OPTIMISATION OF WOOD-FIRED BOILERS USING OPTICAL SENSORS

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Outline

- University of Applied Science of Western Switzerland
- The problems of biomass use for district heating
- Sensor principle
- Early results
- Future perspectives

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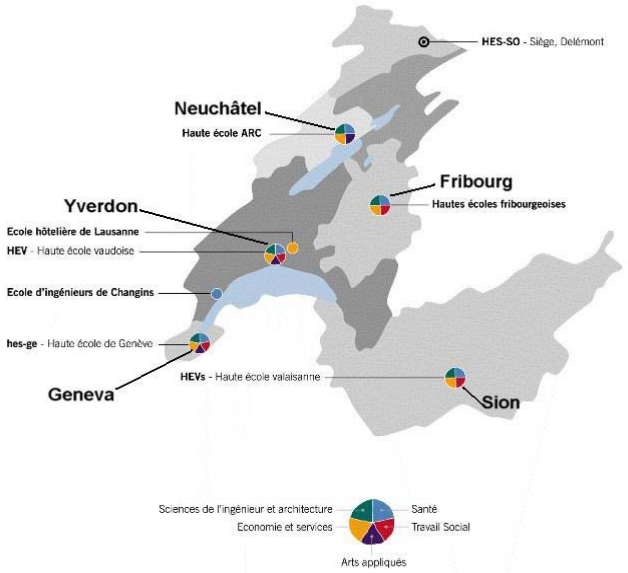
University of Applied Science of Western Switzerland



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Main R&D activities

Fluid mechanics and energy conversion systems Lab, Geneva

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

Thermal Engineering Institute, Yverdon

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

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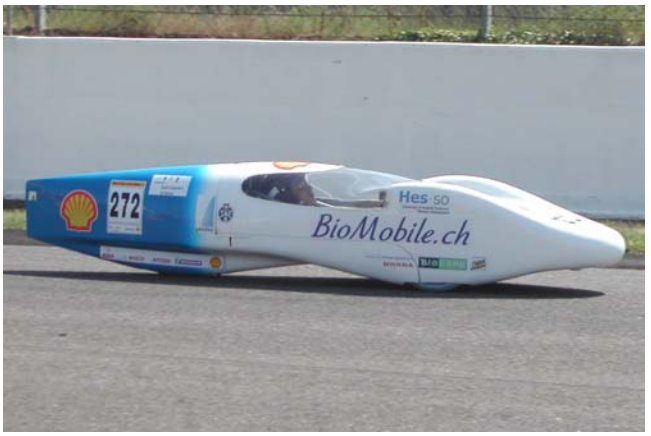
Participation to Shell Eco-Marathon race

Shell Eco-marathon
15 et 16 mai 2004
Circuit de Nogaro
"PRIX DU DESIGN"
2ème Prix



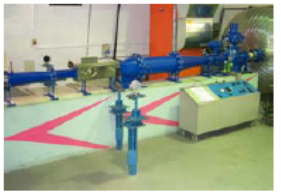
- 2004: 123.4 km with 0.1 litre of benzine
- 2005: Use of biobenzine

Equipments

Soufflerie subsonique

2 veines de mesure : 2.0 x 1.5 [m²] vitesse de 280 [km/h]
3.4 x 3.4 [m²] vitesse de 150 [km/h]

Soufflerie supersonique



Veine de mesure de 0.12 x 0.08 [m²] vitesse de 3000 [km/h]

Lugeurs

Entraînement des lugeurs de l'équipe de France pour les jeux Olympique

Industrial burner/boiler test rig

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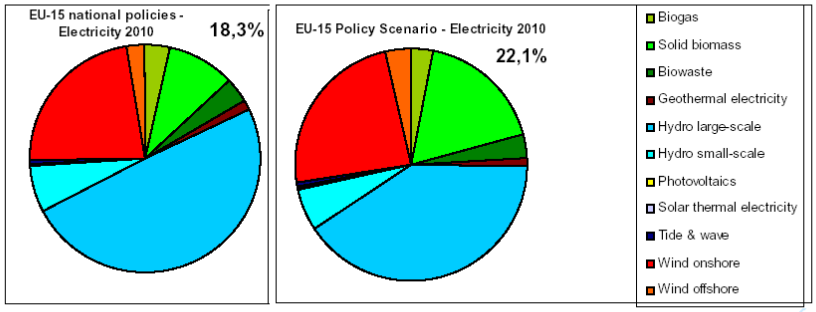
EU report (2003): the share of renewable energy

Currently implemented policies will probably result in a share of between 18% and 19%

RES-E share in 2010 – current national policies vs. practicable scenario



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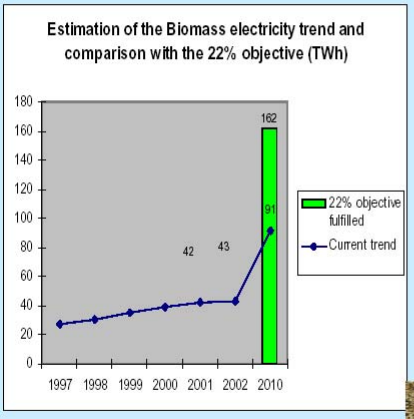
EU report: the share of renewable energy in the EU

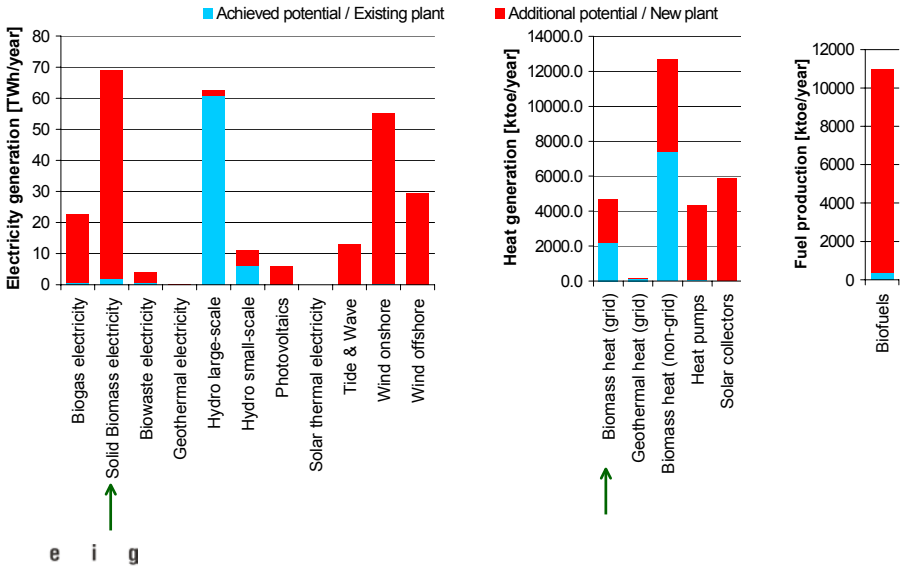
Biomass electricity



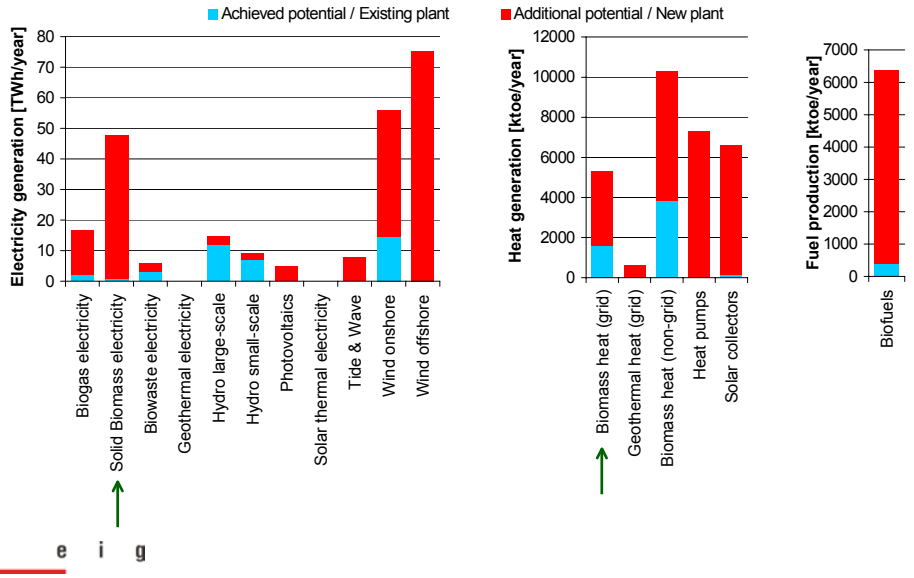
- ✓ 2010 target will only be achieved if biomass contributes 40% to it.
- ✓ Biomass electricity will need to grow by 18%/year compared to 7% during the past 7 years.
- ✓ Additional need of around 32 Mtoe – indicative figure on the biomass availability for energy purposes at EU15 level is 150 Mtoe (additional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

Directorate general for Energy and Transport Information - Communication

Example: French potential of renewables



Example: German potential of renewables



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Factors limiting the increase of biomass for heating

- Availability of the biomass
- Storage
- Investment costs
- 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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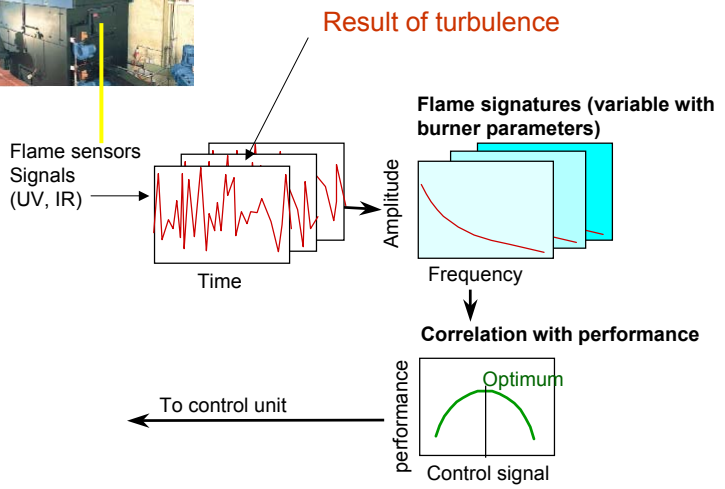
Flame quality sensor principle (CSEM patent)



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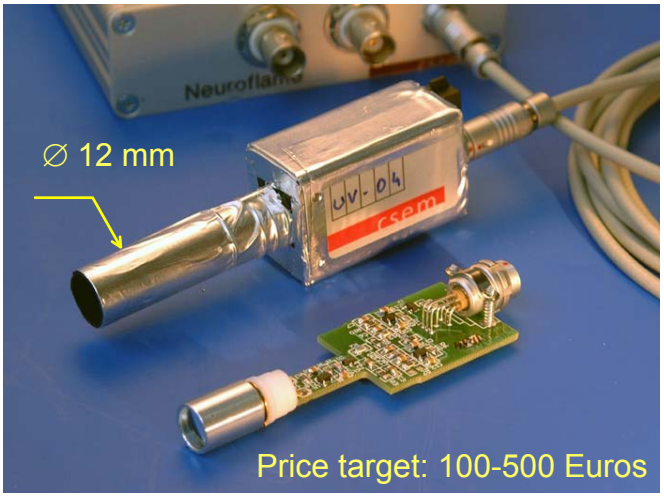
« Neuroflame » sensor



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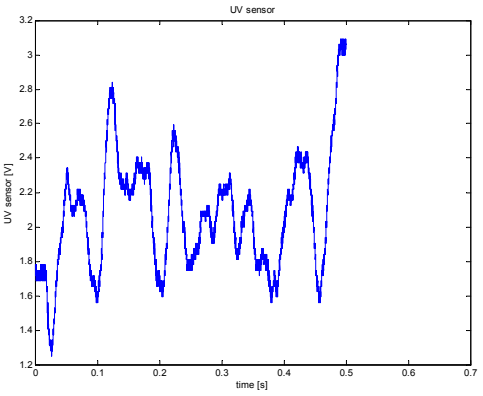
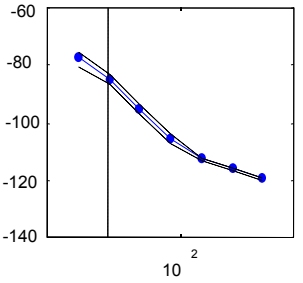
Example of raw signal



Fourier transform



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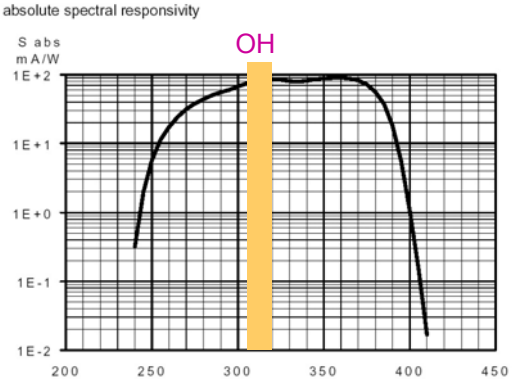
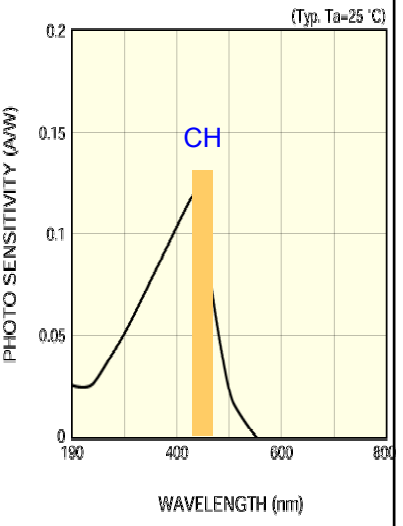
GaP sensor responses



EPD 365-0/2,5



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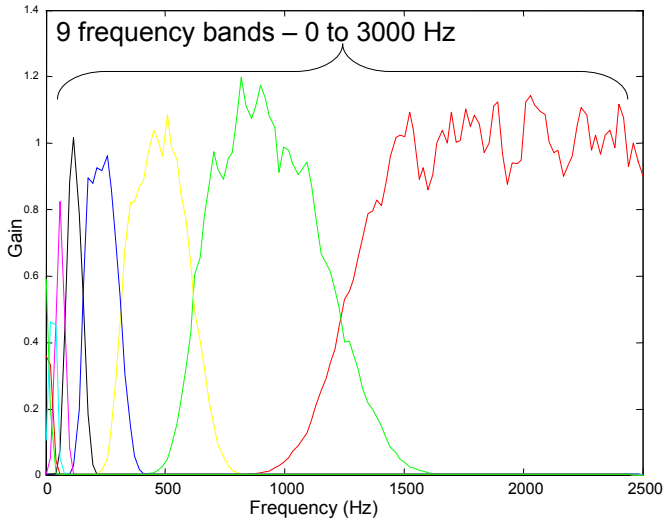
Dyadic time filtering process



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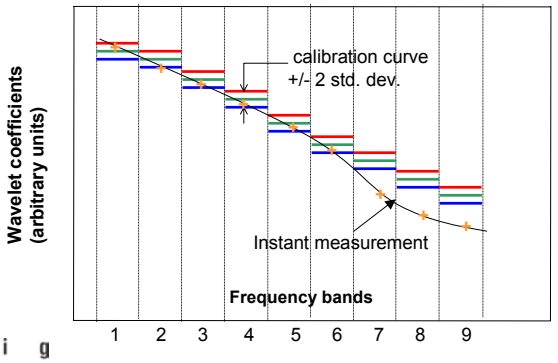
Preventive maintenance scheme

- 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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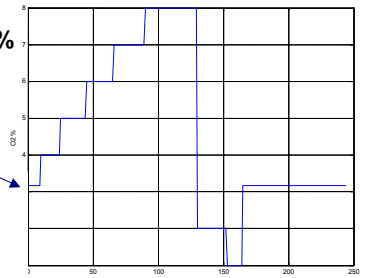
Sensor response to step changes in excess air

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

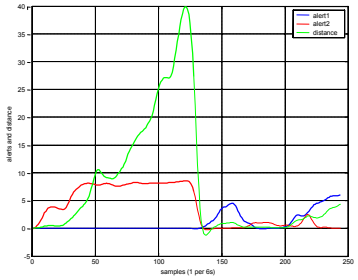
O_2 %



Alert 1(b)

Alert 2 (r)

Dist (g)



Samples (1 per 6 s)

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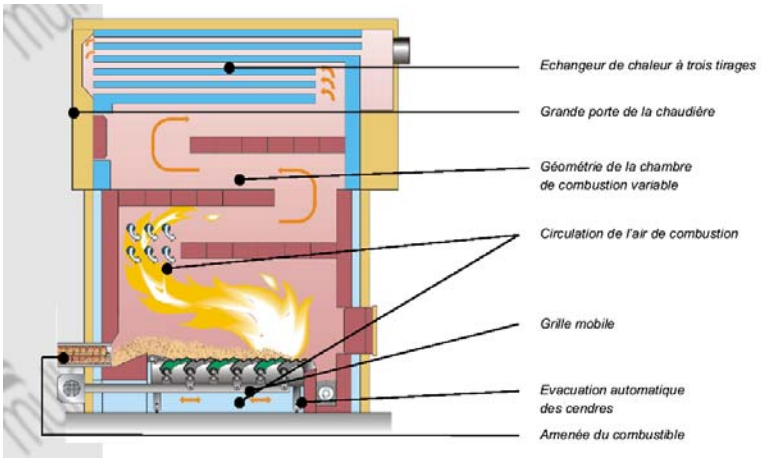
Müller AG – Boiler schematic

- Suitable for variety of wood and wood wastes – variable moisture content - 80 to 1300 kW
- Turn-down 30%



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Wood chips and bark

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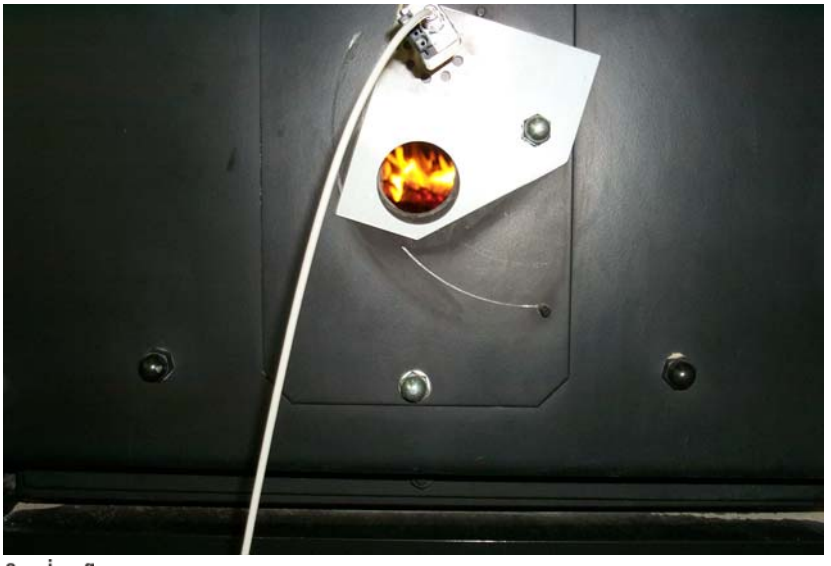
Sensor placement – first trials



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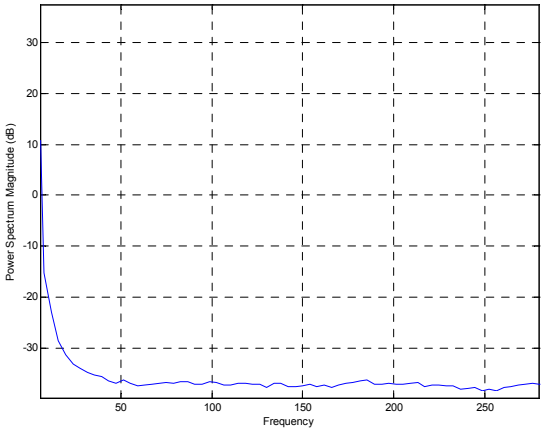
Initial results

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



Furnace from the back

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Conclusions

- Method already proven and partially implemented in industrial oil burner controllers
- Low cost and direct monitoring of excess air variation
- Potentially easy to implement on wood-fired boilers with some improvements needed
- Single sensor for flame detection and flame quality
- Mesures through the flame – not in the flue
  - Fast response (200 ms.)
  - Potential for air adjustment along the grid
- Long life time without drift
- Very suitable for preventive maintenance

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