ALTERNATIVE METHODS FOR BIOMASS COMBUSTION CONTROL

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cmefe
Groupe de compétences en mécanique des fluides et procédés énergétiques

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Outline

- University of Applied Science of Western Switzerland
- The problems of biomass use for district heating
- Sensors for biomass combustion control
- Initial results with an optical sensor for excess air control
- Conclusion and future perspectives

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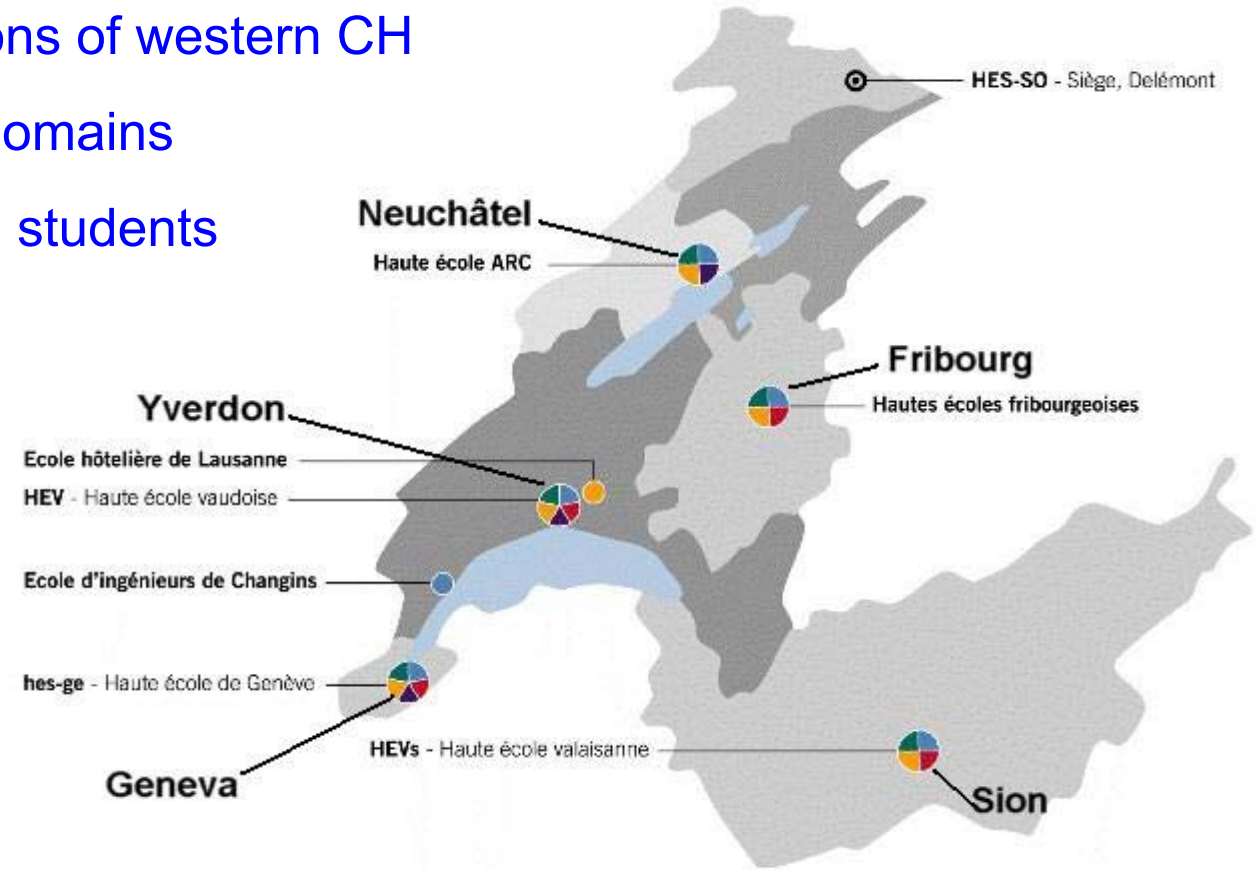
University of Applied Science of Western Switzerland

- 5 regions of western CH
- 6 job domains
- 10’000 students



Engineering and architecture
Economy and services
Health
Social work
Applied arts

Main R&D activities

Fluid mechanics and energy conversion systems Lab, Geneva

- Building design, simulation, HVAC systems
- Aérodynamics of sports.
- Renewable energies
- Thermodynamical cycles

www.cmefe.ch

Thermal Engineering Institute, Yverdon

- Phase change materials and ice slurries (IEA working group)
- Magnetic cooling
- Combustion

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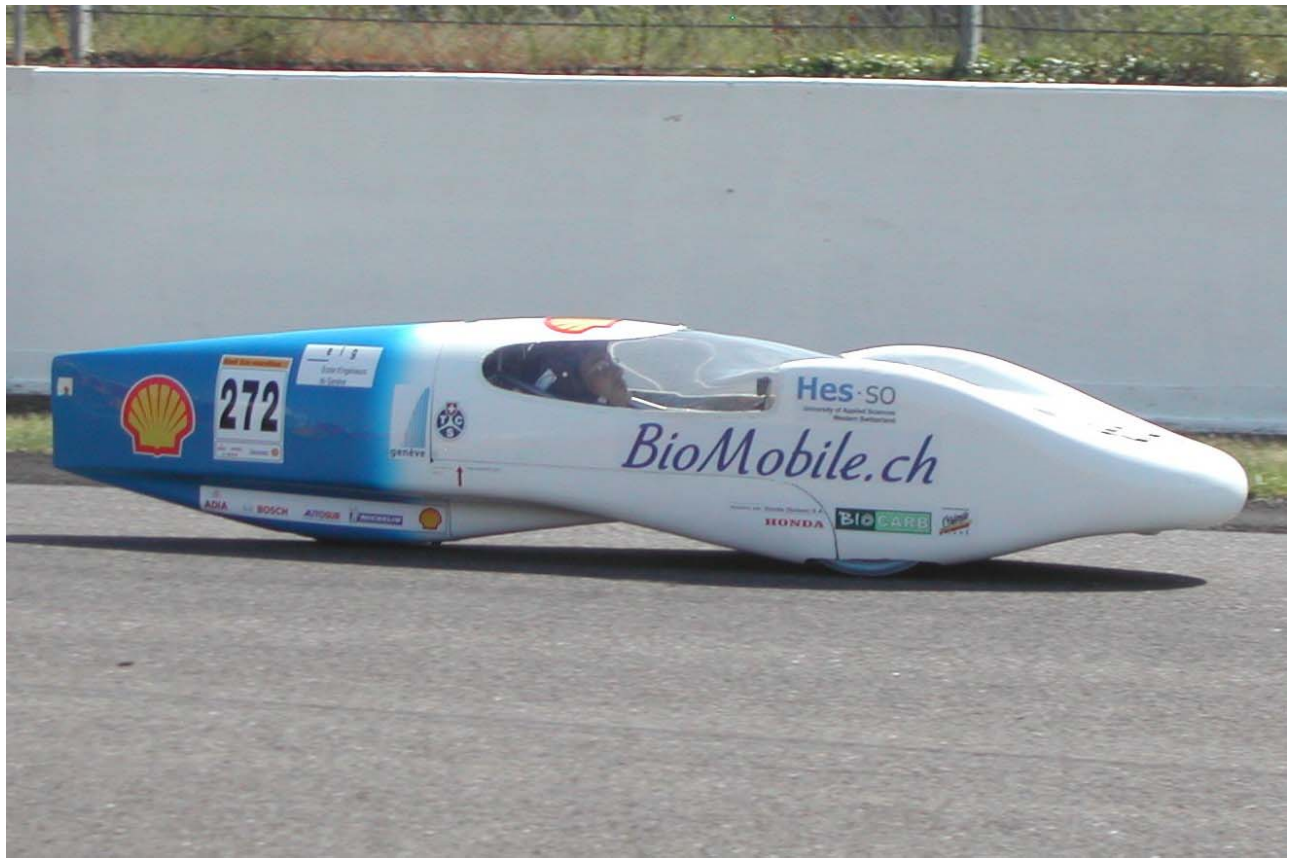
Participation to Shell Eco-Marathon race



- 2004: 123.4 km with 0.1 litre of benzine
- 2005, 2006: Use of biobenzine from organic wastes

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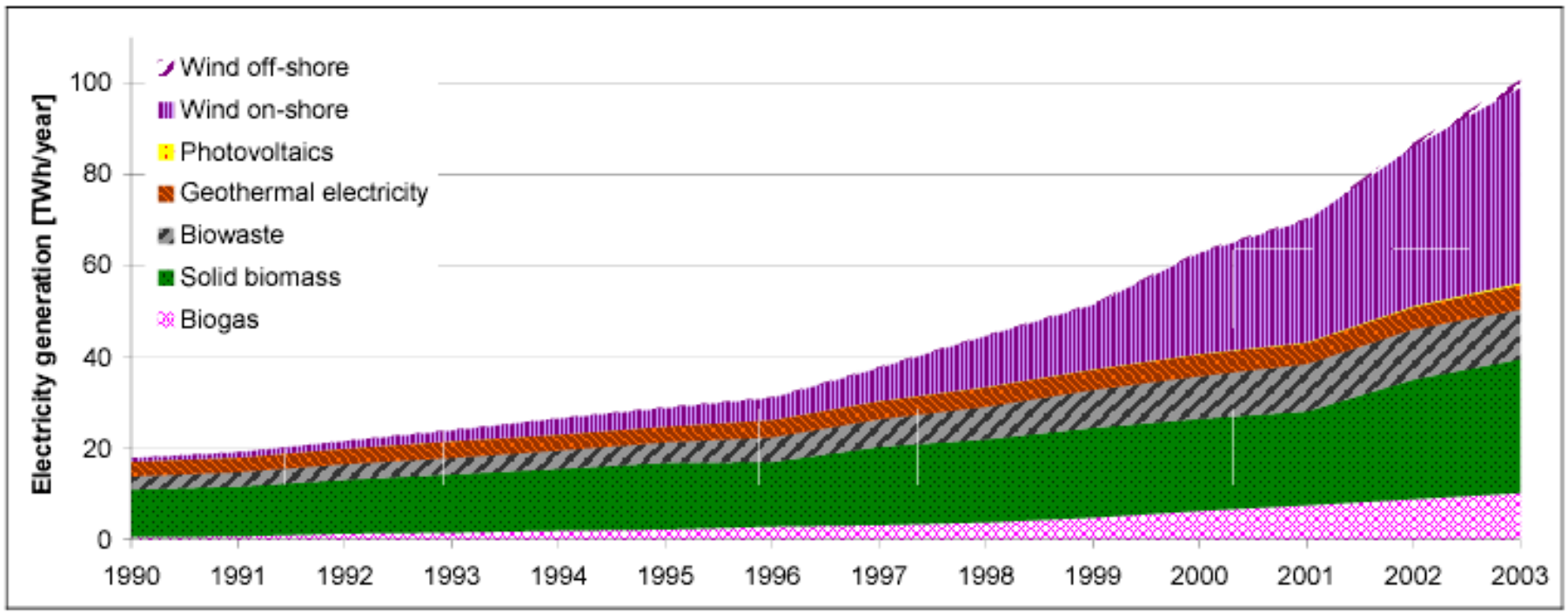
EU targets for 2010

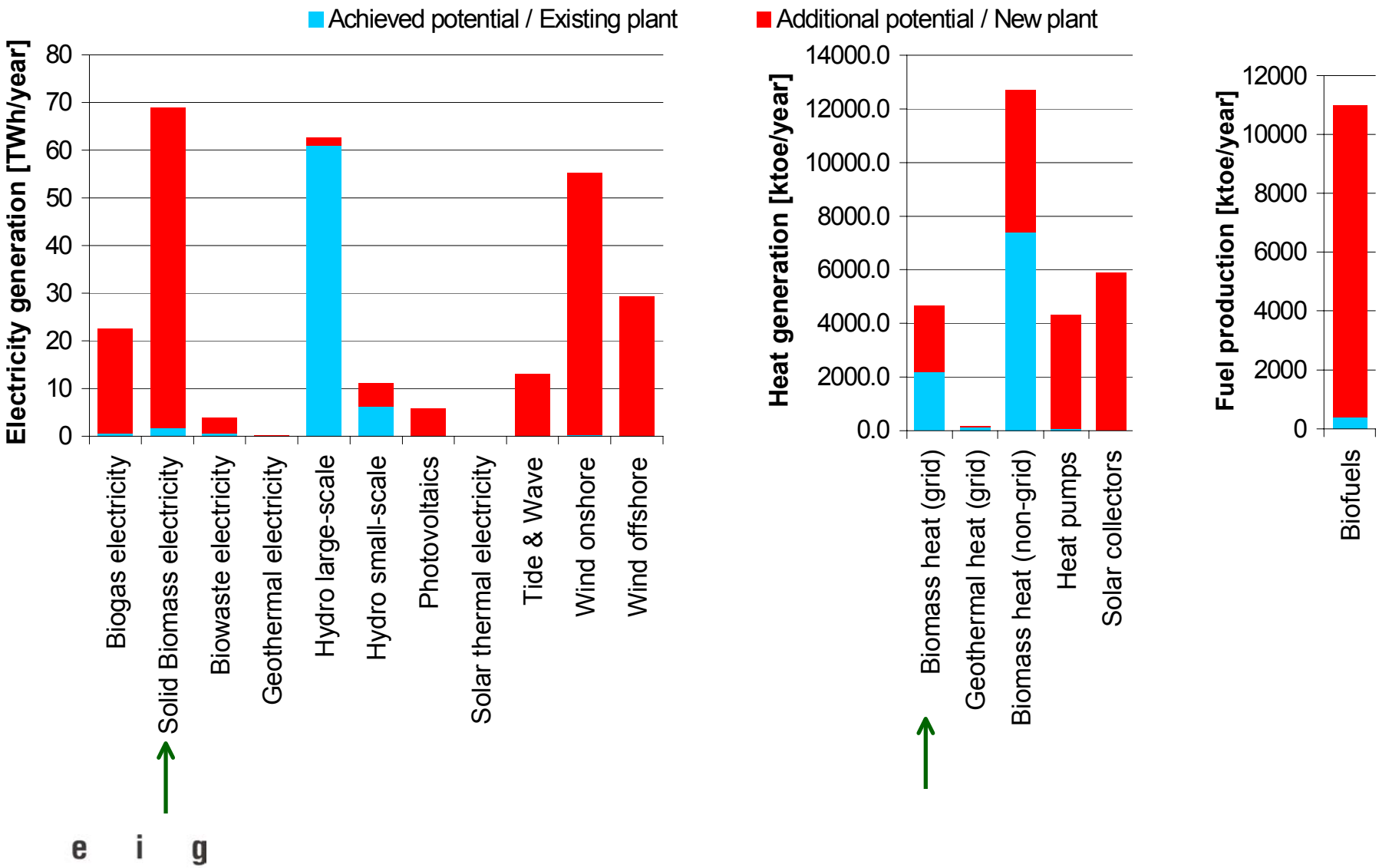
- Double the share of **renewable energy** in national gross energy consumption from **6% to 12%**
- Increase the share of **green electricity** in total electricity consumption from **13% to 21%**

Source: How to support renewable electricity in Europe ? – EU memo, dec. 2005

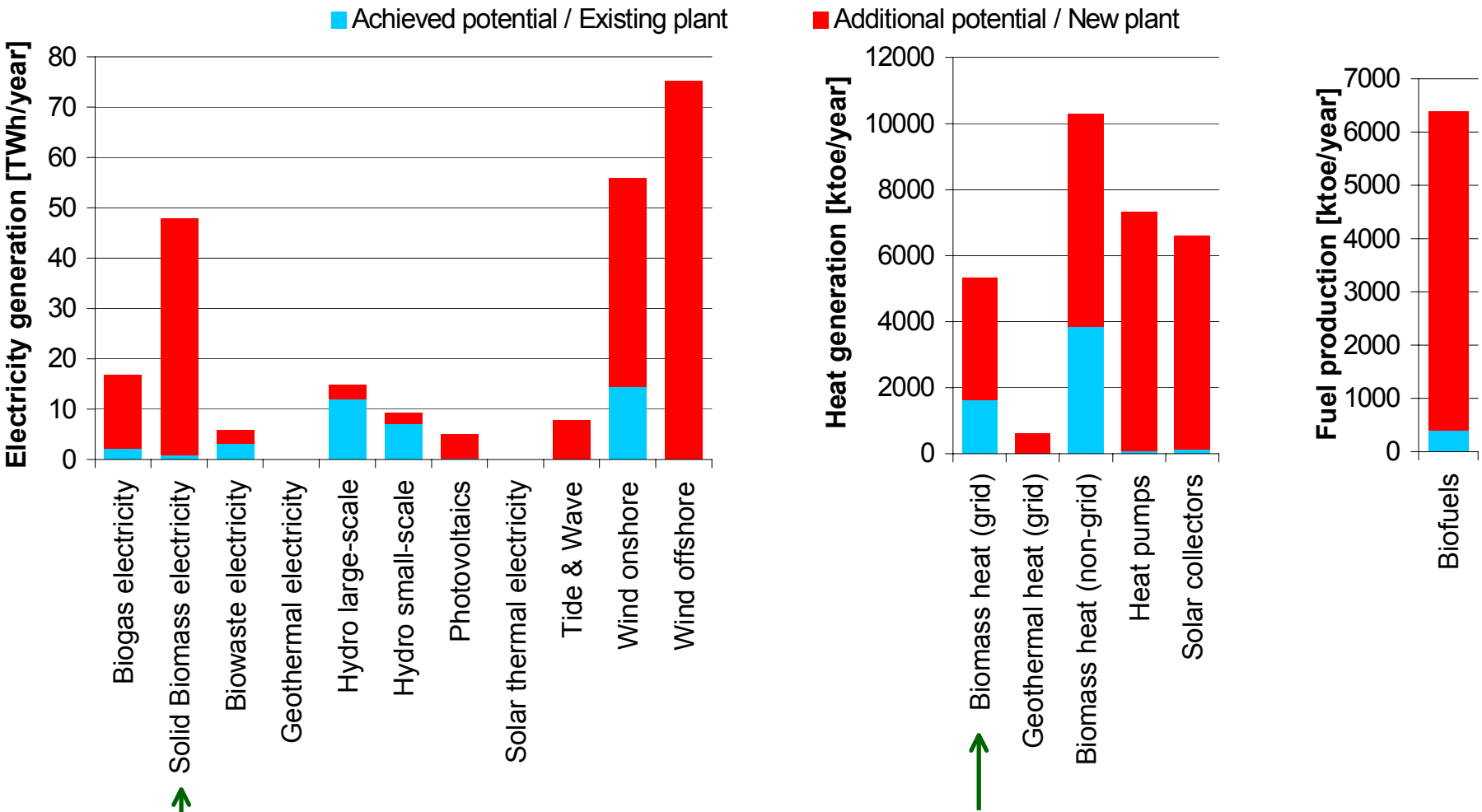
Historical development of new renewable electricity generation in the EU-25 from 1990 to 2003



Example: French potential of renewables

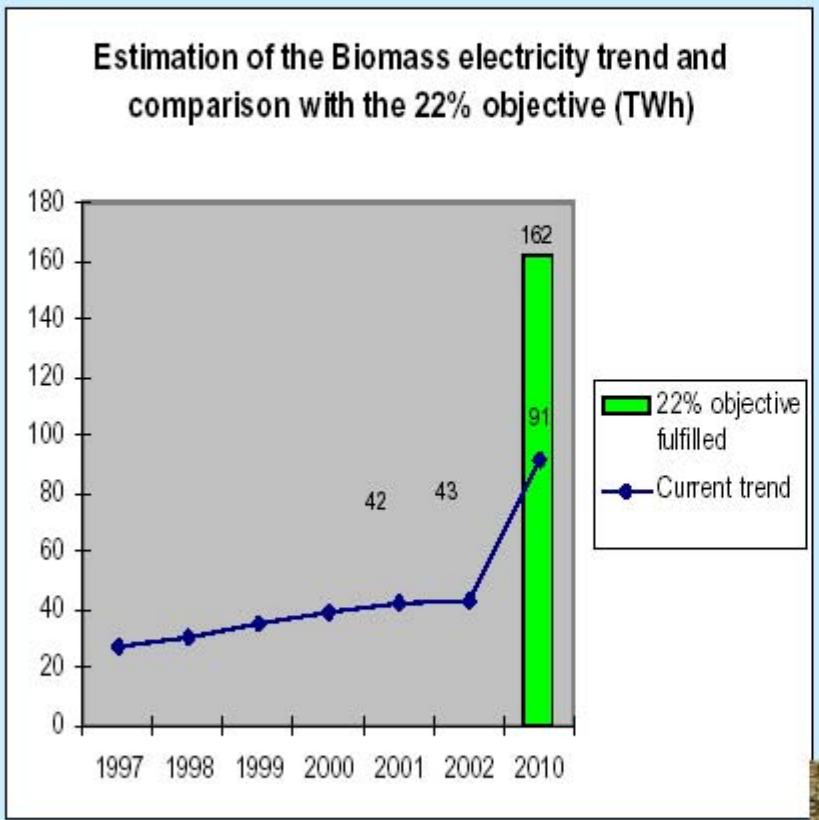


Example: German potential of renewables



EU report: the share of renewable energy in the EU (2004)

Biomass electricity



- ✓ 2010 target will only be achieved if biomass contributes 40% to it.
- ✓ Biomass electricity will need to grow by 18%/year compared to 7% during the past 7 years.
- ✓ Additional need of around 32 Mtoe – indicative figure on the biomass availability for energy purposes at EU15 level is 150 Mtoe (additional 32 Mtoe for EU10).

Directorate general for Energy and Transport

Information - Communication

Factors limiting the increase of biomass for heating

- Availability of the biomass in urban areas
- Storage
- Investment costs
- Emissions
- Variability of the fuel
  - Moisture
  - Size distribution
  - Composition
- Reliability – frequent unwanted stops
  - ➔Economics very much depending on operating variables
  - ➔Need for better monitoring & control of the combustion e.g. excess air, primary/secondary air, CO
  - ➔Need for low cost sensors usable on 300 kWt_h – 3 MW_{th} boilers

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Pellet boiler designed to retrofit oil boilers

HOVAL,
Liechtenstein

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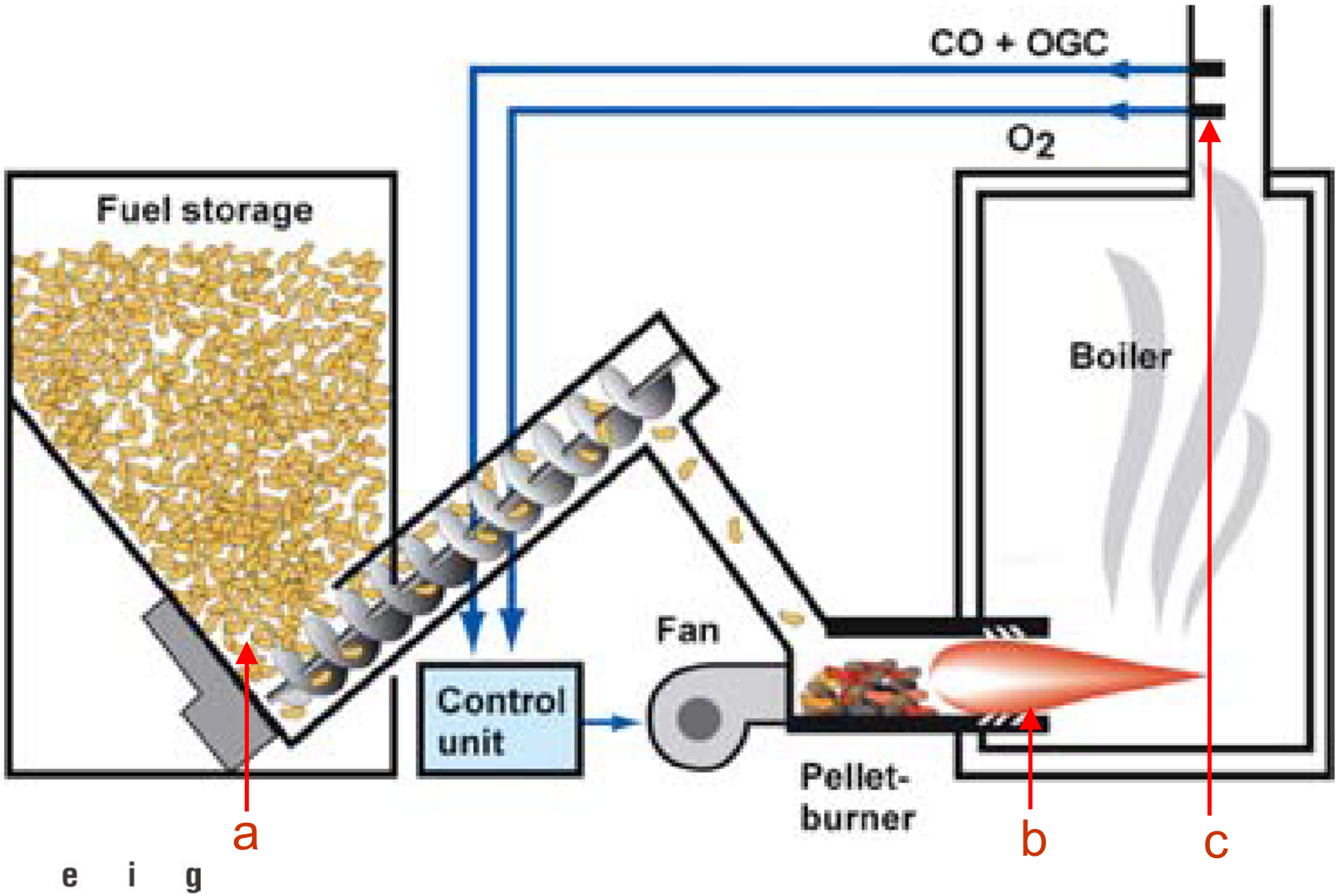
Technical and economical requirements for the sensor system

- Reliability for O2 and CO/HC emisssion control
- Low cost : < 1 Euro per kW as a rule of thumb
- Regulate the primary air flow through and along the fuel bed
- No or very low maintenance.
- Lifetime > 10 years.

Lambda optimisation system (after Eskilsson [8])



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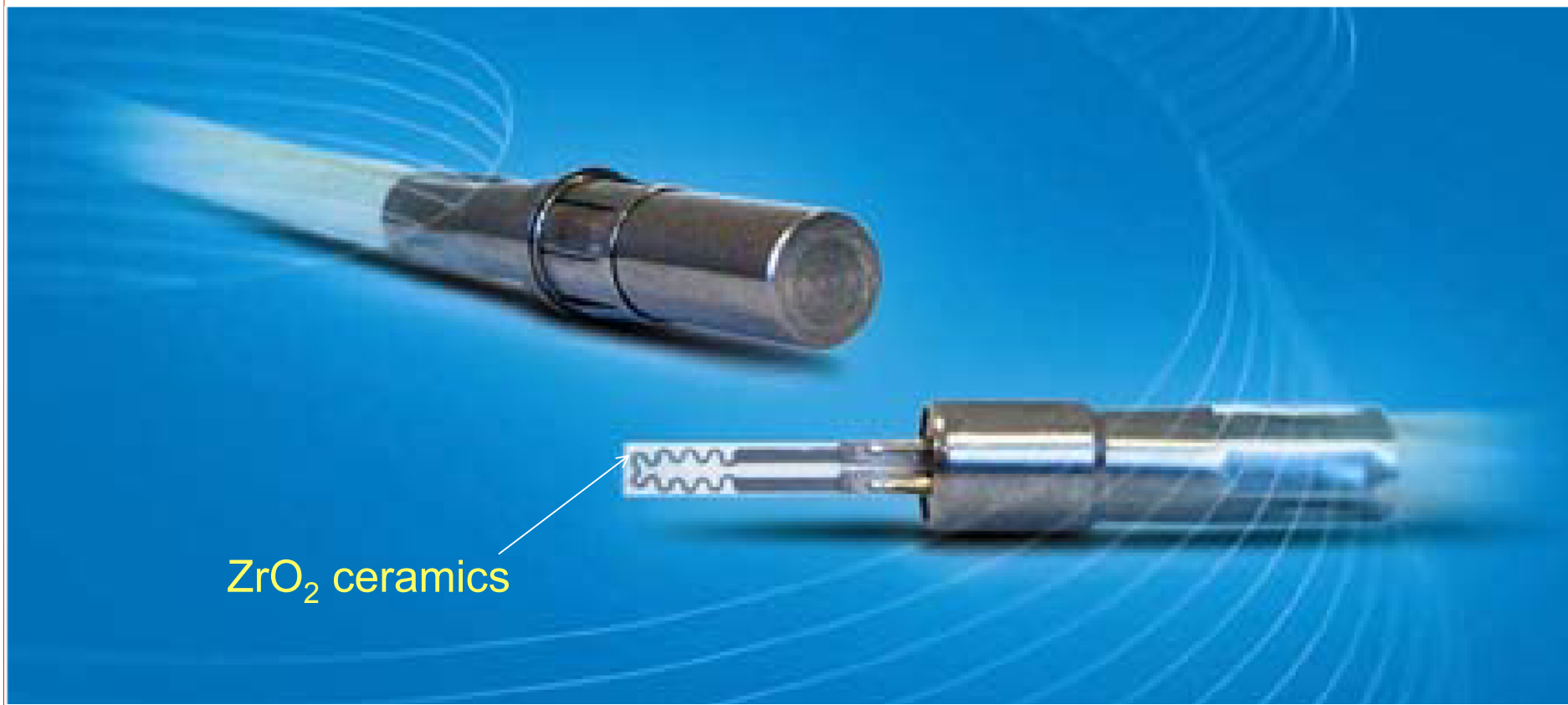
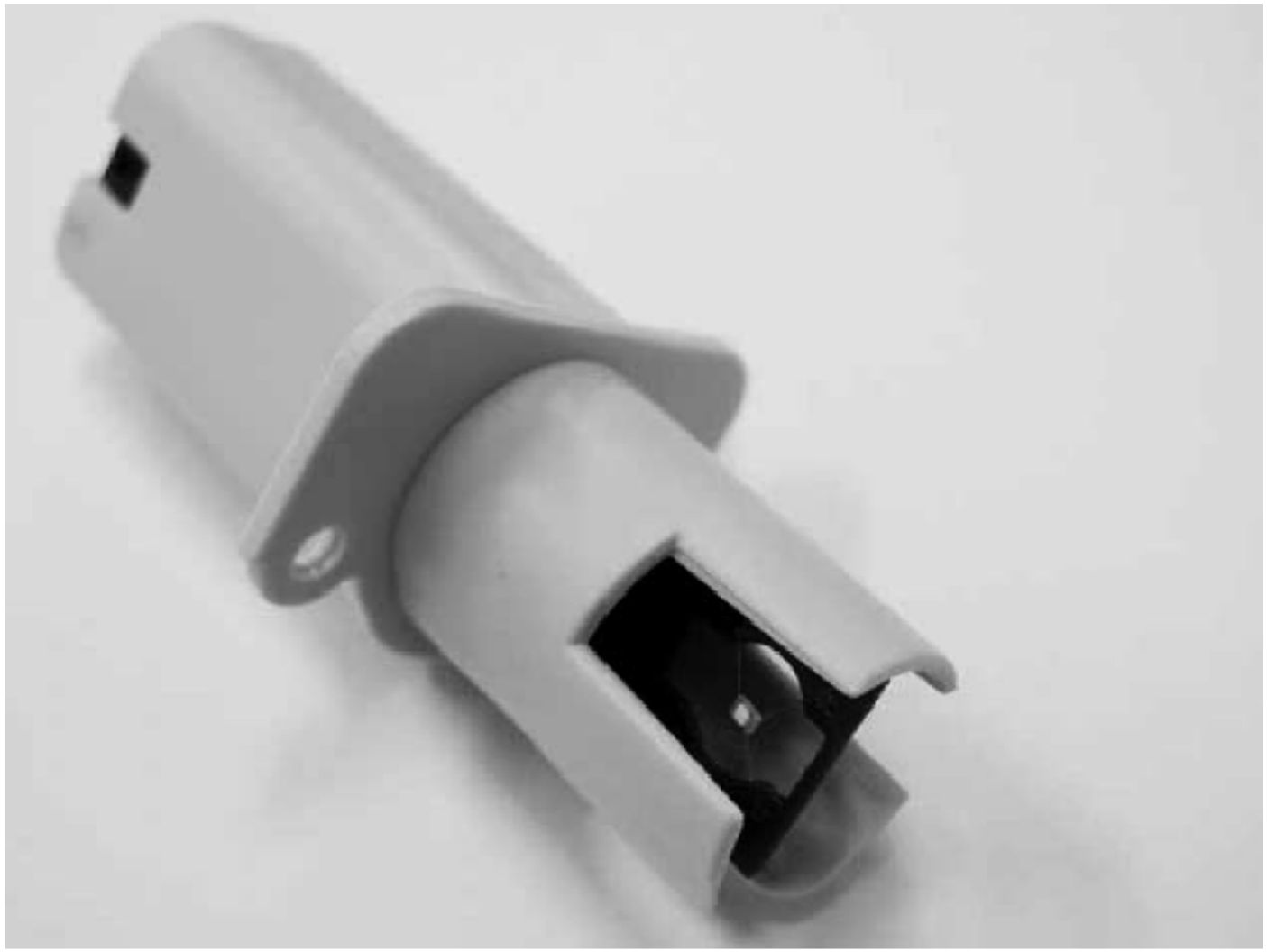
CO/VOC sensor from Lamtec (Escube) – Carbosen 1000



Target price: 10-100 Euros

Steinel Ga_2O_3 sensor suitable for CO and O_2



Target price for steel made sensor (10’000/y): 40 Euros

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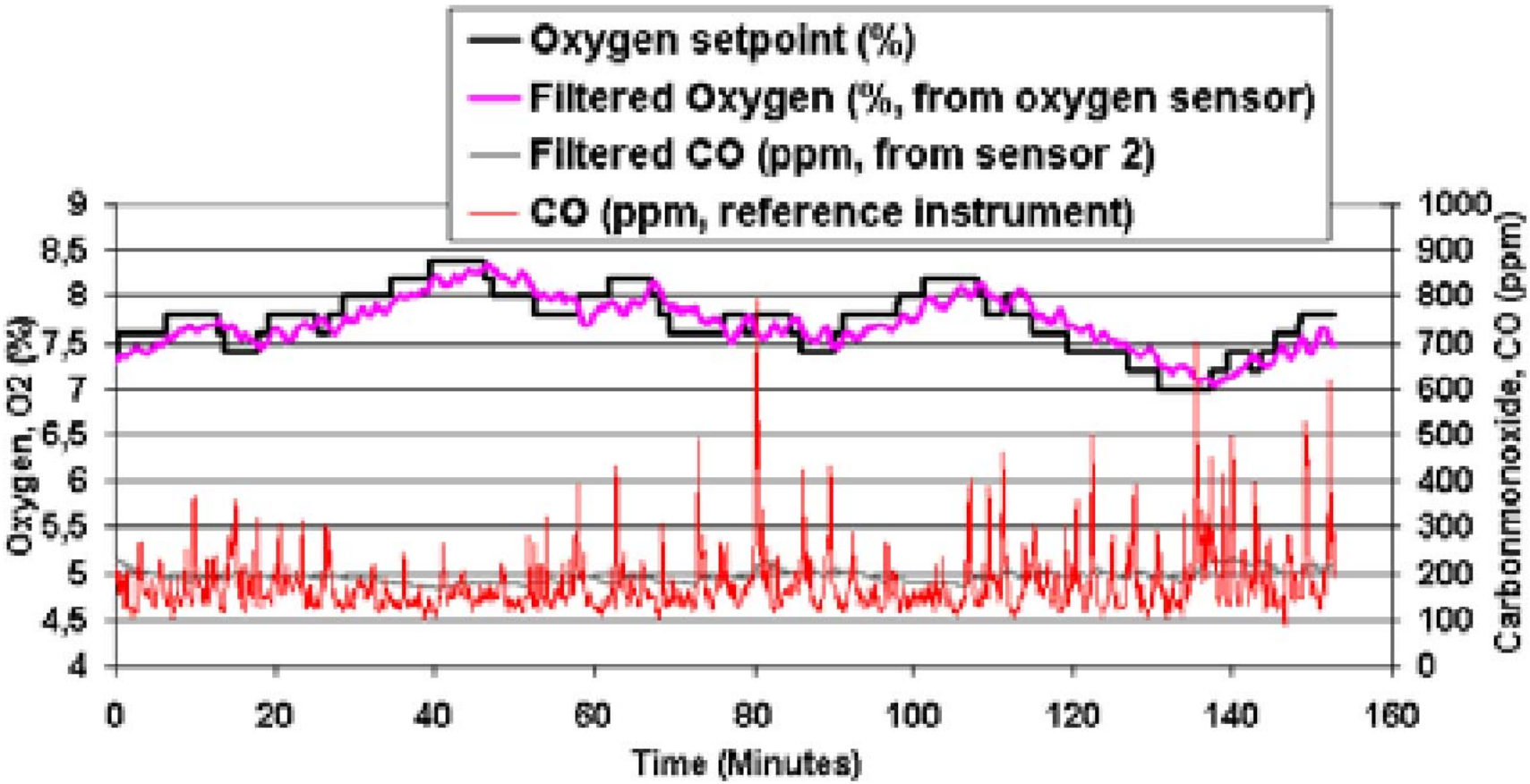
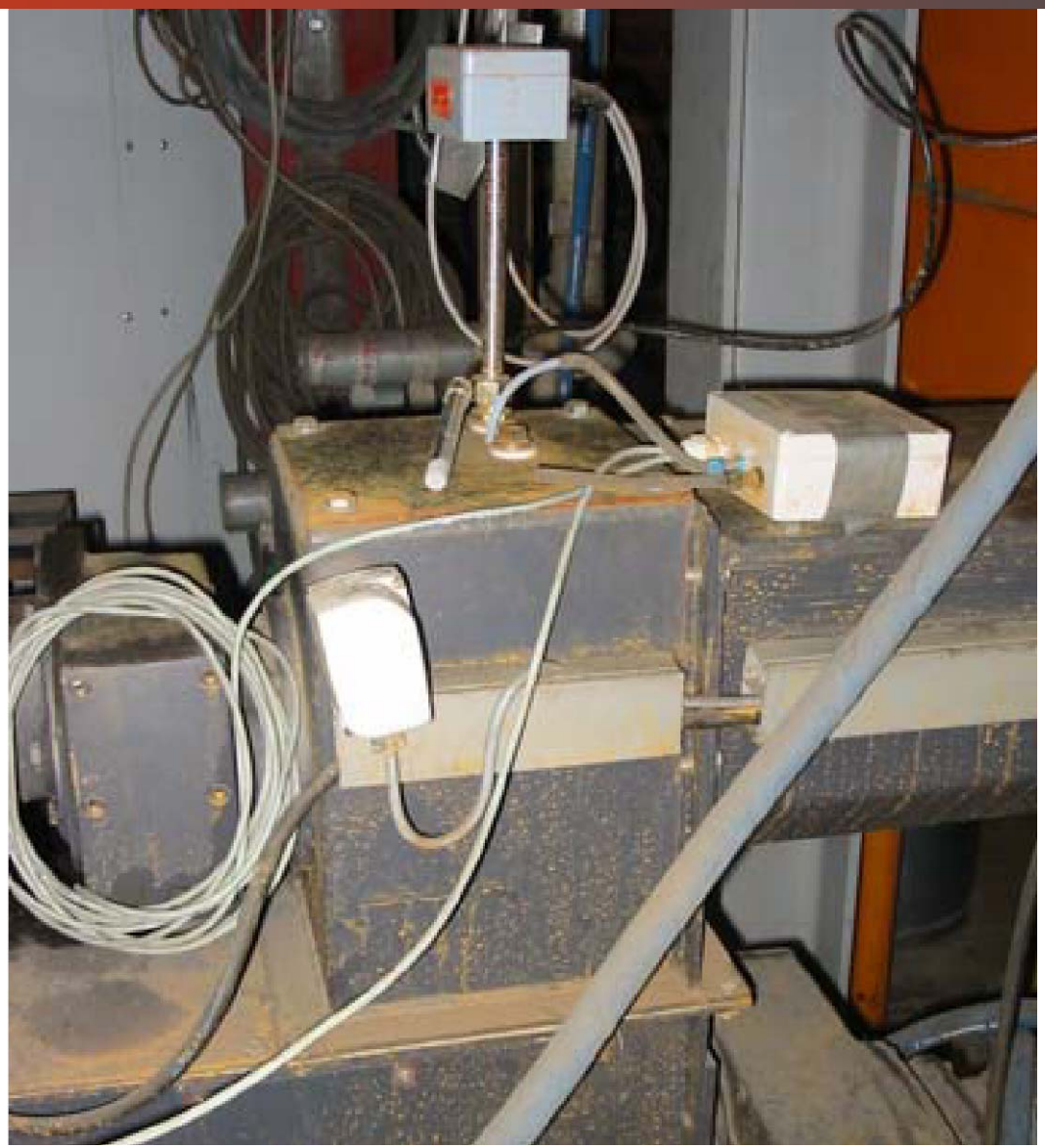
Example of excess air control using CO and O_2 signals

Source: Eskilsson [8], 13 kW pellet boiler



Uni. Stuttgart sensor array for fuel moisture measurement



Yu Yuefen, R. Berger, Klaus R.G. Hein: The Moisture Estimation of Biomass Fuel: A Neural Network Based Method.

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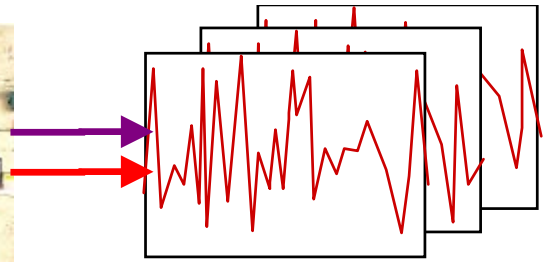
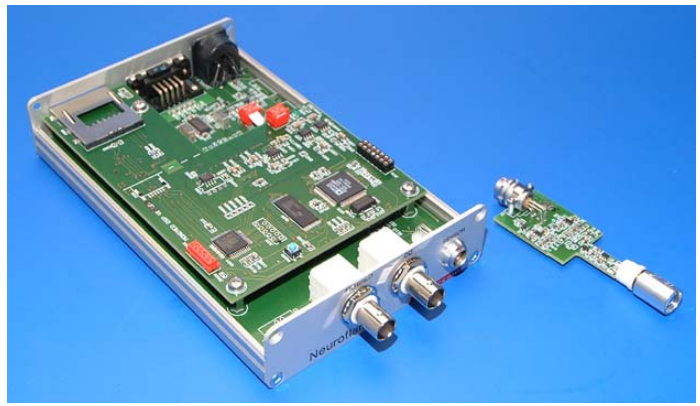
Flame signature sensor principle for biomass flames

Biomass boiler

Sensor signals (OH, CH radiation)



60 seconds samples

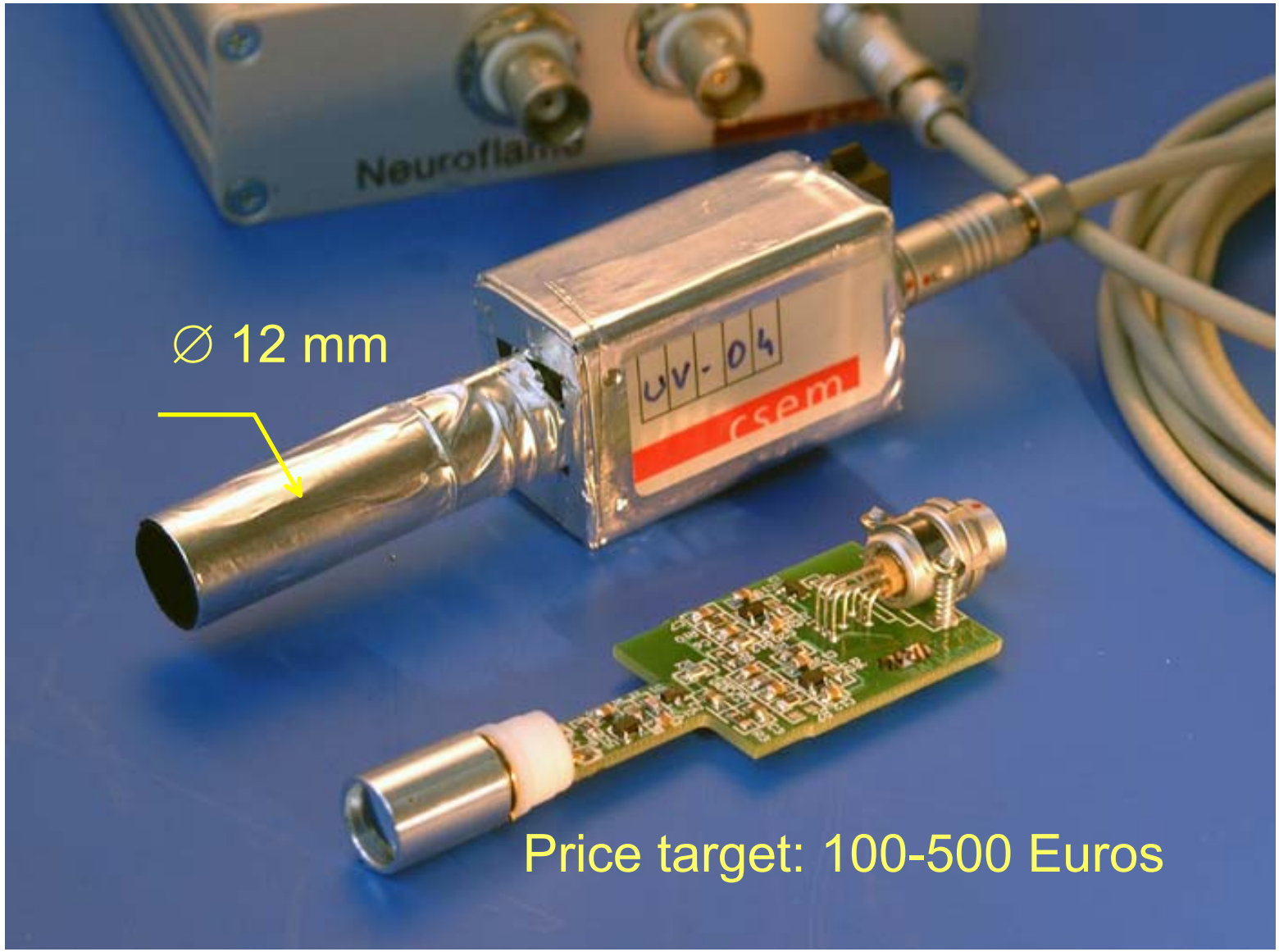


Signal processing:
Average, spectral power
CH/OH and CH*/OH*ratio

Fuel identification

Local fuel richness

Flame signature sensor for gas & oil fired burners



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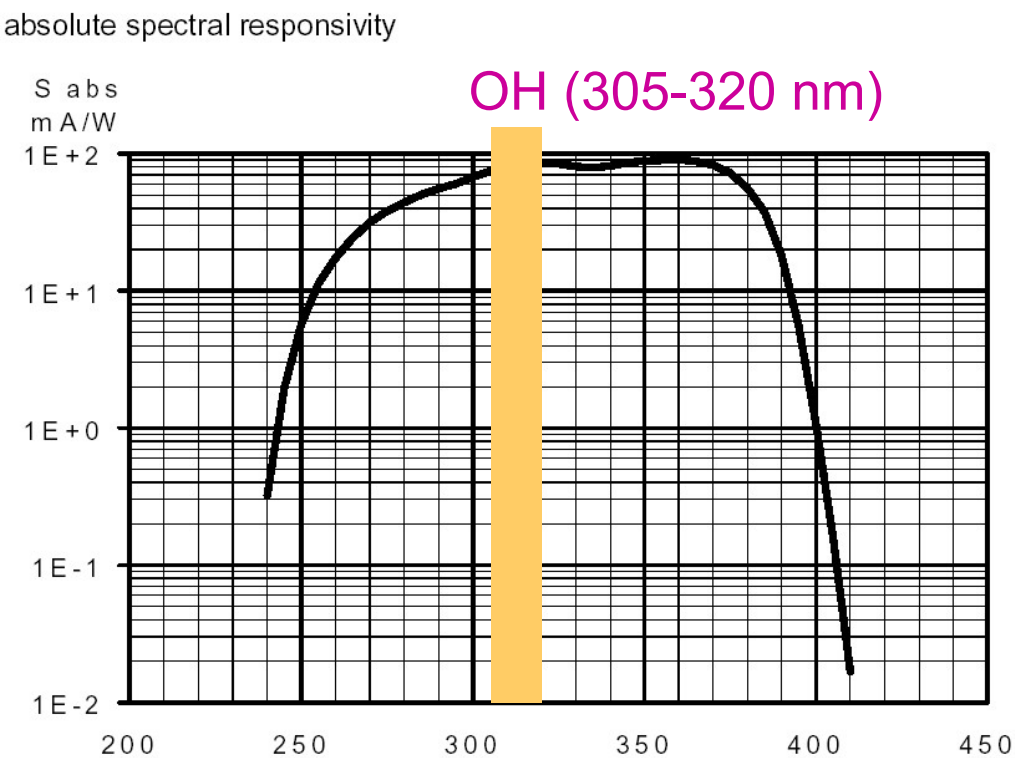
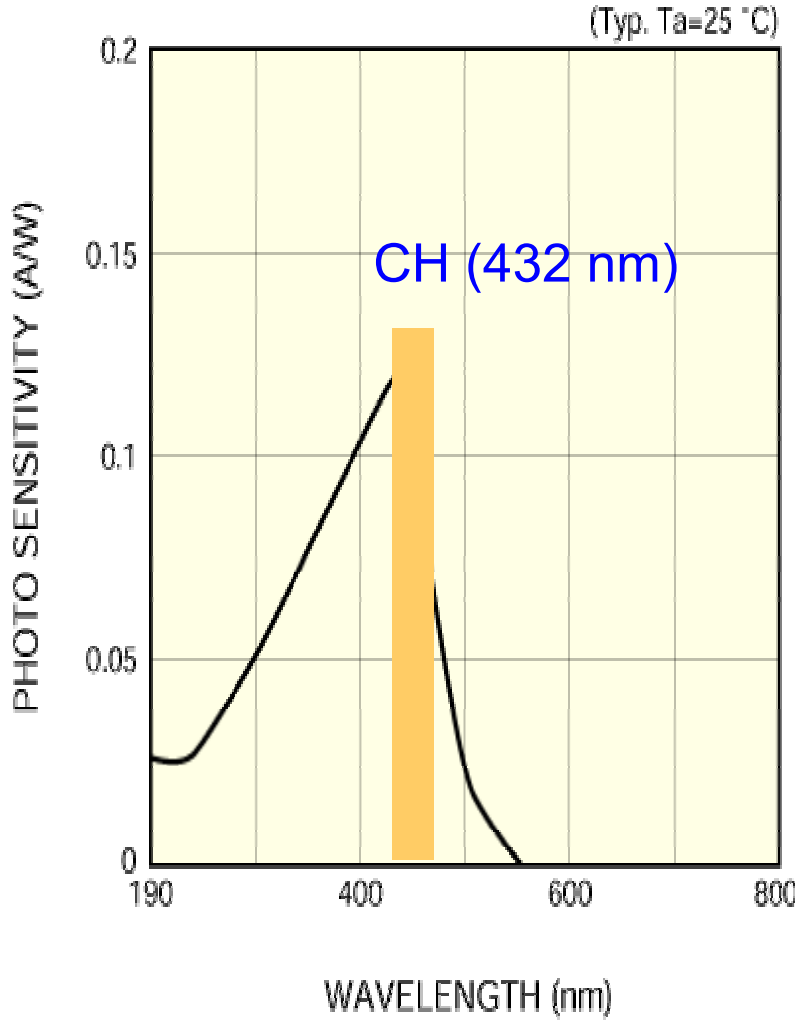
GaP sensor responses



EPD 365-0/2,5



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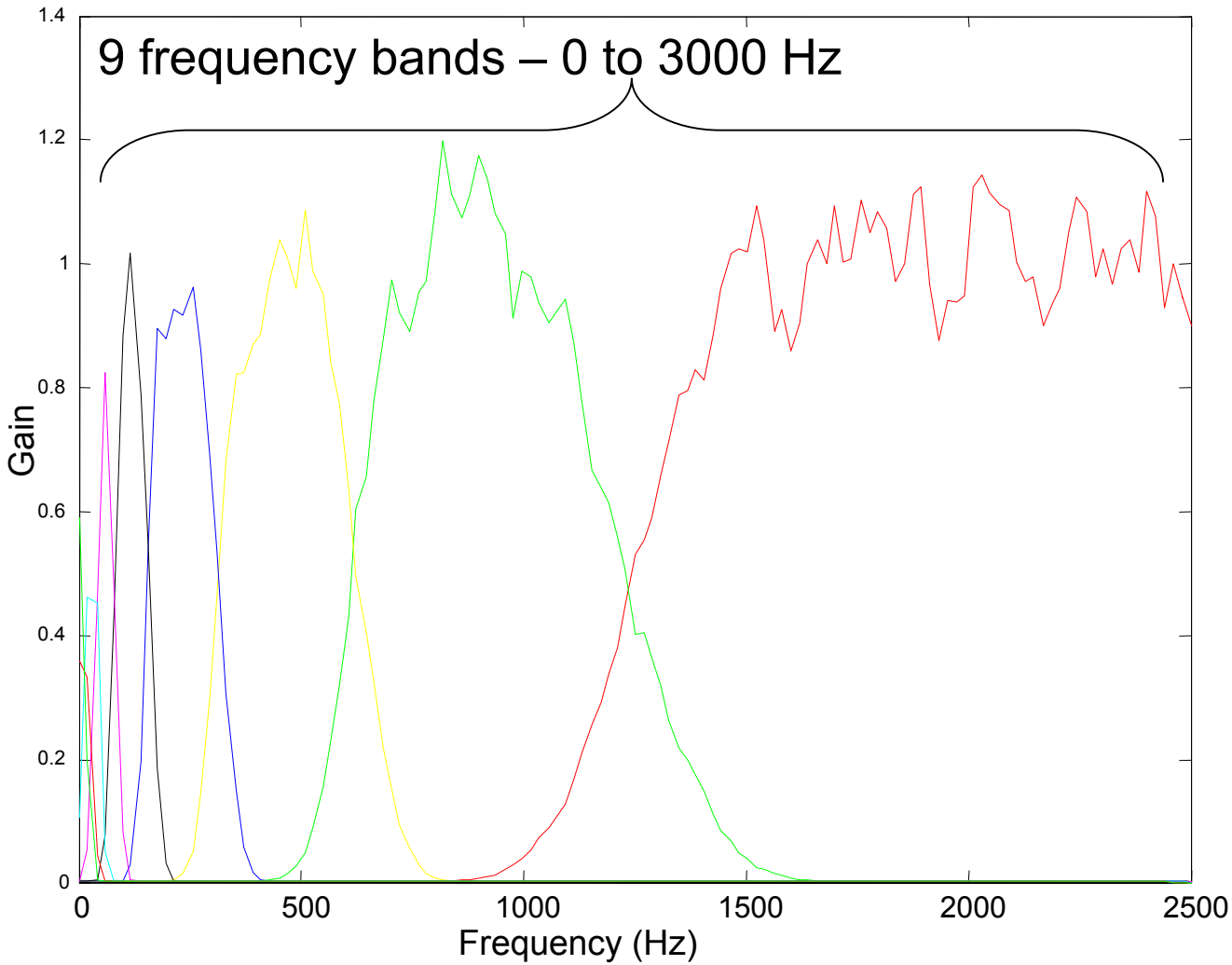
Dyadic time filtering process



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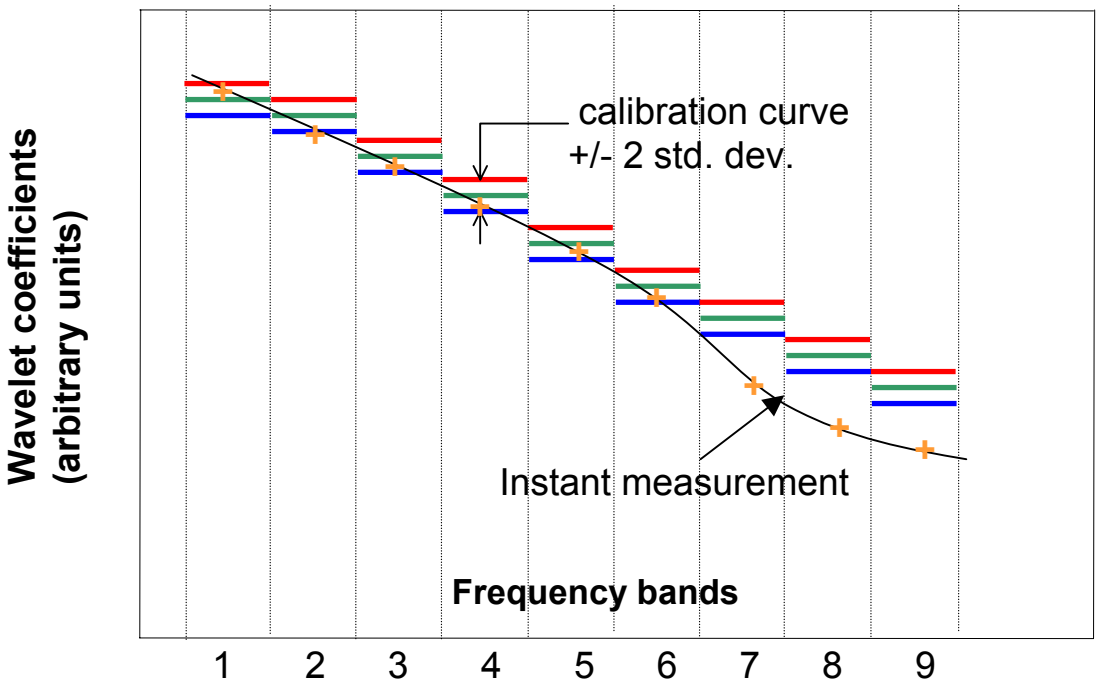
Control scheme

- Record « good » flame signature for 10 minutes at constant load
  - → 9 wavelet coefficients corresponding to 9 frequency bands
  - → Average and Standard deviation
  - → Signal/noise ratio
- Monitor deviation from the norm and provide alerts
- Distance is correlated to excess air variation



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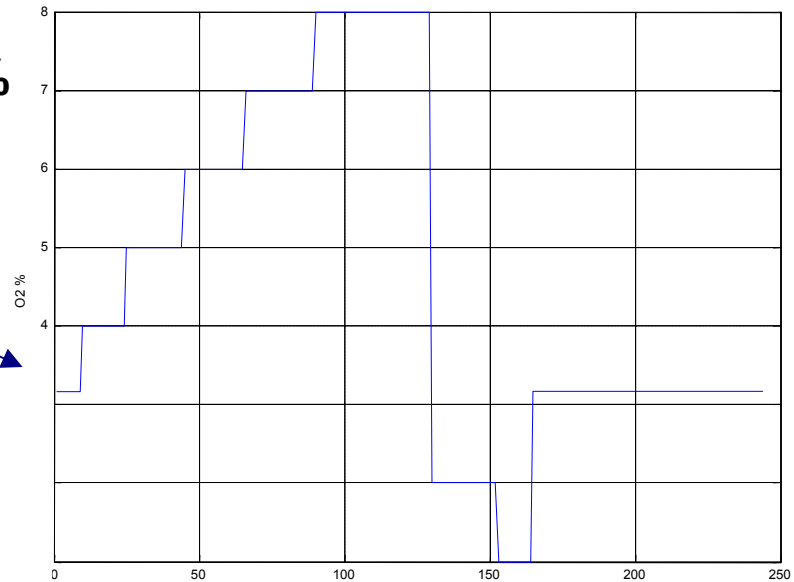
Sensor response to step changes in excess air- Gas flame

Forced-draught gas fired diffusion burner, 180 kW trained for 15% excess air.

O_2 %

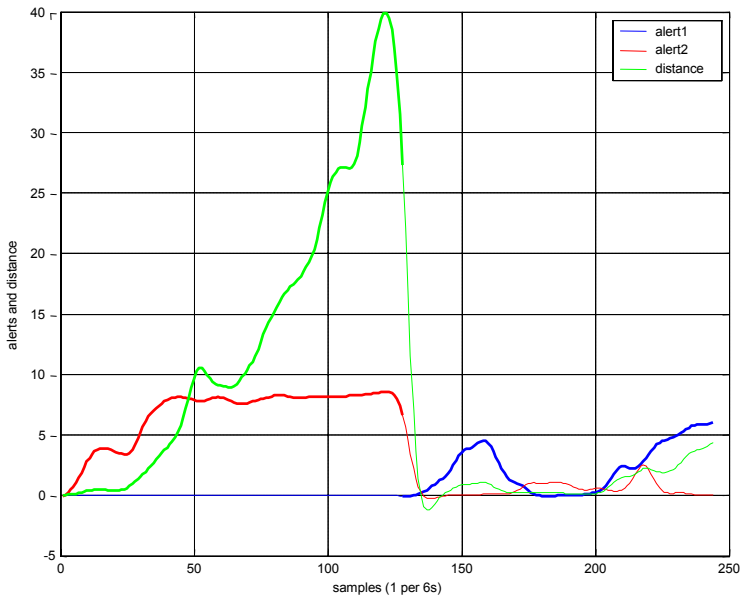


Samples (1 per 6 s)

Alert 1(b)

Alert 2 (r)

Dist (g)



Samples (1 per 6 s)

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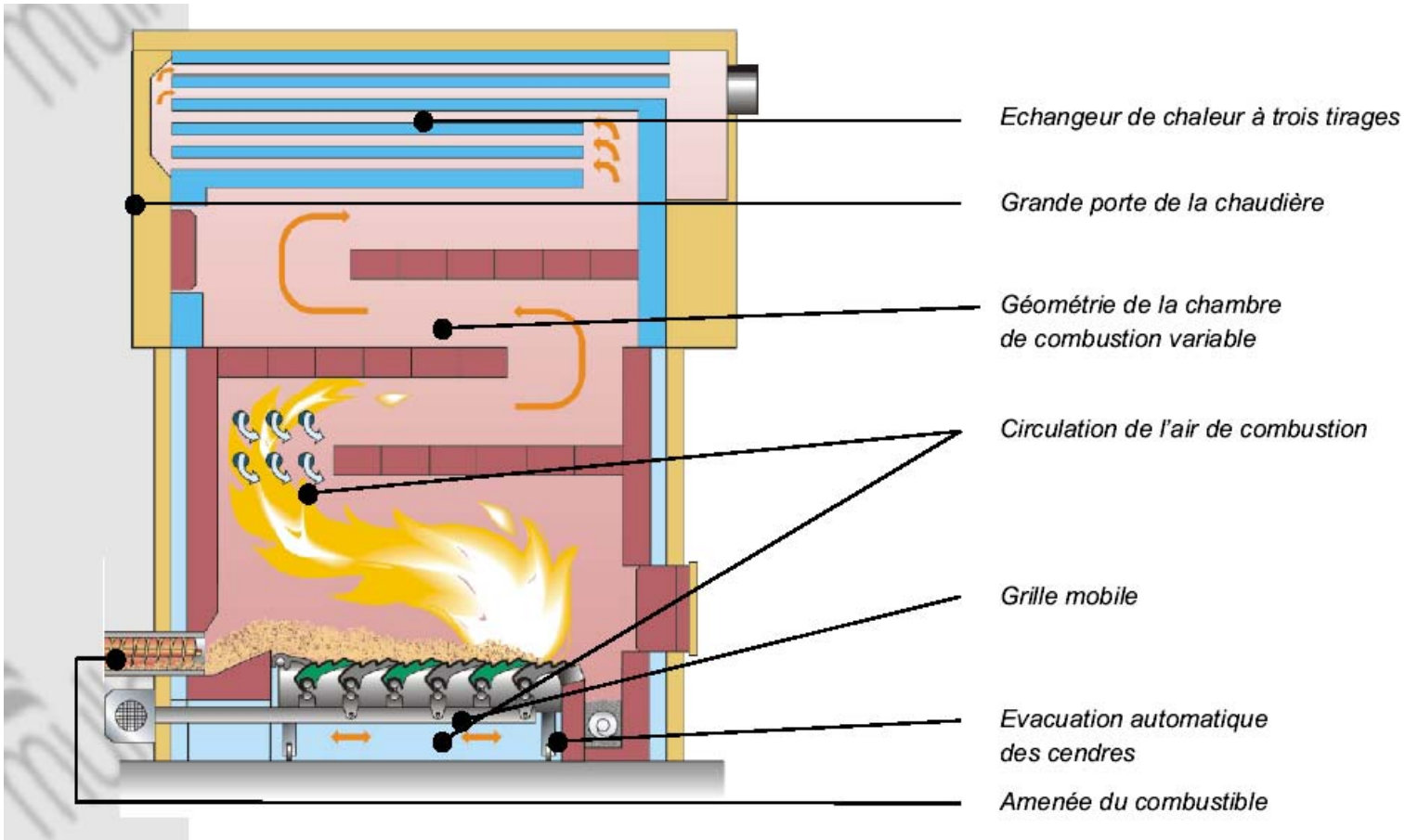
Müller AG – Boiler schematic

- Suitable for variety of wood and wood wastes – variable moisture content - 800 to 1300 kW
- Turn-down 30%



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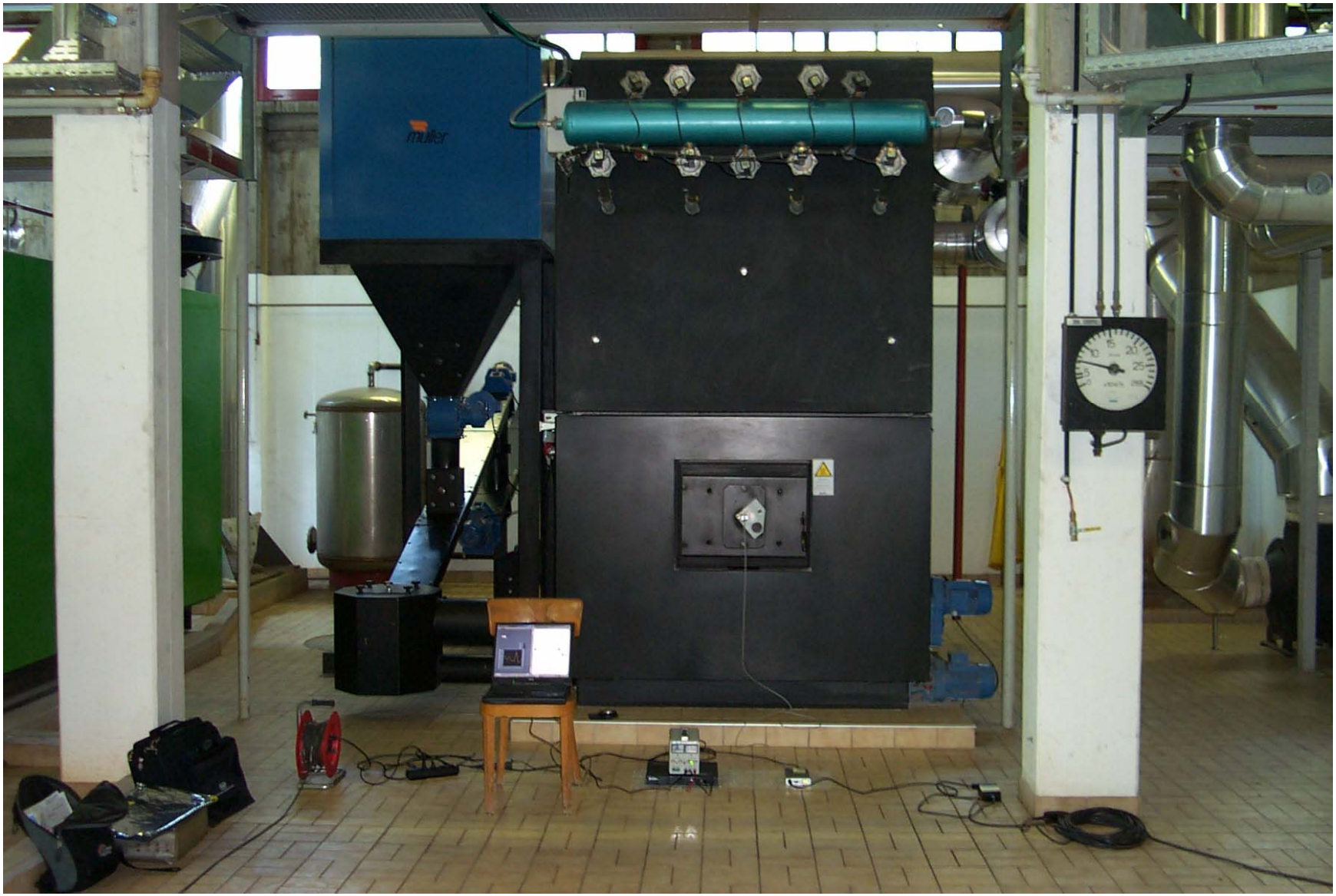
1 MW boiler from the State of Geneva (Lullier)



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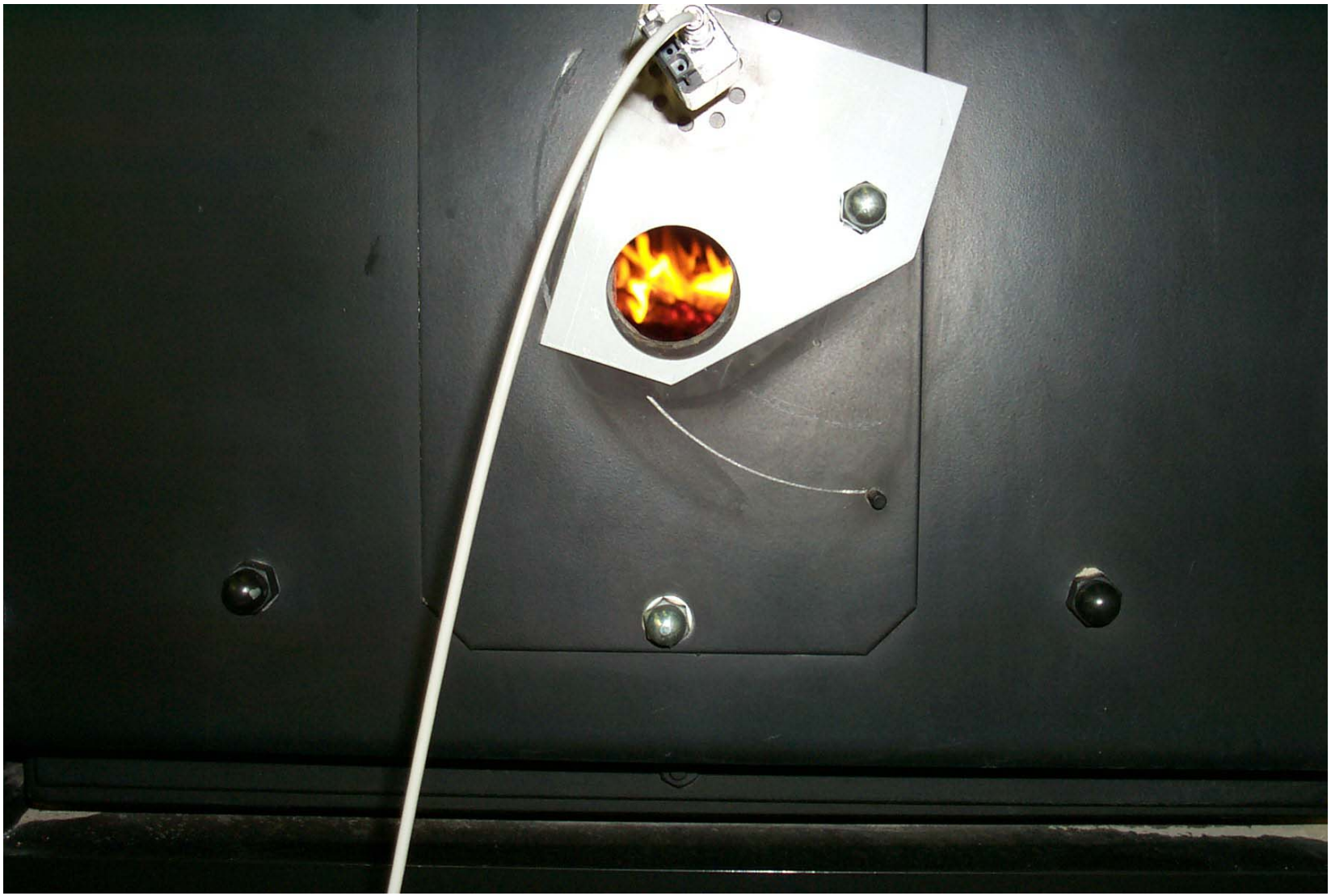
Sensor placement – first trials



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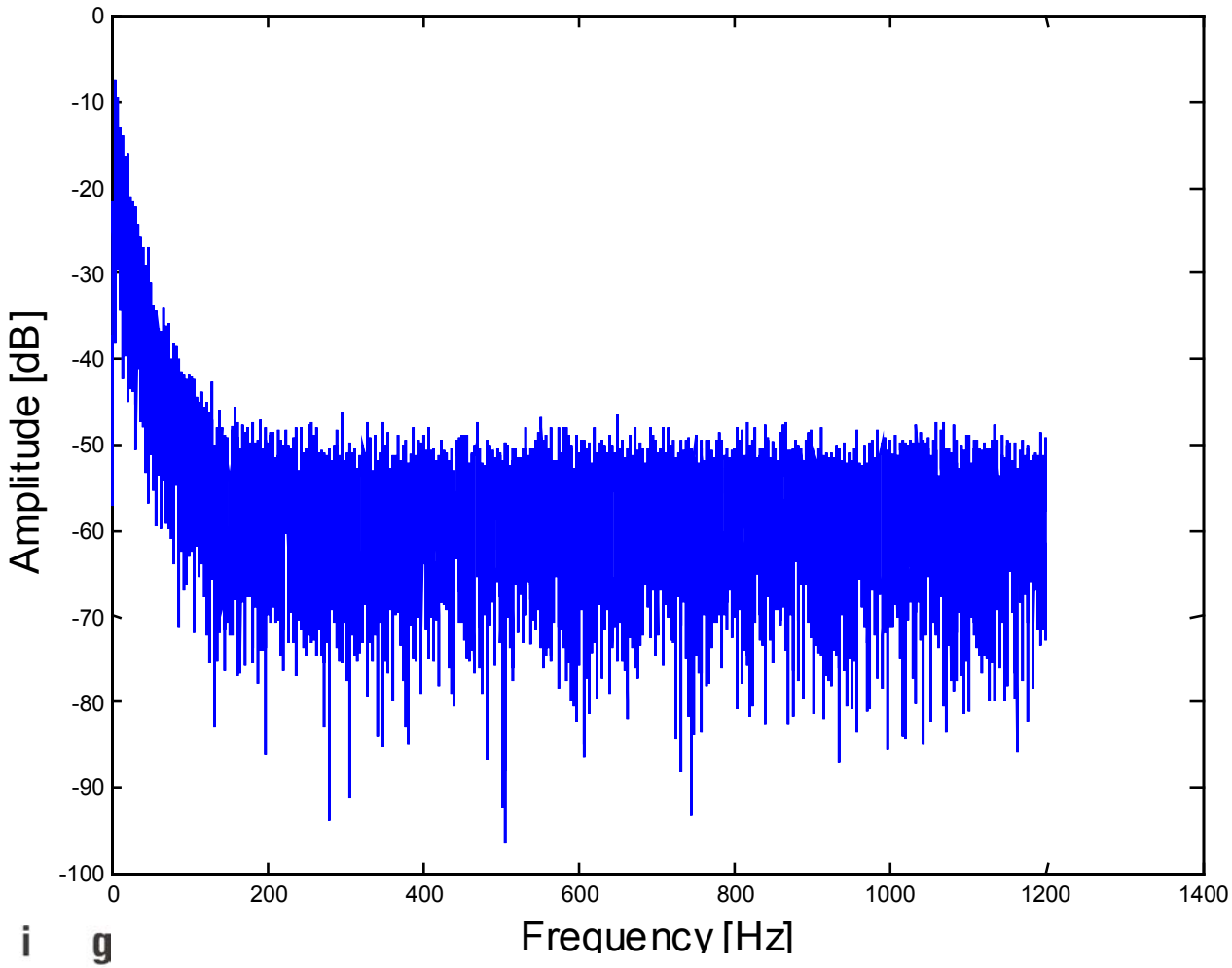
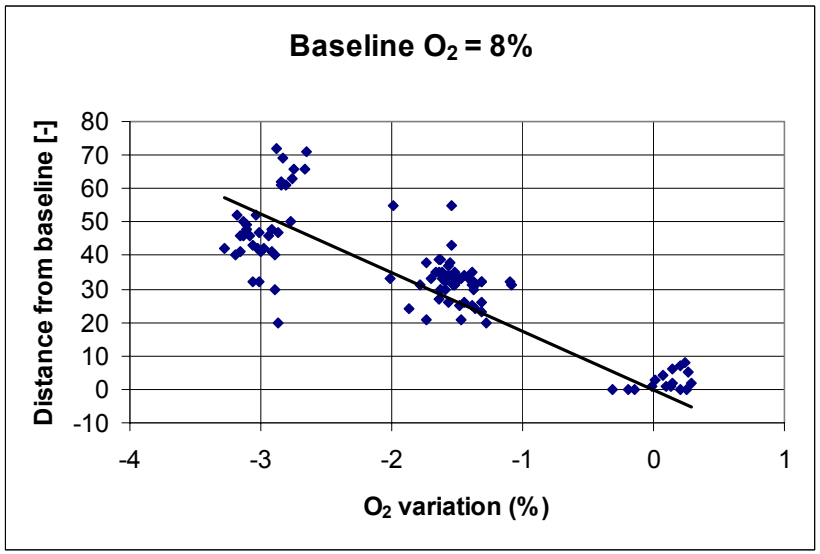
Initial results

- Signature frequencies much lower than with forced draught burners
- Reproducible results with UV/visible sensor



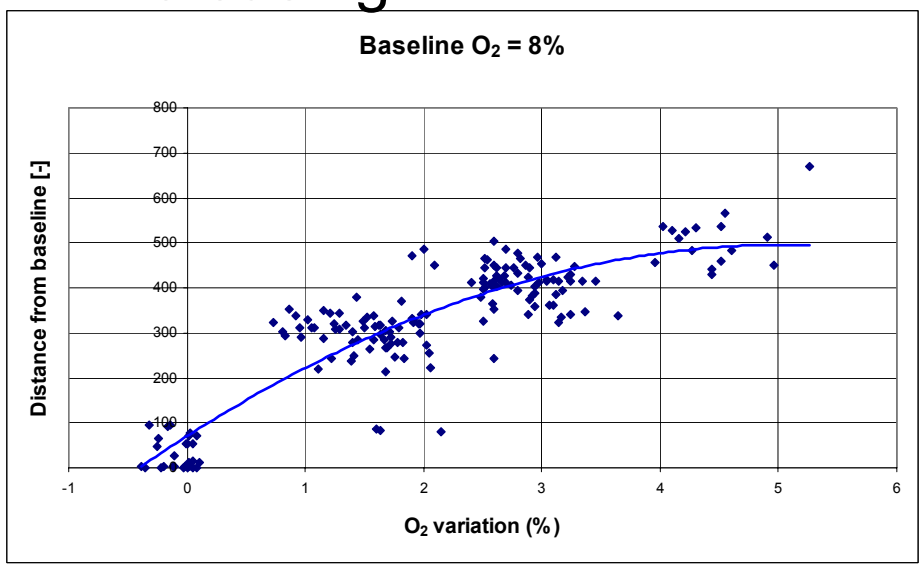
Wavelet distance as a function of flue-gas oxygen



- 200 kW Müller AG Boiler
- wood chips and saw dust
- single UV/visible sensor

decreasing λ

increasing λ



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Veolia environment wood fired experimental boiler

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Conclusion and future perspectives

- Several low-cost methods are in development for biomass combustion control:
  - a) Fuel: In-line moisture indication
  - b) Flue-gas : micro gas sensors for CO/HC and O2
  - c) Flame: optical indication of fuel type and excess air
- b) and c) methods already proven and partially implemented in industrial oil burner controllers
- Low cost and direct monitoring of excess air variation
- Easy to implement on wood-fired boilers
- Optical sensor features:
  - Fast response (~ 5 seconds)
  - Potential for air flow adjustment along the grid
  - Long life time without drift

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Acknowledgements

- Financial and technical support of the CREED (the center for environment, energy and waste research) - Veolia Environnement's research center based in Limay (France)
- City of Geneva in providing access to their 1MW wood-burning boiler for the experimental work.

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