Industrial View
Optical Gas Sensing in Switzerland

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Present Landscape

- ECO PHYSICS — ***NO_x by chemiluminescence***
- ABB — ***Industrial Analyzers from UV to IR***
- a::etris — ***Laser Gas Detection (NH_3 / CH_4 / HF / …)***

- ***Past:*** ***Aritron*** ***(integrated into MSA)***
  Omnisens ***(changed product)***

Example: LGD Sensors by Axetris

Selectivity

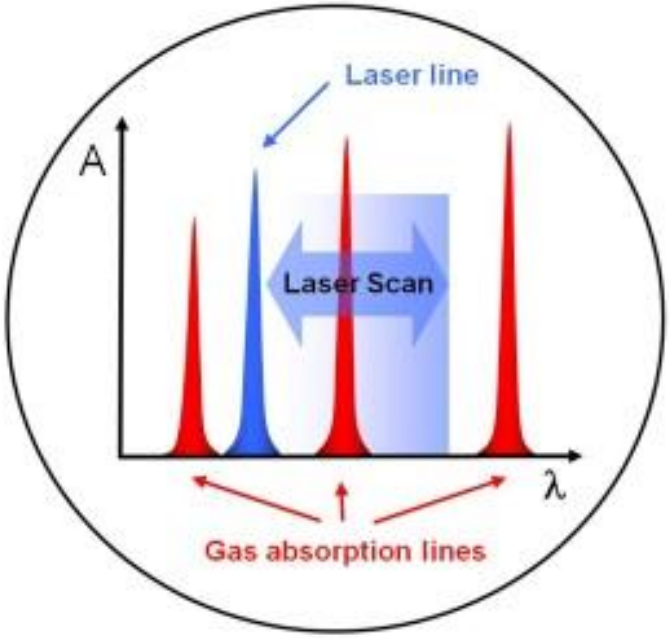
Sensitivity

Initial target:

Low-cost gas sensors for Japanese households
CH_4 / CO_2 / CO , no x-sensitivity to ethanol, $50 at 500k p.a.

Approach:

- ***LGD is highly selective and sufficiently sensitive to CO***
- ***Lasers (VCSEL, DFB) at 500k p.a. should be < €5***



Example: LGD Sensors by Axetris

Lifetime

No Drift

Cost of Ownership

Re-Adjusted Target: Ammonia Sensors for Safety

- ***Annual market around 30k***
- ***Electrochemical sensors drift and die***
- ***Better performance & longer lifetime should allow price premium***
- ***Significant interest from 2 biggest gas sensor manufacturers***
- ***Promising results from proof-of-concept***

Example: LGD Sensors by Axetris

A Long Road from Feasibility to Product

4 weeks	*1.*	***Proof-of-Concept*** 
1 year	*2.*	***Detection limit 1 ppm NH_3 in the lab*** 
4 years	*3.*	***Detection limit 1 ppm from -40 ℃ to 60 ℃*** 
		– ***Optical interference noise >> measurement rang*** 
		– ***Laser packaging, optical components, thermal stabilization, calibration routines***
x years	*4.*	***Detection limit 1 ppm from -40 ℃ to 60 ℃ for every sensor built*** 

Example: LGD Sensors by Axetris

A Long Road from Technology to Market

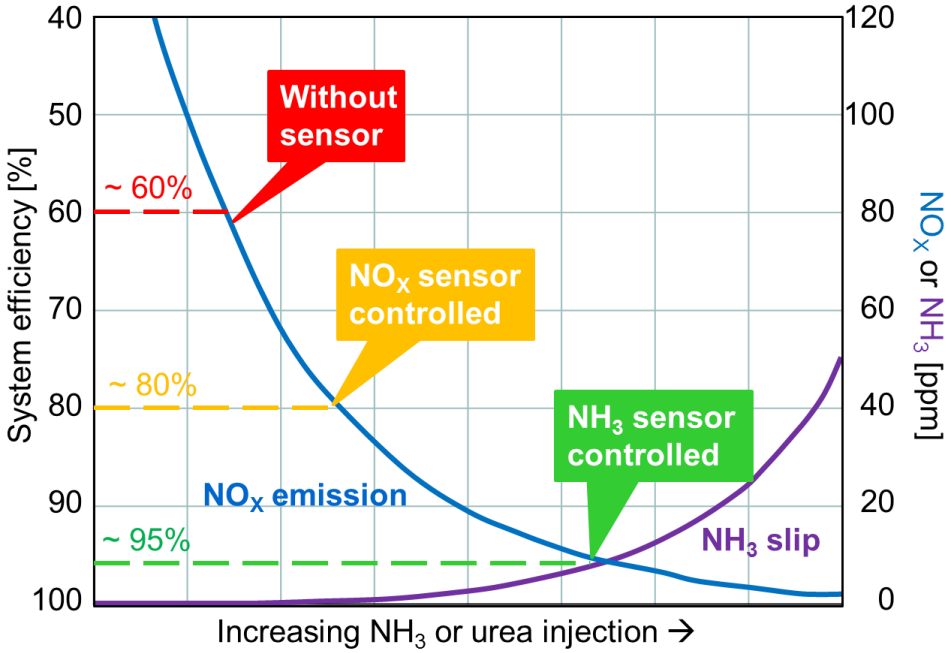
- ***There is no price premium for safety sensors***
- ***Laser prices stay high as long as volumes are low***
- ***Temperature stabilization excludes portable sensors***
- ***No USP, no sale : turning towards process control***
- ***Adding sampling technology / application-specific know-how***
- ***Second source for key components***

Example: LGD Sensors by Axetris

A Long Road from Technology to Market

Example: LGD Sensors by Axetris

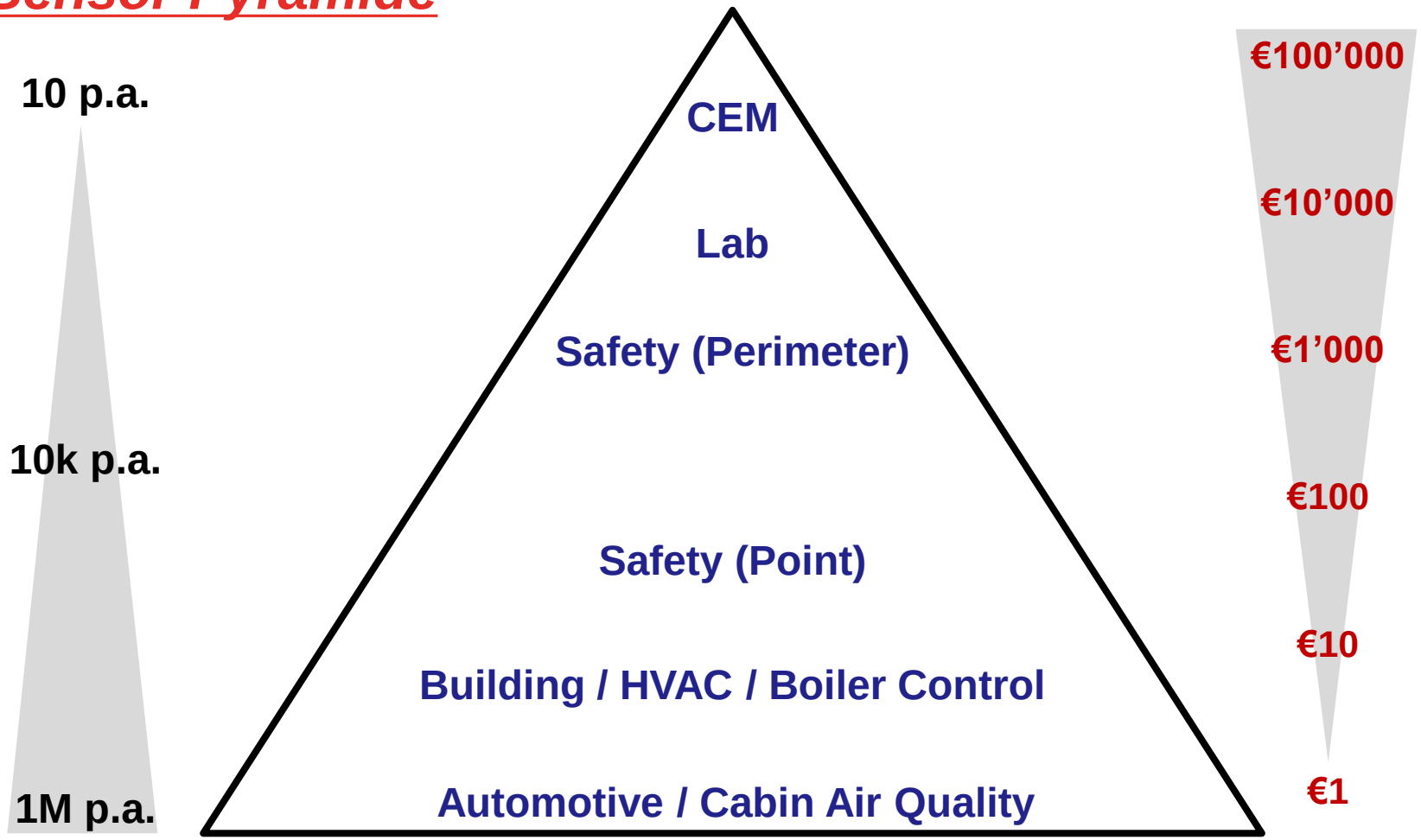
Typical Application: SCR Efficiency



Lessons Learned

- ***Optical sensors always carry a premium on price & power consumption***
- ***The premium brings non-contact, stability, selectivity, speed***
- ***Where the customer needs the added value?***
- ***Safety sensors don't sell – there is always a cheaper one around. Nobody cares about performance.***

Gas Sensor Pyramide



Volume Opportunities for Optical Gas Sensor

- NO_x on diesel engine exhaust (all markets)
  - Surface sensors don't last and are x-sensitive

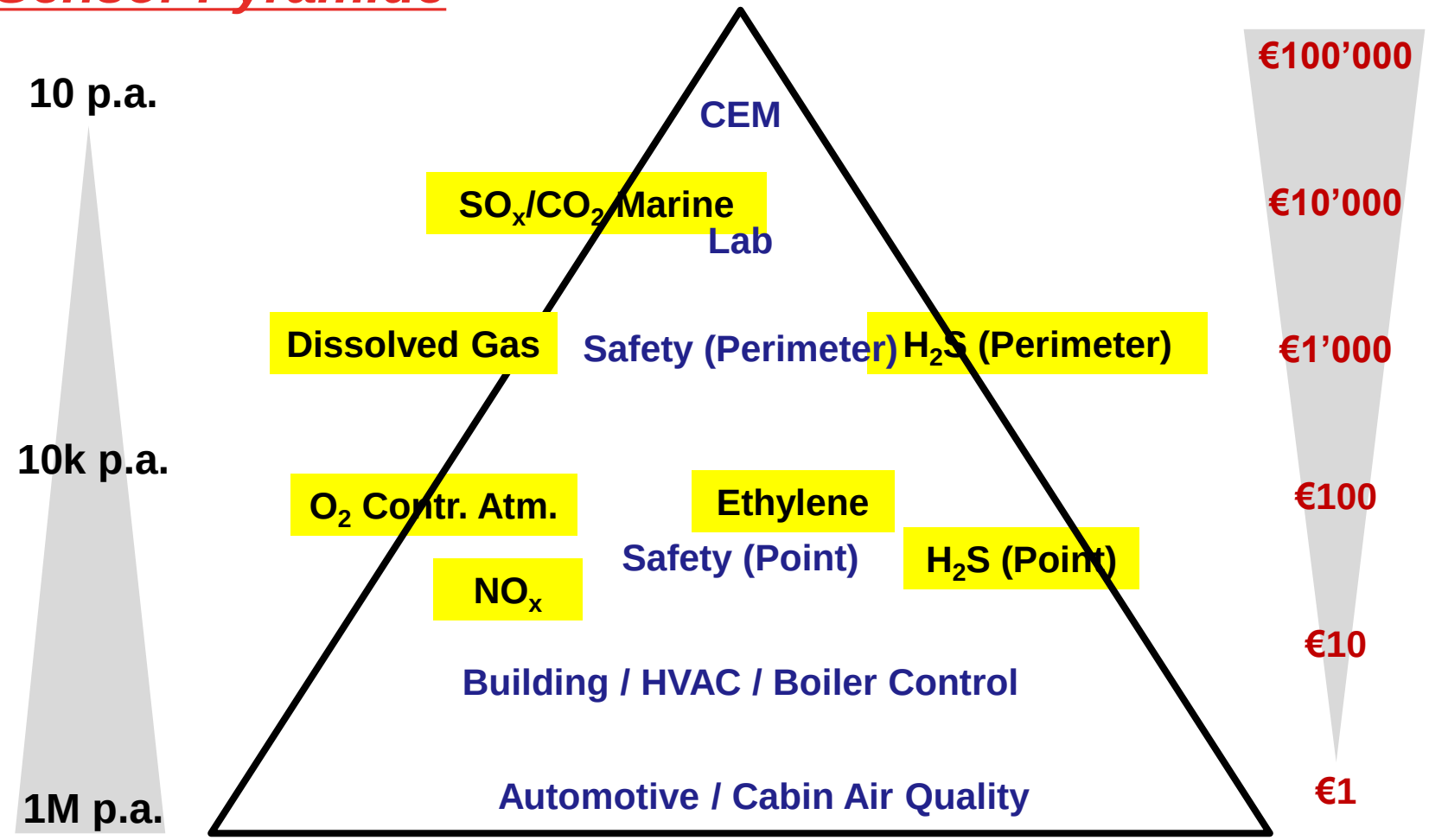
- O_2 in controlled atmosphere containers
  - 10 years lifetime, no drift

- Ethylene for commodities
  - No x-sensitivity to ethanol
- H_2S in refineries, gas wells (point & perimeter)
  - Desert climate runs electrochemical sensors dry

- SO_x/CO_2 on marine diesel engines
  - Massive legal pressure

- Dissolved gas on power transformers

Gas Sensor Pyramide



What Does it Take to Access Volume Opportunities ?

- *Market Approach instead of Technology Approach*
  - *USP is absolutely essential*
  - *The sensor needs to solve an existing problem*
  - *It must enable the customer to reduce costs, or to increase turnover*
  - *Customers care about value and price, not about technology*
  - *There is no such thing as « nice to have »*
- *Limited Customization*
  - *Gas sampling technology is another know-how than gas sensing*
  - *Customization is expensive and/or eats margins*

What Does it Take to Access Volume Opportunities ?

- *Low-Cost Light Sources (and Detectors)*
  - *Light sources need to be supported by other markets (i.e. UV-LED's for water desinfection)*
  - *« Fancy » light sources lead to chicken & egg situation → no chicken, and no egg*
  - *Second source for key components, stability of suppliers*
- *Simple & Robust Calibration*
  - *Significant cost factor*
  - *Single point or span & slope*
  - *Make sensors interchangeable*

Bottom Line

- *Optical Gas Sensors in Switzerland is a small environment*
- *Large community of suppliers for key components*
- *OGS for volume applications not established yet*
- *Price is not an USP*
- *OGS need to provide significant added value*
- *There are volume applications potentially accessible for OGS*