European Sensor Systems Cluster - ESSC

"Renaissance of chemical and biological sensors"
Brussels, Covent Garden, 19 April 2016

ROADMAP Towards EU Leadership in Sensor Systems

INTRODUCTION and METHODOLOGY

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OUTLINE

- **SCOPE and OBJECTIVES of ESSC**:
  - ✓ Roadmap
  - ✓ Inputs for H2020 Calls (RIA, IA: 2018-2021) at different TRL

- **Priority Topics and Horizontal Topics for H2020 Calls**

- **ROADMAP METHODOLOGY and ESSC Working Groups**

- **Smart Sensor Systems for *Industry 4.0***

- **Smart Sensor Systems for *Internet of Things* (IoT)**

- **Commercialization**

- **Sensor System Integration**

- **Market of Sensor-Systems**

- **CONCLUSIONS**

The European Sensor Systems Cluster (ESSC) 19th April 2016

Short History of ESSC Dissemination

- **Preparatory Workshop**, Bruxelles, Belgium, 27 November 2014

- **ESSC Webpages** installed and hosted by ENEA (Italy), January 2015

- **COST Action EuNetAir Workshop**, Riga, Latvia, 26-27 March 2015

- **EMRS-2015**, Board of Delegates, Lille, France, 14 May 2015

- **ESSC Kick-off Meeting**, inside AMA Conference 2015 at SENSOR+TEST Fair, Nuremberg, Germany, 19 May 2015

- **COST Action EuNetAir 4° Scientific Meeting**, Linköping, Sweden, 3-5 June 2015

- ESSC Invited Talks at **EuroNanoForum 2015**, Riga, Latvia, 10-12 June 2015

- ESSC Session at **EUROSENSORS 2015**, Freiburg, Germany, 6-9 Sept. 2015

- ESSC Session at **Europtrode 2016**, Graz, Austria, 20-23 March, 2016

- **ESSC ROADMAP Presentation** to EC DG Officials/Officers, Bruxelles, Belgium, 19 April 2016

SCOPE & OBJECTIVES: Roadmap ESSC

1. Maximize the **cooperation between projects** (avoid duplicating work and improve efficiency)
2. Identify **common interests in on-going research and development** (e.g. open calls, training)
3. Provide a **forum** for discussion, problem solving and analytical planning R&D activities in Europe
4. Establish the **EU-wide meeting platform** for researchers and mainly for involved industries and end-users
5. **Remove commercialization barriers** to ensure the EU leadership in Sensor Technologies
6. **Integrate inputs** and Recommendations from other existing clusters or groups
7. Promote the **connection with external bodies** (EC-RTD, Connect, standardization and regulatory bodies, journals and scientific boards, advisory boards)
8. Disseminate the **sensor-related issues/findings** to informed public (e.g. stimulate awareness for the invisible environmental problems and support *citizen science*)

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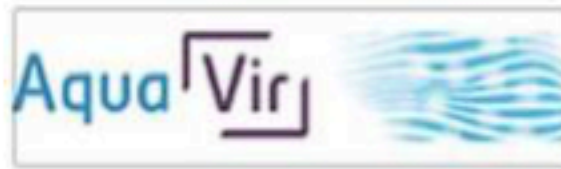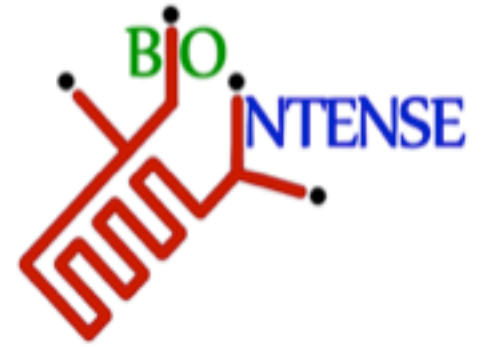# SCOPE & OBJECTIVES: Roadmap ESSC

ESSC Key Areas:

Environmental Sustainability; *Energy Efficiency*; *Health Monitoring*;

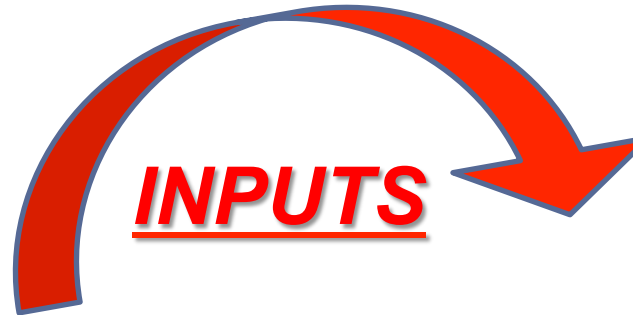*Comfort and Well-Being*; *Industrial Applications and Management*
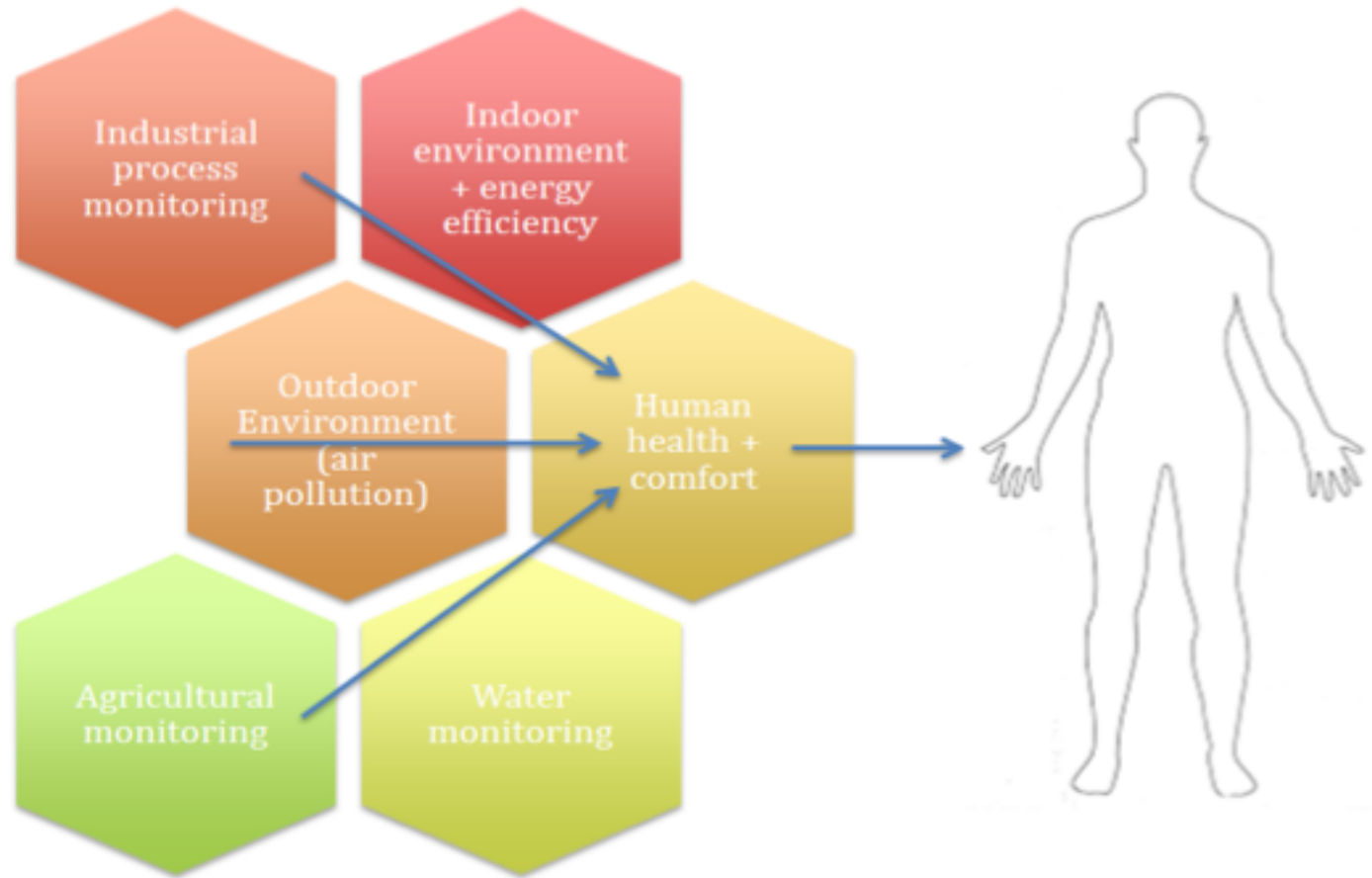
SCOPE & OBJECTIVES:
Inputs for H2020 Calls (RIA, IA: 2018-2021) at various TRL by Survey

INPUTS

- **Some SMEs involved**:

Alphasense Ltd (UK), SenseAir AB (SE), Amires Sarl (CH), Eurice GmbH (DE), NanoSense SARL (FR), 3S GmbH (DE), Efficiency Marketing (FR), NanoAnalytik GmbH (DE), AMA Sensorik (DE), Novasis srl (IT), Bioage srl (IT), Cambridge CMOS Sensors Ltd (UK), Fleming Medical (IE), Shimmer (IE), ………..

- **Some LARGE COMPANIES involved**:

ST Microelectronics (IT+FR); Analog Devices (IE); Bosch (DE); Infineon Technologies (DE), Mettler Toledo AG (CH), BASF (DE), Bayer (DE), Panasonic Industrial Devices Europe GmbH (DE), ams AG (AT), Siemens AG (DE), Endress+Hausser (DE), ………

SELECTED TOPICS for H2020 Calls
(RIA, IA: 2018-2021) at different TRL (1/2)

The Selected Topics of the WG1 - Environmental Sensors:
- *Improved Platforms for Marine and Freshwater/Wastewater Monitoring*
- *Migrating Analytical Instruments from the Lab to the Field*
- *Integrated Approaches to Air Quality Monitoring*
- *Environmental Sensor Informatics and Forecasting*

The Selected Topics of the WG2 - Indoor Air Quality:
- *Development of low cost, high performance PM sensor systems*
- *Integrate mobile sensor systems (primarily smartphones and wearables) into IAQ networks*
- *IAQ User Interface allowing easy understanding and individual tailoring*
- *Bio-chemical sensor systems for mold detection*

The Selected Topics of WG3 - Health Monitoring & Comfort Sensors:
- *Non-invasive sensing platforms for health monitoring*
- *Sensors for detection and quantification of volatile organic compounds*

The Selected Topics of the WG4 - Industrial Monitoring

- *Sensor platform for multiparametric process control*
- *Smart and intelligent process control systems for smart manufacturing and process-intensification*
- *Sensors for single use reactors*

The Selected Topics of the WG5 - Integration and Commercialization (HT)

- *Sensor SMD package standardization*
- *Generic ASIC*
- *Calibration*
- *Cost and size reduction*
- *Modularity and flexibility*
- *Quality of measures*
- *Interoperability*

ESSC Roadmapping Activity   (1/2)

Phase 1:
- Each WG leader defined up to 5 topics
- The remaining members of SC voted (majority vote)

Output: Steering Committee validated titles

Phase 2:
- Topics merged and redistribution
- WG leader prepared extensive topic description
- WG leader shared it with the interest group (members, companies under CDA) and finalized the description
- Topic merge (horizontal and specific topics)

Output: ESSC collective roadmap

Participants involved in the **ESSC Roadmap** by Industrial Interview/Survey:
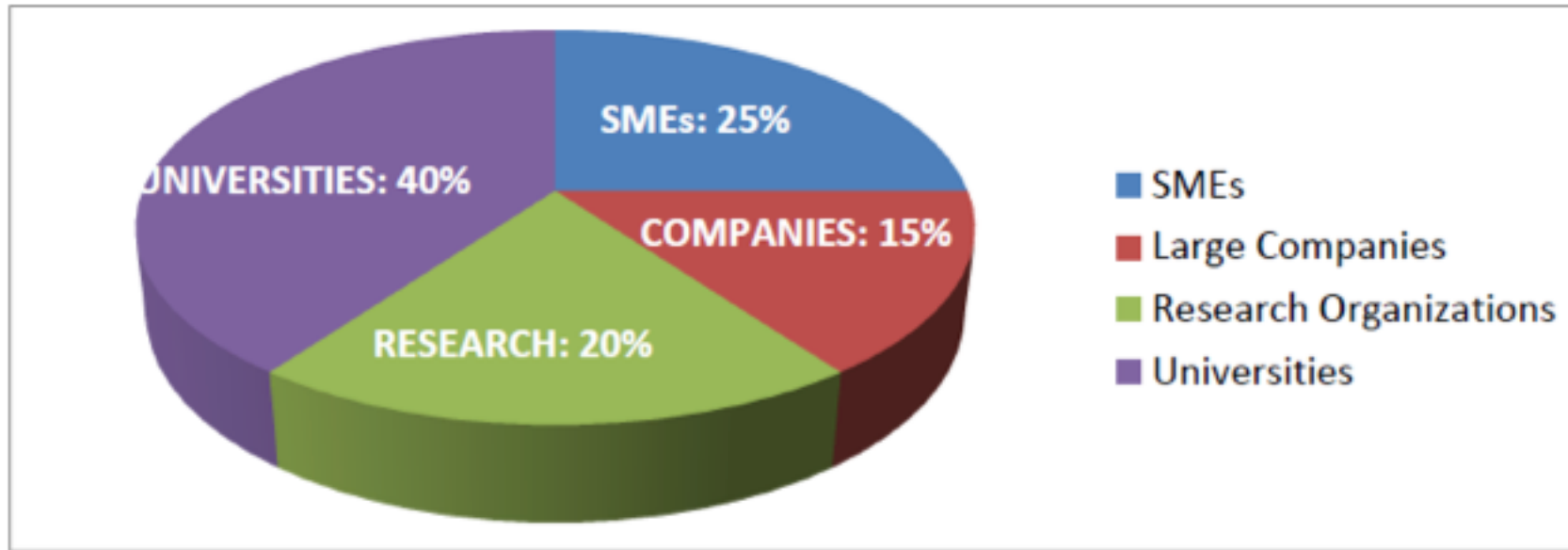
- **120 Contributors (90 registered in ESSC webpage)** informed on Survey
- **9 ESSC Steering Committee Members**
- **6 ESSC Working Groups**
- **8 ESSC Core-Partners**:
  ENEA (IT), Saarland University (DE), Dublin City University (IE), Tyndall National Institute (IE), Graz University of Technology (AT), NanoSense SARL (FR), Amires Sarl (CH), AMA Sensorik (DE)
- **28 SMEs involved**
- **13 LARGE COMPANIES involved**

6 ESSC WORKING GROUPS

WG1:
Environmental Sensors
Leader: Dermot Diamond (IE)
Participation: 32 Members

WG2:
Indoor Air Quality Sensors
Leader: Andreas Schuetze (DE)
Participation: 24 Members

CHAIRMAN: Michele Penza (IT)
COACH: Rudolf Frycek (CZ)
EC OBSERVER: Hans Hartmann Pedersen (DG R&I)

WG3:
Health Monitoring & Comfort Sensors
Leader: Paul Galvin (IE)
Participation: 30 Members

WG4:
Monitoring of Industrial Processes
Leader: Torsten Mayr (AT)
Participation: 25 Members

WG5:
Commercialization
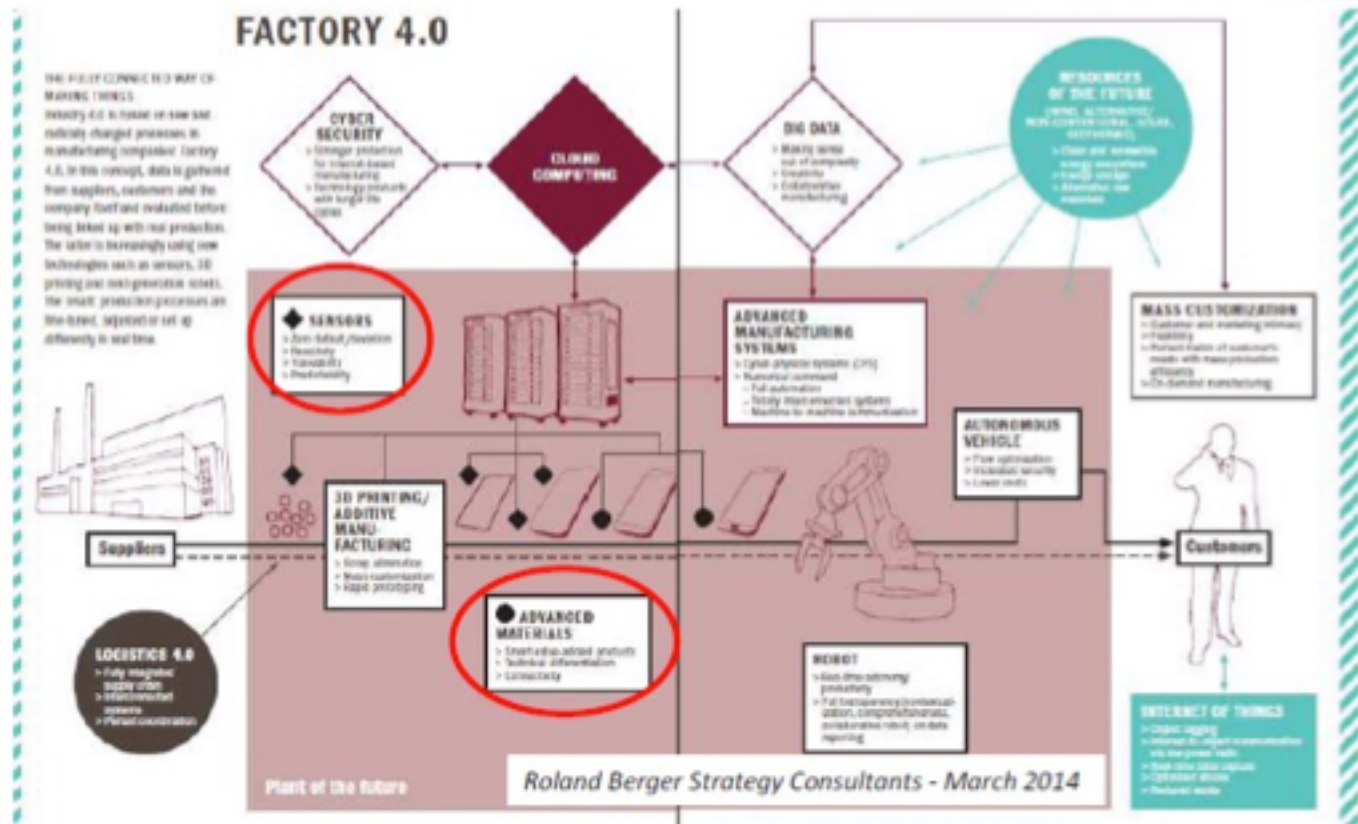*Leader: Olivier Martimort (FR)*
Participation: 10 Members

WG6:
Dissemination & Outreach
Leader: Thomas Simmons (DE)
Participation: Eurice (DE) and 10 Members

ESSC
The European Sensor Systems Cluster

SMART SENSOR SYSTEMS for *INDUSTRY 4.0*

Industry 4.0 is a new paradigm to enhance the efficiency and productivity of the *Factory of Future*. The latter is increasingly using new technologies such as **sensors, *advanced materials*, *3D printing*, *next generation robots*, *autonomous vehicle*, *advanced manufacturing systems*, *cyber-physical systems*, *cloud computing***.

The *Industry 4.0* consists in digitalization of production processes based on capillary *network of smart objects* connected by *Internet of Things* **(IoT)**.

SMART SENSOR SYSTEMS for
Internet of Things (IoT)   (1/3)
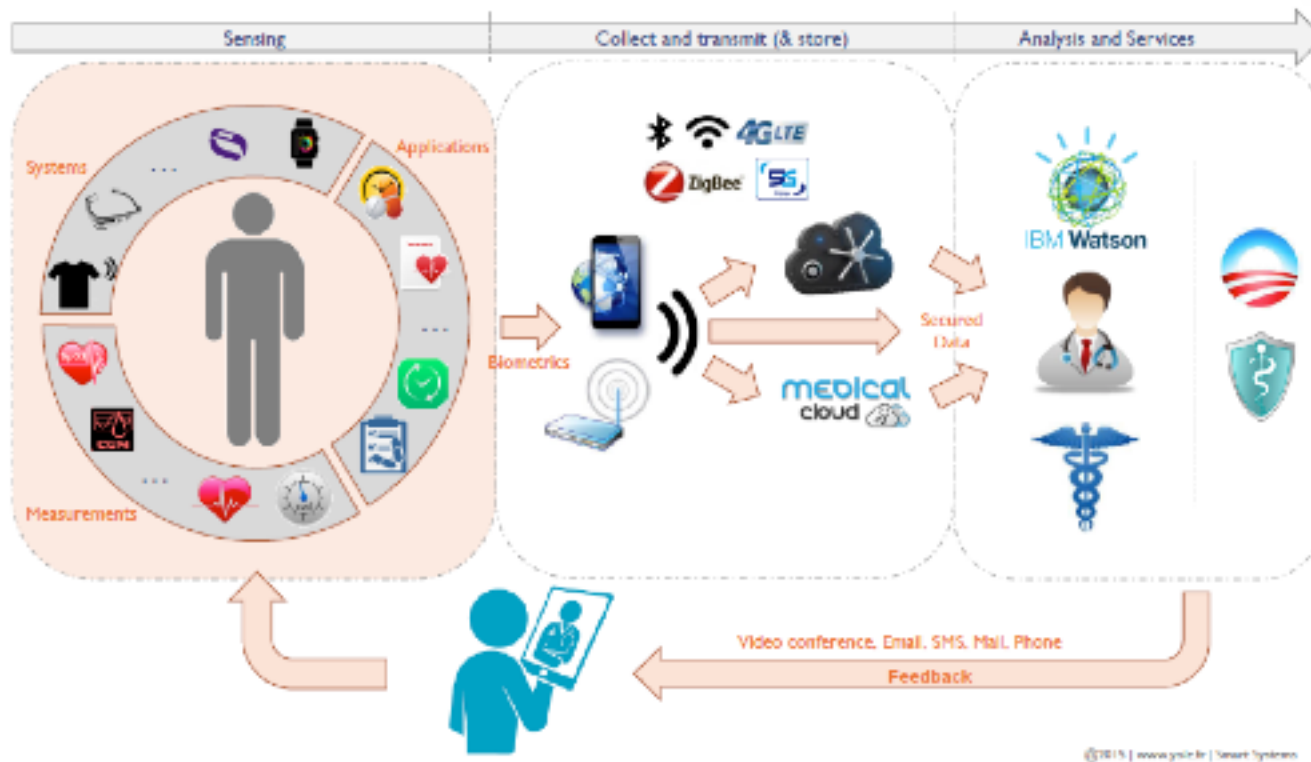
Leading Markets for *Smart Sensing Systems* (<u>*Harbor Research*</u>):
- Cell Phones
- Health Monitoring Devices
- Smart Grid Infrastructures
- Automotive
- Information Technology
- Industry 4.0

Large Companies:

- **Bosch** (Germany) presented a vision for **7 trillion sensors to serve 7 billion mobile subscribers by 2017**. As a starting point, up to 18 sensors have already been embedded in mobile devices today, close to 100 sensors in high end *cars* and up to 100 sensors in high end *smart homes*. Bosch's vision forecasts growth to about 1000 sensors per average person by 2017.

- **ST Microelectronics** (Italy+France) offers advanced **sensor-systems for environmental sensing** (CO_2, Temperature, Relative Humidity), and IoT applications: *MEMS microphones (noise), motion sensors (position), micro-mirrors, gyroscopes, pressure sensors, accelerometers, touchscreen controllers, optical micro-actuators, fluidic micro-actuators* for a big market in the field of **smart cities, industrial applications, smart energy, cloud computing and smart personal area**.

- **Analog Devices** (Ireland) is developing (2015-2016) a **low-cost, power-effective sensor system** for a large market into *Indoor Air, Outdoor Air and Water Quality Applications*.

- **ams AG** (Austria) is developing **miniaturized sensor-syste**ms based on Multi-Project-Wafer for mass-production applications in the *environmental sensing, smart cities, personal area, industrial process control*.

- **Siemens AG** (Germany) offers **sensor-systems for building automation and management** in the field of *smart cities, environmental sensing, safety and security*.

- **Infineon Technologies** (Germany) offers **sensor technologies for smart systems** in the field of *industrial, medical, automotive and environmental applications*.

SMART SENSOR SYSTEMS for
Internet of Things (IoT)   (3/3)

SOME SELECTED EXAMPLES:

SMEs:

- **Alphasense Ltd** (UK) offers a trust of **low-cost and low-powered sensors** for *environmental sensing and industrial applications.*
- **SenseAir AB** (Sweden) offers high-performance **sensor systems for CO_2 detection** in the field of *environmental monitoring (indoor and outdoor), climate change monitoring and automotive.*
- **NanoSense SARL** (FR) offers **IAQ sensor-systems** with designed interface for HVAC and IAQ applications.
- **Novasis srl** (Italy) offers high-performance **optical sensor for NH_3 detection** in the field of *agriculture applications and process control.*
- **Cambridge CMOS Sensors Ltd** (UK) offers **CMOS-based sensor technologies** and IR devices for miniaturized systems to *monitor environment and industrial processes.*
- **SGX**
- **3S GmbH** (DE)
- ………..

VISIONARY TREND of *Trillion SENSORS*
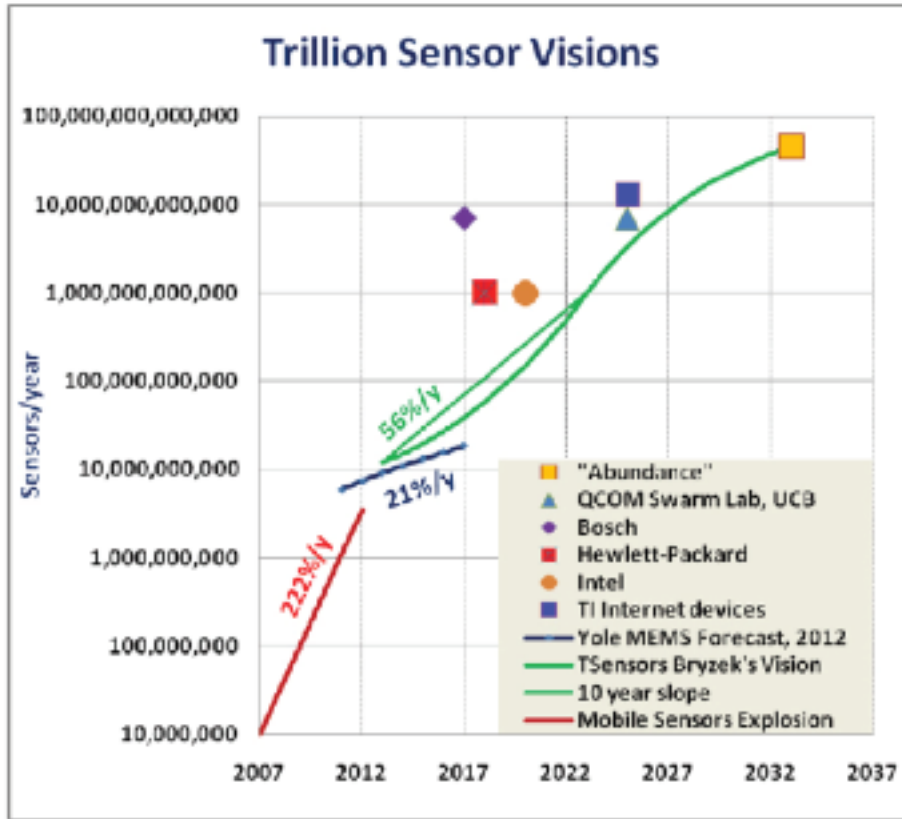
Trillion Sensors Summit 2013,
Stanford University
23-25 October 2013

GDP 2013: USD 64 Trillion
GDP 2023: USD 128 Trillion
*Trillion Sensors* **can represent USD 0.1T**
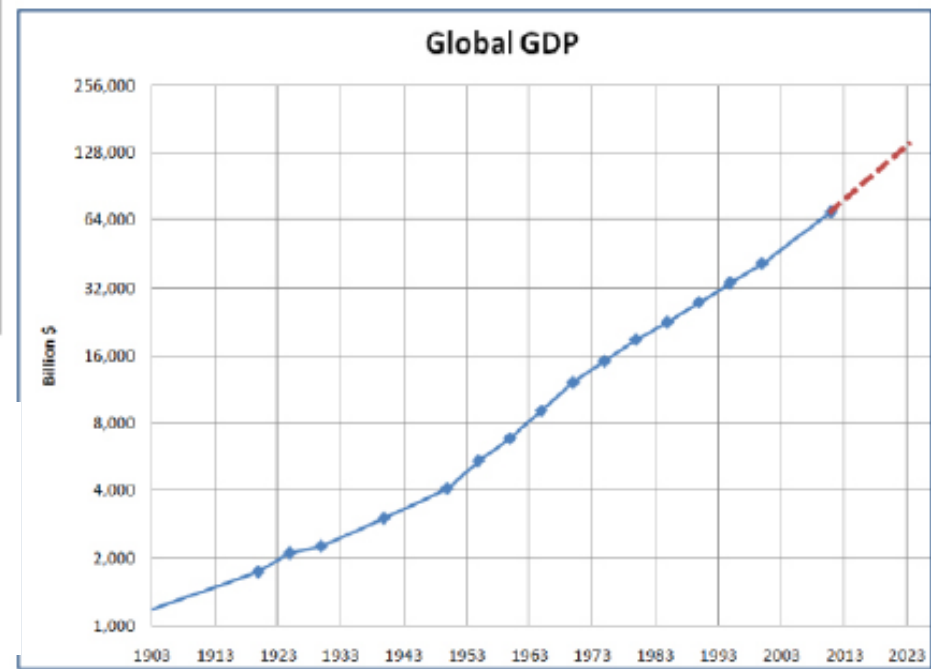
Low-cost estimated for Trillion Sensors:
USD 0.13 including
sensing element, computation, communication, packaging, and powering capability.

Innovation challenges of ESSC for R&D and Commercialization:

- Indoor Sensing
- Environmental Sensing
- Biosensors
- Chemo/Bio Sensors for Liquids
- Modelling and Simulation
- Analytical Tools and Metrology
- Standardization and Regulation
- Business Models and Spin-offs
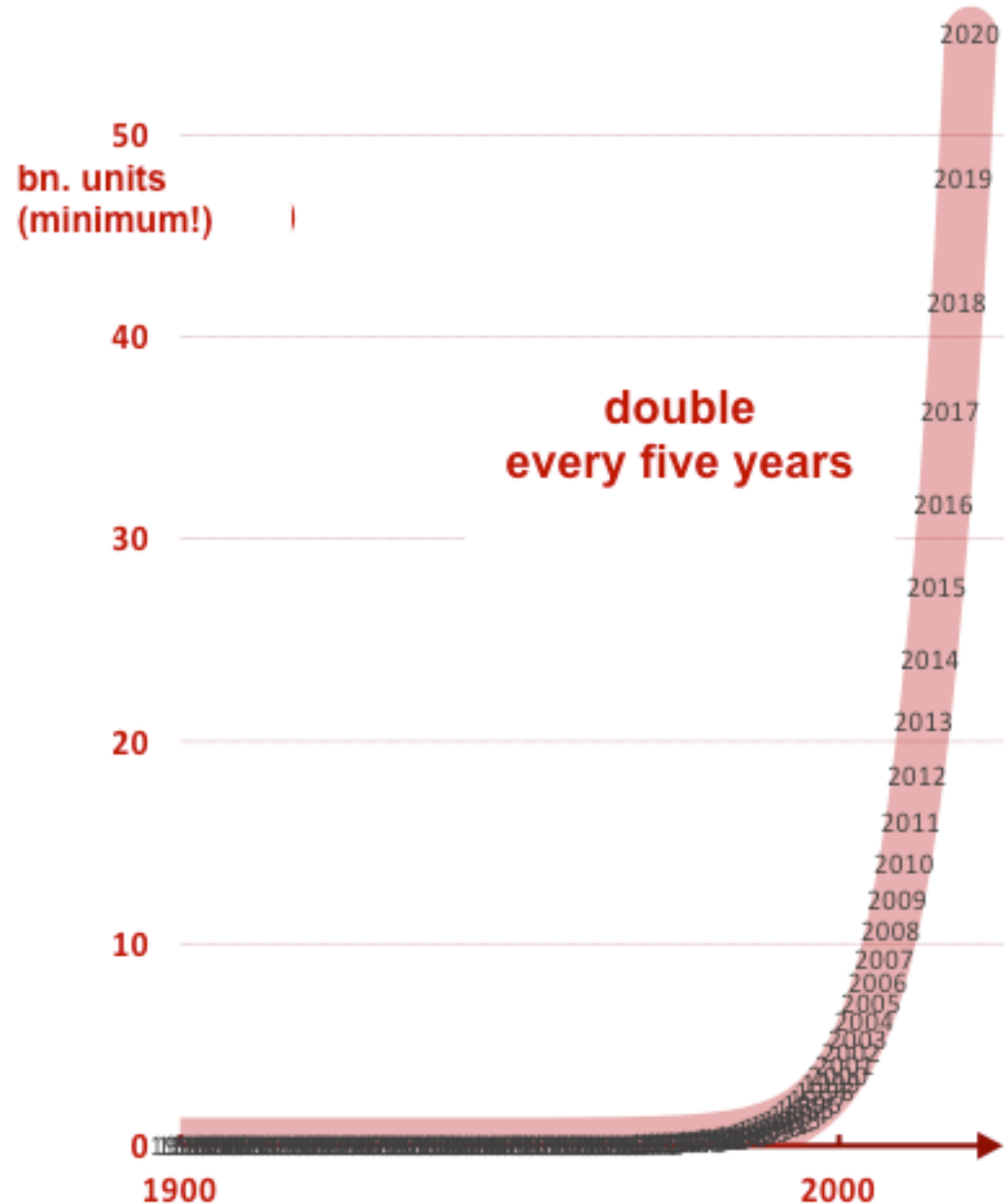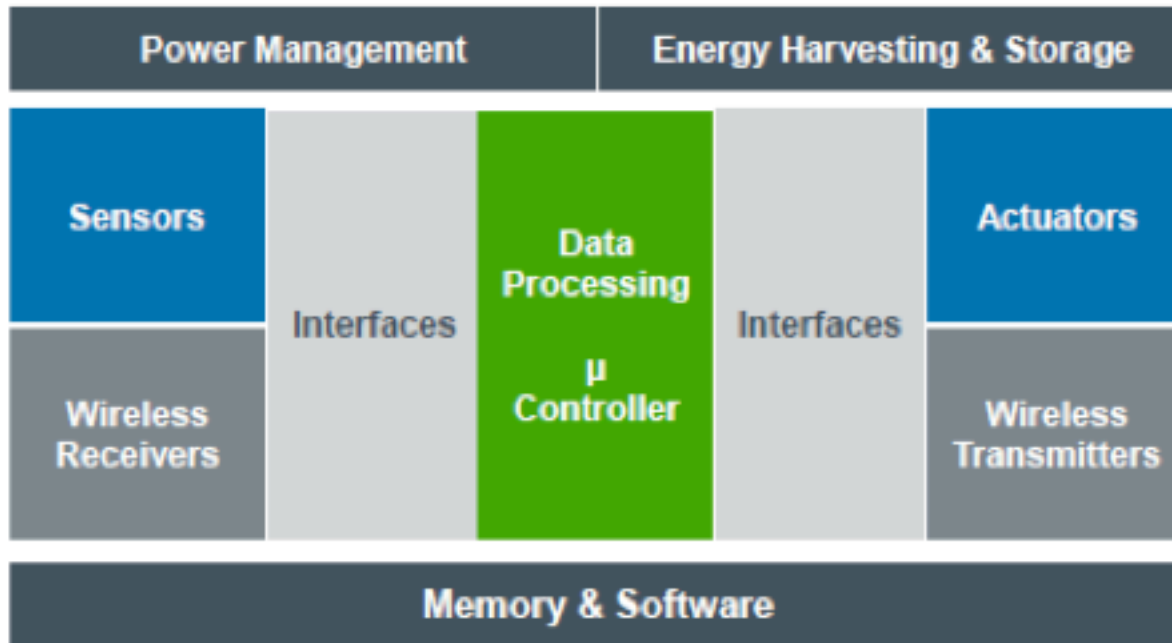
COMMERCIALIZATION (2/2)

SOME BARRIERS FOR
INTENSIVE COMMERCIALIZATION OF SENSOR-SYSTEMS:

- 3S open questions: Sensitivity, Selectivity, Stability
- Ease of use
- Manufacturing questions
- Low accuracy for specified applications
- Moderate reliability for given applications
- Lack of standards for benchmarking
- Lack of protocols for validation
- Lack of guidelines and regulation
- Maintenance for mass deployment
- Periodical re-calibration
- Specific algorithms for calibration
- Cost reduction for robust and accurate sensors
- ....

Several building blocks (**sensing**, **acquisition**, **transmission**, **processing**,

Smart System Block Diagram

Power Management		Energy Harvesting & Storage	
Sensors	Interfaces	Data Processing μ Controller	Interfaces	**Actuators**
Wireless Receivers				**Wireless Transmitters**
Memory & Software				

Examples

Wearable/Fitness

Smart Watch

Smartphone
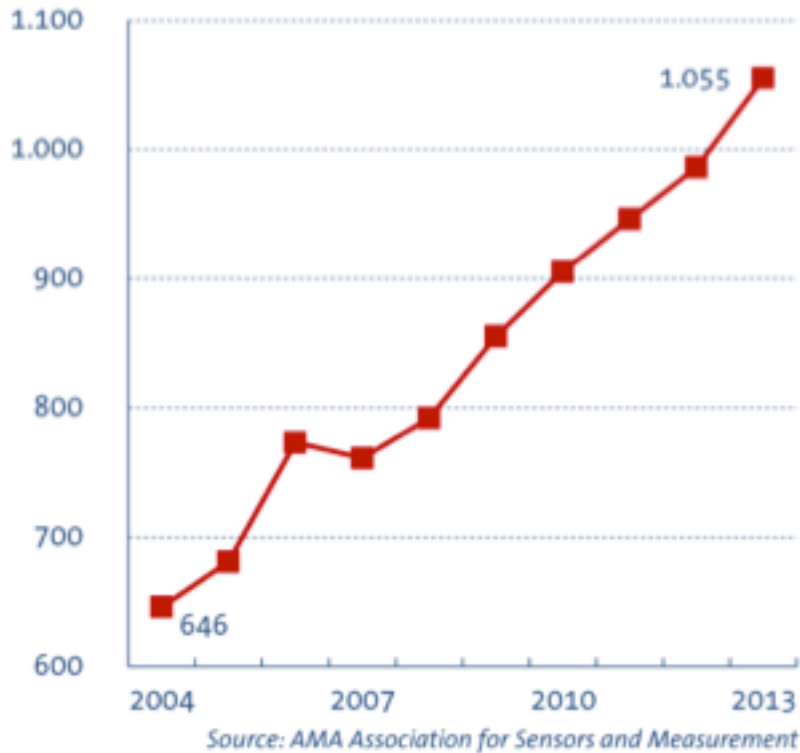
Smart Home

…

Smart Everything
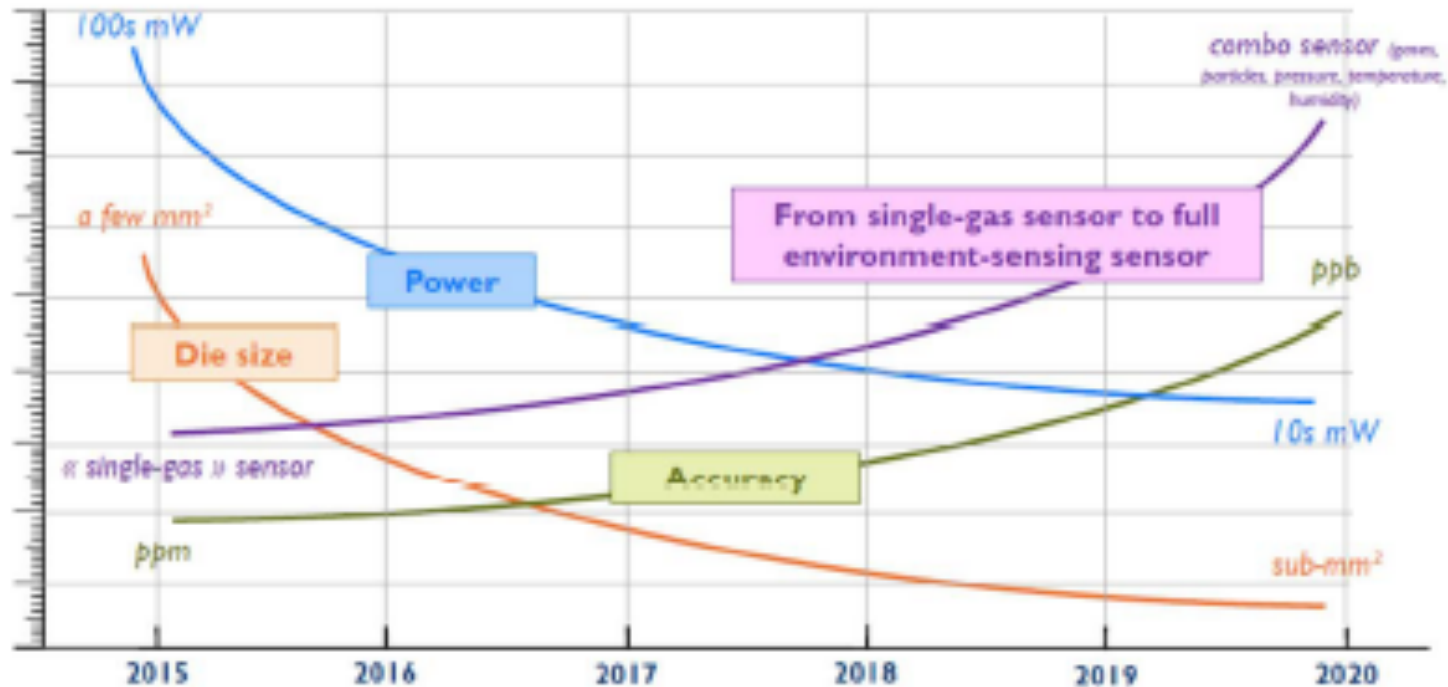
Current trend in SSI:

- Miniaturization
- Low-Power Consumption
- Integration
- Cost Reduction

MARKET of SENSOR-SYSTEMS – World-*vs*-EU PATENTS

Worldwide Patent Activity on "Investigating or analysing materials by determining their chemical or physical properties" (WIPO)

Source: AMA Association for Sensors and Measurement

Source: AMA Association

The European Sensor Systems Cluste

European Contribution to International Patent Activity "Investigating or analysing materials by determining their chemical or physical properties" (WIPO)

at ~ 50 %, Europe is world wide technology leader in this field

Source: AMA Association for Sensors and Measurement

European Contribution to International Patent Category "Measurement" according to WIPO

Source: AMA Association for Sensors and Measurement
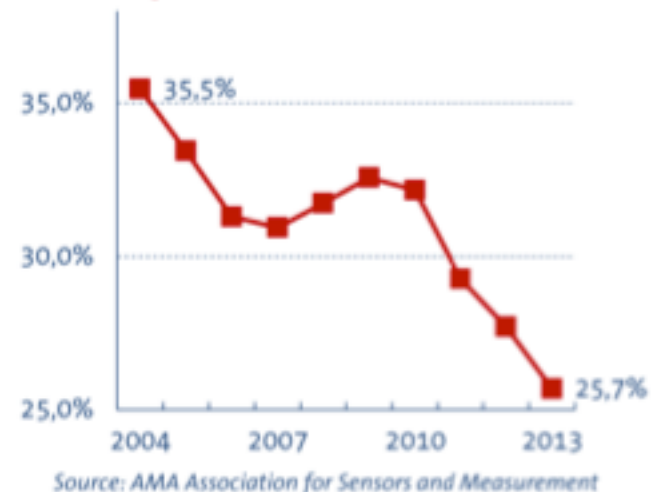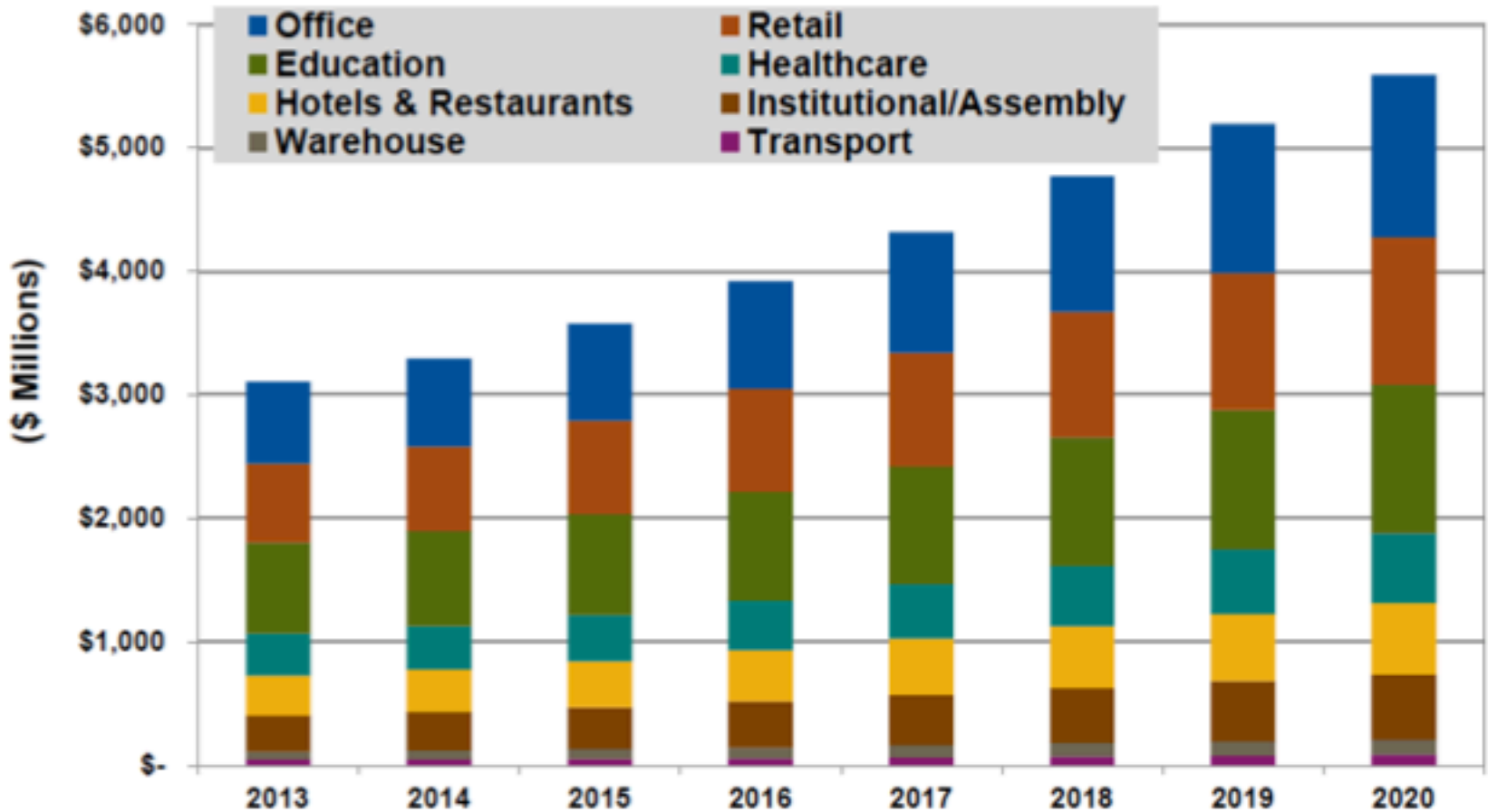
MARKET of SENSOR-SYSTEMS: IAQ   (1/2)

Chart 1.1   *Indoor Air Quality Technologies Revenue by Region, World Markets: 2013-2020*
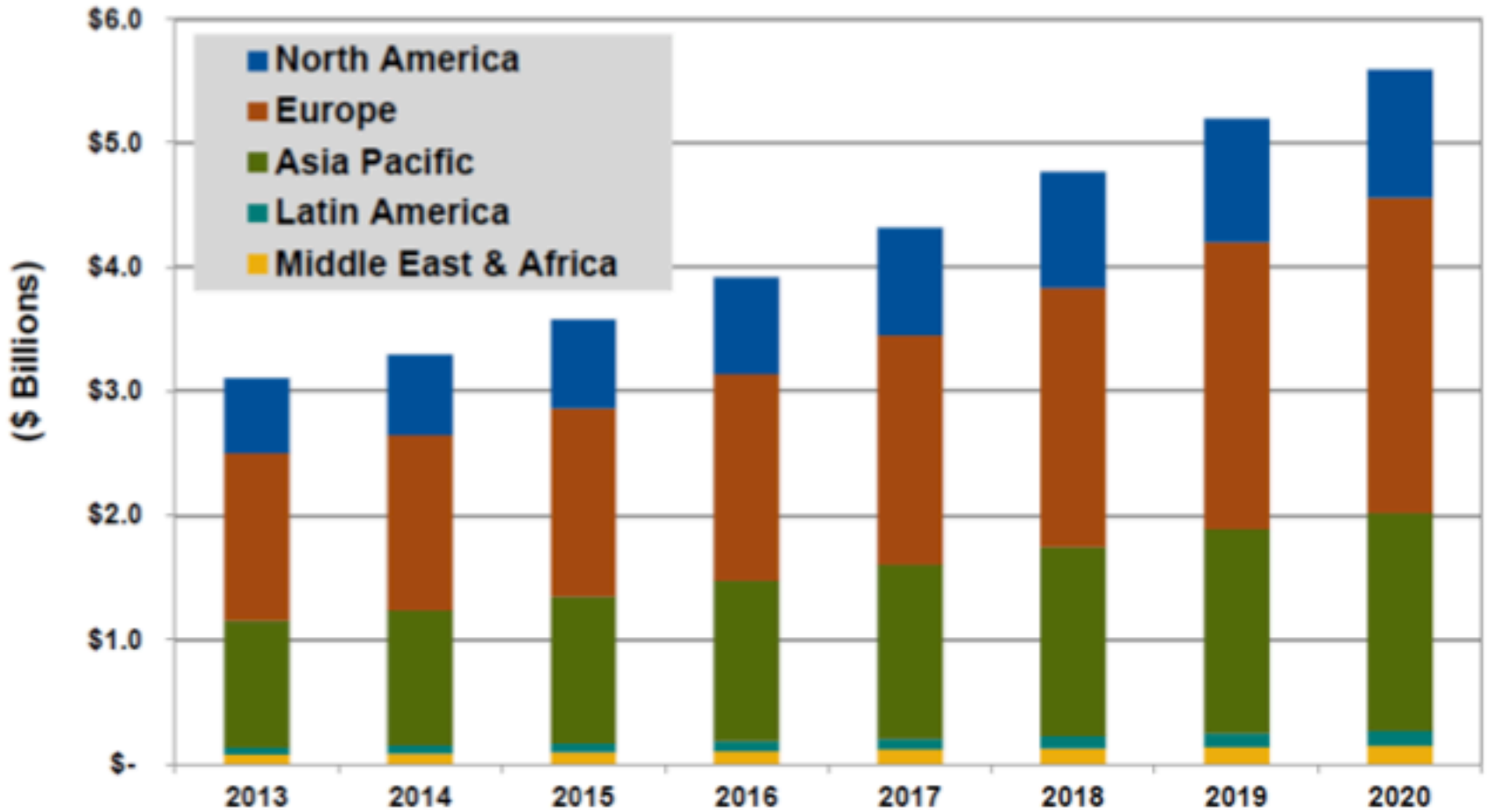
MARKET of SENSOR-SYSTEMS: IAQ (2/2)

Chart 5.2   Indoor Air Quality Technologies Revenue by Building Type, World Markets: 2013-2020

Legend:
- Office
- Retail
- Education
- Healthcare
- Hotels & Restaurants
- Institutional/Assembly
- Warehouse
- Transport

($ Millions)

CONCLUSIONS

The **sensor-systems are at high impact in the following applicative sectors** (*Yole 2016*):

1. Agrofood
2. Pharmaceutical Industry
3. Automotive and Transportation
4. Building
5. City Management
6. Consumer
7. Cosmetic
8. Industrial Instrumentation and Process Control
9. Medical Devices
10. Retail and Logistics
11. Safety and Security
12. Sport and Well-being
13. Telecom and IT
14. Water Management
15. Laboratory Equipment
16. Environment

BENEFITS FOR EUROPE

- Personalised precision healthcare

- Critical success factors for Industry 4.0, precision agriculture and IoT

- Sustainable and managed environment

- Energy saving and efficiency

- Comfort improvement

- Safety and security

- Complex knowledge-based, high-margin products - manufacturing in Europe

- Significant economic leverage effect of sensors

ESSC CONTACT PERSONS:

- **Chairman of the ESSC: Dr. Michele Penza (ENEA, Brindisi, Italy) - michele.penza@enea.it**
- **Coach of the ESSC: Dr. Rudolf Frycek (Amires, Neuchatel, Switzerland) - frycek@amires.eu**
- **EC Observer of ESSC: Dr. Hans Hartmann Pedersen (DG R&I) - hans-hartmann.pedersen@ec.europa.eu**

REGISTRATION AS ESSC MEMBER at:

www.cluster-essc.eu

European Commission - DG Research & Innovation

Directorate Key Enabling Technologies

Unit Advanced Materials and Nanotechnologies

Thanks for your kind attention !