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

COST Action TD1105

WGs Meeting, Belgrade, 13 - 14 October 2015

organized by VINCA Institute and co-organized by Public Health Institute of Belgrade

hosted by Faculty of Mechanical Engineering, University of Belgrade

Action Start date: 16/05/2012 - Action End date: 30/04/2016

Year 4: 1 July 2015 - 30 April 2016 (*Ongoing Action*)

CHALLENGES AND REQUIREMENTS FOR LOW COST ENVIRONMENT MONITORING FOR POULTRY FARMS

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Function in the Action: WG Member

United Kingdom

COST is supported by the EU Framework Programme

ESF provides the COST Office through a European Commission contract

Scientific context and objectives in the Action

Background / Problem statement:

- Environmental issues are concerns for all spheres of life
- This includes food processing and **mass-scale** poultry farming
- There are two primary reasons for this:
  - To maintain quality and safety of food (reduce contamination) and
  - To maintain comfort levels for the animals (reduce spread of disease).
- Such requirements are regulated by the EU standards e.g:
  - CO_2 <2500ppm; NH_3,< 25ppm
  - SO_2 < 10ppb, H_2S,< 10ppb and CO < 100ppb .
- Improve quality of life for the EU community and serve animal welfare

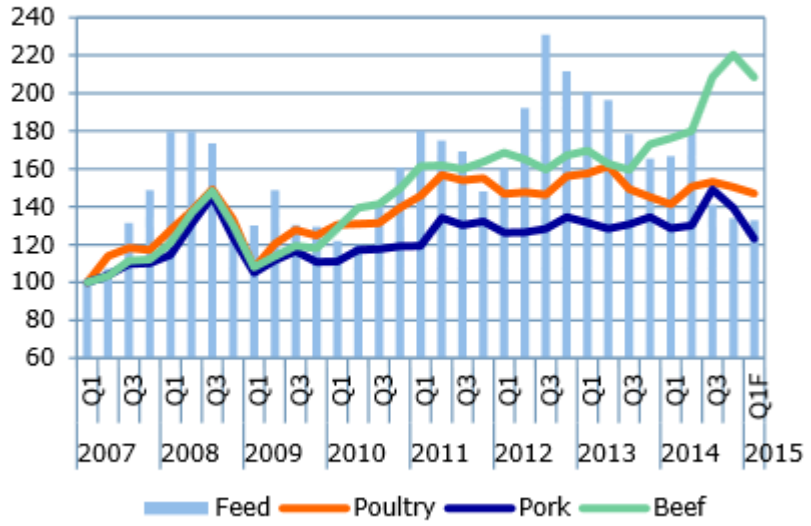
Key challenges:

- Durable; Reliable; Compact; Low power and Affordable

Global Poultry Industry

*Figure 3: Global broiler, beef and pork prices versus feed cost monitor, Q1 2007–Q4 2015**

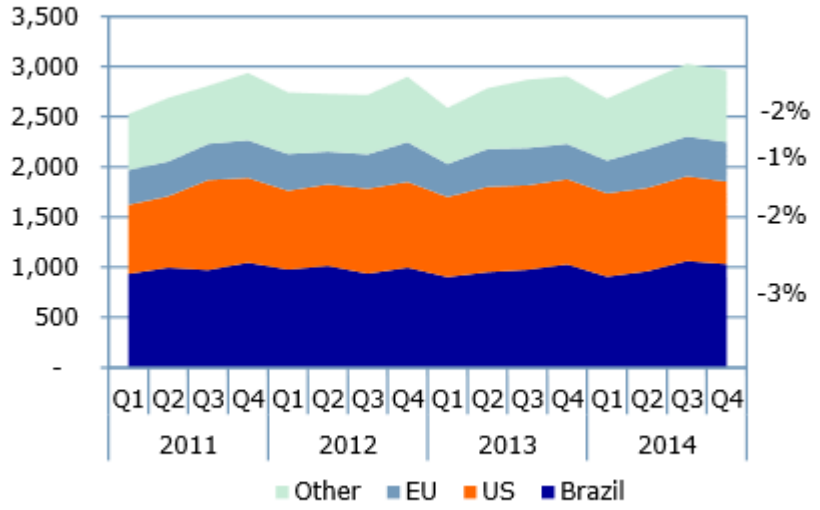
index, Q1 2007=100



Source: Bloomberg, FAO, Local statistics, Rabobank, 2015

Figure 4: Rabobank global poultry trade monitor, 2011-2014

thousand tonnes

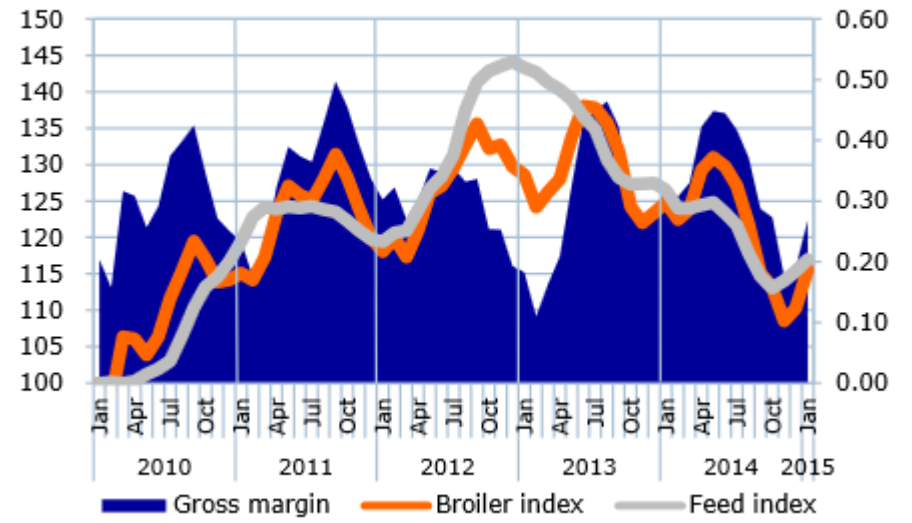


Source: Bloomberg, National statistics, 2015

Without poultry industry it will be difficult to feed global population!

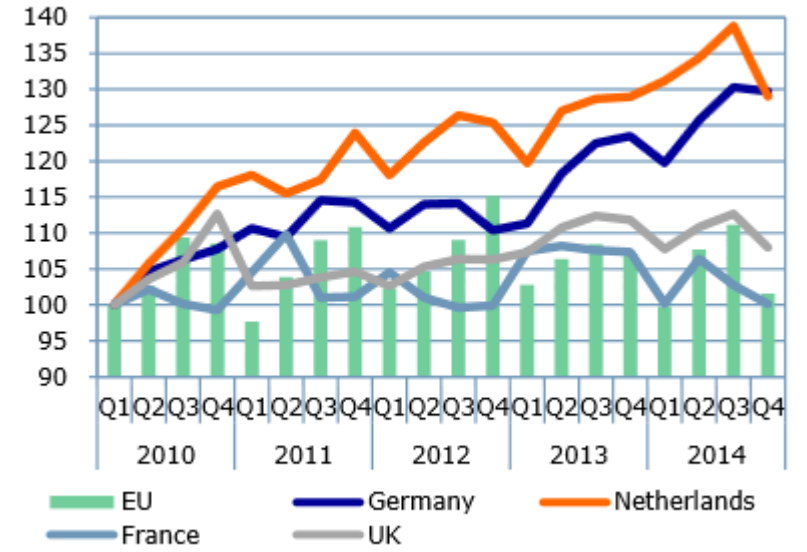
EU Poultry Industry

Figure 11: Northwest European broiler, feed price and margin trend 2010-2014



Source: Eurostat, EMA, PVE, Igreca, Defra, Rabobank, 2015

Figure 12: Quarterly production for the EU and for individual countries, 2010-2014

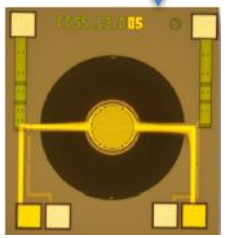


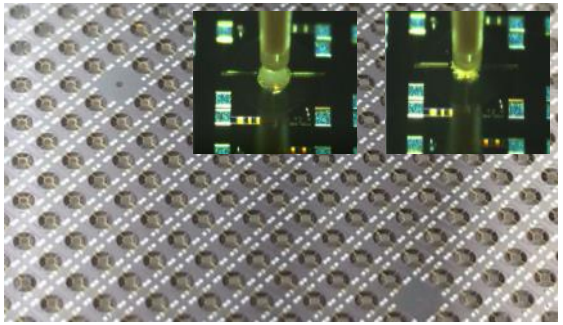
Source: Eurostat, EMA, PVE, Igreca, Defra, Rabobank, 2015

Market is very big with huge impact on food safety concerns!

Technology: CMOS MOX Sensor Critical Process Steps

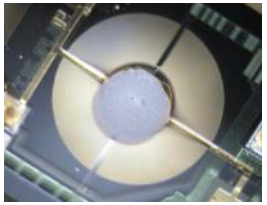
Die with post-CMOS gold electrodes



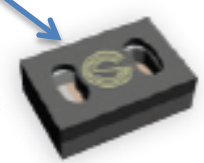


More than 10K MOX sensors on a single 6” wafer!

Even more on larger wafer!



Low cost 2 mm x 3 mm SMD package



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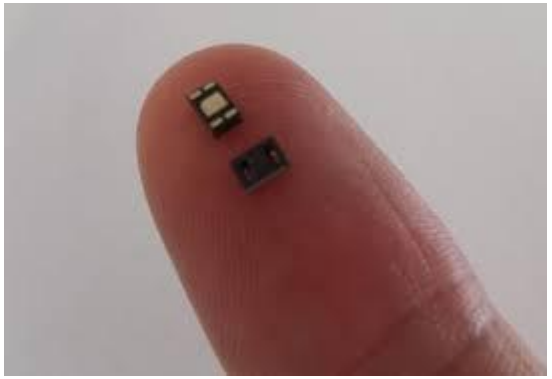
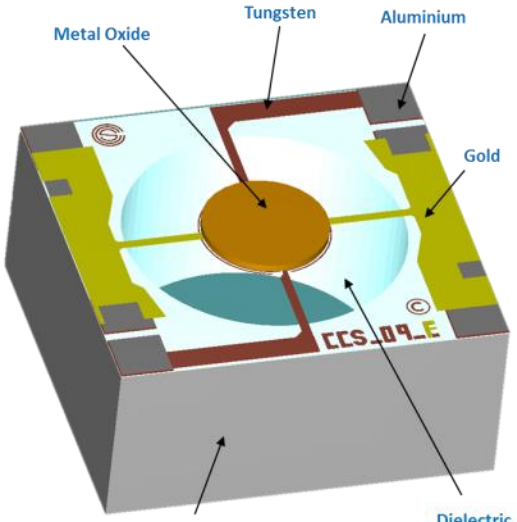




Sensor Module for Poultry AQM

Key features:

- **Platform for benchmarking MOX sensors**
- **Battery backup**
- **External DC or USB power option**
- **For harsh environment tests**
- **Wireless Zigbee interface**
- **Remote data logging**

Types of gasses/parameters measured:

- **EC – NH_3, CO, SO_2, H_2S**
- **MOX – NH_3, CO**
- **NDIR – CO_2**
- **Temperature**
- **Humidity**
- **Pressure**

Any number of wireless sensor clusters can be supported

Practical considerations & Test setup

Challenges:

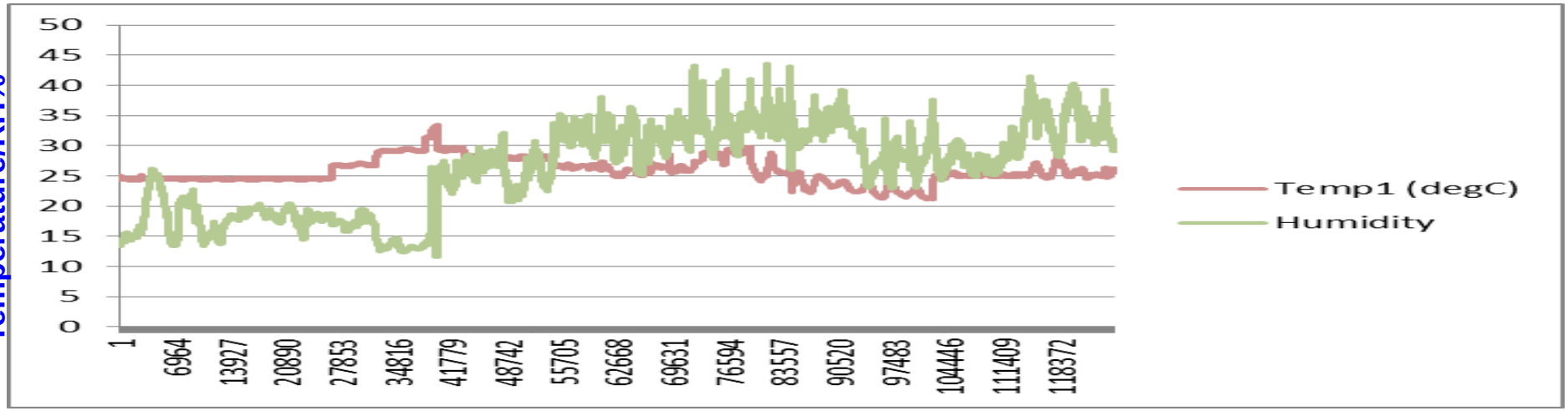
- **Harsh environment**
- **Dust**
- **High humidity**
- **Corrosion**
- **Low voltage shared supply**
- **LED lighting ON/OFF**
- **Battery backup**
- **Compliance**
- **Spray water jet cleaned**
- **Water resistance/proof**
- **Life cycle 6-8 weeks**

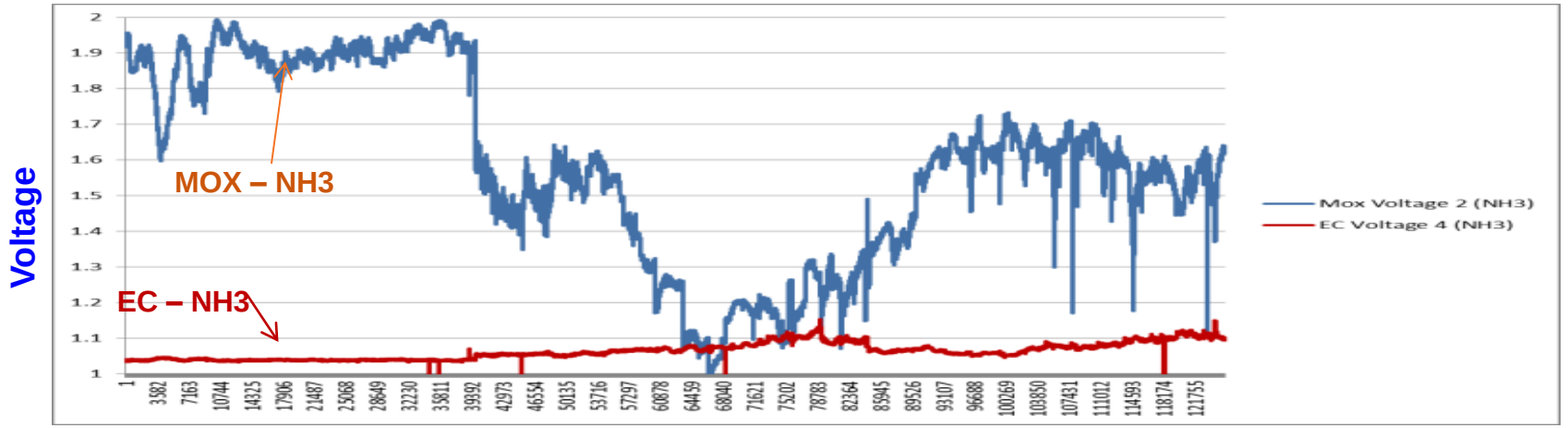
Test setup:

- Start with clean barn (small pen with ~24 chickens)
- Barn was not cleaned over the test period
- Test period was 3 months; sampling rate once per 15s

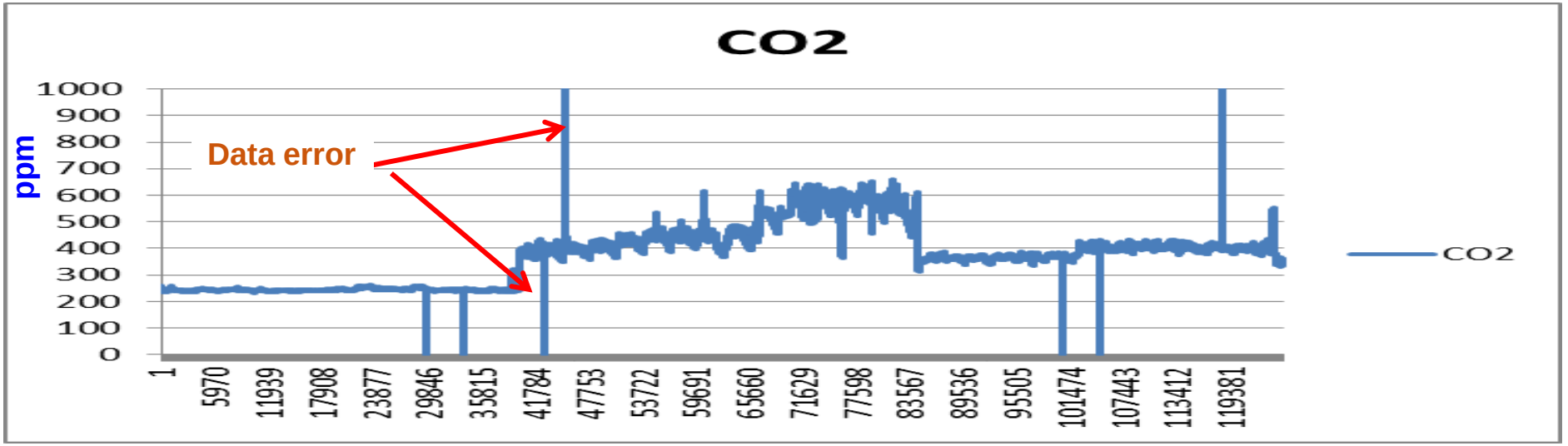
Keep chicken healthy!

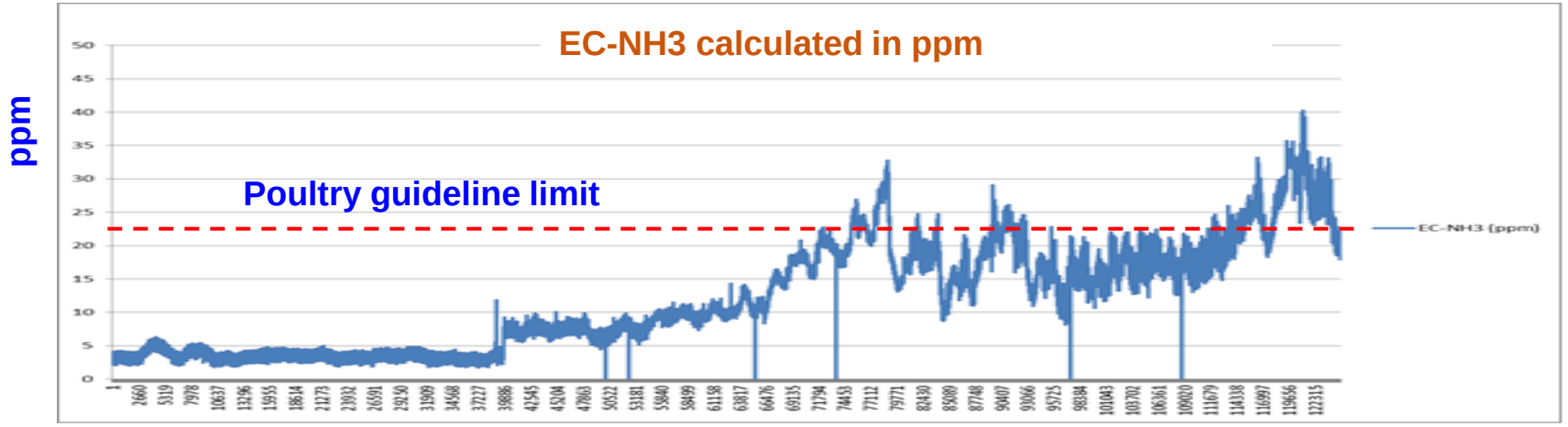
Measurement Results





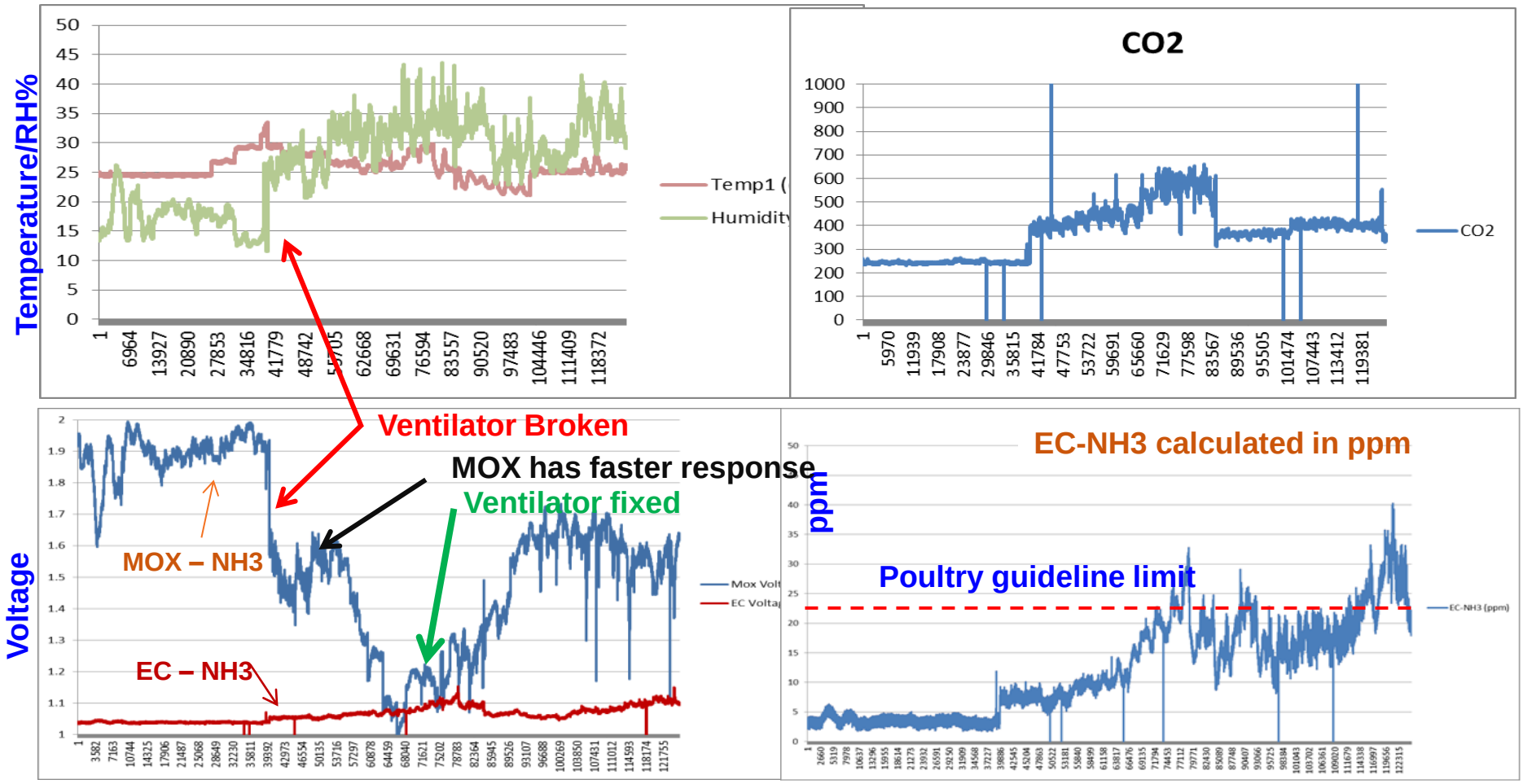
Measurement Results





Response of CO, SO2 and H2S were negligible

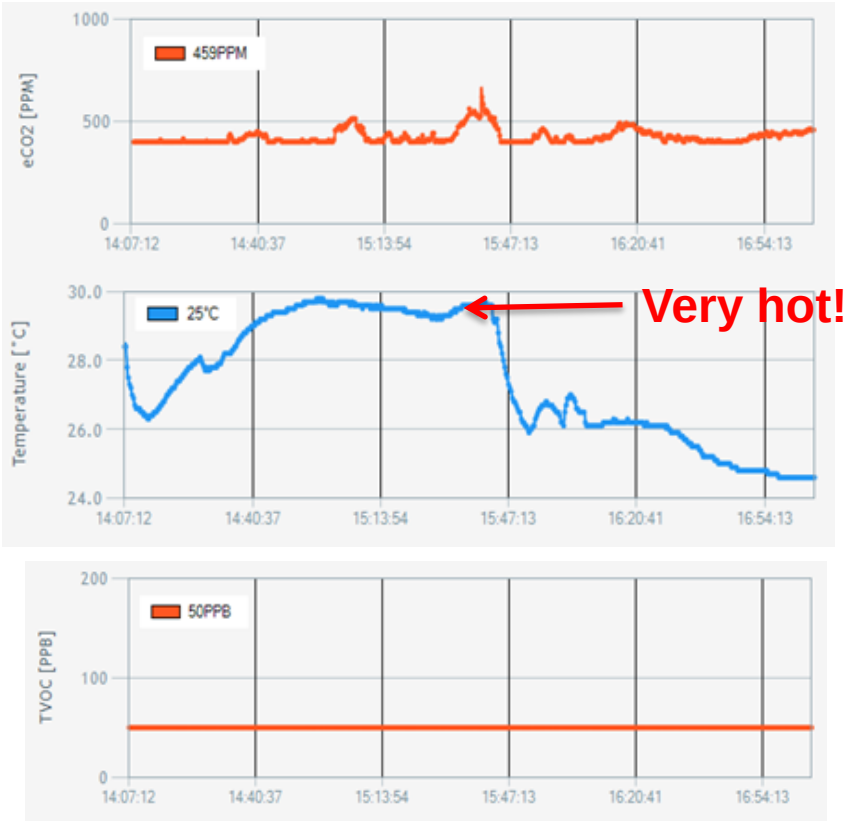
Results Analysis



Concluding remark: NH_3 response for MOX sensor shows faster response
Effect of temperature and humidity variation is not observed on other CO and VOC MOX sensors
More data need to be collected.

Air quality in COST Meeting room – Belgrade (Day 1)

Live demonstration



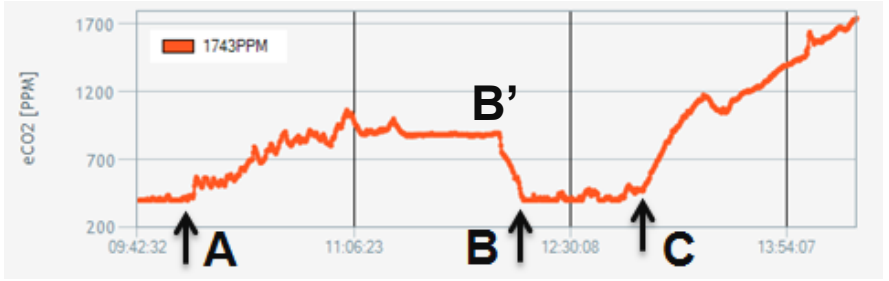
Motivations & Test condition:

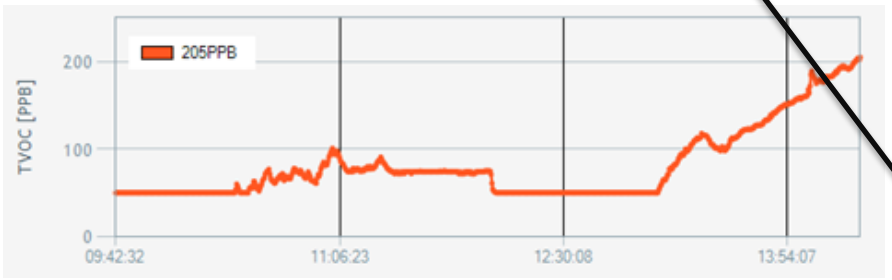
- An informal demonstration of a new generation of low cost metal-oxide (MOX).
- To show how easily such miniature sensors can be exploited to access air quality by the an user.
- To relate indoor air quality level with comfort level.
- Room size 10m x 20m x 5m (Approx).
- Approximately 25 people in the room.
- Some windows partially opened
- Occasionally people left or entered the room
- eCO_2 measured is very representative
- Data can easily be correlated with reference

Monitored with CCMOSS MOX 8XX device for indoor AQ

Air quality in COST Meeting room – Belgrade (Day 2)

Live demonstration





A – Meeting start (windows closed)
B – Lunch (window opened)
C – Meeting re-start (windows closed)

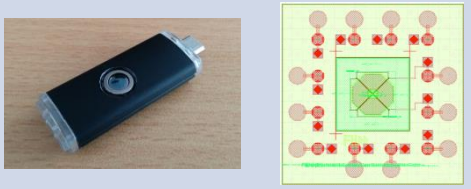
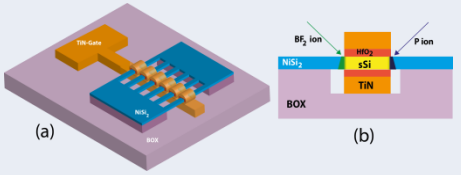
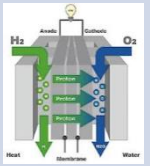
Observations:

- With windows closed CO_2 level increased as expected (A to B')
- Window opened and people left the room for lunch (B to C) CO_2 and temperature dropped. CO_2 level returned to ambient level.
- More VOC activity was observed on this day.
- Door briefly opened and closed, more people entered the room

Monitored **live** with CCMOSS MOX 8XX device (after lunch)

Some of Current research activities

WG2: CMOS Sensors, Devices and System for Air Quality Control

Project	Sensor Type	Application	Picture
MSP	TPD + TPD array	IR Sensor for People presence	
E2SWITCH	Low voltage Circuit & MHP	TFET Low voltage Gas sensor	
EPSRC (HFC)	CO, H_2S, NH_3	Hydrogen Fuel Cell	
TSB (GGP)	CO, H_2S, SO_2, NH_3	Poultry environment	

Looking forward to AirCities success!

Research Facilities at CCMOSS

- **Research Facilities:**
- In-house MOX preparation, deposition, packaging and testing
- Global supply-chain partners for high volume manufacturing

Wafer probe station, ASL1000, batch tester designed for sensors, wire bonding machine

- Indoor Air Quality (IAQ) sensor detects a wide range of indoor air pollutants
- Alcohol detection for breathalyser applications
- Carbon Monoxide Toxic Gas Detection
- World's Smallest, Lowest Power multi-gas sensors

ISO 9001 001

nmi Semiconductors to Systems — 2014 Innovation Award Winner

MEMS Industry Group® — Technology Showcase Winner

HOT 100 EDN 2014

cost EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

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North America
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Company Mission

"To be the leader in advanced sensor solutions for enabling improved health and wellbeing"

Suggested R&I Needs for future research

- Improve long term reliability
- Improve SSS
- More data
- Data correlation with animal welfare
- Data correlation with spread of disease
- Global or central data for enforcement
- Low maintenance affordable IoT enabled solution

References:

1. **Poultry Stats: Chicken Market, https://www.nfuonline.com/assets/18447**
2. **P.L.M. Van Horne, "Animal welfare in poultry production systems: impact of European Union standards on world trade", http://www.fao.org/ag/againfo/home/events/bangkok2007/docs/part2/2_5.pdf**
3. **http://www.poultryhub.org/production/husbandry-management/housing-environment/climate-in-poultry-houses/**
4. **G Corkery et el, 2013. Incorporating Smart Sensing Technologies into the Poultry Industry. *J. World's Poult. Res.* 3(4): 106-128.**
5. **J. Bang et al, Design and Implementation of a Smart Control System for Poultry Breeding's Optimal LED Environment, International Journal of Control and Automation Vol.7, No.2 (2014), pp.99-108**
6. **http://www.avisite.com.br/relatorios/Rabobank_Poultry_Quarterly_Q1_2015.pdf**

SUMMARY & CONCLUSIONS

- Measurements taken in a small barn and controlled environment
- **Two** modules were placed in the barn.
- All MOX sensors responded well (CO and NH_3 were only on the boards)
- All EC sensor (CO, NH_3, H_2S, SO_2 were operational)
- For NH_3 measurements show that MOX has faster response
- As expected, insignificant response was seen with commercial EC, CO, H_2S and SO_2 (they should be @ low ppm or @ppb level)
- **Test showed that sensors functioned under harsh environment condition**
- At the end of the test, the modules were covered with dust and feathers!
- Better filtering and assembly will be required for future trials
- Good reference sensors are always required to validate the accuracy of the data.
- Low cost sensors provide indicative information of the environmental air quality
- This may be sufficient for general health and wellbeing applications
- With calibration sensor accuracy can be improved.

Acknowledgements

Founders, Investors and Team at Cambridge CMOS Sensors Limited.

Thank you for listening!

EuNetAir
COST Action

UNIVERSITY OF CAMBRIDGE

WARWICK
THE UNIVERSITY OF WARWICK

SEVENTH FRAMEWORK PROGRAMME

Greengage Lighting Ltd.

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EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

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

Newcastle University

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