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Sensors for Life

Standards for AQC Sensors creating a more Healthy Environment

AIAI 2012

8th Artificial Intelligence Applications and Innovations conference

ISQL 2012

3rd Intelligent Systems for Quality of Life information services workshop

29 Sept 2012

Professor Ingrid Bryntse

Senior Scientist, SenseAir AB

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* SenseAir
* Air quality in general
* Air quality standards today
* COST EuNetAir WG-4
* Benefits from better air quality

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SenseAir

World leading within research, development and production of maintenance free NDIR gas sensors and analyzers

Large volumes of various gas sensors, > 300 000 per year

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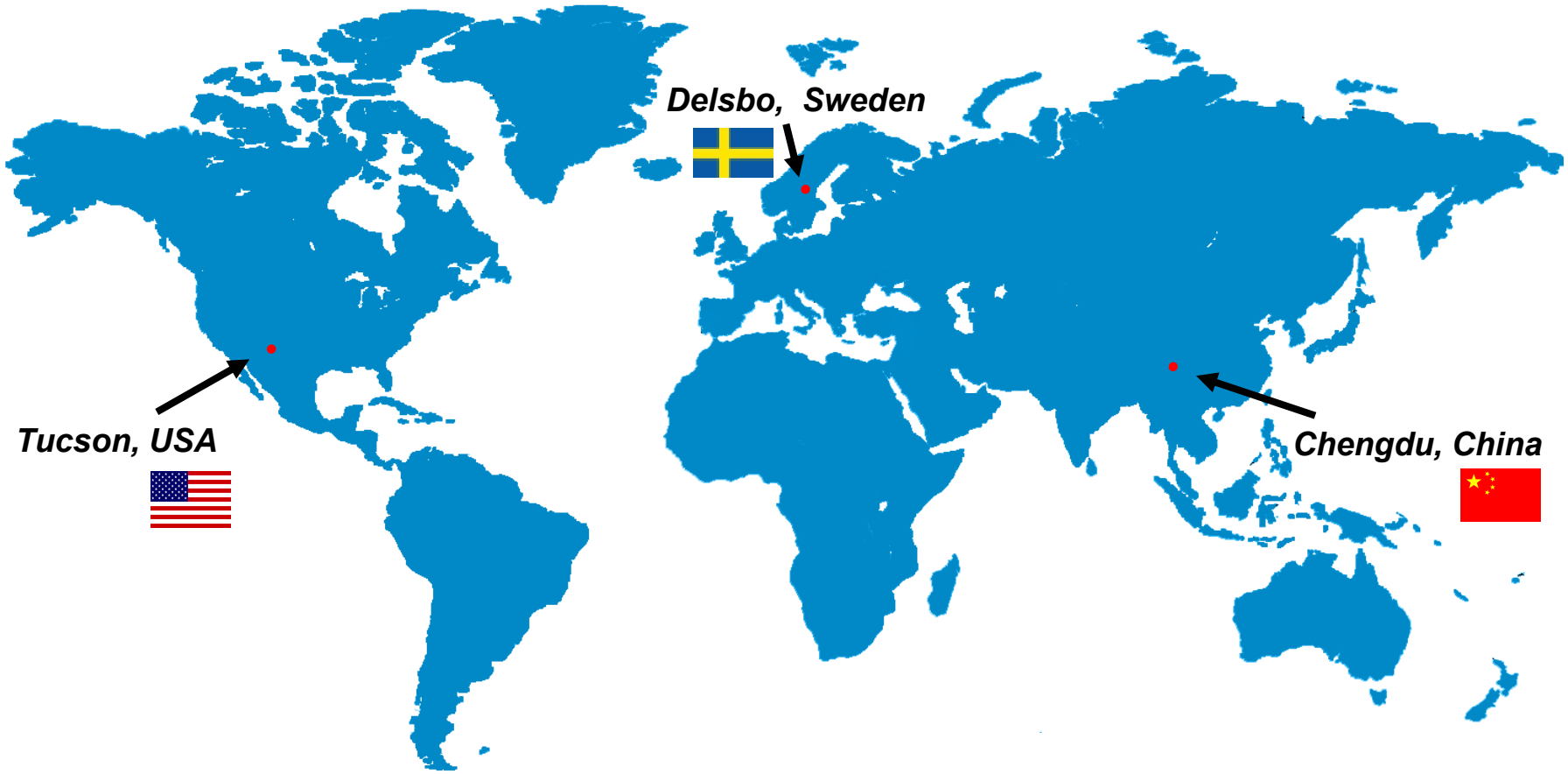
SenseAir, a Swedish corporate group



SenseAir uses NDIR technique

Optical waveguide + PCB

2-12 µm IR emission

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***K20*, product for kerosene heater**

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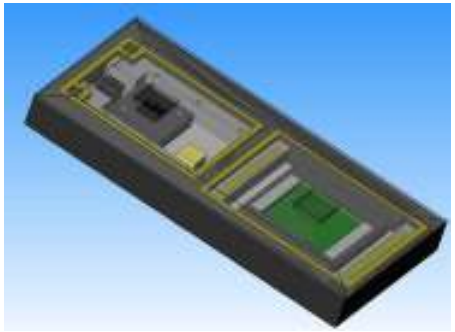

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***S8*, the smallest CO_2 sensor in the world**

Future product, made with MEMS technique

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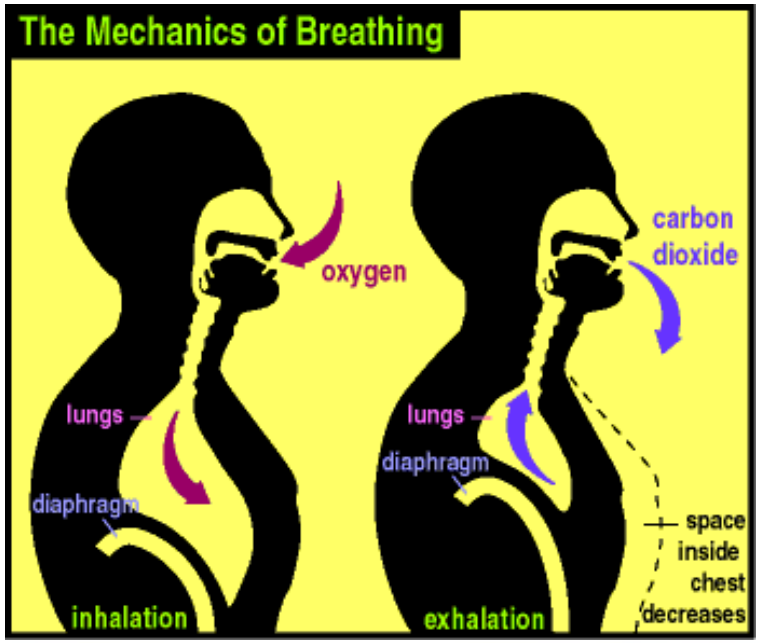
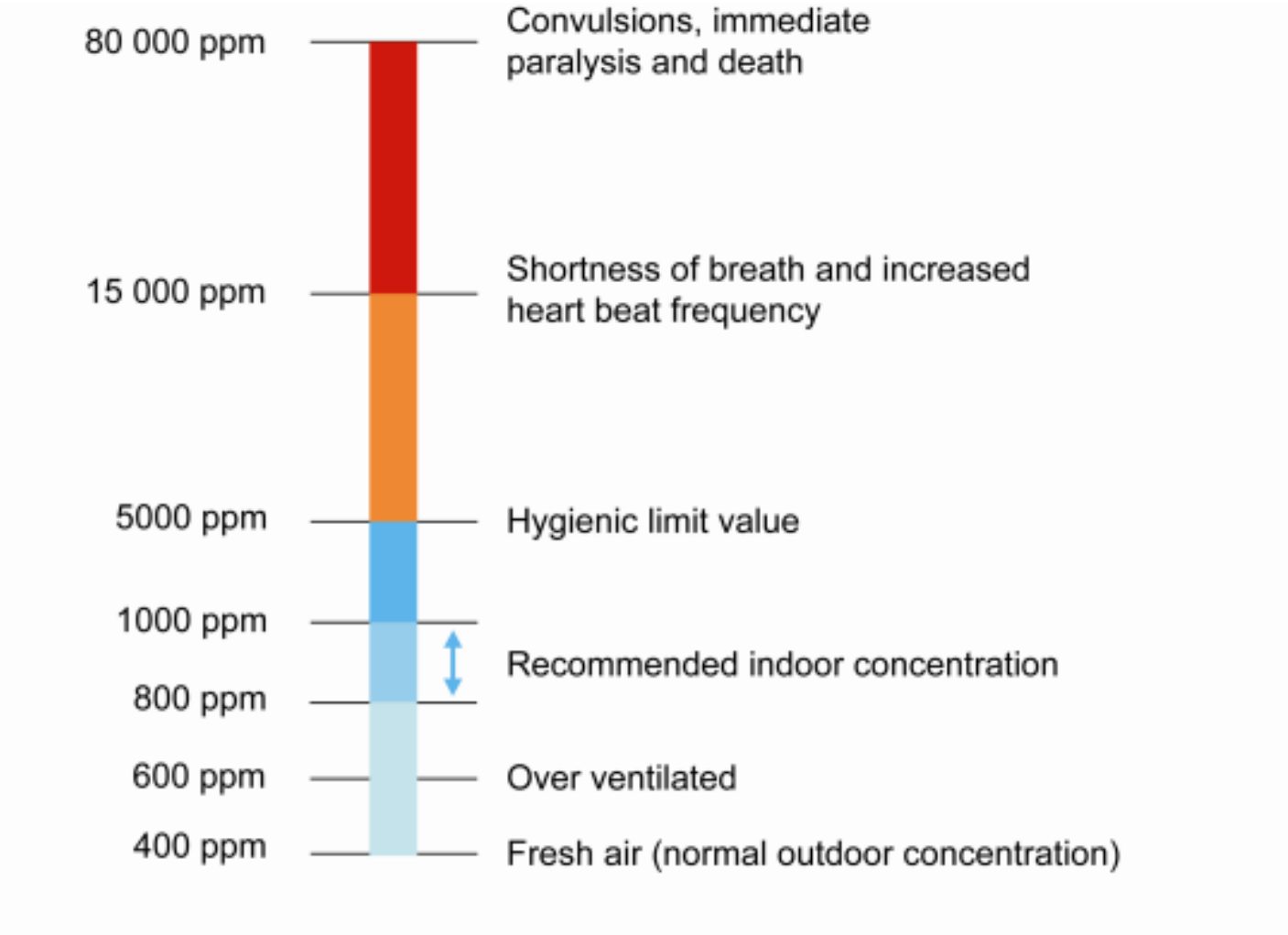
Why measure in-door CO_2?

- People in a room cause a quick carbon dioxide rise
- A high CO_2 concentration is dangerous for living beings
- The ventilation rate can be coupled to CO_2 level
- SenseAir s analyzers automatically control fans or window openers so that the CO_2 level is optimized
- Levels of VOC, virus & bacteria are also decreased
- Besides a better health, CO_2 control saves a lot of energy!



How CO_2 influences



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Fixed ventilation, based on maximum occupancy

Ventilation is based on calculation of a probable maximum load of people

Many rooms are overventilated - waste of energy!

Some rooms need more ventilation – people are uncomfortable!

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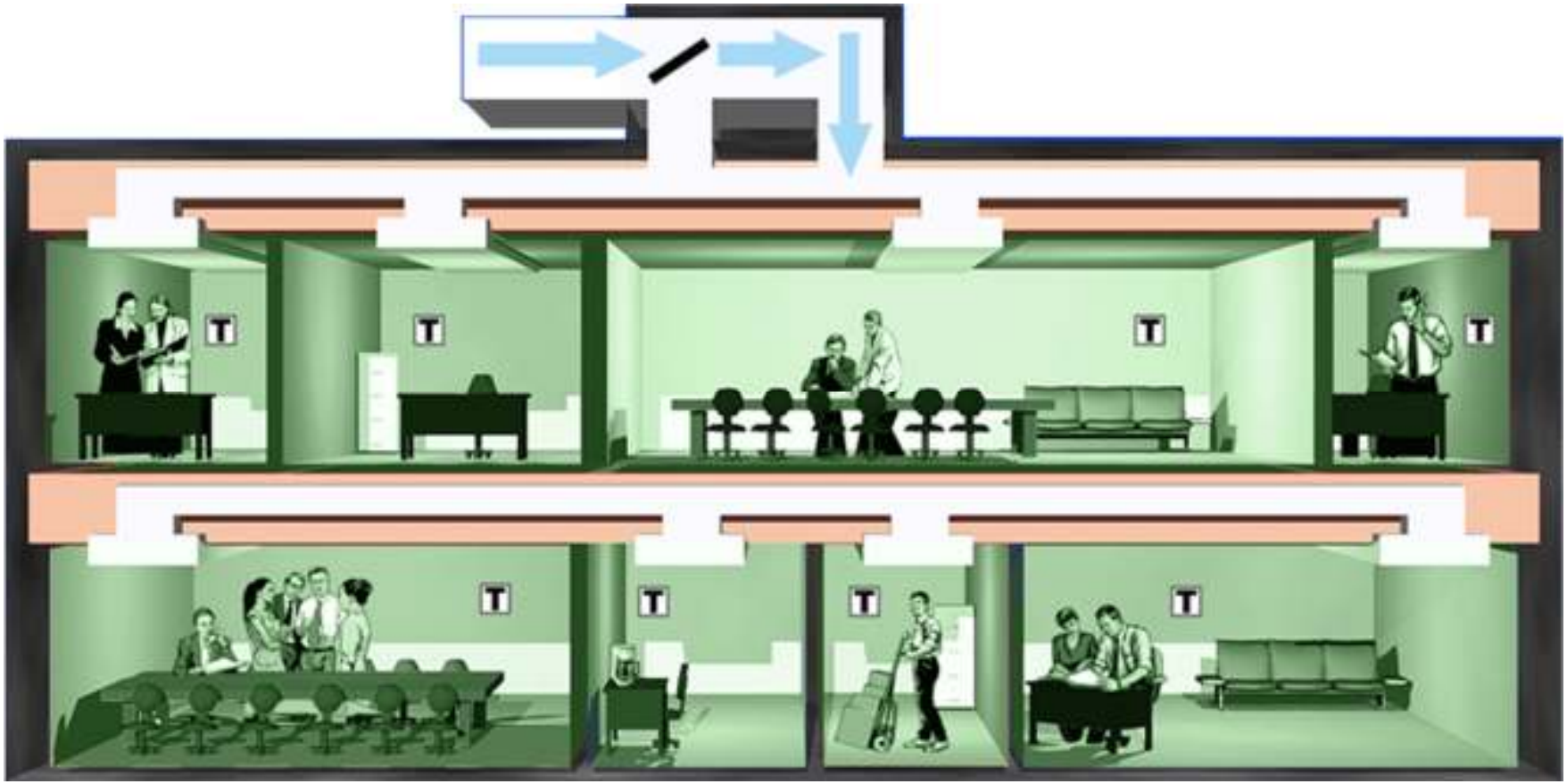
CO_2 controlled ventilation



The ventilation fits exactly for the actual number of people in every room

Fresh air everywhere and large energy savings!

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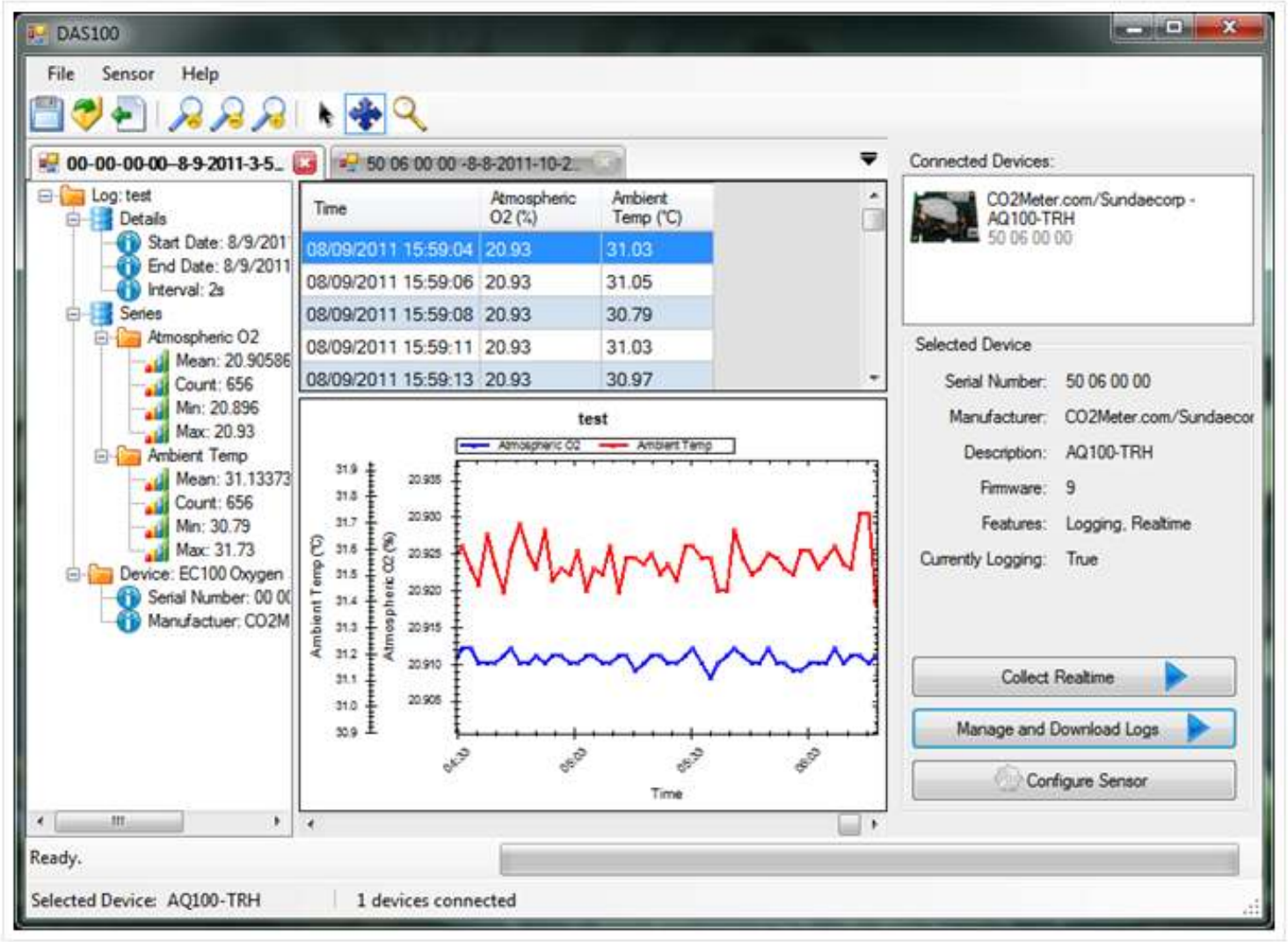
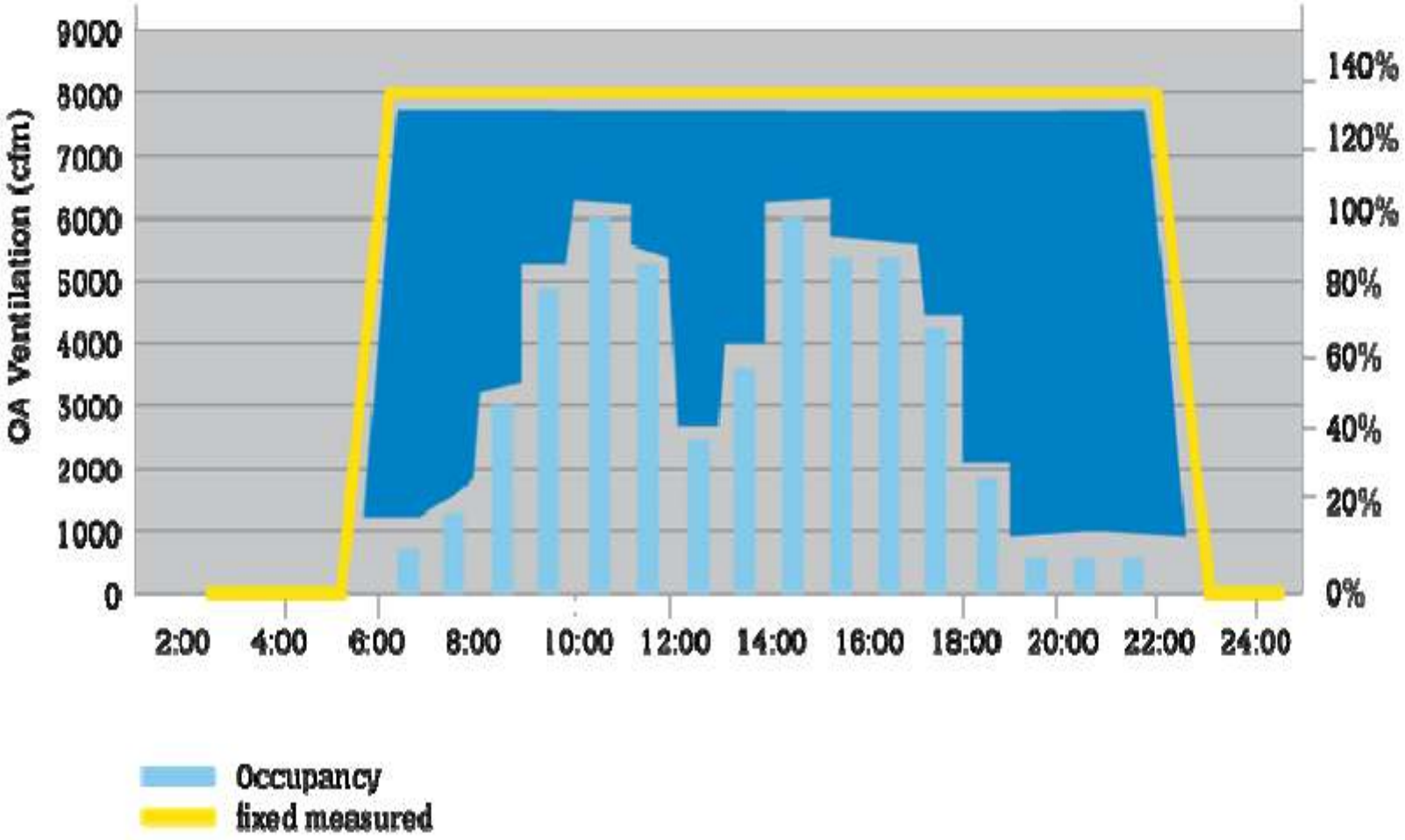
CO2 Meter‘s data acquisition package to configure sensors, view data in real-time, or manage stored logs on sensors with internal memory



The blue area corresponds to energy saving when CO2-demand ventilation is used



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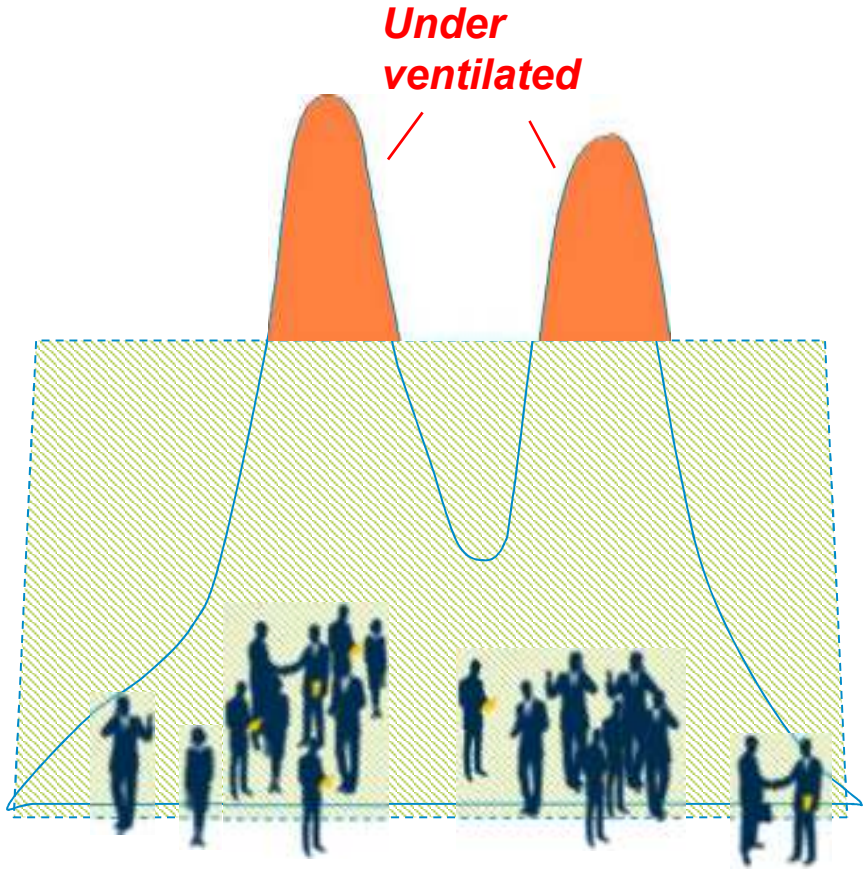
The red area shows that the air quality is getting poor due to too many people – if not CO2 demand ventilation is installed



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Reference project

Subway, Seoul Metropolitan

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Reference project

The Kremlin in Moscow has our CO_2-analyzer since 1995

Photo from 2000

Photo from 2008

Reference project

Hong Kong´s international airport, 1997

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In-door & Out-door Air Quality - reduced by various reasons

Species	More details	Symptoms / problems
Chemicals	CO_2, CO, NO_x, SO_2, O_3, …	Allergy, tiredness, poisoning
Odours	Perfume, smell, sweat…	Irritation or allergy
Radon	Rn, radioactive gas	Lung cancer
Particles	PM_{10}, $PM_{2.5}$, ultrafine particles	Allergy, lung decease
Microbes	Virus, bacteria	Allergy, sickness
Pets	Cats, dogs, minipigs, …	Allergy
Humidity	Water vapor	Too dry climate or mold growth
Ventilation	Air change	Noise, draught
Temperature	Around +20 C	Chilliness, tiredness

Most important out-door air species according WHO Air quality guidelines, global update 2005

Species / µg/m3	Annual mean / µg/m3	Short period mean / µg/m3	Risks
PM-2.5	10	25, 24-hour	Premature mortality, lung cancer, cardiopulmonary
PM-10	20	50, 24-hour	Premature mortality, lung cancer, cardiopulmonary
O_3	-	100, 8-hour	Inflammatory lung effects
NO_2	40	200, 1-hour	Children asthma, respiratory symptoms
SO_2	-	500, 10-minute 20, 24-hour	Respiratory symptoms, mortality

Management plan 2012, EU within DG ENV, Directorate General Environment C.3 Industrial Emissions, Air Quality & Noise

Species	By 2010 / million tonnes	Reduction by 2020
SO_2	8.3	18 %
NO_x	9.0	40 %
NM-VOCs	8.8	-
NH_3	4.3	73 %
PM-10	-	41 %

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Most common gas sensors for e-noses

Sensor type	Measurand, sensitivity	Advantages	Disadvantages
Polymer composites	Conductivity, ppb-ppm	Cheap, operating at room temp	Sensitive to temp and humidity
Intrinsically conducting polymers	Conductivity, ppm	Cheap, operating at room temp, senstive to polar analytes, good respons time	Sensitive to temp and humidity Baseline drift
Metal oxides	Conductivity, ppm	Cheap, fast respons & recovery time	High operating temp, sulphur poisoning
SAW	Piezoelectricity, ppm	High sensitivity, good respons time	Complex interface circuitry, difficult to reproduce
QCM	Piezoelectricity, ppm	Good batch to batch reproducibility	Complex interface circuitry, poor signal-to-noise ratio
Optical devices	Intensity / spectrum, ppb-ppm	Immune to electromagnetic interference, fast response time, cheap, light weight	Complex interface circuitry, restricted light sources
MOSFET	Threshold voltage change, 0.1 ppm	Small, low-cost sensors, CMOS integratible and reproducible	Baseline drift, need controlled environment

SAW= surface acoustic wave, QCM= quartz crystal microbalance,

MOSFET= membrane-oxide semiconductor field-effect transistor

Other gas sensors for analyzers / systems

Sensor type	Measurand, sensitivity	Advantages	Disadvantages
Combustible catalytic	Heat increase which gives a resistance change	Simple, low cost, handles combustible gases, 20-30 s response time	Can be poisoned, low response time, high power, need oxygen to work, needs recalibration
Semiconducting oxide	Resistance change from conducting gas, high conc	Simple, robust and sensitive, can handle binary gas mixtures	Nonspecific for a certain gas, affected by temp and humidity, higher maintenance costs, needs recalibration
Thermal conductivity	Heated sensing element, temp change proportional to conc, high conc of binary gas mix	Suitable for CH_4, H_2 and gases with higher thermal conductivity than air	Water vapor interferes, NH_3, CO cannot be measured
Infrared gas detector	IR absorption, ppm	<10 s respons time, low power, small, functions in various temperatures and pressures	Cannot detect nonpolar molecules such as H_2, high initial purchase cost, humidity might disturb
Electrochemical	Electrode potential change, 0.02 ppm – 50 ppm	Compact, very low power, excellent linearity, 30-60 s respons time, measures toxic gases: CO, H_2S, Cl_2, SO_2 etc	Oxygen must be present, affected by temp and humidity
”Chemcasette”	Colorimetry / photodetector	Fast, leaves physical evidence	

Examples of existing standards…..

$NO/NO_2/NO_x$	Nitrogen oxides	Chemical luminescence	SS-EN 14181 CEN/TC 264 CEN/TS 14793	10% of values in mg/m^3 dry NO_2 gas (273 K och 101,3 kPa).
CH_4	Methane	Gas chromatography	SS-EN 14181	0-1500 mg/m^3
Odours		Olfactometry Determination of Odour Intensity	CEN 1995 VDI 3882 Part 1 (VDI, 1992) NVN 2820 March 1995 CEN TC264/WG2 1995	
	Workplace atmospheres - Electrical apparatus used for the direct detection and direct concentration measurement of toxic gases and vapours - Part 4: Guide for selection, installation, use and maintenance	Electrical apparatus / CENELEC	EN-45544-4:1999	
Aerosols with ultrafine particles	Various arenes benspyren, antracene aso		SS-EN 15980:2011 SS-EN- ISO 28439:2011	

Example, ASHRAE Green Building Standards

All CO_2 sensors used for Demand Control Ventilation, DCV must meet the following requirements:

Spaces with CO_2 sensors leading to a central CO_2 monitoring station shall have one sensor for every 10,000 sq ft of floor space and shall be located in the room between 3 and 6 feet (1 - 2 m) above the floor

CO_2 Sensors must be accurate to ±50 ppm at 1000 ppm

Outdoor air CO_2 concentrations shall be determined by one of the following:

- ***Outdoor Air CO_2 concentrations shall be dynamically measured using a CO_2 sensor located in the path of the outdoor air intake***
- ***When documented statistical data are available on the local ambient CO_2 concentrations, a fixed value typical of the location where the building is located shall be allowed in lieu of an outdoor sensor***

Occupant CO_2 generation rate assumptions shall be shown in the design documents

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WG4 Protocols and Standardisation Methods

Leader (Coordinator) Prof. Ingrid Bryntse, SenseAir AB, Sweden

Vice-Chair Dr. Nicolas Moser, E2V Microsensors SA, Switzerland

WG 4.1 Protocols, standards and methods for AQC by analyzers/instruments (no-sensors) technologies

Dr. Grisa Mocnik, Aerosol doo, Slovenia

WG 4.2 Protocols, standards and methods for AQC by sensors (no-analyzers) technologies

Dr. Anne-Claude Romain, Universitè de Liège, Belgium

WG 4.3 Benchmarking of new products and market of commercial AQC sensors

Dr. John Saffell, Alphasense Ltd - UK

Plans within COST EuNetAir WG-4, 2013-2016

Focus on the most important species among gases, odours & particles

Check most useful sensor / analyzer technique for measurements & calibration in cooperation with certified laboratories

Evaluate present standards, suggest new variants or changes

Communicate with COST members and European Union

European standards concerning:

concentration interval / limits

accuracy / linearity

temperature span

pressure variations

humidity influence

interactions from other gases

allowed sensor drifting

response time

calibration procedures

sensor energy consumption

impact on society

Gas sensor standards

General standard for each gas / specie and if possible:

Standards for certain common applications, for example:

Ventilation

Mining

Automotive

Special industries

Agriculture

Hospitals

Waste water treatment

.....

Four examples of what we - all of us - can gain if new standards are fully implemented in Europe

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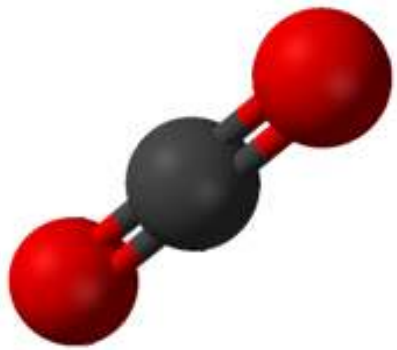
1. CO_2 appplications and benefits

CO_2	Application	Benefits
Ventilation	Private houses, vehicles	Reducing greenhouse gases, lower energy costs, higher comfort, less virus & bacteria etc..
Safety	Industries, restaurants	Less death injuries, less fires
Safety	Kerosene heaters	Less death injuries
Capnography	Intensive care at hospital	Less death, quicker recovery
Farming	Greenhouses, chicken hatcheries	Better production control, lower costs, higher yield



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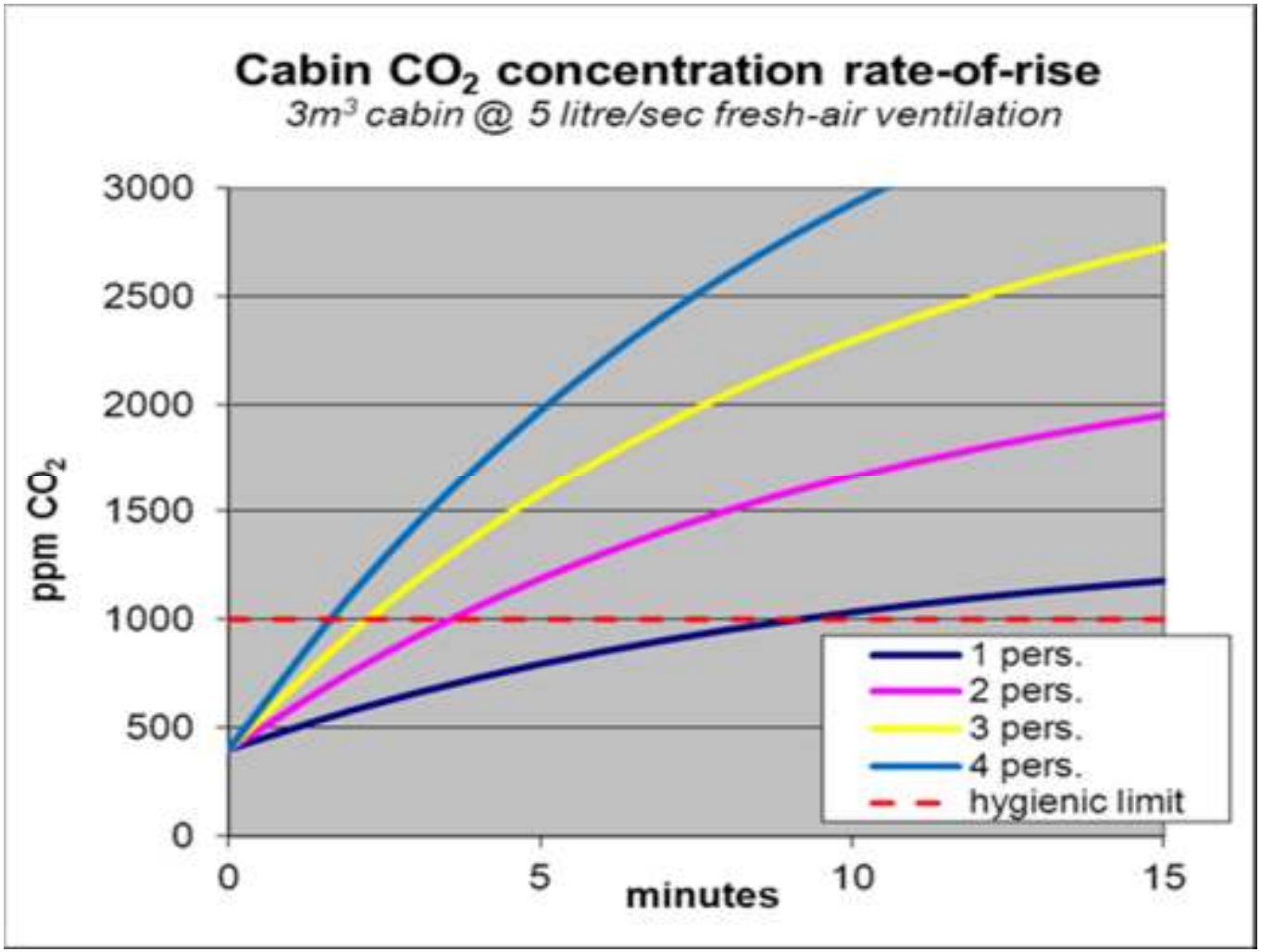
CO_2 concentration in a car cabin



Despite ventilation the hygienic threshold is rapidly overcome in a full car

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CO_2 influences our decision making ability and productivity

New study*

22 persons, 18-35 years old:

Decision testing ability was tested at three different CO_2 concentrations:

600 ppm, 1000 ppm and 2500 ppm.

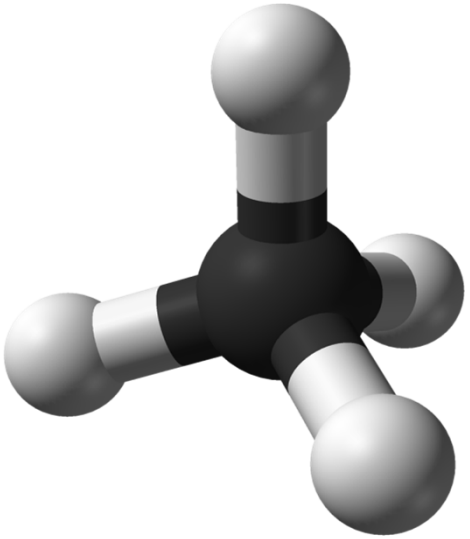
All other parameters were kept constant.

A CO_2 level >2500 ppm decreased the ability to draw conclusions and to think strategically. These levels are common in office buildings.

Usha Satish, William J. Fisk, Mark J. Mendell, Krishnamurthy Shekhar, Lisa B. Cleckner, and Kailing Teng,* ***Indoor Air 2011, Austin, Texas*

2. Hydrocarbons, applications and benefits

HC, hydrocarbons	Application	Benefits
Safety alarm	Burners / kitchen appliances in private homes	Less death injuries, less explosions or fires
Safety alarm	Mining	Less death injuries
Fuel analysis	Gasoline – engine optimising	Lower energy costs



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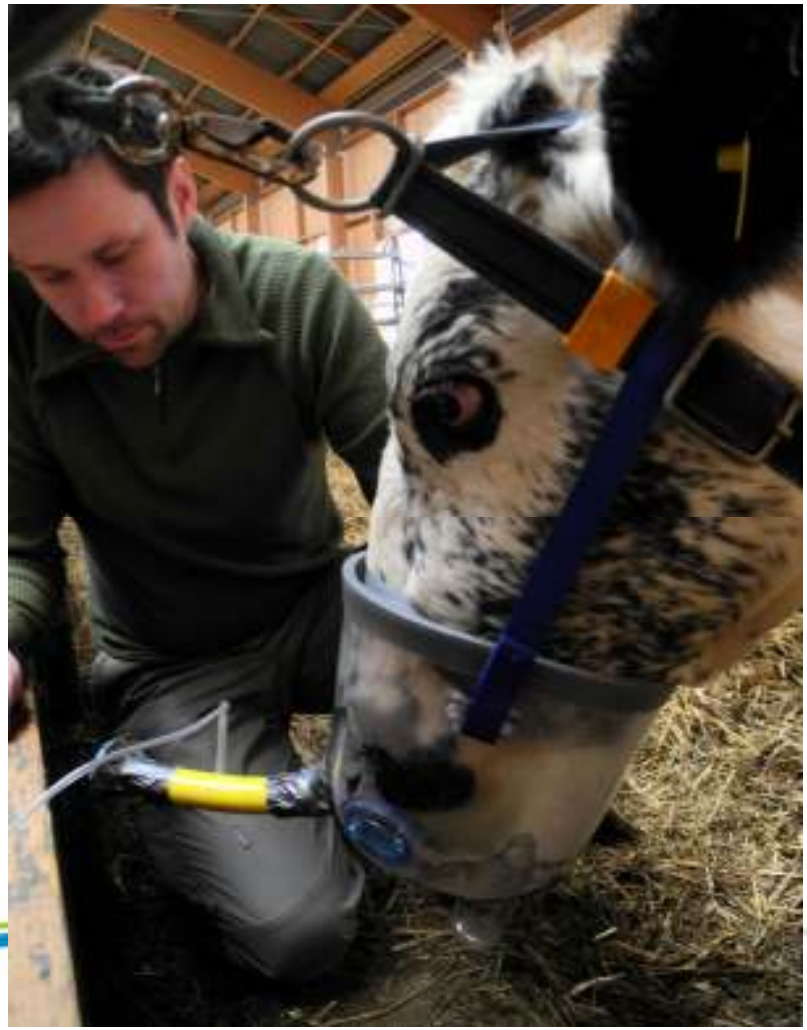
Soil Measurement System

Vinnova project with India 2008-2010

Hans Olofsson, SenseAir

The variation of CO_2 in soil is monitored



Environmental sensors

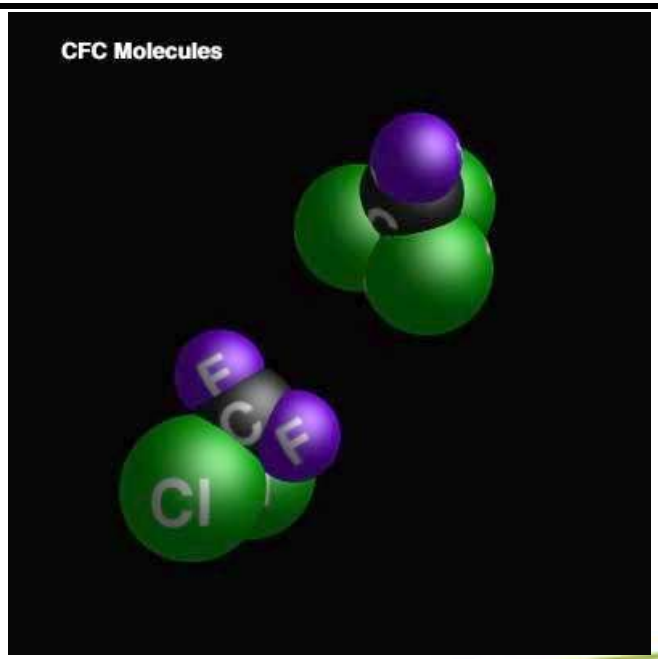
Vinnova project together with SLU & JTI 2010-2012

Henrik Rödjegård, SenseAir

Dinitrogen oxide and methane is measured in soil and cow ”out-breath”

3. Freons, applications and benefits

Freons, other defrigerants	Application	Benefits
Freezer systems	Industries, shops, private homes	Reducing greenhouse and ozone depleting gases, lower costs for refilling or destroyed food
Safety alarms	Industries, service personel	Lower risk of injuries or death



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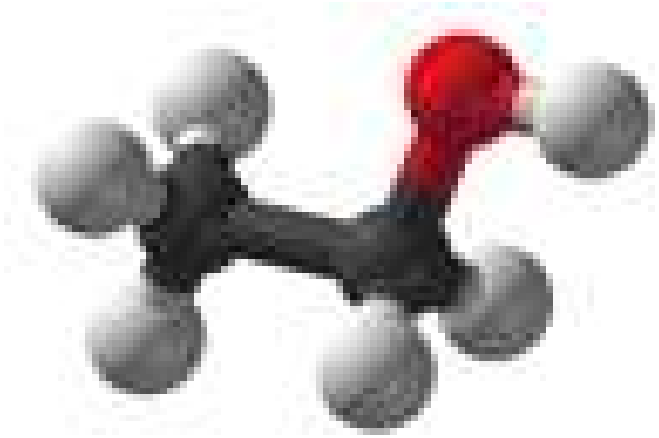
4. Alcohol, applications and benefits

EtOH, ethanol	Application	Benefits
Safety	Cars, aeroplanes, other vehicles	Less dead or damaged people, lower costs caused by drunk driving
Monitoring / safety lock	Certain classified sites	Prevent accidents caused by drunk employees at job
Healthcare	Ambulance transport	Better care and quicker recovery of patients



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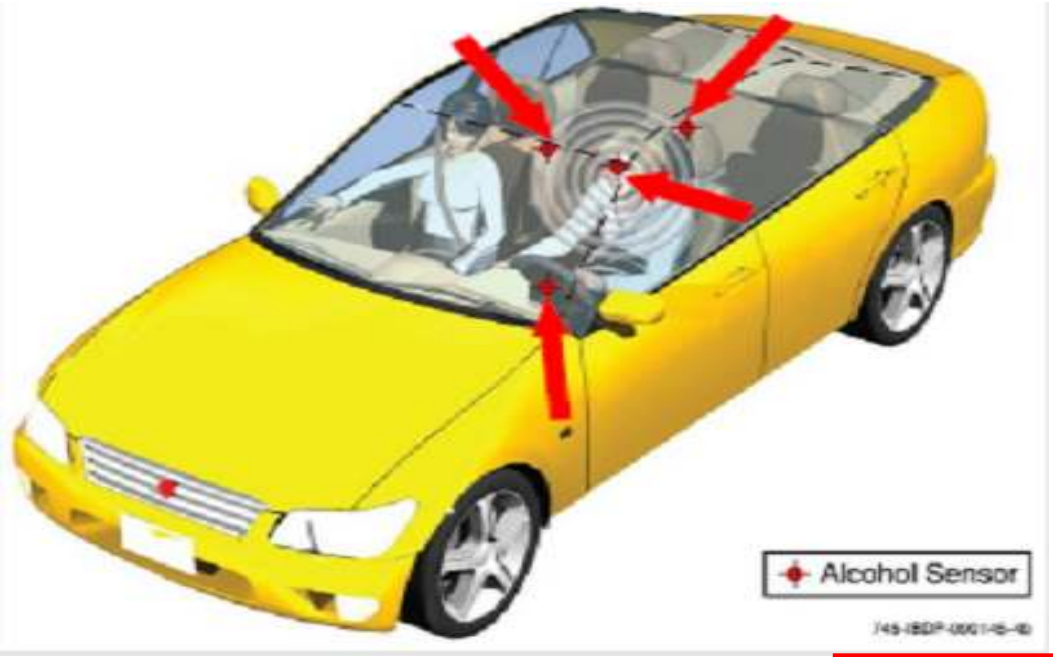
Traffic safety

Death injuries due to alcohol

Thousands of road traffic deaths in EU could be prevented every year if alcohol detection devices were used in all vehicles



Alcolock advanced sensor

Autoliv

VOLVO

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New European Standards give a Healthy Environment and Save Costs

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Thank You!

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