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# Turbulent combustion with oxygen enrichment and capture of CO<sub>2</sub> in industrial boilers of medium power



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## CO<sub>2</sub> EnergiCapt project

- ✓ **Period** : 2010-2015
- ✓ **Support** : ANR French National Research Agency
- ✓ **ANR grant**: 1 261 469€
- ✓ **Subject**: Integration of oxygen-enriched air combustion and CO<sub>2</sub> capture for existing industrial boilers: development of a demonstrator

## Project partners

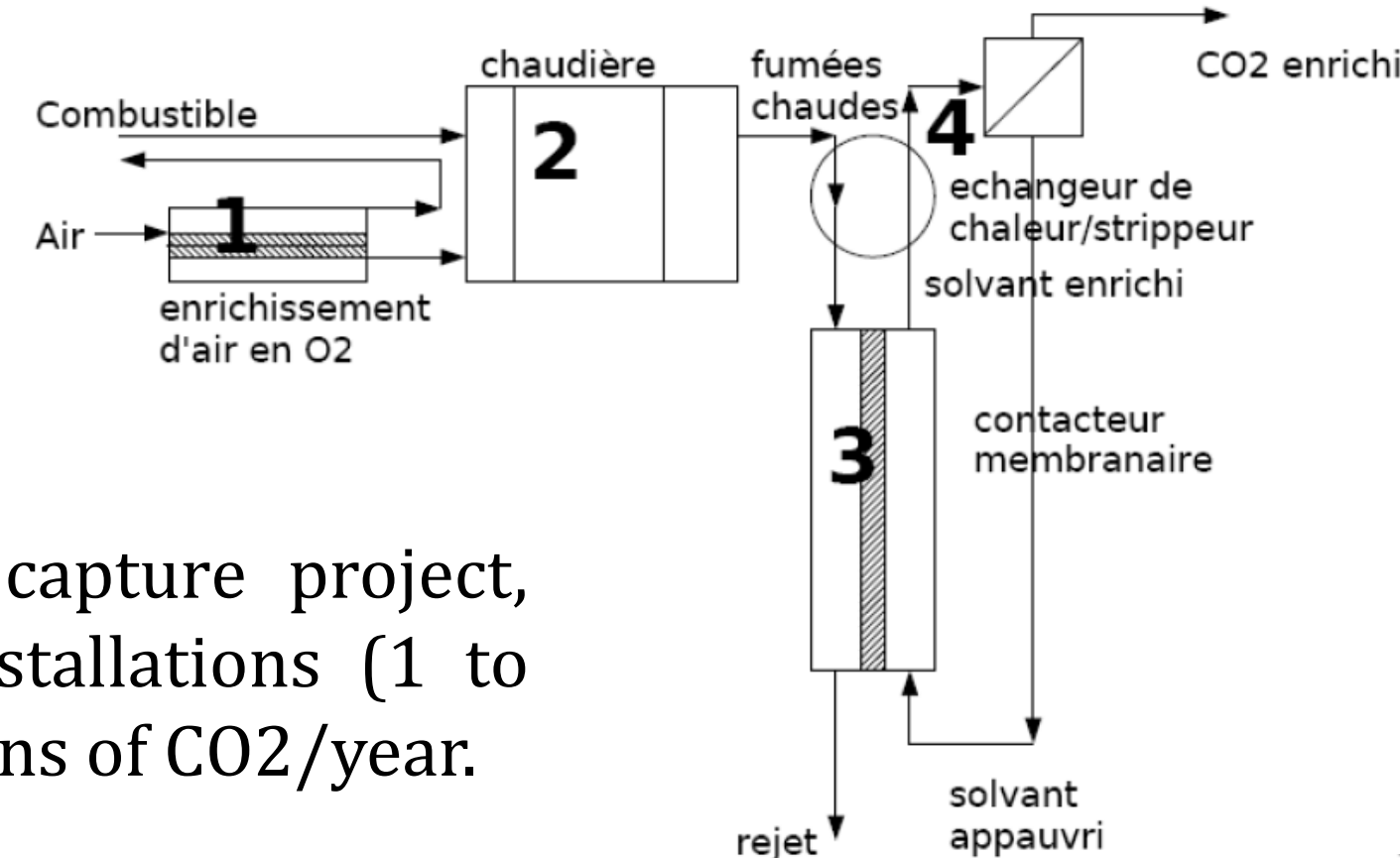
- ✓ **ICARE CNRS**, specialist in combustion
- ✓ **LRGP CNRS**, specialist in capture of CO<sub>2</sub>
- ✓ **LLT** «Leroux et Lotz Technologies», manufacturer of industrial equipments
- ✓ **Polymem**, manufacturer of fiber membranes for fluid treatments
- ✓ **CPCU**, operator of boilers of the Paris metropolis

## Objective

- ✓ **Optimization of industrial boilers** by the combination of **combustion air enriched** with oxygen and reducing CO<sub>2</sub> by a membrane capture.
- ✓ Development of a **CO<sub>2</sub> capture pilot unit** dedicated to district heating heat production units and validate it on an industrial site

## Description of CO<sub>2</sub> EnergiCapt project

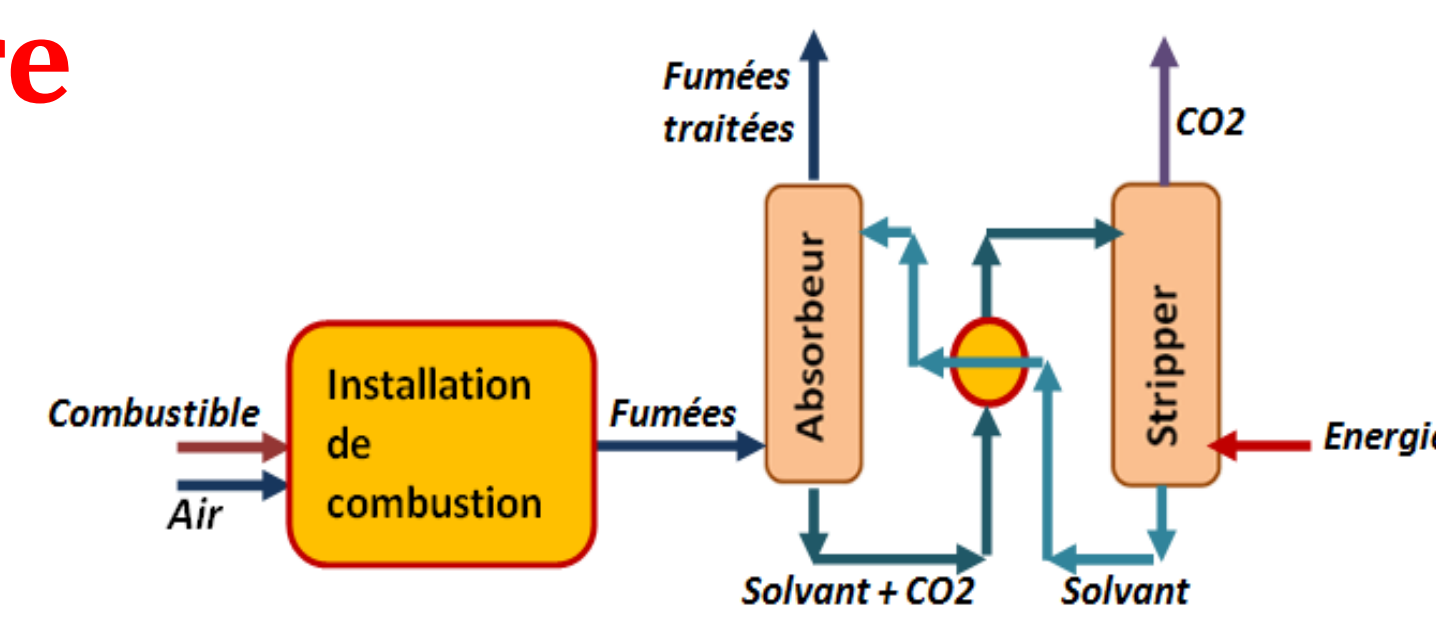
- 1 - Oxygen Enriched Air
- 2 - Combustion
- 3 - CO<sub>2</sub> capture
- 4 - Exchanger for CO<sub>2</sub> separation



✓ CO<sub>2</sub> EnergiCapt is an innovative CO<sub>2</sub> capture project, intended primarily for medium-power installations (1 to 100 MW), i.e. emitting 25,000 to 100,000 tons of CO<sub>2</sub>/year.

## Post-combustion CO<sub>2</sub> capture

- ✓ **Step 1 - Absorption**: This step consists in putting the flue gas in contact with a solvent having a chemical affinity with CO<sub>2</sub> in order to absorb it. The flue gas are then evacuated without the initial carbon dioxide.
- ✓ **Step 2 - Desorption**: this step consists of providing energy to break bonds between the CO<sub>2</sub> and the solvent. The latter is then regenerated and reused to absorb CO<sub>2</sub> in step 1. The CO<sub>2</sub> is evacuated from the process.



## Originality and application

- ✓ **Technology** : efficient, compact and competitive
- ✓ **Application**: medium power plants (1 to 100 MW). This range of facilities (9% of overall CO<sub>2</sub> production) are almost ignored by CCS projects.
- ✓ **O<sub>2</sub> enriched combustion**: improved combustion ⇒ better thermal efficiency.
- ✓ **Thermal integration** of the solvent regeneration process.
- ✓ **Intensification of mass transfer** and capture by membrane contactors ⇒ better mass transfer.
- ✓ **Conception and realization a pilot**: test and installation on a real boiler.

## Experiments and CO<sub>2</sub> capture results

- ✓ Experiments in real conditions allowed to **validate** the performances of the membrane contactor and to **capture CO<sub>2</sub>** in the CPCU boiler by the CO<sub>2</sub> EnergiCapt pilot developed.
- ✓ Results are **very promising** in terms of CO<sub>2</sub> capture efficiency and the **robustness** of the pilot in terms of startup and **reactivity**.
- ✓ Tests on 10 and 50 m<sup>2</sup> contactors showed that the demonstrator has a **CO<sub>2</sub> abatement rate of about 90%** (with or without MEA regeneration) for flue gas flows of 12 and 150 Nm<sup>3</sup>/h, respectively.

CO<sub>2</sub> capture unit is **currently marketable** by LLT. The unit is **easily integrated** into an existing installation without the need for retrofit.

CO<sub>2</sub> EnergiCapt has won **two national trophies**:

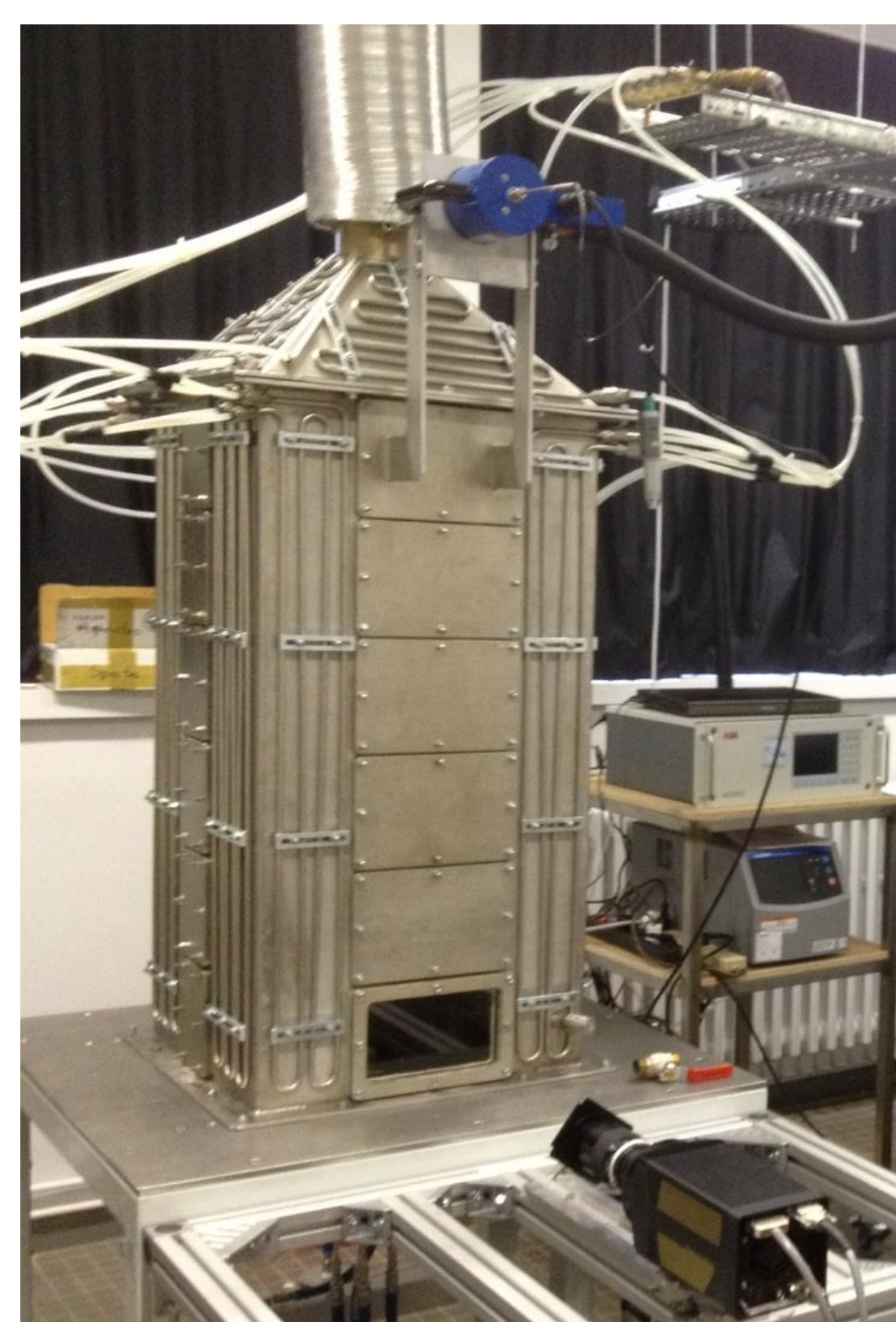
- Trophy for public research on Energy-climate-environment, 2015.
- Energy Transition Trophy in Technology category, 2017.

CO<sub>2</sub>-EnergiCapt demonstrator installed at the CPCU (LLT ®)



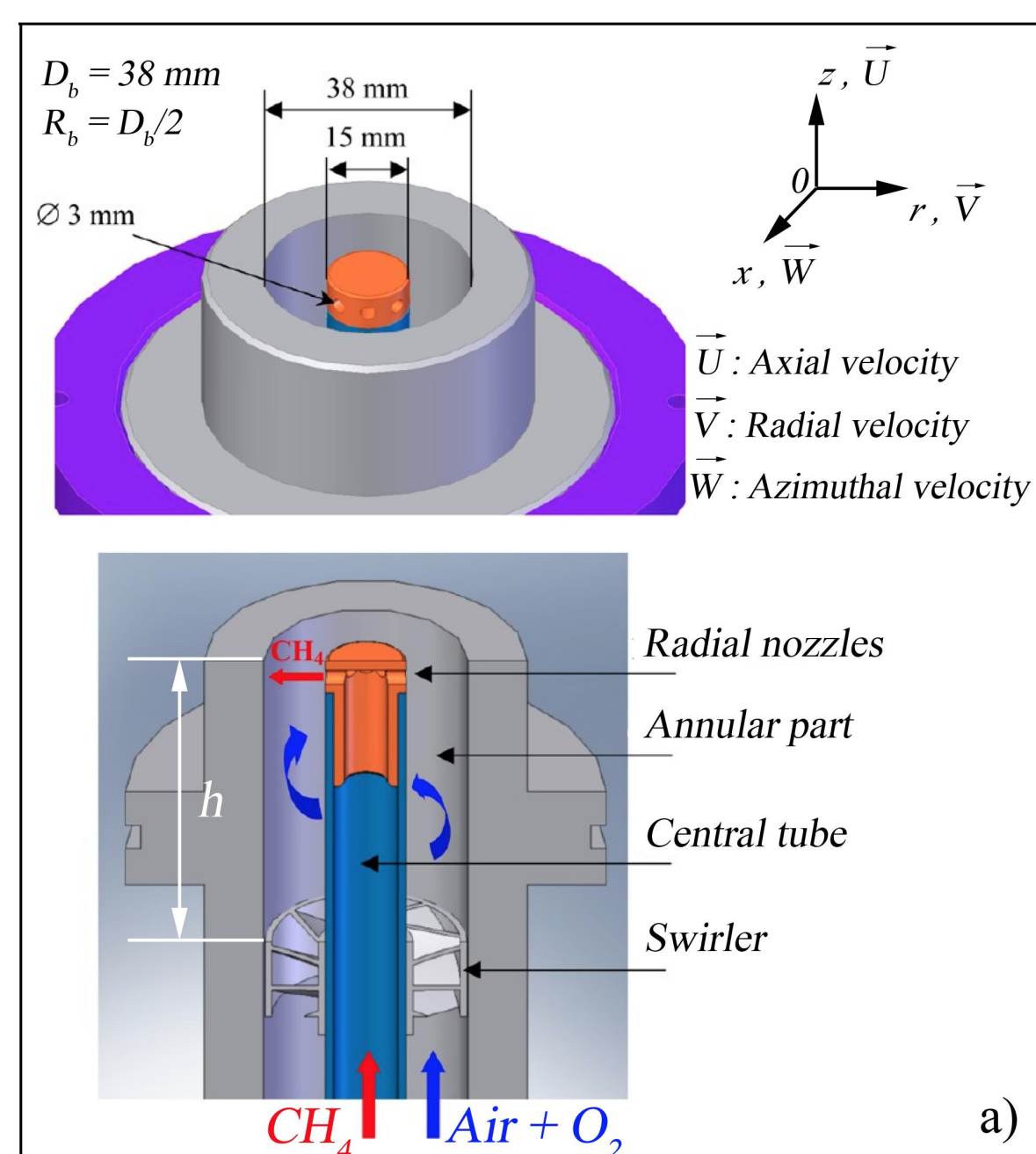
## ICARE-CNRS research results

### Combustion chamber



Combustion chamber with the OH\* Chimiluminescence system and gas analyzers.  
Dimensions 0.5x0.5x1 m<sup>3</sup>  
Power 25 kW.

### Burner

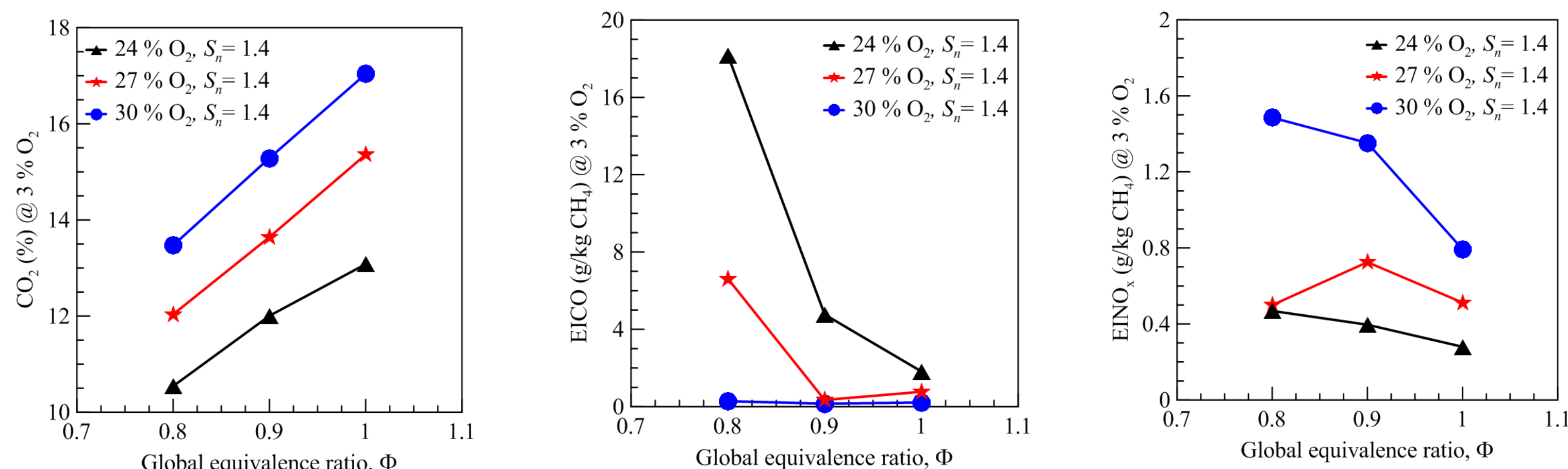


Two concentric tubes with a swirler in the annular part

Example of flame

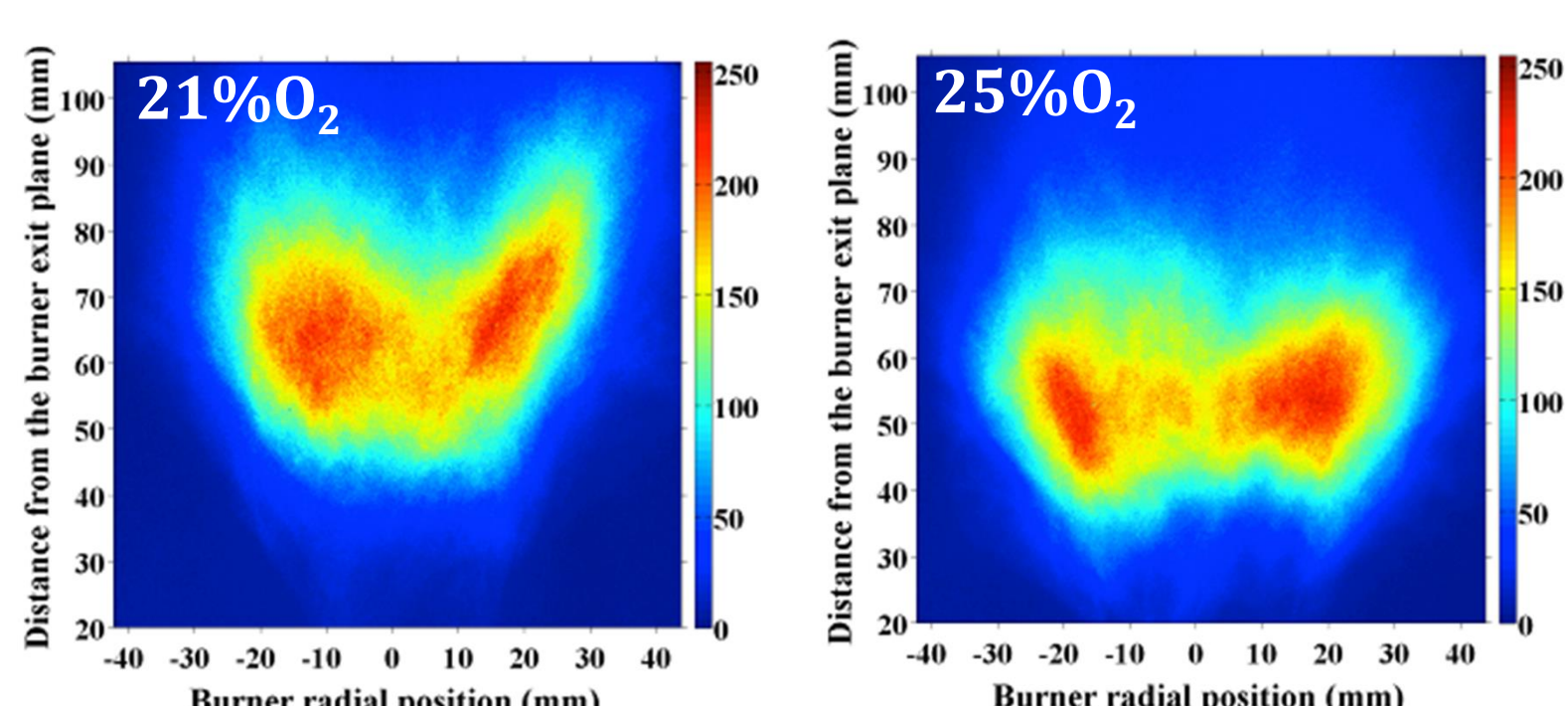


### Pollutant emissions



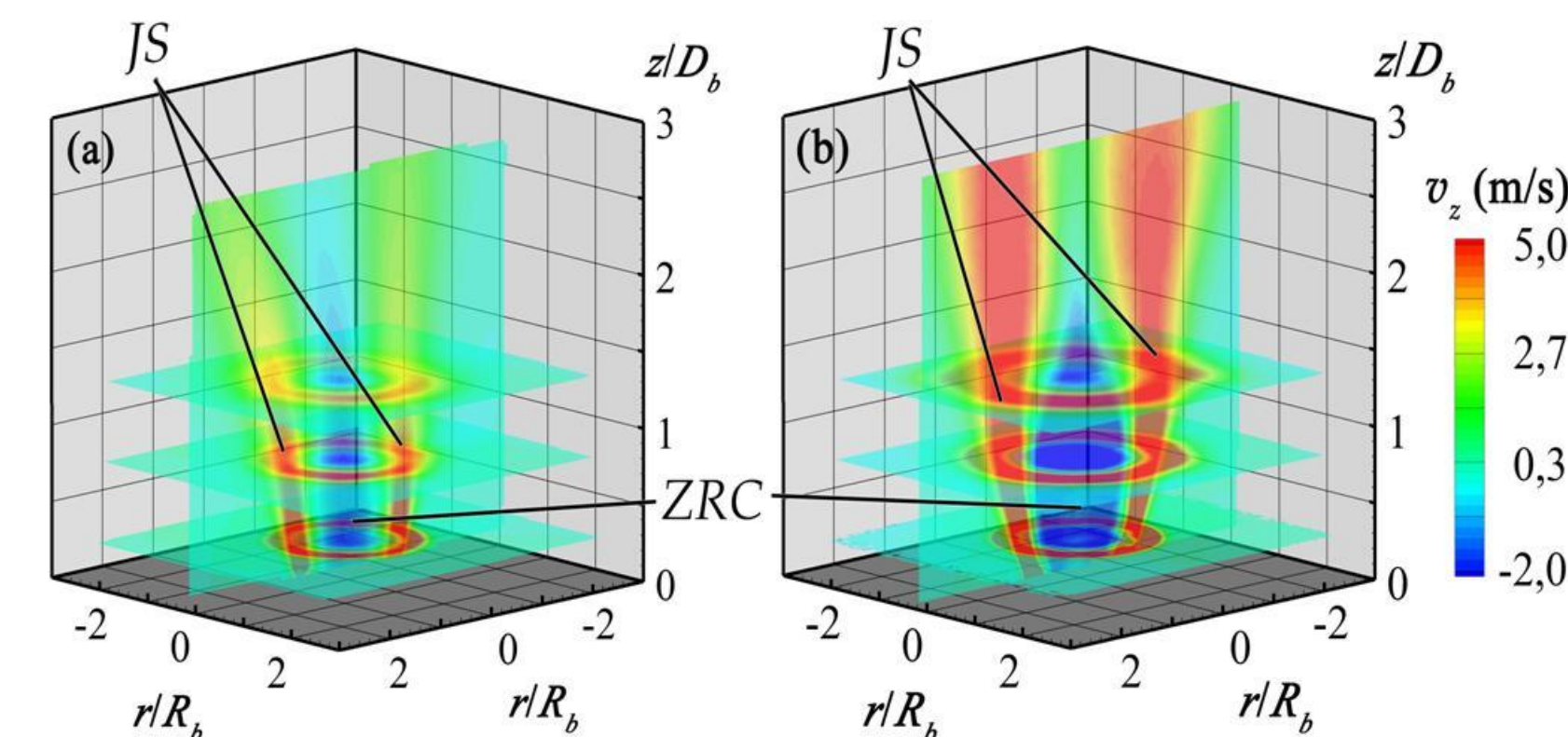
✓ With O<sub>2</sub> enrichment : CO<sub>2</sub> increases, CO decreases, NO<sub>x</sub> increases

### Instantaneous OH\* images



⇒ Flame stability is enhanced with oxygen addition even for low oxygen enrichment rates.

### Velocity mean fields of non reacting and reacting flows



⇒ Recirculation zone at the flow center, and the swirling jet in the peripheral flow