Worshop LAB^{TQ} – MARCOGAZ Brussels

NO_X in EN standards

Test conditions

- *Heat input : +/-2%*
- *Gas composition → comply with EN standards*
  - *Preferably G20*
- *Excess air → as constant as possible*
- *Ambient air used for combustion → no pollution (contamination by NO_X or CO, etc)*
  - *CO - NO_X - CH4 < 1 ppm*
    - ☞ *still air and ventilated testing room*
- *Reference conditions*
  - *Temperature = 20°C*
  - *Humidity = 10 g H2O/kg dry air*

Conversion and corrections

- *Measurement of NO_X emissions under the test conditions in ppm-volume (ml/m3)*
  - *analysis based on dry or wet flue gas sampling*
- *Conversion of ppm-volume to dry and air free (0% O_2) or other O_2 concentrations (3 - 6 - 10%)*
- *Conversion of NO_X from ppm-v (x% O_2) to mg/kWh*
- *Correction to reference conditions*
  - *Ambient temperature and humidity*
  - *Reference gas if distributed gas is used*

Correction to reference conditions (T - H)

$$NO_{x,o} = NO_{x,m} + \frac{0{,}02\,NO_{x,m} - 0{,}34}{1 - 0{,}02(h_m - 10)}(h_m - 10) + 0{,}85(20 - T_m)$$

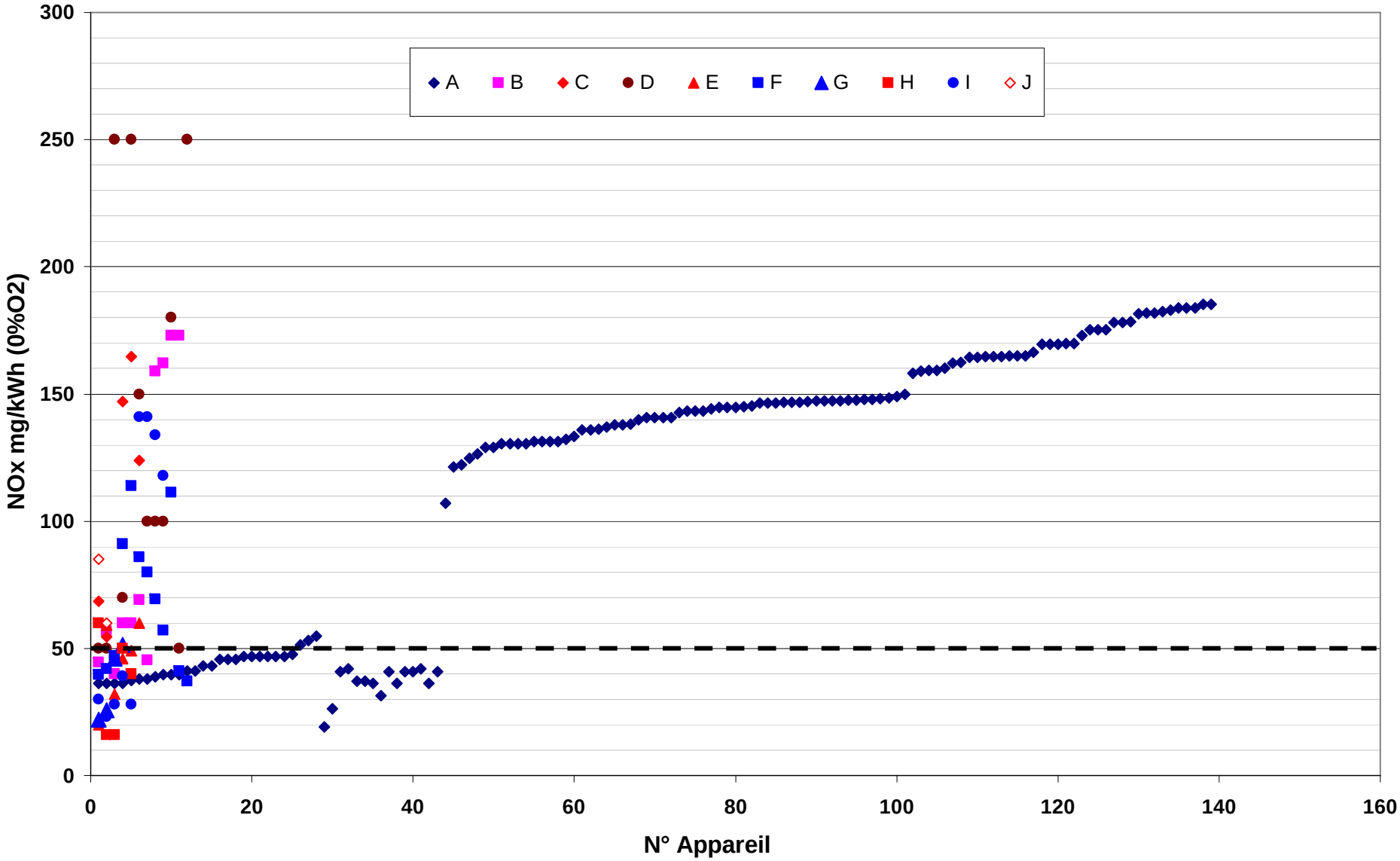
- $NO_{x,0}$: NO_X corrected to reference conditions
- $NO_{x,m}$: measured NO_X from 50 to 300 mg/kWh
- h_m : ambient humidity from 5 to15 g/kg dry air
- T_m : ambient temperature from 15 to 25°C

- Derived from the results of a project (1991) supported by the commission with the participation of CETIAT – DGC – GASTEC
  - ☞ Convenient for ON/OFF boilers with atmospheric burners

Correction not valide …

- *NO_X emissions of new boilers below 50 mg/kWh*
- *Correction gives sometimes negative values*
- *…. Benchmarks for NO_X emissions for Eco-design very low*
  - ☞ → *35 mg/kWh*
- *Think about a new method of correction for low NO_X*

Declared NO_X gas boilers



Proposal for a new method

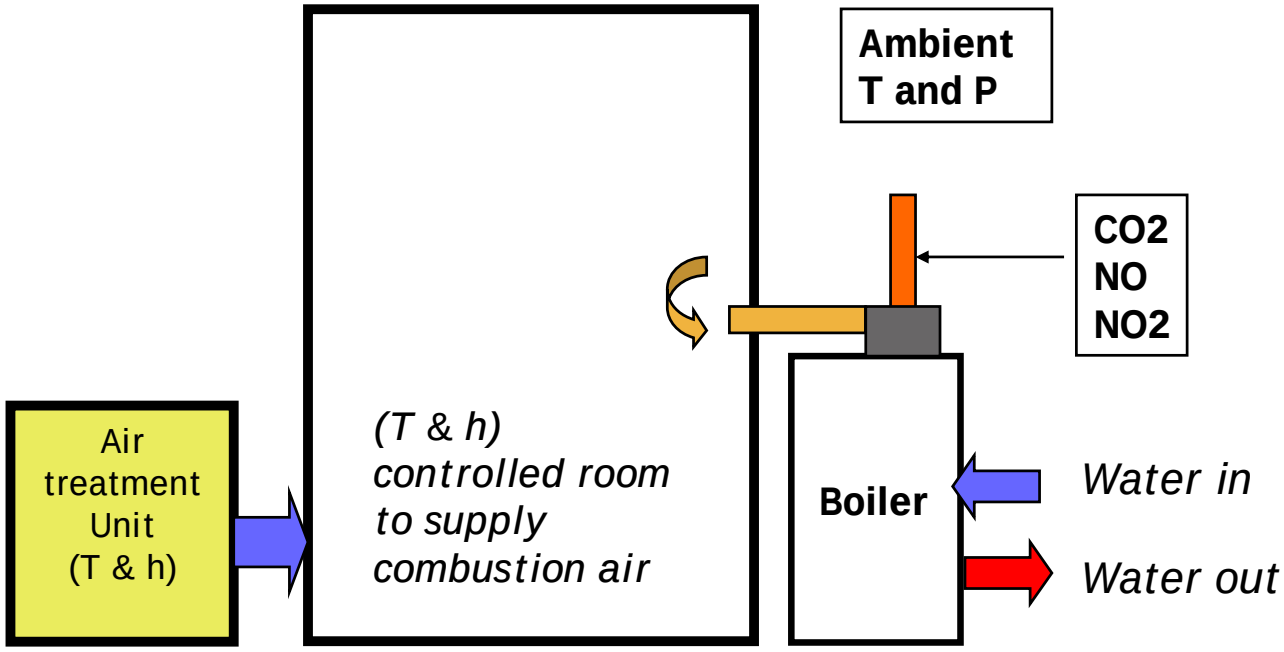
- *Think about a new correction formula for emissions below 50 mg/kWh based on*

- *Experimental work → testing*
- *Theoretical work → effect of ambient humidity and temperature on NO_X emissions*

- *Could be based on concentration of CO2 or O2 in the flue gas*

New approach

- *Investigation done at CETIAT on a room sealed modulating and condensing gas boiler*
  - *Heat output from 5 to 24,5 kW*
  - *NO_X below 50 mg/kWh*



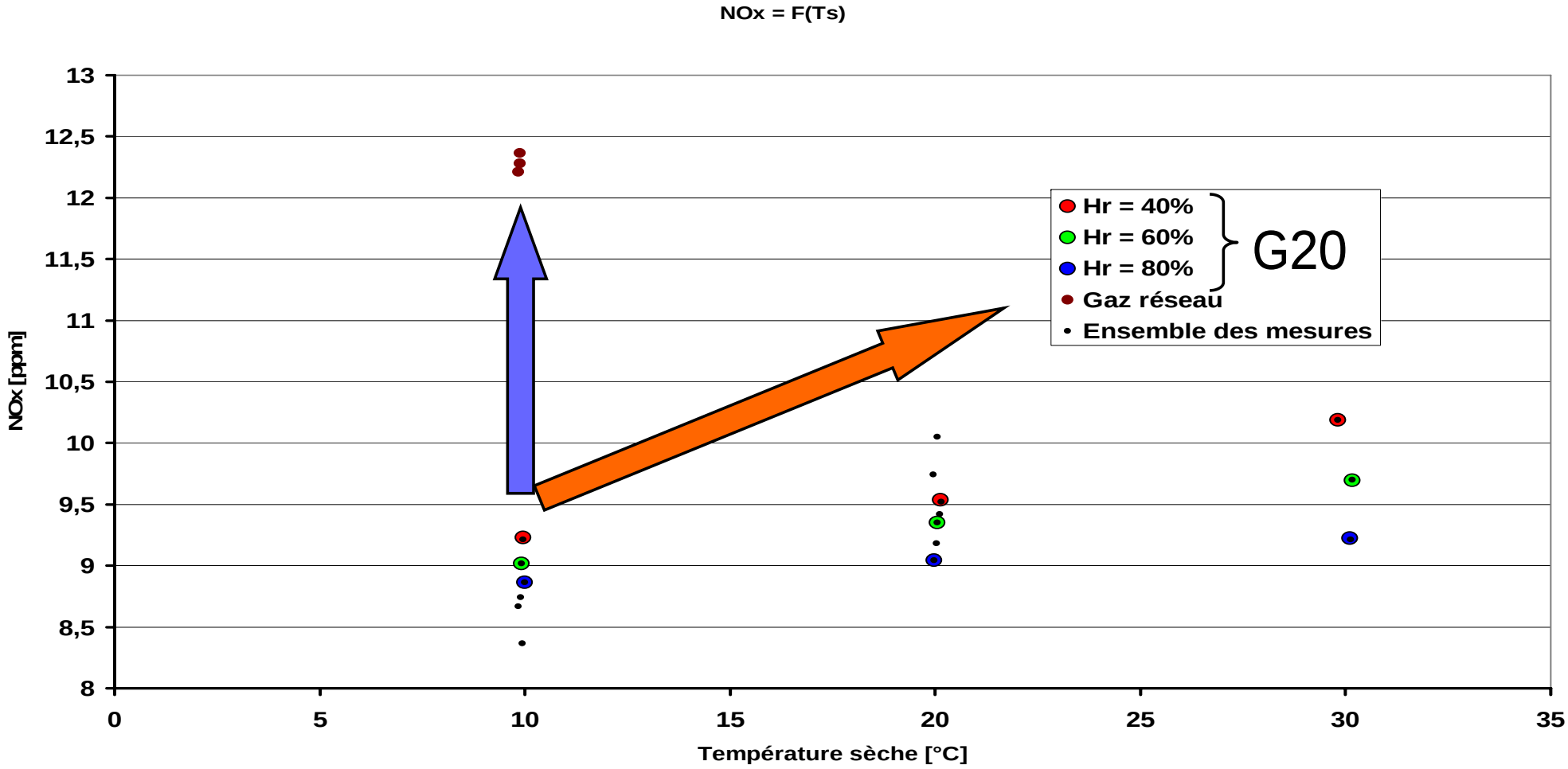
Test programme

- *Air temperature constant : NO_X measured at 40/60/80% humidity (air ratio)*

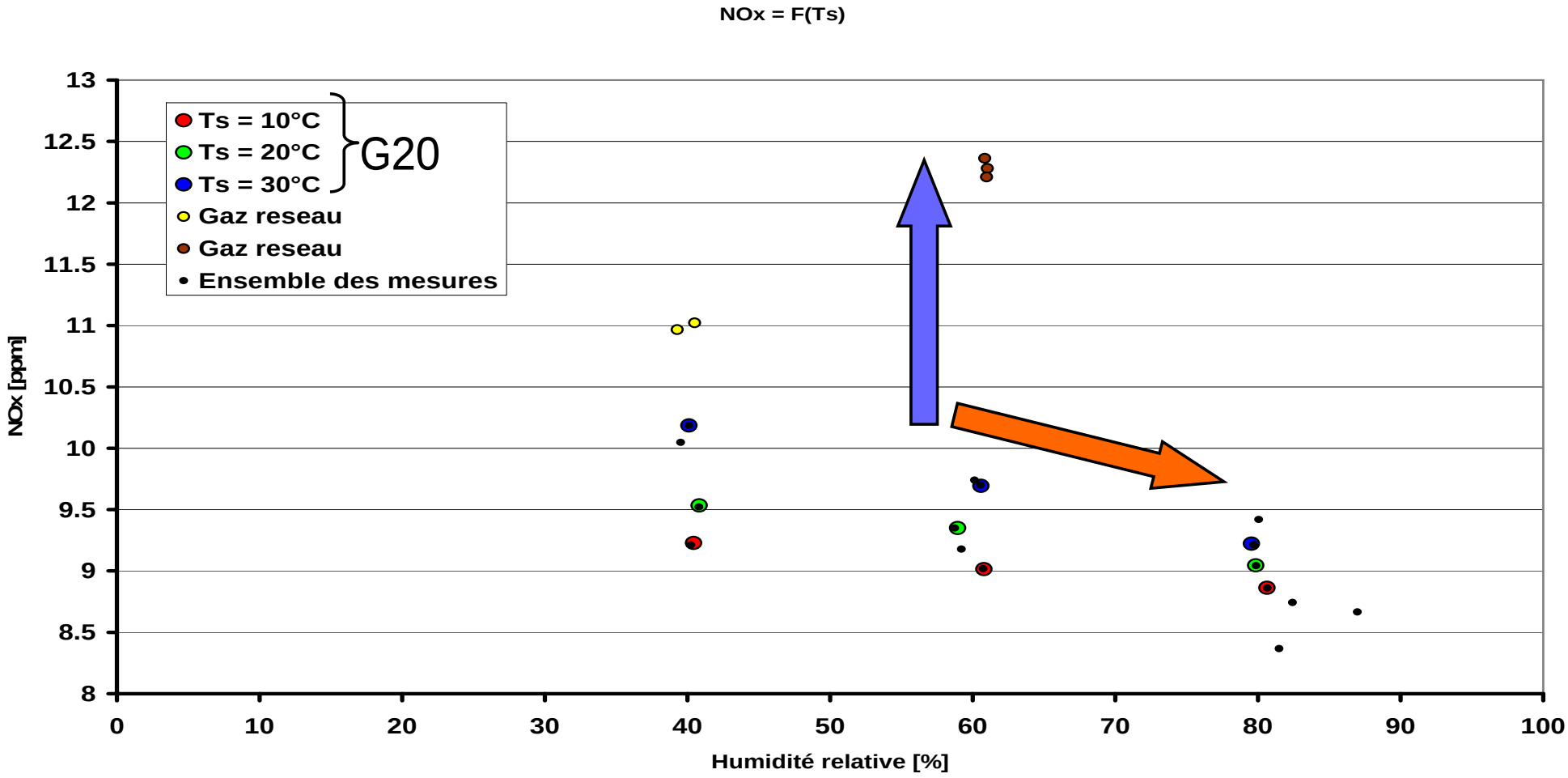
- *Air humidity constant : NO_X measured at 10/20/30°C*

  - *Tests done mostly with G20 and few with distributed gas to check the effect on higher hydrocarbons on NO_X emissions*

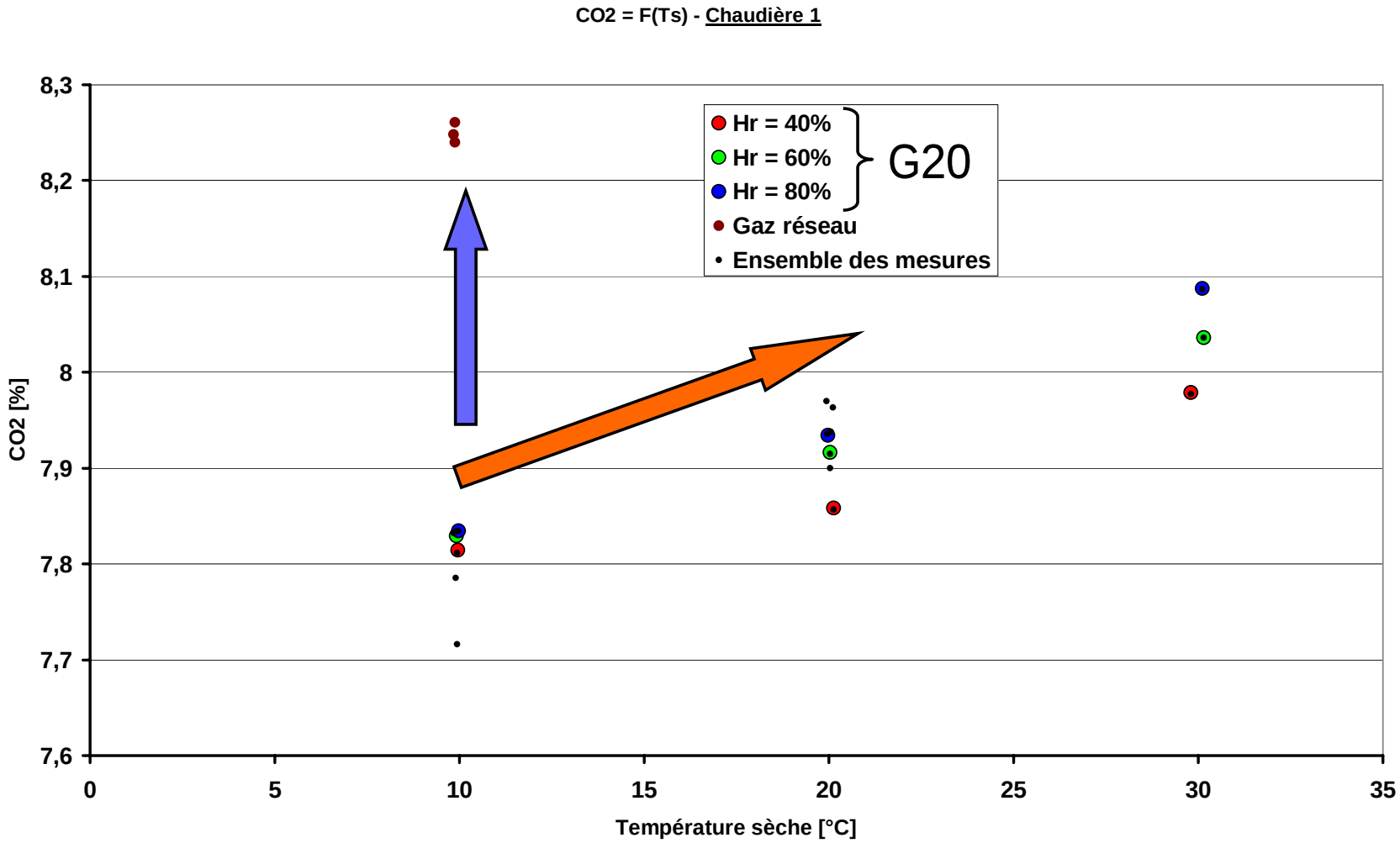
- *NO_X emissions increase with combustion air temperature and with type of gas*



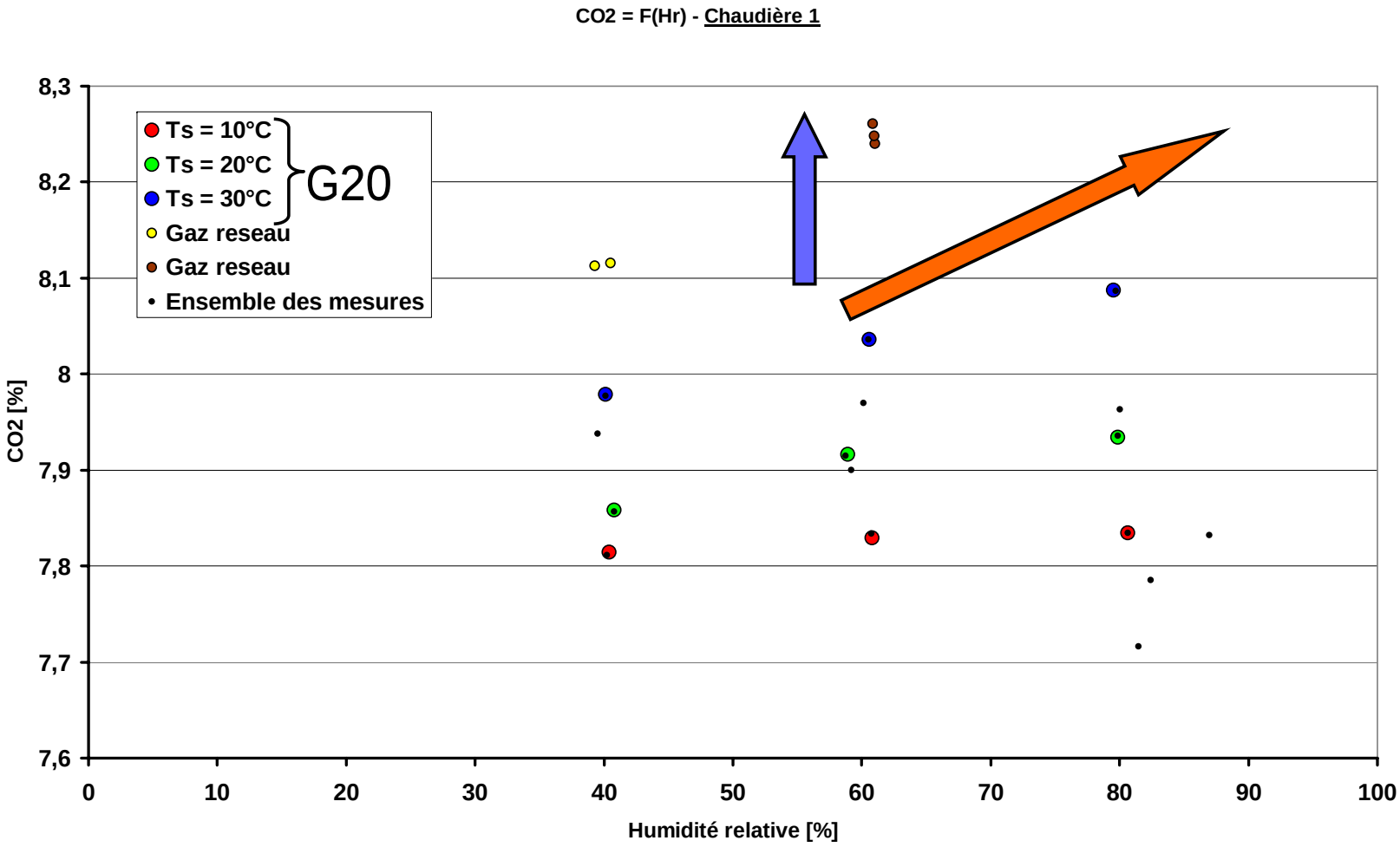
- *NO_X emissions decrease with air humidity and type of gas*



- *CO_2 increases with air temperature and type of gas*



- *CO2 increases with humidity and type of gas*



Effect of air (T and h) and type of gas on CO_2

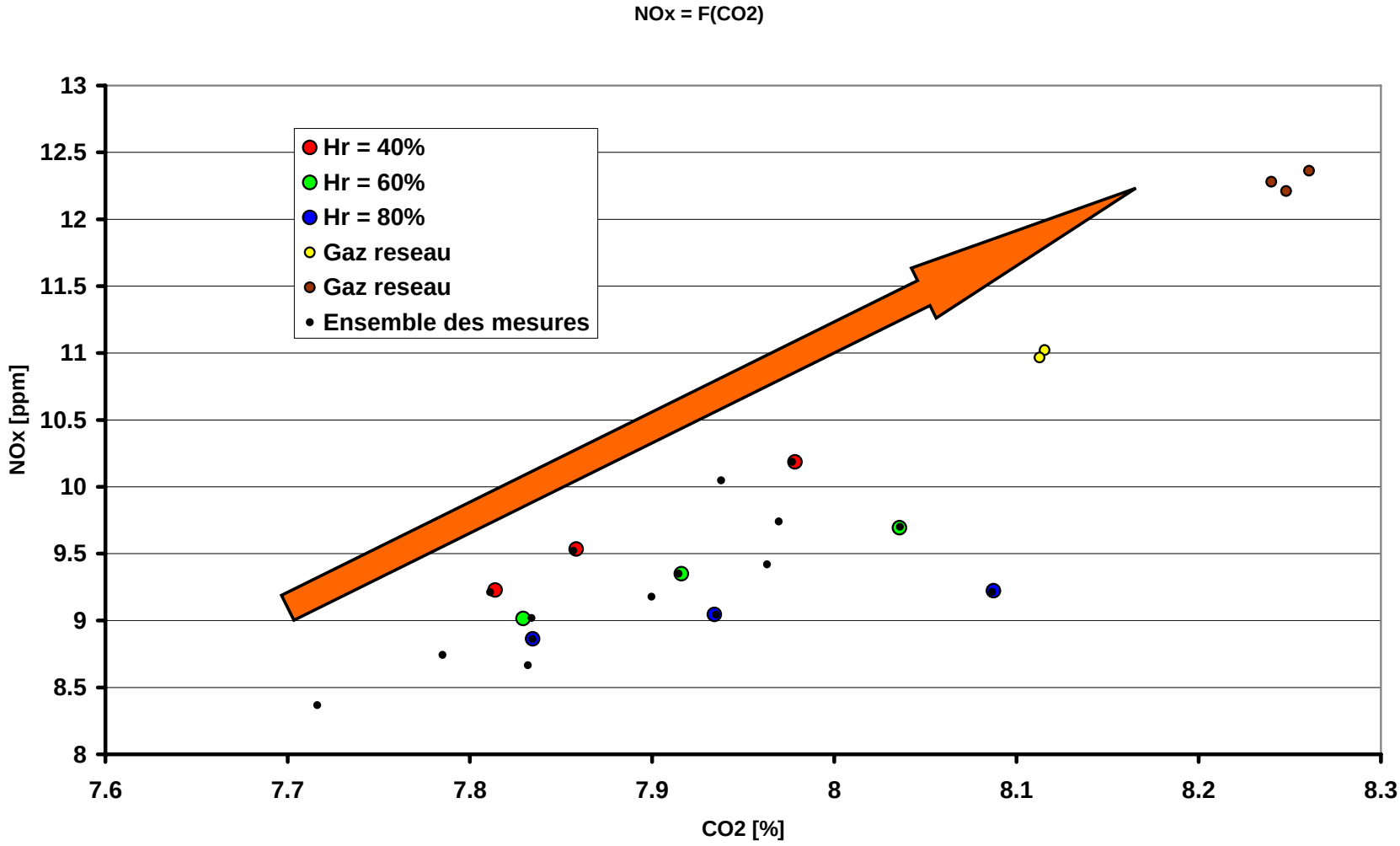
- *CO_2 increases when distributed gas is used*
  - *→ Evident because of the presence of C3H8, C2H6 in distributed gas*

- *CO_2 varies also with the air temperature and humidity*
  - *Modification of excess air and oxygen concentration in the flue gases*
    - *Modification of the flue gases temperature*

- *CO_2 Depends strongly on the burner technology and its control*

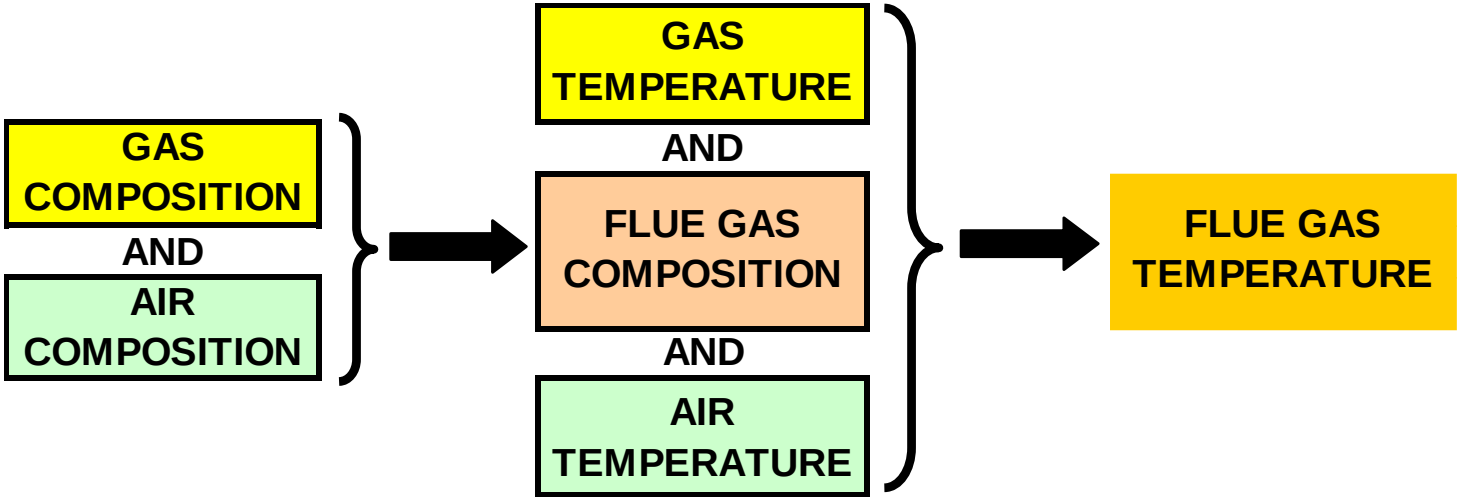
Effect of CO_2 on NO_X (from measurements)

- *NO_X increases with CO_2*



Flue gas temperature before the heat exchanger

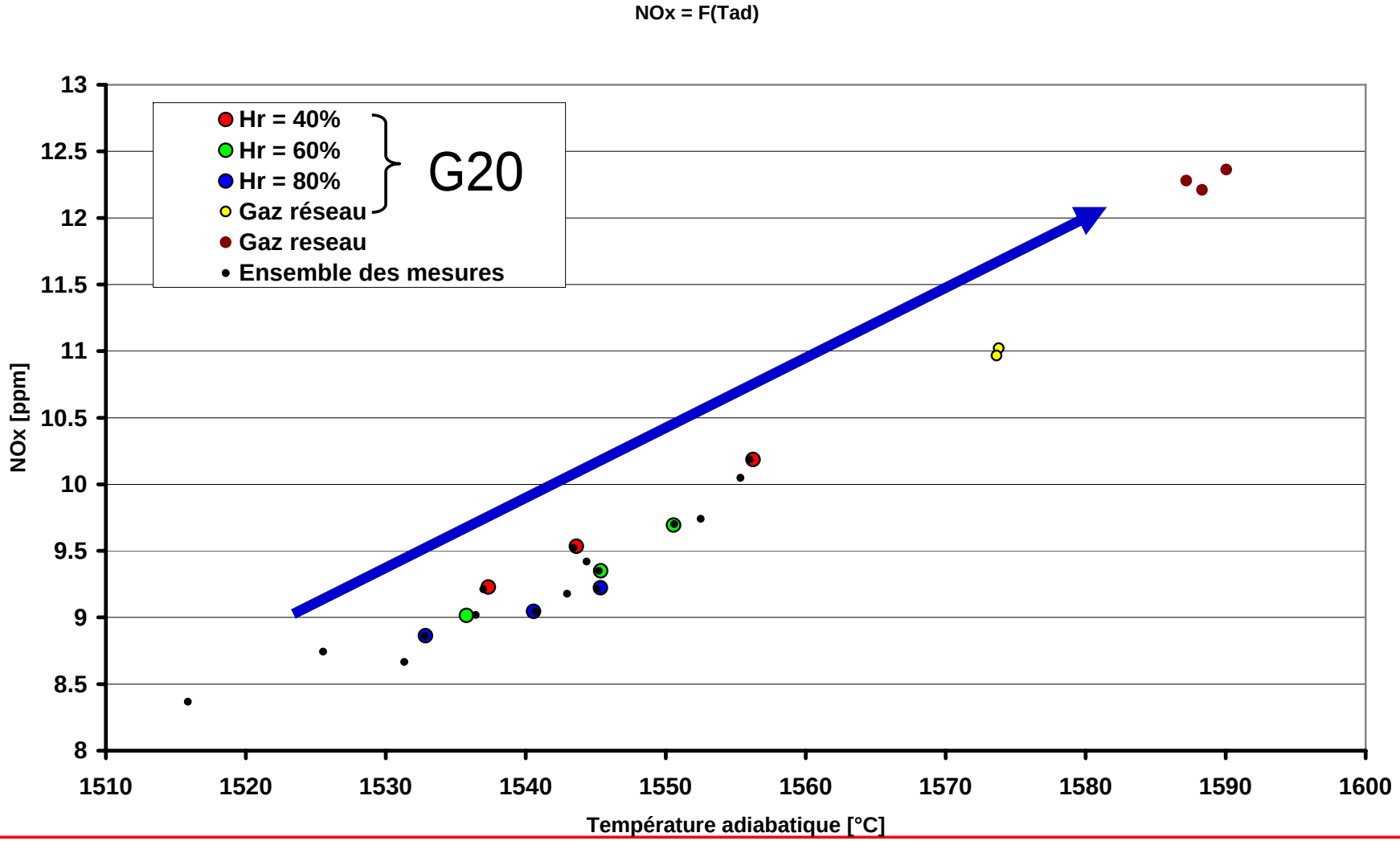
- *The best control parameter is the flue gas temperature which can be calculated accurately for each test point*



- *The flue gas temperature was calculated by a software developed by CETIAT for each point of the curve (CO_2/NO_X)*

NOX = f(Flue gas temperature)

- *NO_X depend strongly on the flue gas temperature*



Conclusions

- *NO_X emissions increase with air Temperature and decrease with air Humidity*
- *NO_X emissions increase with CO_2 and with flue gas temperature*
  - *The burner reacts to air Temperature and Humidity variations by changing the CO_2 in the flue gases*
  - *CO_2 variation implies a variation of the flue gas temperature which implies the variation of NOX emissions*
- *The technology and the control of the burner may affect also NO_X emissions*

Conclusions

- *A general formula for correction based on air temperature and humidity variation is not easy for low NO_X emissions knowing the importance of the uncertainty of such measurements*
  - *Solution 1 : Perform the measurements at reference conditions of temperature and humidity inside an air conditioned room*
    - → *NO correction needed but costly*
  - *Solution 2 : develop a correction method for low NO_X emissions with the support of the different stakeholders*
    - *CEN TC 238 / Marcogaz/Commission*

Objectives of such study

- *Effect of the temperature and humidity of the combustion air on low NO_X emissions of boilers and other gas appliances (water heater – burners)*
- *Any study for a project requires a clear mandate for a pre-normative work and consists of*
  - *Bibliography and state of the art*
  - *Theoretical analysis of the production of NO_X emissions*
  - *Testing programme on several appliances according to a defined protocol to get maximum number of test data*
  - *Development of a correction formula (s)*

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Thank you

for your attention.