regional and local scale forecast of the propagation of harmful air pollutants;
- perform, in an off-line mode, a more detailed and comprehensive analysis of the possible longer-term impacts on the environment and human health including assessment of the climate change impact on air quality;
- At a warning signal from the measuring network, by using inverse modeling and the functions of influence techniques, to detect (if not known) the harmful release location and evaluate the nature and the amount of the released harmful gases.

In the last years, the concept of "chemical weather" arises and in many countries respective forecast systems are being developed along with the usual meteorological weather forecasts. Respective systems were developed in many European countries. As long as air pollution easily crosses national borders, it would be cost-effective and beneficial for citizens, society and decision-makers that national chemical weather forecast and information systems would be networked across Europe. For this purpose, COST Action ES0602 Towards a European Network on Chemical Weather Forecasting and Information Systems - http://www.chemicalweather.eu/ - aimed at providing a forum for harmonizing, standardizing and benchmarking approaches and practices in data exchange and multi-model capabilities for air quality forecast and (near) real-time information systems in Europe. It examined existing and work out new solutions for integrating the development efforts at national and international levels and served as a platform for the information exchange between the meteorological services, environmental agencies, and international initiatives. The achievements of COST Action ES0602 are very important for this COST Action and must be assimilated and intensively used.

WG3 Workplan Objectives will include:

- Assessment of environmental measurements long-term campaigns by AQC gas sensors at laboratory experiments level;
- Assessment of environmental measurements in field by AQC gas sensor-systems in the air-quality stations;
- Assessment of air-quality modelling with data assimilation from integrated AQC gas sensors;
- Report on chemical weather forecasting at global area and hot-spot case-studies;
- Evaluation of integrated air quality plans and strategies: role of low-cost AQC gas sensors;
- Assessment of clean technologies and environmental management systems reducing the emission of air-pollutants, green-houses, particulate matter, aerosol, nanoparticles, etc.;
- Assessment of new sensing technologies, including AQC gas sensors and wireless sensors network, for environmental management;
- Report on harmonisation of environmental measurements in EU-zone and non-COST areas;
- Report on IP Rights of air-quality modelling and chemical weather forecasting.

WG3 Deliverables:

- Recommendations for laboratory and field experiments for evaluation of low-cost AQC gas sensors performance;
- Recommendations for research and development needs to improve cost-effective AQC gas sensors to be integrated in air-quality models and chemical weather forecasting;
- Recommendations for short-term operational developments and AQC gas sensors priorities and strategies in the air-quality plans;
- Recommendations for improving portable AQC gas sensor-systems in integrated models for mid- and long-term applications;
- Overview of the current state-of-the-art on air-quality modelling and chemical weather forecasting;
- Guidelines for management of new AQC sensing wireless technologies.

Current topics in the research related to the Action WG3 issues

*The **hot-issues** in the current research related to the Action WG3 topics with emphasis to the selected activities from Action WG3 members are described.*
WG3 parallel session at Rome Meeting (ENEA Headquarters, 4-6 December 2012) to collect inputs from members during WG3 discussions to address the current research.

Description of current research related to WG3 Issues

Exposure assessment should be defined:

- Various exposure windows - short & long term exposure
- Address based - coupled to traffic exposure from previous works
- Exposure when commuting e.g. between home and work
- Using selected cohorts
- Using full country population
- Currently working on mapping address exposure entire population

Environmental measurements should be defined:

- Various portable sensor-systems will be explored as *personal sensors* and *wearable sensors* in the life of every day (e.g., bikes, pedestrians, cars, smart cities, etc.)
- Sensors for air quality monitoring at outdoor applications
- Sensors for air quality monitoring at indoor applications (green buildings, low CO_2 emissions, offices, air-ventilation systems, HVAC devices, open spaces, indoor energy efficiency, etc.)
- Wireless sensors and wireless sensor networks

Air-quality modelling should be defined:

- Air-pollution dispersion modelling at local, urban, regional and global range
- Chemical weather forecasting (gases, vapors and particulate matter)

Priorities in the research and networking activities related to the Action WG3 issues

*The **PRIORITIES** in the current research related to the Action WG3 issues with emphasis to the selected activities from Action WG3 members are described.*
WG3 parallel session at Rome Meeting (ENEA Headquarters, 4-6 December 2012) to collect inputs from members during WG3 discussions to address the priorities.

Description of WG3 Priorities

The scientific context and priorities in the Action WG3 can be summarised as follows as:

- What are the health effects of various air pollutants & airborne allergens in Europe ?
- Do simultaneous environmental exposures result in synergistic negative health effects ?

In particular, some definitions can be described as:

- smoke from domestic wood stoves
- allergenic pollen from trees, grasses & new invasive species
- airborne allergenic material (skin tissue, hair, etc.) released from livestock
- fungal spores from agriculture and other sectors
- airborne PM natural sources (sea spray, soil dust)
- long-range transported organic & inorganic PM including agricultural emissions
- pesticides applied in Europe farming
- Radon & EMF in domestic buildings
- Toxic gases and VOCs as air-pollutants at indoor and outdoor level

WG3 Priorities

- *Priority #1*: What do we want to provide on the long term - in relation to routine monitoring and public information ?
- *Priority #2*: Micro-sensors should not substitute but supplement routine monitoring devices
- *Priority #3*: Future routine networks may look very different from today and include low-cost sensoring ?
- *Priority #4*: The green route through the city or access to information about pollutant load at address might be future goals
- *Priority #5*: Still many unknowns in respect to health effects - e.g., what in PM is causing negative health effects – constituents, ultrafine ?
- *Priority #6*: Airborne allergenes may also be an issue of interest - > 20% suffer from hay fever but monitoring still based on 1950 technology
- *Priority #7*: Model validation is another issue of high importance - model calculations using CTM's or LUR provides high resolution data of high importance from providing public information, use in health impact assessment and supplementation of routine monitoring

Updating of the WG4 Workplan

Working Group 4: Protocols and standardisation methods

ROLE - TASK	NAME	COUNTRY
WG4-Leader (Coordinator) Protocols and Standardisation Methods	Prof. Ingrid Bryntse SenseAir SA	Sweden
WG4 Vice-Chair Protocols and Standardisation Methods	Dr. Nicolas Moser E2V Microsensors SA	Switzerland
Sub-WG 4.1 Protocols, standards and methods for AQC by analyzers/instruments (no-sensors) technologies	Dr. Grisa Mocnik Aerosol doo	Slovenia
Sub-WG 4.2 Protocols, standards and methods for AQC by sensors (no-analyzers) technologies	Dr. Anne-Claude Romain Universitè de Liège	Belgium
Sub-WG 4.3 Benchmarking of new products and market of commercial AQC sensors	Dr. John Saffell Alphasense Ltd	UK
MEMBERS WG4		

From Memorandum of Understanding

WG4: Protocols and standardisation methods

Quality assurance and quality control (QA/QC) for European air quality measurement data may only be achieved by means of the implementation and harmonisation of instrument testing and standard operation procedures, as well as of equivalence testing procedures (for real-time automatic monitors for pollutants regulated in the Air Quality directive). These are currently in place for regulated compounds (SO_2, NO_2, NOx, O_3, Pb, Cd, As, Ni, PM_{10}, $PM_{2.5}$, benzene, and CO). However, efforts should be dedicated to achieve this level of QA/QC for emerging air quality monitoring instruments and sensors. Once tests and inter-comparison exercises have been fulfilled, and data quality ensured, detailed and specific standard operating procedures need to be devised for each sensor/instrument, with the aim to guarantee that operational procedures will be comparable across networks. This will be a pre-requisite to consider the implementation of the new air quality monitoring strategies in near future air quality research programmes in the EU Member States.

During the lifetime of this Action, the WG4 activities aim to standardize the methods in sensing measurements and harmonise test procedures, chemical analyses, protocols and prevention to monitor air quality (in particular particulate matter, organic volatile compounds and odours). During this phase, the following activities will be carried out:

- proposal of a methodological approach for an odour guideline with the purpose of defining acceptability and monitoring criteria for odour emission produced by industrial activities.

In the perspective of the improvement of life quality and citizens wellness, odour pollution is becoming a more and more relevant topic. In fact, among the variables that could influence the citizens, the sense of a healthy environment and odour emissions play an important role, as they deeply affect the human life quality and psycho-physical wellness. For this reason, in the last decade the scientific community has been developing an increasing attention for odour pollution, generally caused by industrial activities. Different types of productive plants such as tanneries, refineries, slaughterhouses, distilleries, and especially civil and industrial wastewater treatment plants, landfills and composting plants are often sources of olfactory

nuisances.

In order to establish a policy and a system to defend residents from annoyance caused by odour impact, it is necessary to define a common reference for the determination of odour concentration. The dynamic olfactometry is the most suitable measure technique to provide punctual odour concentration data but it is not sufficient to evaluate completely a case of olfactory nuisance, because it does not allow to obtain information about chemical composition of the odour sample, to conduct continuous measurements and above all because it needs very high costs and times of analysis.

For this reason, an integrated approach is convenient for odor monitoring including chemical characterization, the development of sensor-system based on solid-state gas sensors (i.e., electronic noses) coupling to a predictive approach, based on dispersion models. This will be achived by the standardization of different sampling and analysis methods of Volatile Organic Compound both in indoor and outdoor environments.

The emission of VOC represents not only an important indicator for the evaluation of the air quality but even an element for the estimation of the environmental sustainability of the new materials and technologies. In order to perform this estimation, it is necessary to have an appropriate and standardized investigation tool. In fact, for determination of such compounds, there are a lot of sampling methodologies (both on and off line, active or passive sampling, GC/MS, GC/FID, HPLC, etc.) that would be necessary to compare and optimize. These include methods for chemical analyses and source identification of Particulate Matter.

Particulate matter (PM) sources and processes are deeply investigated in order to provide useful information for air quality management policies. During the project, it will be necessary to combine different information to determine the different origin of high PM events. It will be useful to join different instruments such as:

- dual channel system for automatic sampling of PM_{10} and $PM_{2.5}$;
- OPC monitor, optical particle counter that allows to perform the real-time dimensional characterization of particles with optical diameter greater than 0.3 micron;
- PBL Mixing Monitor, a sequential automatic system able to estimate the low PBL layers mixing ratio by means of ß activity related to Radon decay products;
- sonic anemometer in order to determine wind speed and direction on three non-orthogonal axes.

The coupling of this system with chemical characterization (ionic components, Polycyclic Aromatic Hydrocarbons (PAHs) and carbonaceous fraction (OC, EC) and statistical methods application could give further details about the PM origin and diffusion.

WG4 Workplan Objectives will include:

- Assessment of characterisation, quality assurance, quality control, property database, standardization of AQC gas sensors;
- Assessment of testing, standard operation procedures, safety aspects for AQC gas sensors;
- Evaluation of case-studies in round-robin testing of AQC gas sensors in odour-pollution, air-pollution, indoor control, outdoor control;
- Report/Recommendations of the new sensing AQC technologies for the future strategies in the EU research programmes of air quality monitoring and environmental management;
- Report on scaling up, applications and commercialisation of AQC gas sensors.

WG4 Deliverables:

- Evaluation Summary of AQC gas sensors performance through validation for selected case studies of environmental monitoring in the air-quality plans;
- Overview of the current state-of-the-art on regulations, protocols and standards of the no-sensors based AQC: possibilities of procedures extended to the AQC sensors;
- Recommendations/Guidelines for the validation methodology/protocol of AQC gas sensors;
- Recommendations on environmental applications of low-cost AQC gas sensors.

Current topics in the research related to the Action WG4 issues

*The **hot-issues** in the current research related to the Action WG4 topics with emphasis to the selected activities from Action WG4 members are described.*
WG4 parallel session at Rome Meeting (ENEA Headquarters, 4-6 December 2012) to collect inputs from members during WG4 discussions to address the current research.

Description of current research related to WG4 Issues

The scientific context and objectives in the Action WG4 can be summarised as follows as:

- Protocols and Standardisation Methods / WG4 in *EuNetAir*
- We will try to establish common general standards for modern European sensor / analyzers based on different measurement techniques; focusing on gases, odors and particle detection
- We will choose some common analytes every Action year and concentrate on them
- Certified test laboratories or well-known universities / institutes will investigate method accuracy and performance according a general test guideline
- SenseAir (SME by WG4 leader) can investigate and compare commercially available CO_2 sensor / analyzer performance in our Analysis & Test laboratories parallel to the ongoing testing of our prototypes and products
- SenseAir (SME by WG4 leader) is summarizing the main CO_2 applications focusing on impact from environmental, safety or economical point of view from an European perspective
- We discussed the general scope of *EuNetAir* and decided that we´are aiming at low-cost sensors and in this case the price for the user is below **€100 for small sensor with simple pcb** (OEM manufacturer price to a customer which use in their system) and **€300 for sensor modules**. This is something to further discuss and decide in EuNetAir !
- We selected some species to start with. We chose the analytes that are believed to either causing severe harm for living beings (e.g., carcinogenic benzene) or being of great importance from an energy saving point of view (CO_2).
- We are not certain that WG4 has the resources (time / money) to write *new* standards. Also we do not know if we should produce a general standard for a specific analyte, advice on improving current standards or write a standard directed to a certain application.
- If we choose specific applications, who should direct which applications to focus on? Input from other *EuNetAir* members are highly appreciated.
- For SMEs in *EuNetAir* it is impossible to add a lot of work to write standards - we must focus on surviving in economically tough times.

Priorities in the research and networking activities related to the Action WG4 issues

*The **PRIORITIES** in the current research related to the Action WG4 issues with emphasis to the selected activities from Action WG4 members are described.*
WG4 parallel session at Rome Meeting (ENEA Headquarters, 4-6 December 2012) to collect inputs from members during WG4 discussions to address the priorities.

Description of WG4 Priorities

- Summarise the "*state of the art*" of some important and commercially available, low cost gas sensors / analyzers.
- Summarise possible and most common applications for a certain gas sensor.
- Produce lists of tests, "test protocol", that should be used in order to validate sensor specifications. These protocols and corresponding test results could later be used for creation of modern standards.
- Identify test sites which could be used for field testing of sensors and sensor networks, if *EuNetAir* partners and other companies (in Europe or elsewhere) would like to provide sensors.
- Initiate laboratory and field testing at national accredited test laboratories. Other labs could be used: Alphasense / Rod Jones at Cambridge for lab / field validation and SenseAir for CO_2 testing. The testing timeplan and costs for testing are not set.
- At present WG4 has no resources (time / money) to write new standards. It is unclear if we should produce a general standard for a specific analyte, advise on improving current standards or write application standards.
- If we choose certain application standards, who should direct which main applications to focus on? Comments from other *EuNetAir* members or *EuNetAir* MC are highly appreciated
- CEN contacts are important for quickly implementing any future new standard.
- For European SMEs in *EuNetAir* it is hard to add a lot of work on writing standards - we must focus on surviving in economically tough times. Could *EuNetAir* or someone else provide financial support ?

WG4 Priorities

- *Priority #1:* **Odorants**
  - ✓ H_2S and organic thiols (mercaptans)
  - ✓ *Action:* A state-of-the-art summary of sensors / analyzers will be written by WG4 members. Goal: First draft May 2013.
- *Priority #2:* **PM, Particulate Matter**
  - ✓ PM_{10}, $PM_{2.5}$, ultrafine PM and BC
  - ✓ *Action:* A state-of-the-art summary of sensors / analyzers will be written by Vice-Chair and WG4 members. Goal: First draft May 2013.
- *Priority #3:* **VOC, Indoor air**
  - ✓ CH_2O methanal (formaldehyde) and C_6H_6 benzene
  - ✓ *Action:* A state-of-the-art summary of sensors / analyzers will be written by WG4 members. Goal: First draft May 2013.
- *Priority #4:* **Inorganic gases**
  - ✓ NO_2 nitrogen dioxide & O_3 trioxygen (ozone), analysed simultaneously
  - ✓ *Action:* A state-of-the-art summary of sensors / analyzers will be written by WG4 members. Goal: First draft May 2013.
  - ✓ CO_2 carbon dioxide (ventilation indicator and greenhouse gas)
  - ✓ *Action:* Ingrid Bryntse, WG4 Leader, at SenseAir will write a summary of main applications. Goal: First draft February 2013.

Special Interest Group 1: Network of Spin-offs

ROLE - TASK	NAME	COUNTRY
SIG1 Leader (Coordinator) Network of Spin-offs	Dr. Marco Alvisi ENEA	Italy
SIG1 Deputy Network of Spin-offs	Prof. Florin Udrea Cambridge CMOS Sensors Ltd	UK
MEMBERS SIG1		

❑ **Objectives**:

- Mapping of EU spin-offs and their S&T related activities in the Action issues.
- Technology offer of the EU spin-offs. Technological Transfer.

❑ **Activities**:

- Supporting to the writing of the State-of-Art planned in the Action for spin-offs activities related to the Action issues.
- Promotion/Definition of EU proposals for funding of new SMEs in the core-business of Action for research and innovation.

❑ **Deliverables (MoU)**:

- Reports on mapping of EU spin-offs.
- Reports on proposed Activities to be approved by Action Management Committee.

Priorities in the research and networking activities related to the Action SIG1 issues

*The **PRIORITIES** in the current research related to the Action SIG1 issues with emphasis to the selected activities from Action SIG1 members are described.*
SIG1 parallel session at Rome Meeting (ENEA Headquarters, 4-6 December 2012) to collect inputs from members during SIG1 discussions to address the priorities.

Description of SIG1 Priorities

- Special Interest Group 1 – **Network of spin-off** – involve, at present, 11 spin-off and/or start-up from 8 different COST Countries that develop their economic activities on the four principal areas of the Action (Sensor Material and Nanotechnology, Sensors, devices and systems for AQC, Environmental measurements and air-pollution modelling, protocols and standardisation methods).
- The network **will favour the reciprocal exchanges for knowledge transfer towards industrial and project partnership** and will be useful to **boost the exploitation of the research results** and to promote technology transfer towards new business models based on green economy and environmental sustainability.
- Favour reciprocal knowledge between innovative SME in the field of AQC.
- Contribute to the state-of the art report focusing on actual technology needs, future perspectives, integration possibilities, standards, protocols and guidelines for future agenda.
- Mapping the similar or complementary industrial organizations (i.e., spin-off, start-up, spin-out, etc.) in the EU area involved in the fields covered by the Action.
- Define and propose new cooperative instruments for EU spin-offs and innovative SME.
- Support to define Action position papers in the knowledge transfer in air quality control (AQC) issues for future research and innovation agenda.
- Supporting to the writing of the *State-of-the-Art* planned in the Action for spin-offs activities related to the Action issues.
- Promotion/Definition of EU proposals for funding of new SMEs in the core-business of Action for research and innovation.
- Map of EU Spin-offs in AQC.
- Information of EU instruments and opportunities.
- Create a virtually-linked community.
- Reports on mapping of EU spin-offs.
- Reports on proposed activities to be approved by Action Management Committee.
- Contribute to the *state-of-the-art* report focusing on actual technology needs, future perspectives (new customer market) integration possibilities, standards, protocols and guidelines for future agenda.
- Mapping similar or complementary industrial organizations.
- Define and propose new cooperative instruments for EU spin-offs and innovative SMEs (screening of available EU instruments and evaluate their effectiveness, etc.).
- Support to define Action position papers in the knowledge transfer in air quality control (AQC) issues for future research and innovation agenda.

SIG1 Priorities

Activities as SIG1 PRIORITIES for Action TD1105:

- *Activity #1*: Odour measurements is not big market due to absence of regulation so harmonization of odour measurements
- *Activity #2*: Push the adoption of regulations (i.e. methodologies, guidelines)
- *Activity #3*: Low cost devices and easy to use for odour monitoring
- *Activity #4*: Performance that reduce the cost
- *Activity #5*: Communication distances for wireless network of sensors
- *Activity #6*: New sensors for odour assessment
- *Activity #7*: Air-quality case-studies, stability assessment
- *Activity #8*: Calibration strategies for low cost sensing devices
- *Activity #9*: Work on Persistent Organic Pollutants (POP) detection

Research Directions as SIG1 PRIORITIES for Action TD1105:

- *Priority #1*: Chemical and radiation environmental monitoring
- *Priority #2*: Ozone sensors, NOx and CO and CO2 sensors for automotive application
- *Priority #3*: Improve stability of the available sensors, compatibility with CMOS microelectronics, soft CMOS post-processing methods for reproducible high throughput manufacturing
- *Priority #4*: Toxic and explosive (hydrogen) gas leakage
- *Priority #5*: Biosensor based on enzyme for dioxin and POP, work on POP detection
- *Priority #6*: VOC detection developing sensors modules and sensor systems
- *Priority #7*: Indoor air quality control, leak detection
- *Priority #8*: Odour monitoring system (odour-telephone)
- *Priority #9*: Enhancement of the sensing properties by introducing functional receptive groups
- *Priority #10*: Coupling different transduction modes in the same device

Special Interest Group 2: Smart Sensors for Urban Air Monitoring in Cities

ROLE - TASK	NAME	COUNTRY
SIG2 Leader (Coordinator) Smart Sensors for Urban Air Monitoring in Cities	Prof. Rod Jones University of Cambridge	UK
SIG2 Deputy Smart Sensors for Urban Air Monitoring in Cities	Dr. Jordi Llosa Worldsensing SL	Spain
MEMBERS SIG2		

❑ Objectives:

- Mapping of R&D activities on Sensor Technologies in the Smart Cities and related Action issues.
- Research & Technology in Sensors for air-pollution control in EU Cities.
- Technological Transfer and Demonstration.

❑ Activities:

- Supporting to the writing of the State-of-Art planned in the Action for *Smart Sensors in Cities* activities related to the Action issues.
- Promotion/Definition of EU proposals for funding of new research projects in the Sensors for Smart Cities and related Action research and innovation on environmental monitoring.

❑ Deliverables (MoU):

- Supporting to Reports on *Smart Sensors in Cities* for state-of-art in Action.
- Reports on proposed Activities to be approved by Action Management Committee.

Priorities in the research and networking activities related to the Action SIG2 issues

*The **PRIORITIES** in the current research related to the Action SIG2 issues with emphasis to the selected activities from Action SIG2 members are described.*
SIG2 parallel session at Rome Meeting (ENEA Headquarters, 4-6 December 2012) to collect inputs from members during SIG2 discussions to address the priorities.

Description of SIG2 Priorities

- This Special Interest Group (SIG2) - **Smart Sensors for Urban Air Monitoring in Cities** - currently involves 11 institutions including universities, nationally funded research institutes and one spin-off/start-up, collectively representing 8 separate COST Countries. All the partners have particular interests and expertise in various aspects of promoting the development and/or use of smart sensors for urban air quality monitoring in cities and in a wider sense to help define the city environment.
- The SIG2 focuses on smart sensor technologies for air quality monitoring, including currently deployable sensor technologies, near market, and the horizon mapping of new technologies including smart sensors, sensor networks and integration into city management and ultimately GMES networks. The SIG2 aims to promote effective knowledge exchange on smart sensor technologies and their applications across the current COST partners, and to identity and encourage new research activities.

Objectives:

- Horizon scanning of gas sensors for A/Q.
- Research & Technology in Sensors for air-pollution control.
- Technological Transfer.

Activities:

- Support writing of the State-of-Art planned in the Action for *Smart Gas Sensors and Transducers* activities related to the Action issues.
- Promotion/Definition of EU proposals for funding of new research projects in the AQC Sensors and related activities.

Deliverables (MoU):

- Support preparation of reports on *Smart Gas Sensors and Transducers*
- Report on proposed Guidelines *Air-Pollutant coupled to Best Transducer* Activities to be approved by Action Management Committee.

SIG2 Priorities

Activities as SIG2 PRIORITIES for Action TD1105:

- *Activity #1*: Excellent papers on sensors, sensor networks, deployments - current and future, analysis of existing networks, sensor calibration, network management, adaptive sensors/machine learning.
- *Activity #2*: Improvements in basic sensor performance

  Further improvement in sensors/networks still required:
  - Chemical Species: gas phase, particulates (ultra-fine, composition), etc.

  - Selectivity/stability, power/size
  - Communications (lower power)
  - Cost-effective sensors for air quality monitoring
- *Activity #3*: Definition of sensor performance requirements
  - Action/Activities which should come from SIG2 *and other WGs/SIGs*

Research Directions as SIG2 PRIORITIES for Action TD1105:

- *Priority #1*: **Discussion** of '*smart*':
  - ✓ Self-monitoring - e.g. fault detection
  - ✓ Clever design/manufacturing - e.g. self-calibrating
    Ideally both needed
  - ✓ Smart use of '*stupid*' (not educated) sensors
- *Priority #2*: **Sensor Systems**:
  - ✓ sensors + analysis/correction + archiving + data mining + mapping + interpretation/dissemination
    - Deliver *answers* to:
      - *General public (low pollution routes/traffic flow)*
      - *Legislature/compliance?*
      - *Health impacts community?*
      - *Activity goes way beyond 'simple' sensor development*
- *Priority #3*: **Other issues**:
  - ✓ Transferring A/Q knowledge from one environment to another (do we have to have networks everywhere? Continuously deployed?)
  - ✓ Use of modelling? Philosophy of testing models, combining model/sensor network outputs - Data assimilation - routinely used in NWP - applicability here?
  - ✓ Highly cross-disciplinary, are all other communities represented here?
- *Priority #4*: **Roadmap issues to be discussed more in the SIG2**.

Special Interest Group 3:
Guidelines for Best Coupling Air-Pollutant and Transducer

ROLE - TASK	NAME	COUNTRY
SIG3 Leader (Coordinator) Guidelines for Best Coupling Air-Pollutant and Transducer	Prof. Giorgio Sberveglieri University of Brescia	Italy
SIG3 Deputy Guidelines for Best Coupling Air-Pollutant and Transducer	Prof. Eduard Llobet Universitat Roviri I Virgili, Tarragona	Spain
MEMBERS SIG3		

❑ Objectives:

- Mapping of Gas Sensors for AQC applications.
- Research & Technology in Sensors for air-pollution control in Europe.
- Technological Transfer and Demonstration.

❑ Activities:

- Supporting to the writing of the State-of-Art planned in the Action for *Smart Gas Sensors and Transducers* activities related to the Action issues.
- Promotion/Definition of EU proposals for funding of new research projects in the AQC Sensors and related Action research and innovation on environmental monitoring.

❑ Deliverables (MoU):

- Supporting to Reports on *Smart Gas Sensors and Transducers* for State-of-Art in Action.
- Report on proposed Guidelines *Air-Pollutant coupled to Best Transducer* Activities to be approved by Action Management Committee. These Guidelines were suggested by TDP-SAB from COST Office at Hearings on September 2011.

Priorities in the research and networking activities related to the Action SIG3 issues

*The **PRIORITIES** in the current research related to the Action SIG3 issues with emphasis to the selected activities from Action SIG3 members are described.*
SIG3 parallel session at Rome Meeting (ENEA Headquarters, 4-6 December 2012) to collect inputs from members during SIG3 discussions to address the priorities.

Description of SIG3 Priorities

Partner activities can be summarized as:

- Materials (metal oxides, molecular organic semiconductors, graphene and CNMATs)
- Transducers (rigid/flexible substrates, u-hotplates, FET, contactless) resistive/conductometric, impedimetric, potentiometric, resonant mass-sensitive.
- Applications: (indoor/outdoor, sensors/dosimeters SO_2, NO_x, VOCs (BTEX), H_2S, NH_3, CO,O_3

Objectives:

- To help the different groups focus on a reduced set of applications
- To reach a meaningful comparison of sensor advantages, drawbacks, etc.
- To promote the use of different, innovative transduction modes.

Activities:

- Suggest common evaluation protocols for sensors (sensor benchmarking)
- Study the combination of different transduction principles to enhance selectivity
- Selection of target applications so specifications (sensitivity, selectivity, interference rejection, use of sample pre-treatment, response time) can be set.

Deliverables (MoU):

- Report on the physical parameters being affected by gas/material interaction
- Report on the common evaluation protocols to be used

SIG3 Priorities

- *Priority #1*: Identify which are the **physical parameters** being affected by gas/material interaction (for a rationale design of the transducer)
- *Priority #2*: Continuous versus exposure/recovery **measurements**
- *Priority #3*: Study of the **best coupling** of the air pollutants associated to a given transducer

Special Interest Group 4:
Expert Comments for the Revision of the Air Quality Directive

ROLE - TASK	NAME	COUNTRY
SIG4 Leader (Coordinator) Expert Comments for the Revision of the Air Quality Directive	Dr. Thomas Kuhlbusch Institute of Energy and Environmental Technologies (IUTA)	Germany
SIG4 Deputy Expert Comments for the Revision of the Air Quality Directive	Dr. Gianluigi De Gennaro University of Bari	Italy
MEMBERS SIG4		

DIRECTIVE 2008/50/EC: Ambient air quality and cleaner air for Europe

❑ Objectives:

- Comments on Revision of Air Quality Directive 2008/50/EC towards the new EC directive by 2018.
- Suggestions to be proposed to European Environment Agency.

❑ Activities:

- Supporting to the writing of the State-of-Art planned in the Action for environmental monitoring activities related to the Action issues.
- Promotion/Definition of EU proposals for funding of new research and innovation in the Action.

❑ Deliverables (MoU):

- Reports on Comments to Revision of Air Quality Directive 2008/50/EC towards 2018.
- Reports on proposed Activities to be approved by Action Management Committee.

Priorities in the research and networking activities related to the Action SIG4 issues

*The **PRIORITIES** in the current research related to the Action SIG4 issues with emphasis to the selected activities from Action SIG4 members are described.*
SIG4 parallel session at Rome Meeting (ENEA Headquarters, 4-6 December 2012) to collect inputs from members during SIG4 discussions to address the priorities.

Description of SIG4 Priorities

Scientific context and SIG4 objectives in the Action:

- The AQD is the main European regulation with regard to ambient air quality.
- Other important aspects are covered by regulations related to emissions, e.g. National Emission Ceilings (NEC), traffic emission regulation.
- How can COST and specifically SIG4 contribute to improvements to European regulation to improve the quality of life, environment and international competitiveness?

Some current activities related to SIG4 activities:

- **Air Review**
  European Commission is currently conducting a comprehensive review of EU air pollution policy (Ending 2012).
- **REVIHAAP (WHO Initiative)**
  REVIHAAP is addressing a list of 26 key questions. First phase: Nov. 2011 - April 2013.
- **AirMonTech (FP7)**
  Presentation at Rome COST meeting, Ending Mid-2013.
- **Thematic Strategy**
  DG ENV framework contract: AQUILA/FAIRMODE/**S**takeholder **E**xpert **G**roup

Critical Topics addressing or not addressing by SIG4:

Don'ts

- Related to AQD means **outdoor** air. Thus, **indoor** excluded for SIG4.
- Communication of air pollution is important, but will not particularly addressed.
- Restrict recommendations to AQD improvements that can be envisaged by application of sensor technology.
- Compliance monitoring is not targeted at the current time; sensor quality demands may be lower than those of reference methods! Nevertheless, characterization is needed and specific data quality requirements have to be set (WG3 and WG4).

Do's

- **Modelling** of urban air pollution and population exposure can be improved by sensors due to higher spatial resolution.
- **Ammonia** being a precursor for PM might be worth more attention; sensor networks could help in identifying sources; increasing contributions from traffic, and other sources in particular situations (e.g., garbage boxes).

SIG4 Priorities

Possible outputs from SIG4 :

- Review of AQD implementation problems and proposals how these could be targeted by application of sensors
- Recommendations on:
  - ✓ New metrics
  - ✓ Data quality requirements
  - ✓ Use for model improvements
  - ✓ Specific research needed
- Guidelines on data quality requirements for sensors to be used in relation to AQD (e. g. support indicative screening or complementary modeling).

SIG4 Timeline:

- Outputs will not be available in time for the upcoming revision (draft probably by 2014).
- SIG4 addressing AQD revision planned for 2018.
- Next SIG4 meeting?