

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

COST Action TD1105

3rd International Workshop *EuNetAir* on

New Trends and Challenges for Air Quality Control

University of Latvia - Faculty of Geography and Earth Sciences

Riga, Latvia, 26 - 27 March 2015

GAS SENSORS - FIRE DETECTION AND BEYOND

Oliver von Sicard

Function in the Action: WG Member

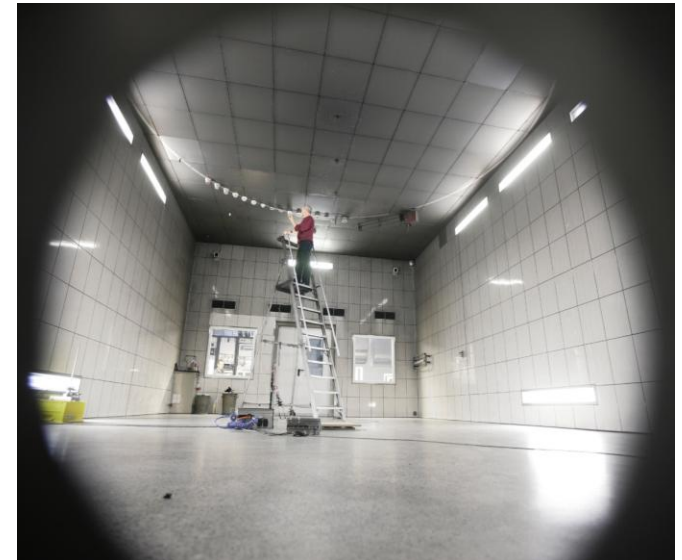
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Siemens AG / Germany

SIEMENS

Outline

- History & Basics
- Status Quo
- Gas Sensors for fire detection?
- The Main Issue
- Where to Go?

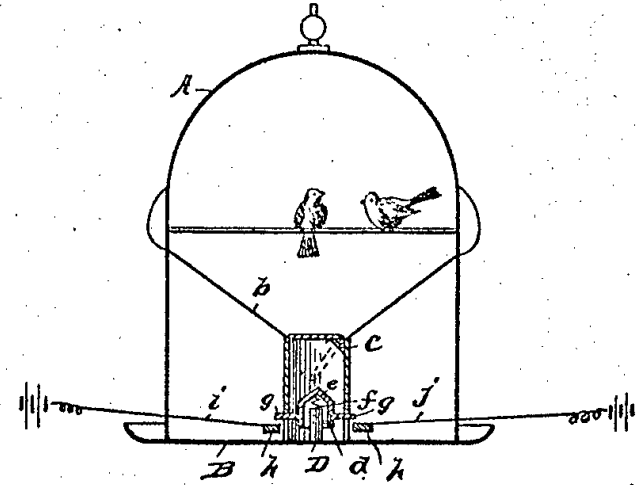


Short History of Fire Detection



Mine Safety and Health Administration

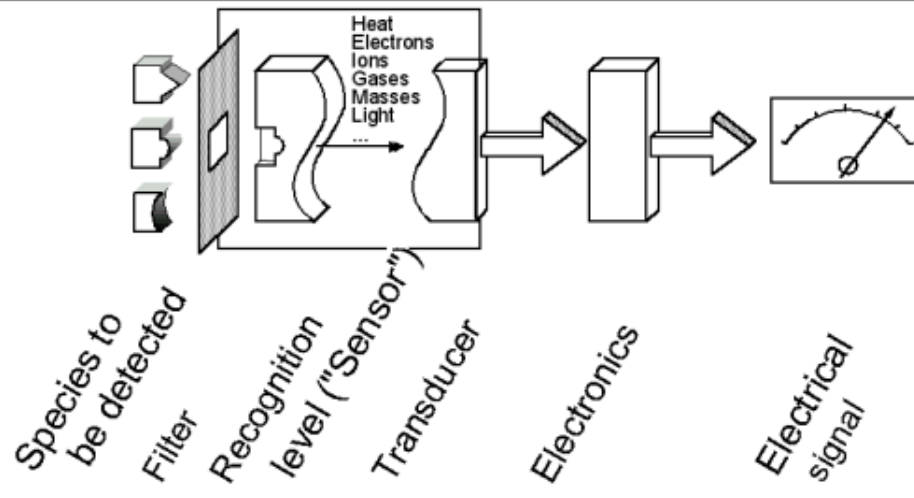
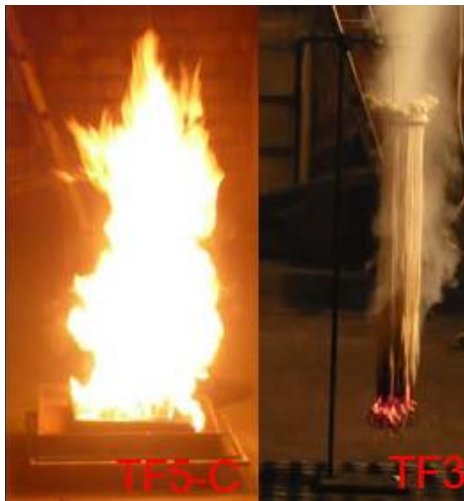
ROBERT WILLIAM JACOB KRAUS IN NEW-YORK
U. JOHN KOSTER IN BROOKLYN (N.-Y., V. ST. A.).
Verfahren und Vorrichtung zum Geben eines Signals beim Auftreten von Rauch oder
schädlichen Gasen.



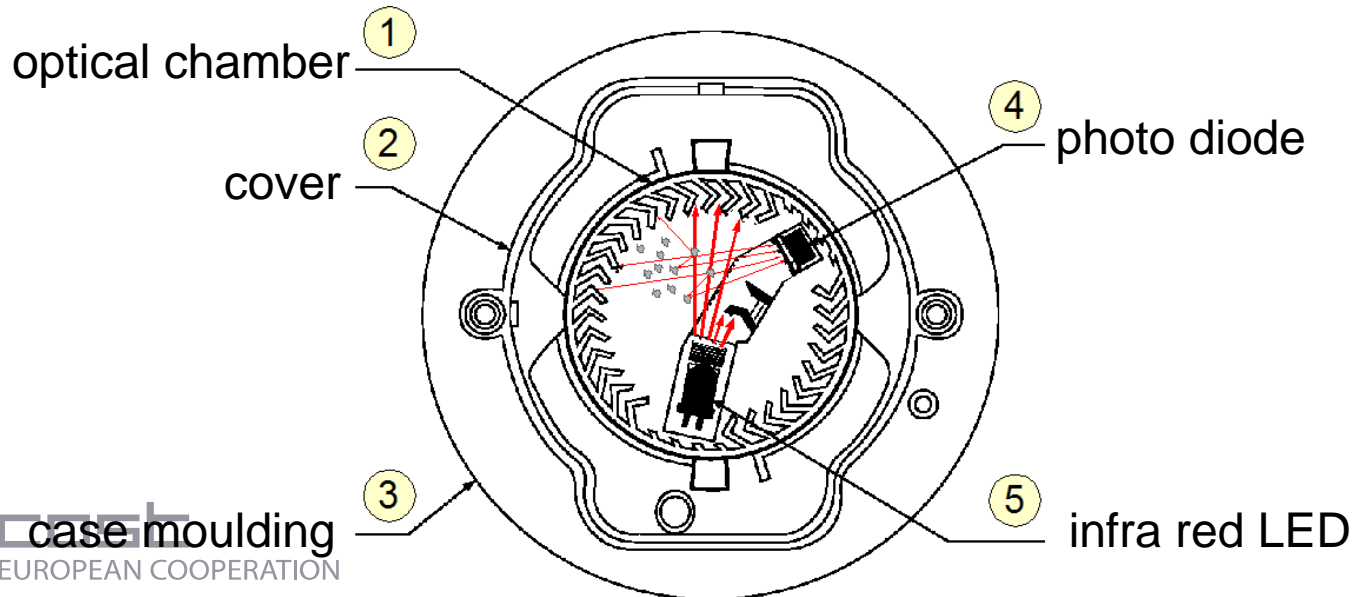
Chemiker-Zeitung, Band 1896

- Canaries were the first “poisonous gas detectors”, used mainly in coal mines
- First automatic electric fire alarm invented in 1890 by Francis R. Upton (U.S. patent no. 436,961)
- 1960ies: smoke detectors started to be mass produced in the US

Optical Detector Basics



data analysis



Fire Detection is Smoke Detection

Historical



Author: Snowmanradio; wikimedia commons; CC BY-SA 2.0

„gas sensors“ - detection of CO and other poisonous **gases**

Technology

Today's standard

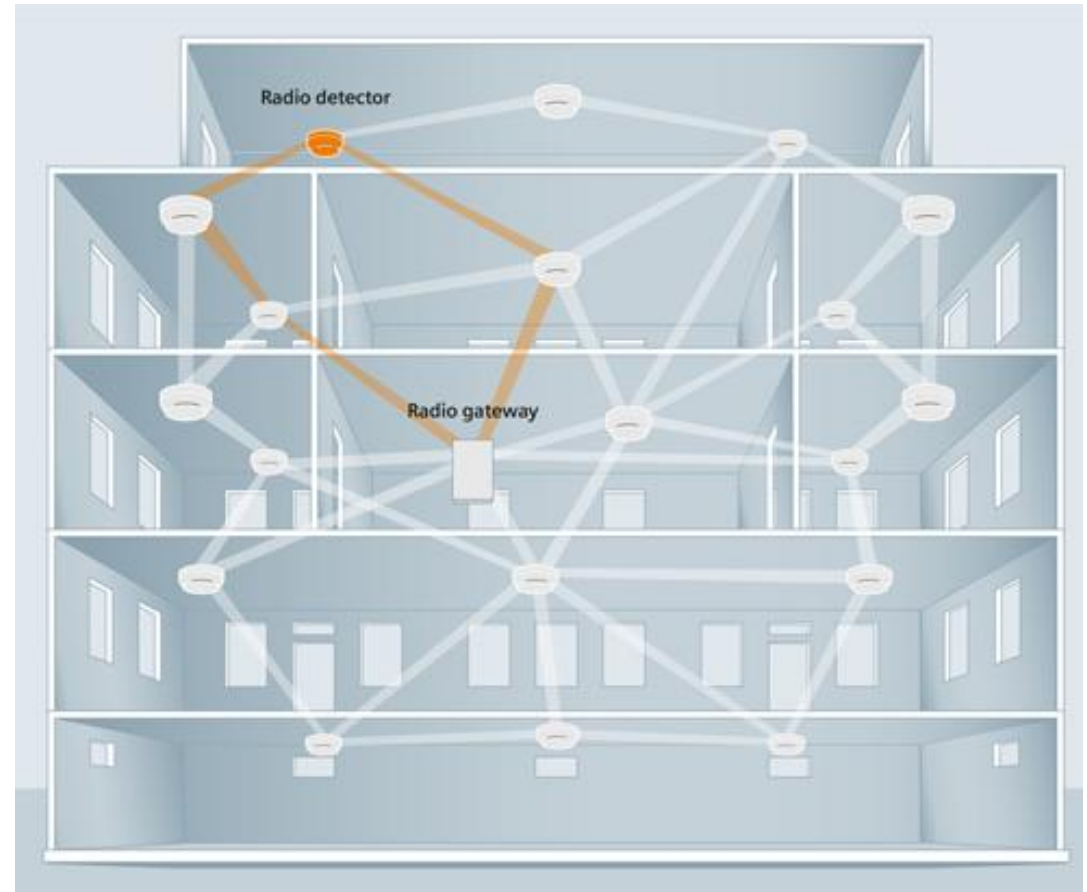


Smoke detectors - fires are detected via the **smoke** they produce.

Nowadays detection criteria are strongly governed by standards!

Siemens SWING

- Safe wireless communication by using at least two redundant communication paths
- self-mending mesh network with deception-free ASA technology
- radius of 60 m – spanning up to five floors



SWING: Siemens wireless fire detector network mesh technology

Main challenges: 100% safe communication + battery lifetime

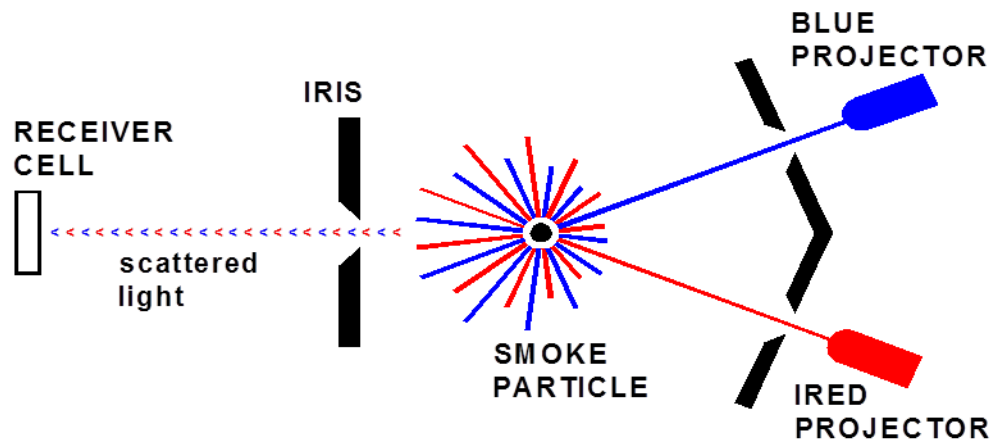
Aspirating Smoke Detectors

Aspirating smoke detectors (ASD) combine

- a highly sensitive detector (optical)
- a pump
- a tubing system that can cover large areas

Air/smoke particles are transported towards the detector through small holes in the tubes

There is a standard (EN 54-20)



Siemens ASD

Aspirating Smoke Detectors

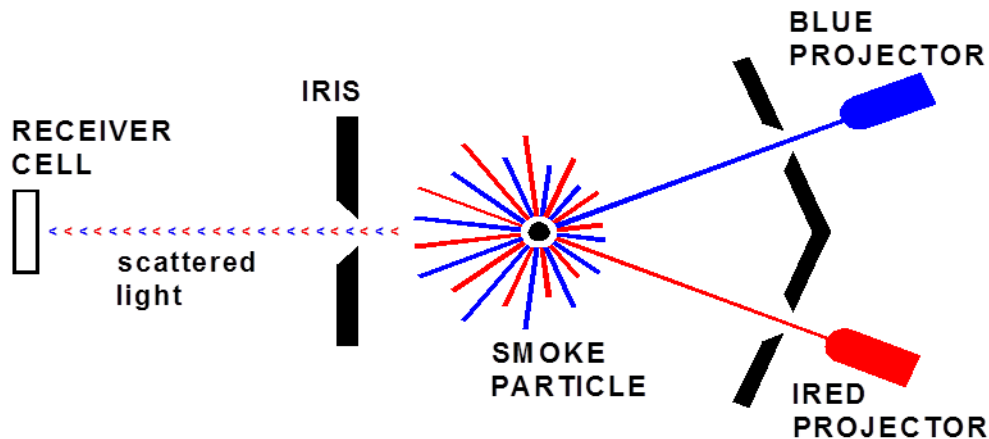
Aspirating smoke detectors (ASD) combine

- a highly sensitive detector (optical)
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- a tubing system that can cover large areas

Air/smoke particles are transported to the detector through

Still all optical smoke detectors

There is a standard (EN 54-20)

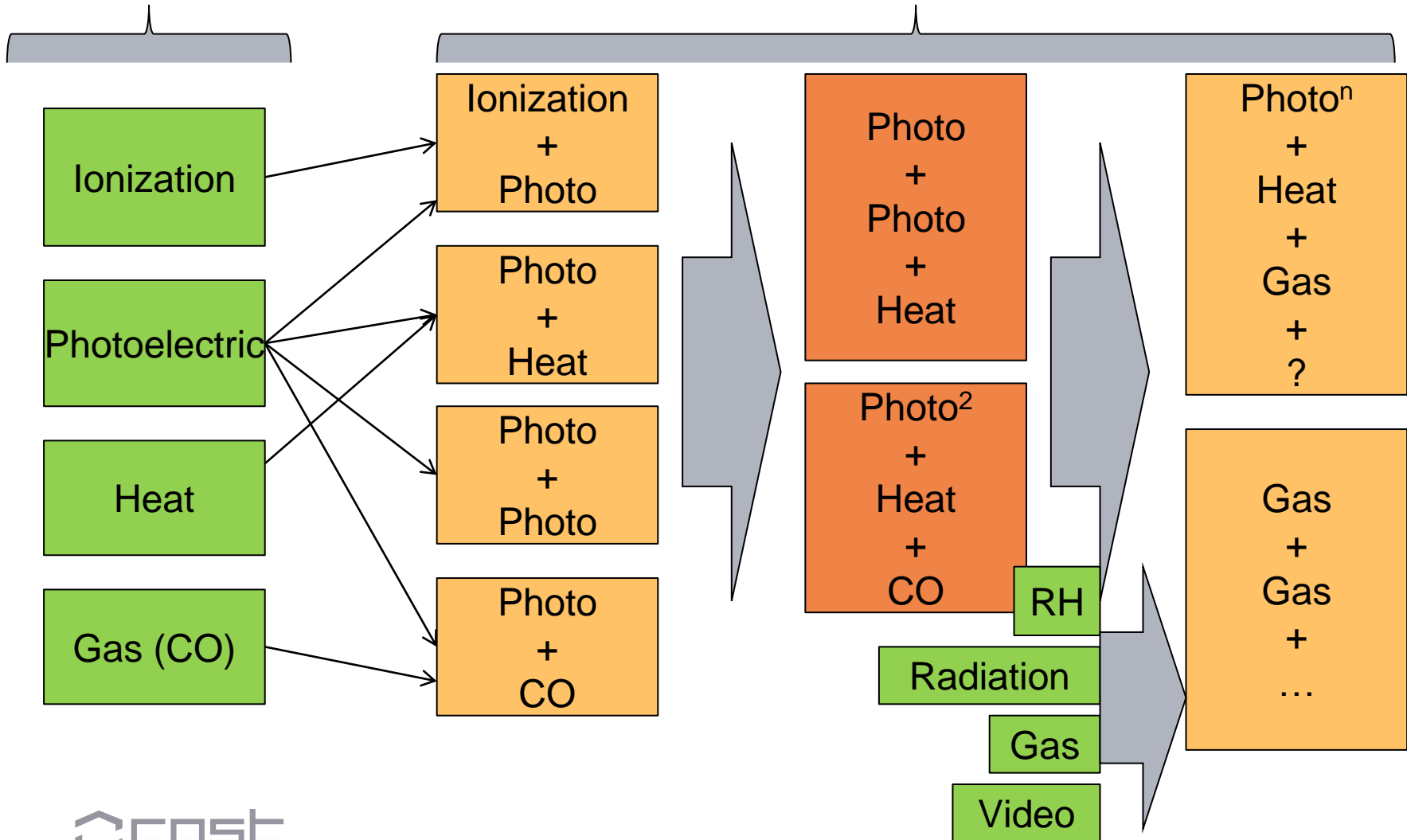


Siemens ASD

Evolution of Multi-Criteria Detectors

Single-Sensor Detectors

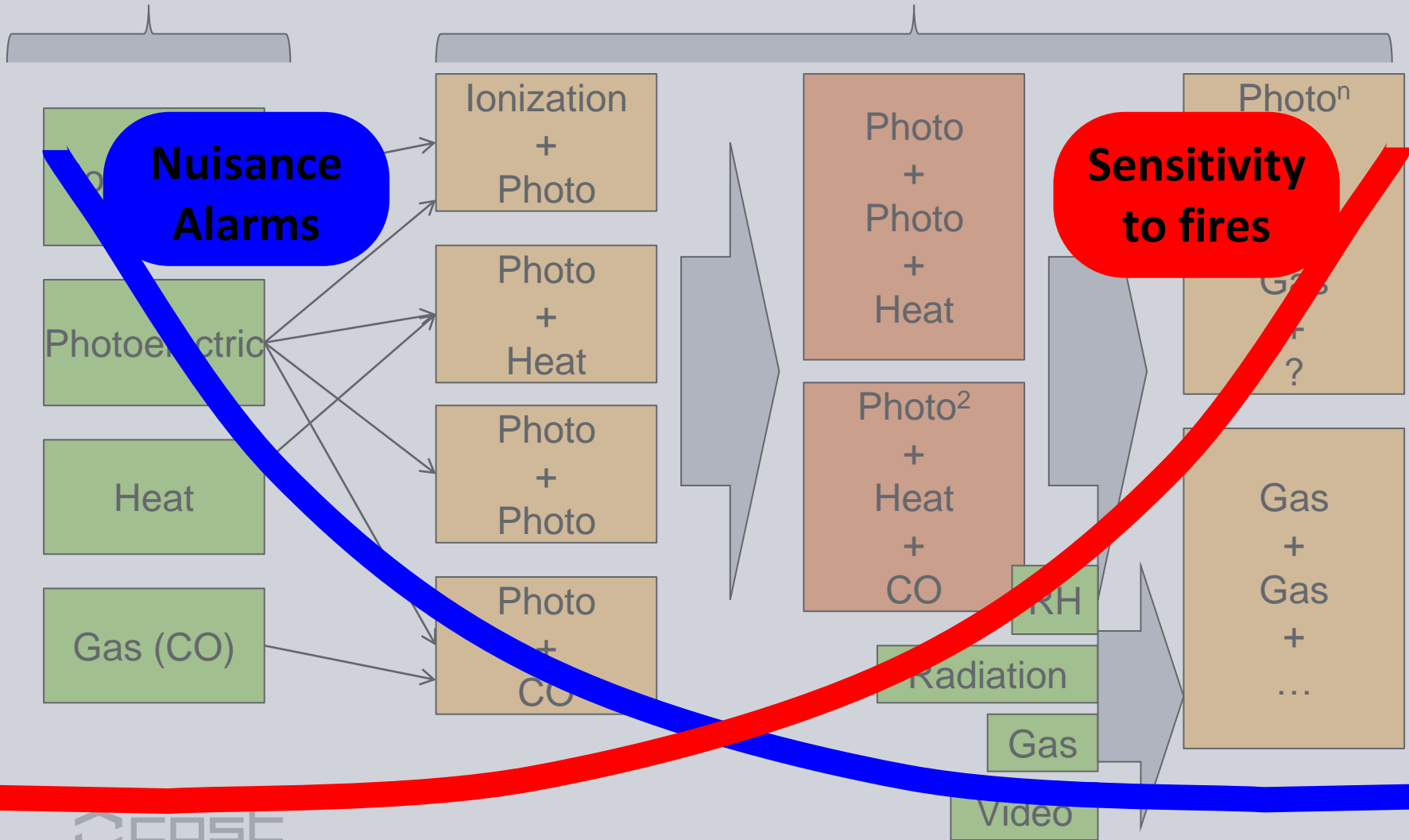
Multicriteria/Multi-Sensor Detectors



Evolution of Multi-Criteria Detectors

Single-Sensor Detectors

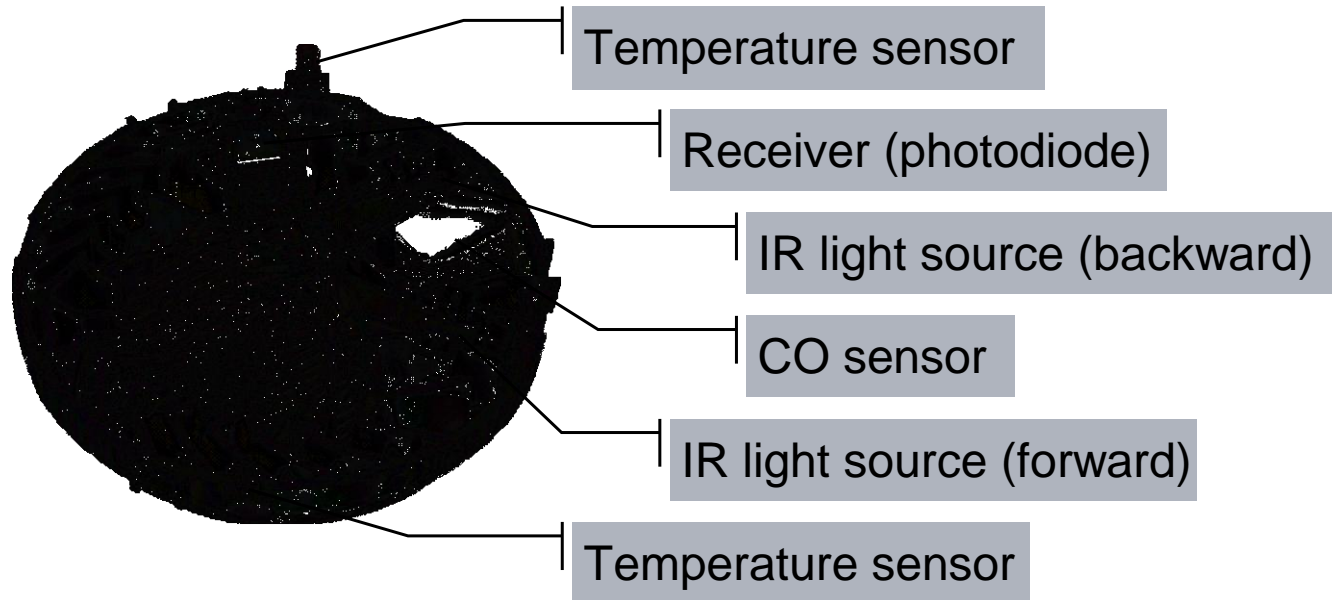
Multicriteria/Multi-Sensor Detectors



Multi-Criteria detector



Multicriteria
Fire Detection

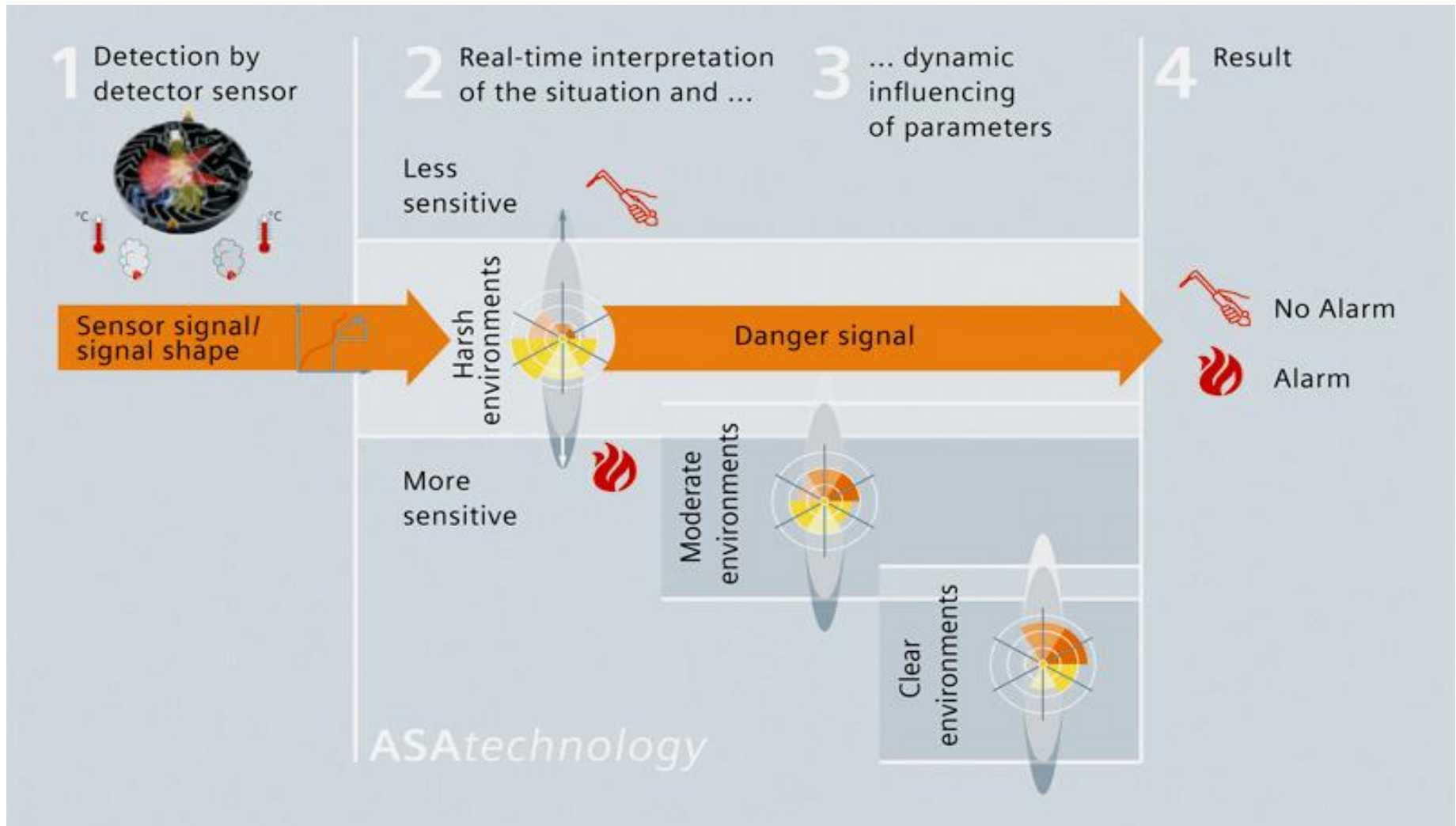


Signals available for other systems:

- Obscuration [%/m]
- Temperature [°C]
- CO concentration [ppm]

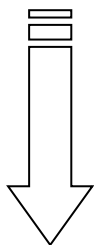
ON/OFF control signal for T and CO

Multi-Criteria Fire Detection



Signal evaluation adapted to environment using gas sensor signal

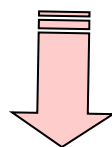
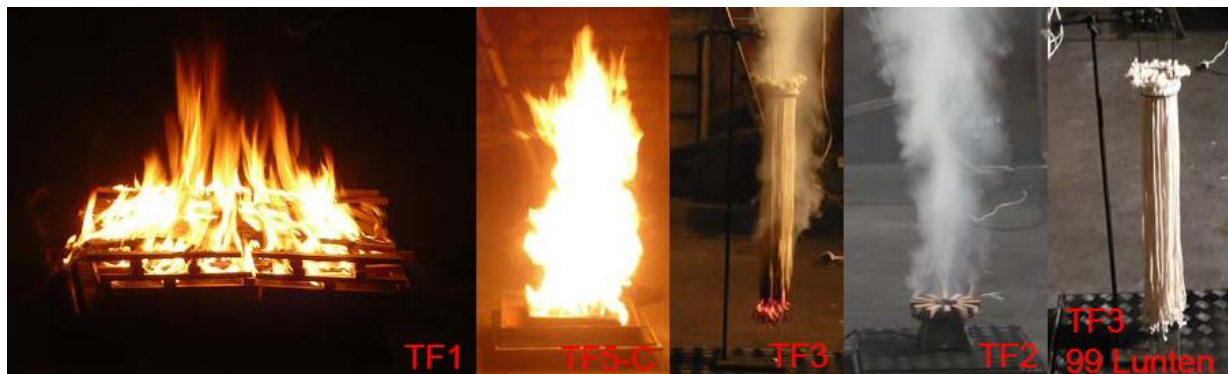
Target Gases for Fire Detection



Particles/
Aerosols
false alarms



sensitivity



Simple inorganic gases
(CO, H₂, NO_x, CO₂, H₂O, NH₃)



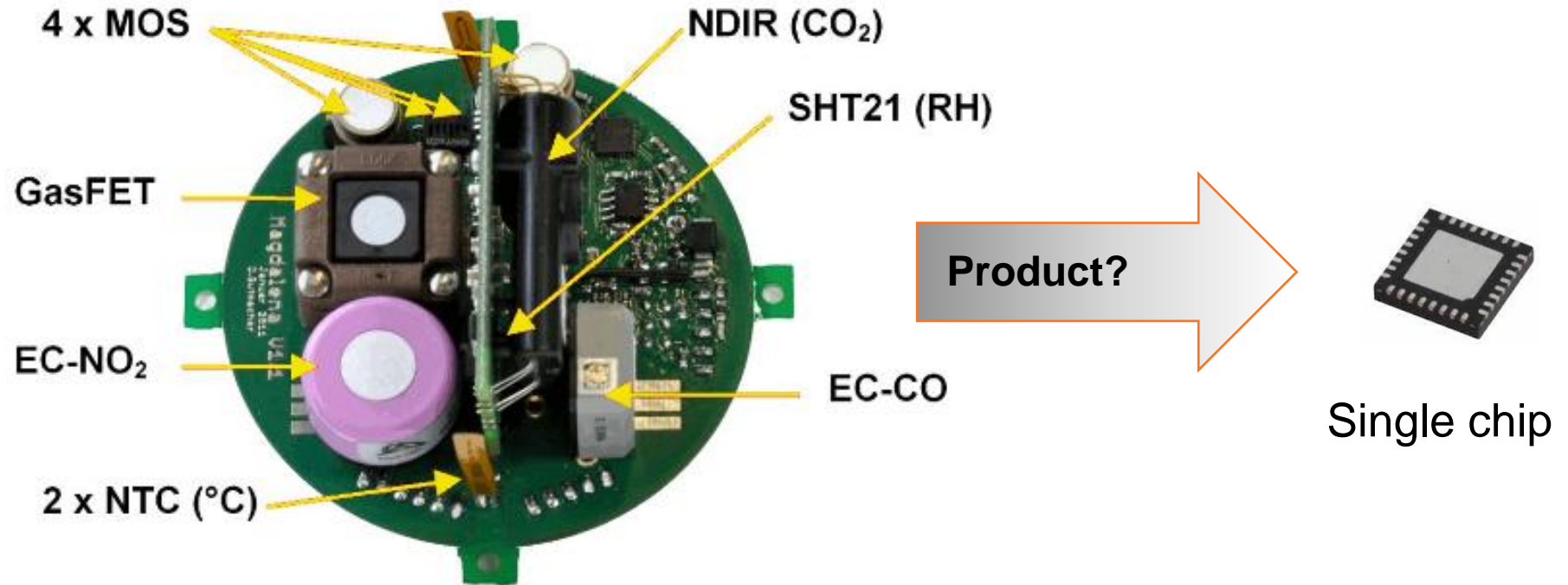
Complex gases
(Amines, Amides, Organic
Acids, Ketones,
Aromates...)



Reliability of fire detection

Miniaturisation

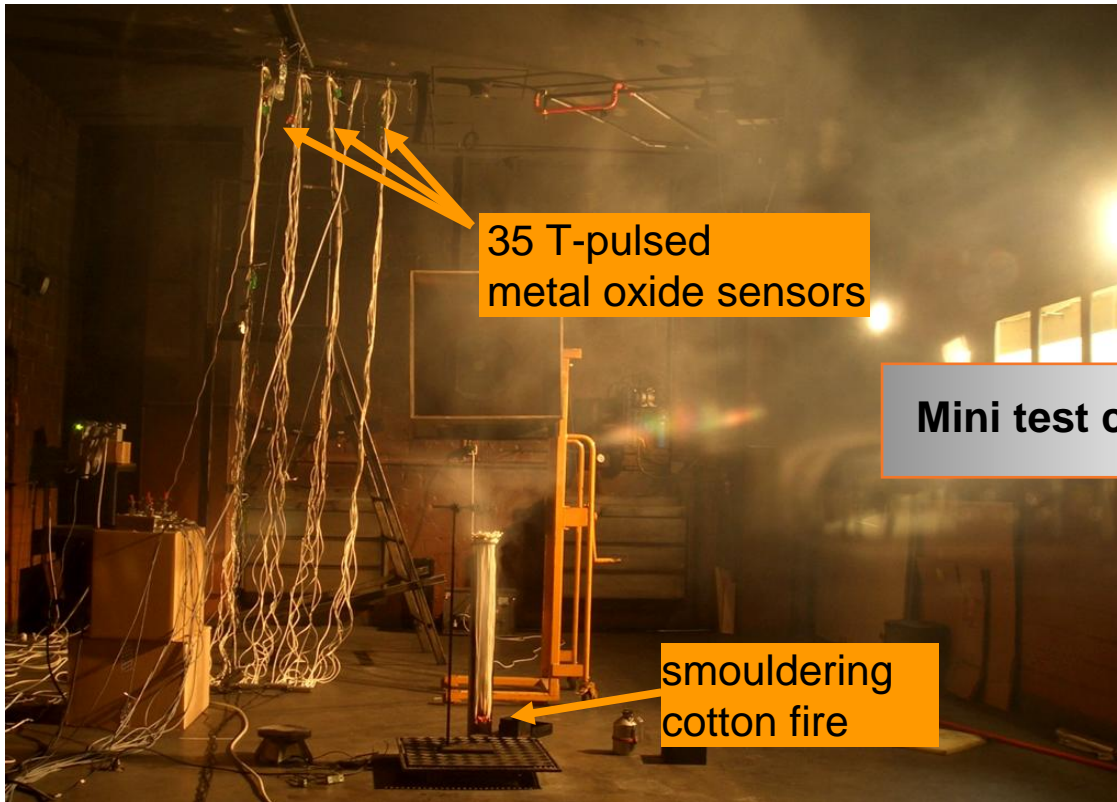
Research platform for fire gas detection



D. Gutmacher et al., Siemens AG,
Gas sensor technologies for fire detection,
Sens. Actuators B: Chem. (2011),
doi:10.1016/j.snb.2011.11.053

What are the target gases?

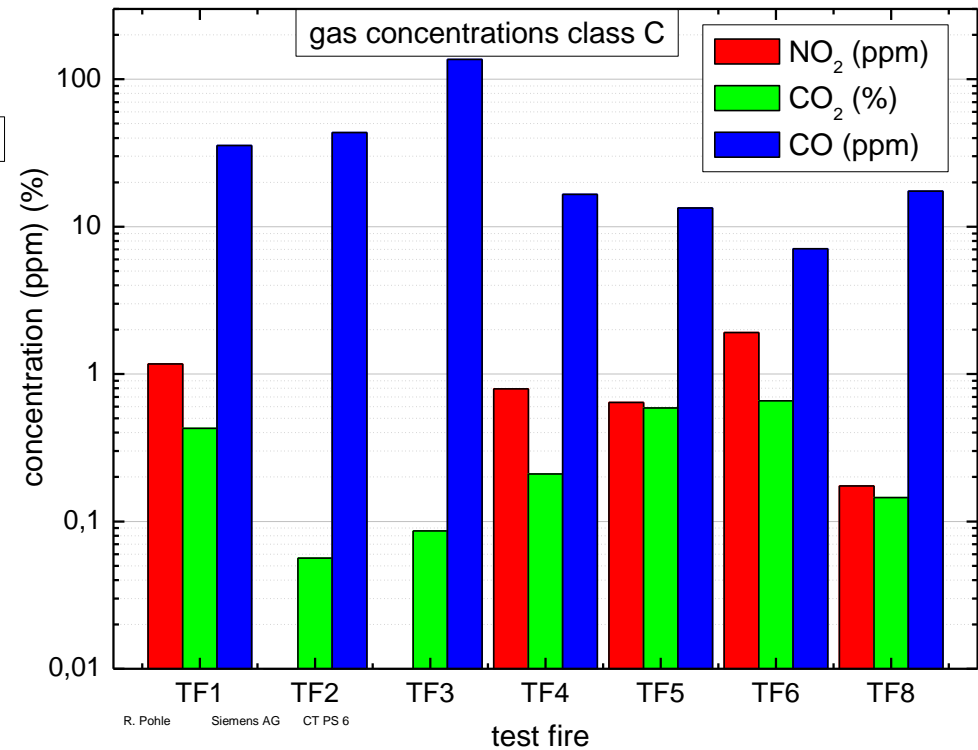
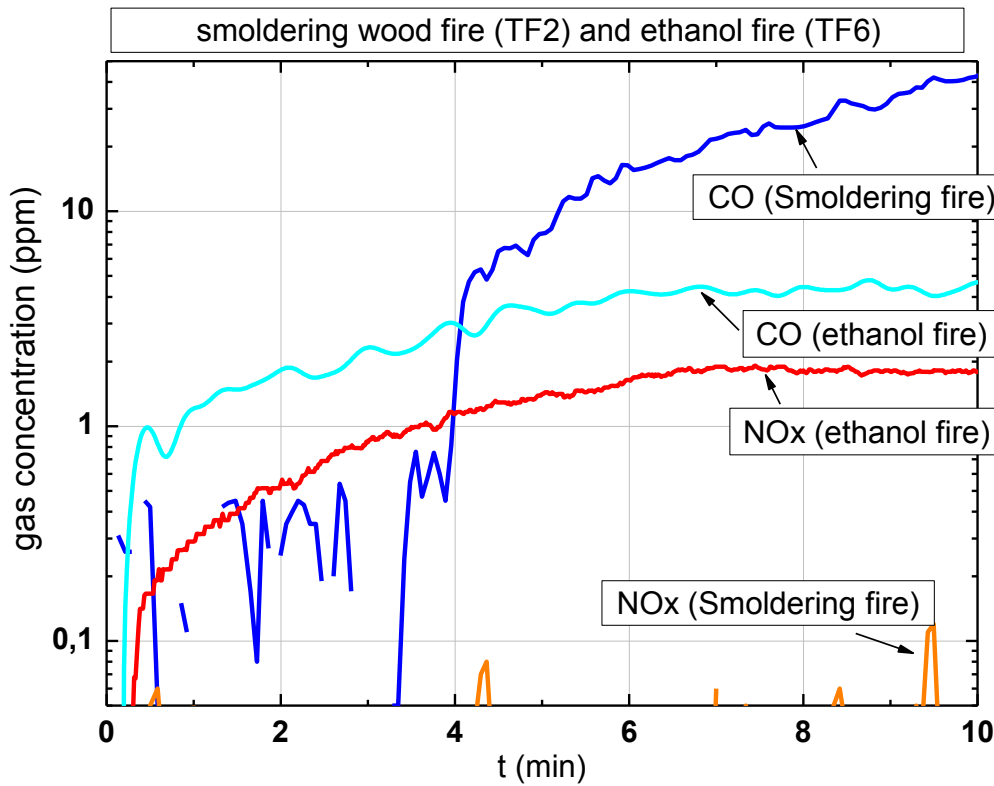
Empirical approach: Fire tests



Standardized test fires → standardized smoke particles
What about gas concentrations?

Simple Target Gases

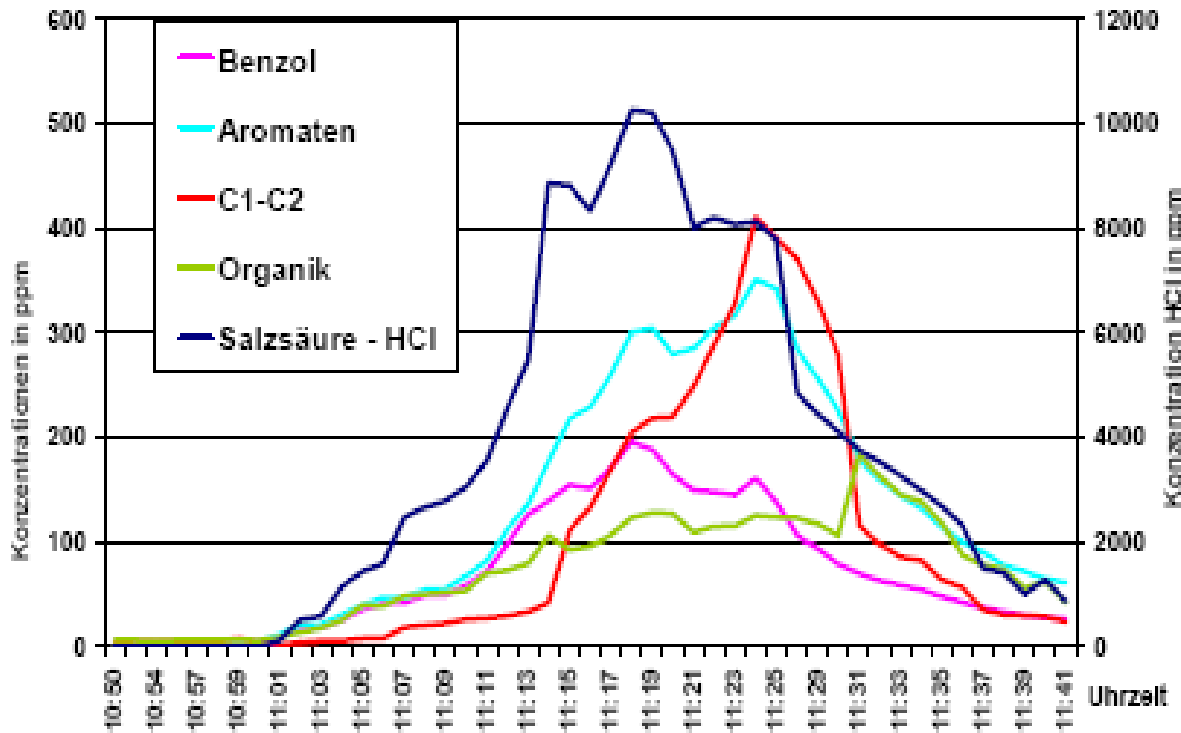
Known guiding gases in fires: CO, H₂, NO_x, CO₂, H₂O, NH₃...



Different fires produce different gas mixtures

→ discrimination of fire types possible

Complex Target Gases



gas	concentration
CO ₂	300-5000 ppm
NO ₂	0.05 - 5 ppm
CO	10 – 70 ppm
H ₂ O	2 –40 % rel.
H ₂	4 – 20 ppm
Methanol	< 10 ppm
Formic Acid	< 5 ppm
Methane	< 10 ppm
Formaldehyde	< 10 ppm
Ethylene	< 10 ppm
Acrolein	< 10 ppm
...	

Figure 5.1: Gases arising during a cable fire.
 Quelle: Messung des Giftgascocktails bei Bränden Dipl.-Ing. (FH) Peter Basmer (Forschungsstelle für Brandschutz, Universität Karlsruhe) Dr. Gerhard Zwick (Ansyco GmbH, Karlsruhe)

Complex target gases point to specific fire events e.g. smoldering cable insulation, toxic chemicals... but usually low ppm range

Price Issues for Fire Detection

Industry and consumers are driven by money!
Smoke detectors are no lifestyle product.



Kidde 0915E Smoke Detector, 9V Battery Powered Ionization (i9050)
by Kidde

\$8.49 ~~\$39.99~~

Source: amazon.com



See more choices

Kidde Model Pi9010 Dual Sensor, Battery Operated Photoelectric / Ionization Smoke Alarm
by Kidde

\$24.49 ~~\$35.99~~



Shot-in Honeycomb Gas Smoke Detector Soot Carbon Monoxide Alarm
by shot-in

\$7.95

FREE Shipping

**How will we compete here?
Why is gas sensor based fire detection so much better?**

Price Issues for Fire Detection

Industry and consumers are driven by money!
Smoke detectors are no lifestyle product.

Because we can detect so much more!

Model 0915E Smoke Detector, 9V Battery Powered Ionization (i9050) by Kidde
\$8.49 ~~\$39.99~~

Model Pi9010 Dual Sensor, Battery Operated Photoelectric / Ionization Smoke Alarm by Kidde
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**How will we compete here?
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FREE Shipping

CO2 for HVAC

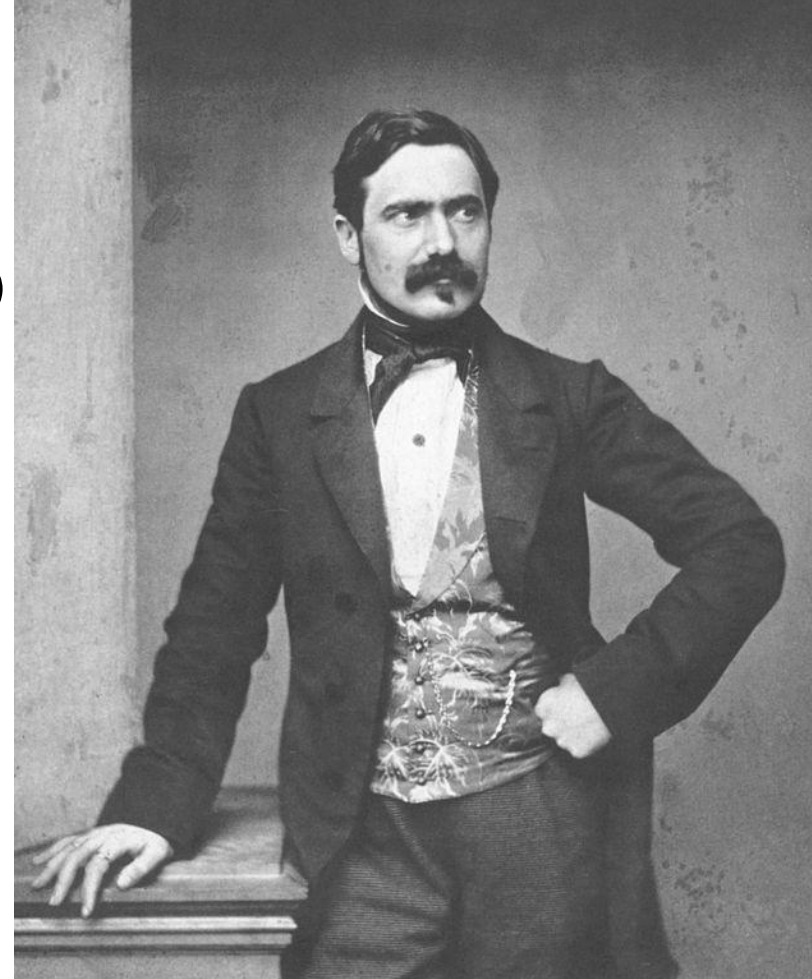
CO2 is used as an input for HVAC control

- Stay below Pettenkofert limit (1000ppm CO2)
„comfort application“

CO2 is measured using optical sensors (NDIR)

- high price, high energy use, big size
- application limited to duct-systems

**If your smoke detector measures CO2,
use it for HVAC!**



CO₂ and VOCs for Automated Cooking

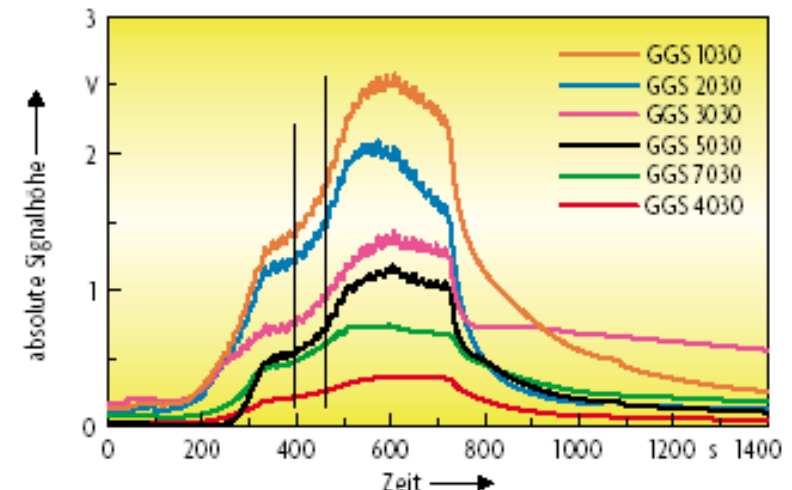
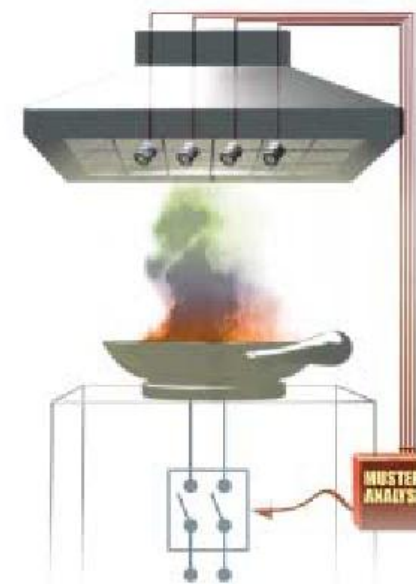
Benefit

Early Fire detection + comfort and quality control with baking, roasting and toasting

Approach

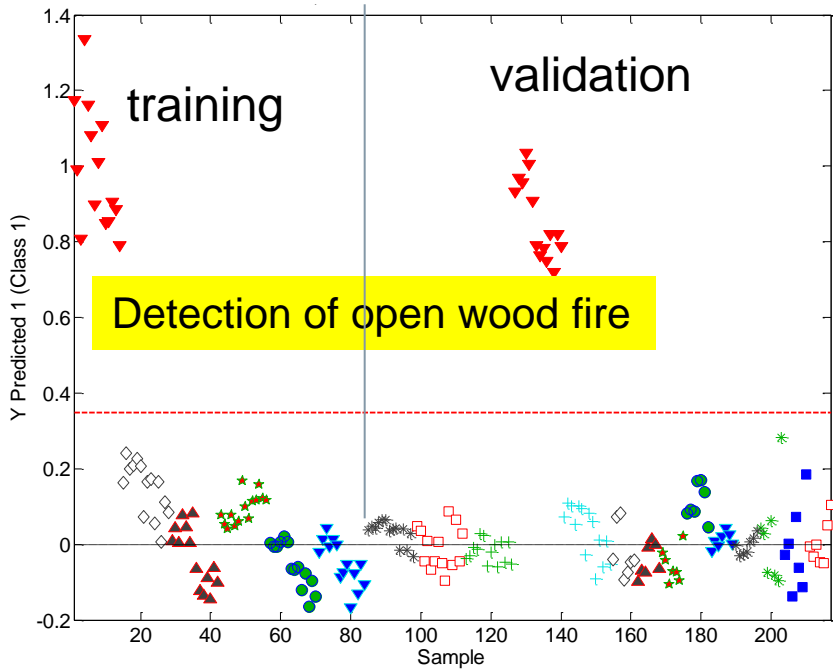
- Detection of gases emitted during cooking process using gas sensors
- CO₂-sensors as approach for bakery
- Fire Detection in Fume Hood

Combine fume hood baking control with a fire detector in the kitchen

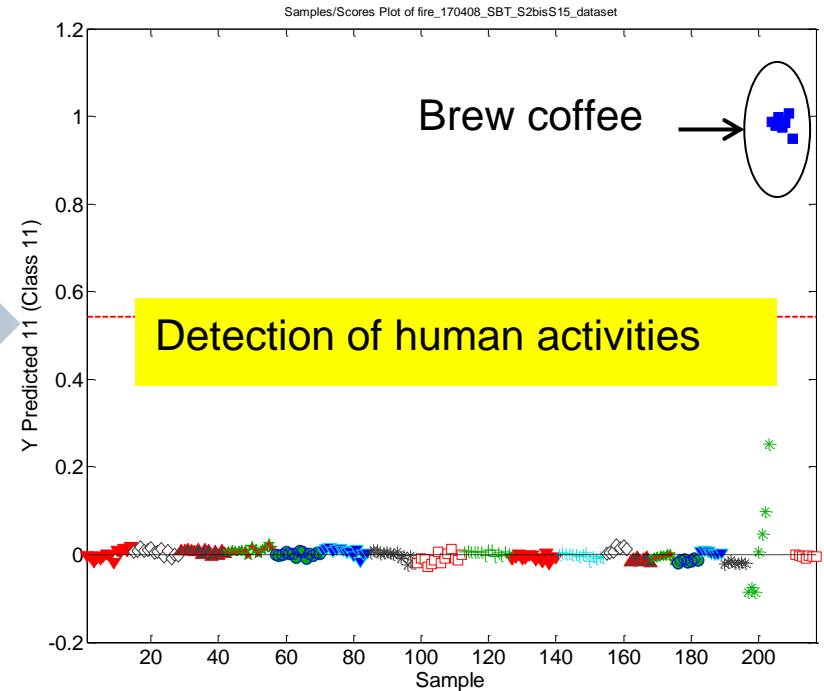


Signal transient of conventional gassensor array

Activity Monitoring with Gas Sensors



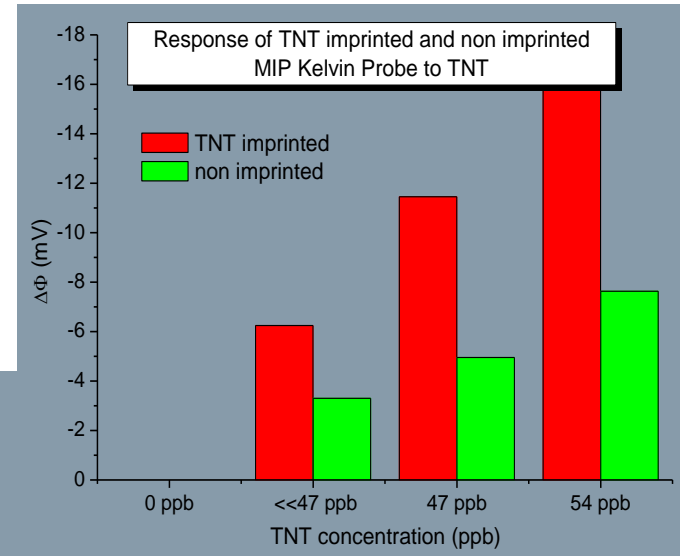
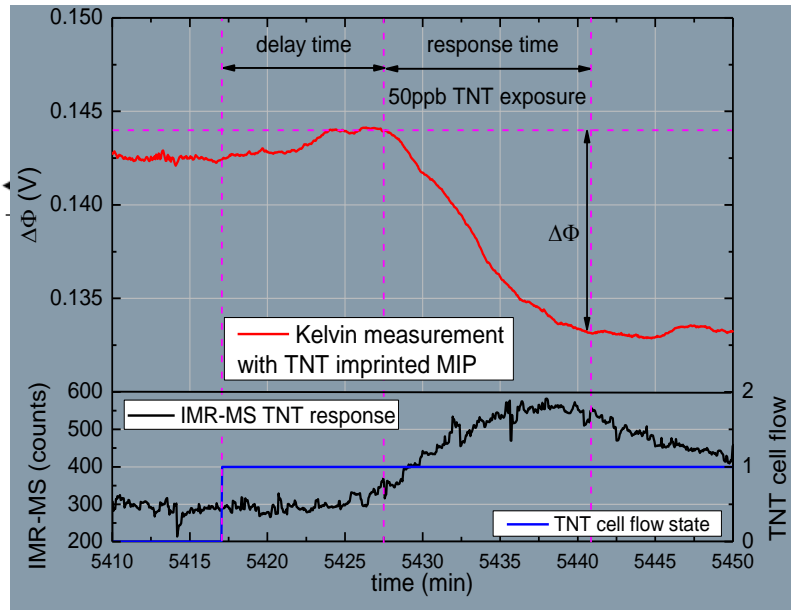
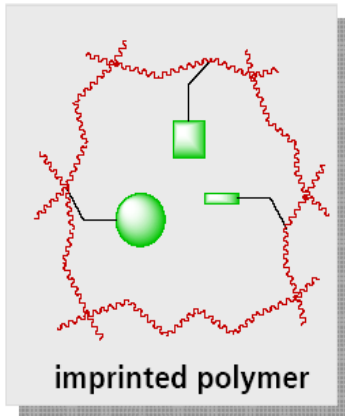
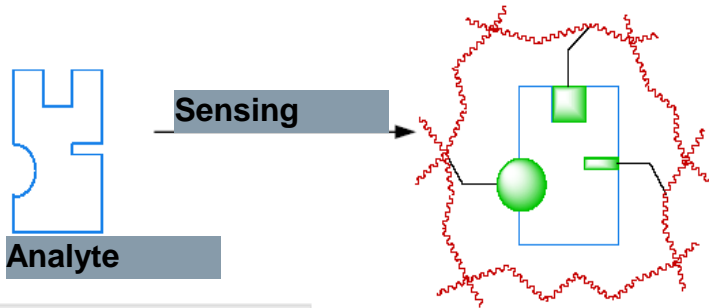
classification of test fires
(demonstrated)



Classification of human activities

Use multivariate data analysis of the gas sensor data for activity monitoring

Explosives Detection for Security



Lets add a different layer: e.g. molecular imprinted polymers for TNT / TATP detection

Combination and Integration

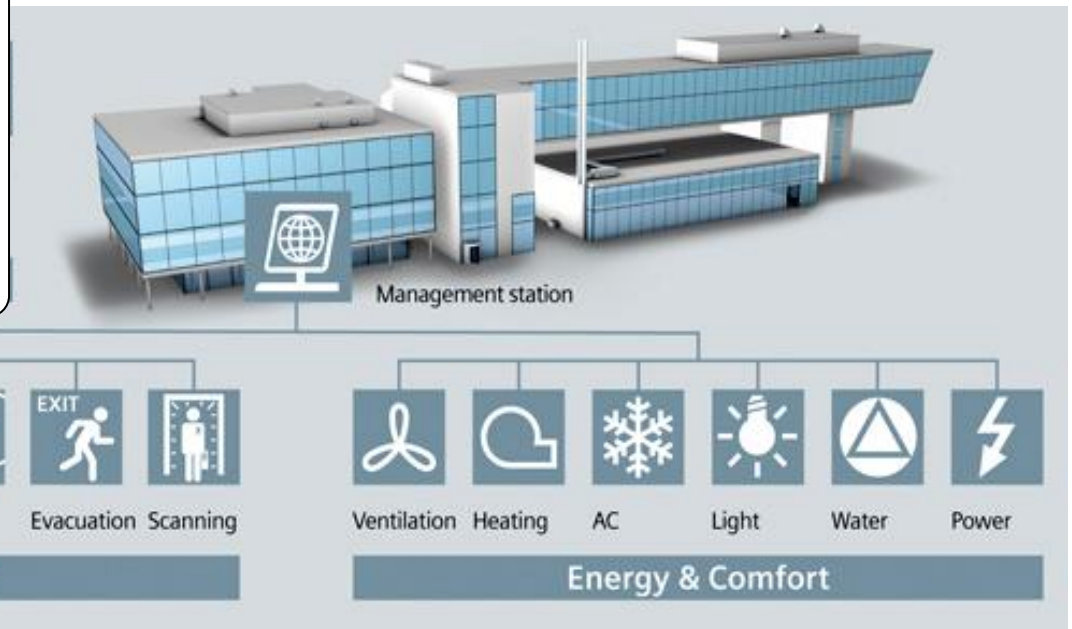
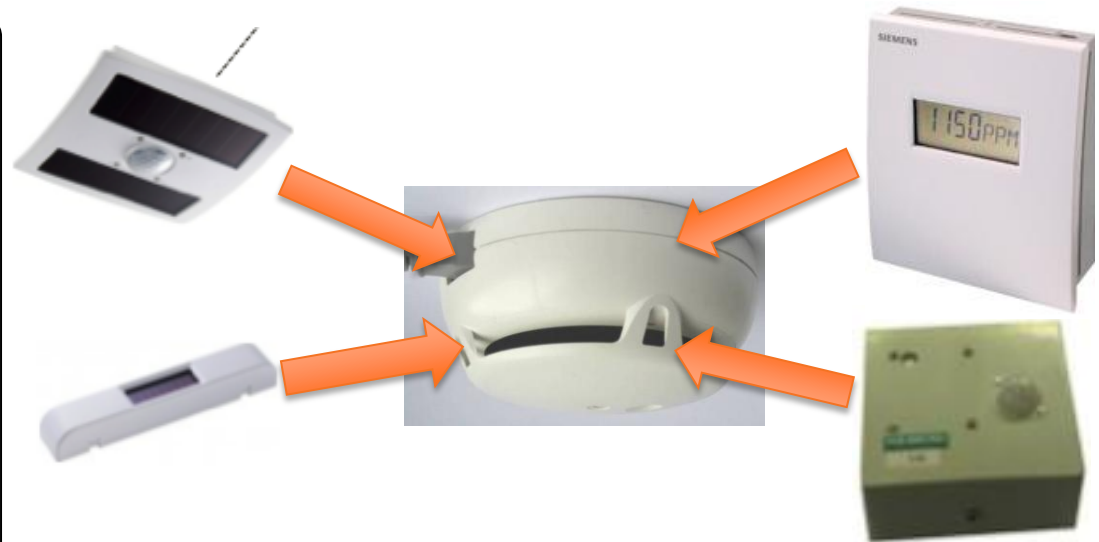
- **Sensor combinations**

- 1 housing
- 1 power supply
- 1 communication module
- + many sensors

- **Data (signal) availability and reuse**

- input for AQ
- occupancy detection
- internet of things (interconnected appliances)
- security applications

- **Architectural benefits!**





Conclusion

**If you cannot beat the costs of conventional
smoke detectors,
beat them with added functionality!**

(But please, keep the fire detector functional)