

1st International Conference on Chemical Looping
An Alternative Concept for Efficient and Clean Use of Fossil Resources



Hydrogen production coupled with CO₂ capture by chemical-looping combustion using mixed Fe-Ni oxygen carriers

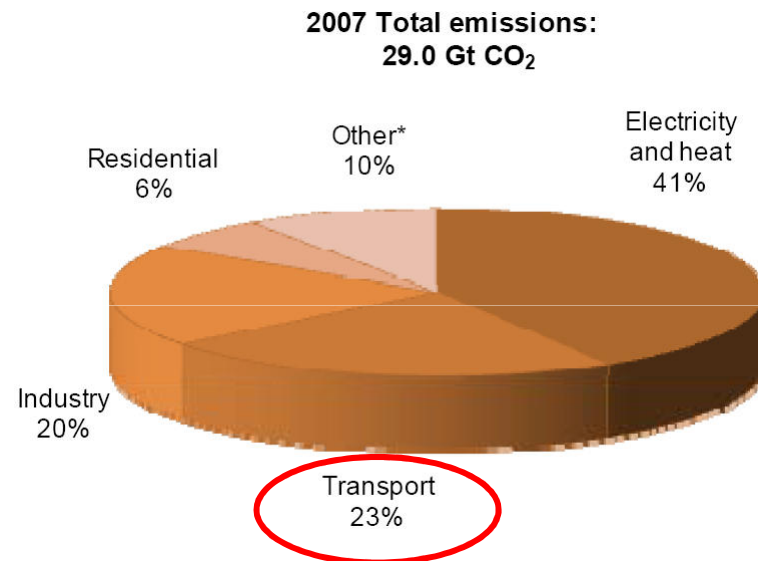
M. Ortiz, L.F. de Diego, P. Gayán, M.A. Pans,
F. García-Labiano, A. Abad, J. Adánez



LYON, 17-19 March 2010



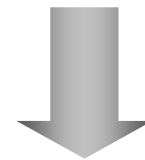
Distribution of CO₂ emissions



SOURCE: IEA Statistics 2009

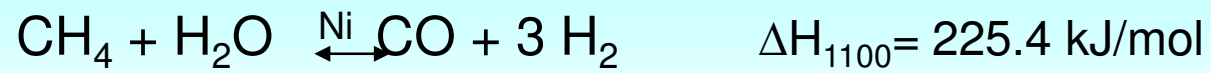
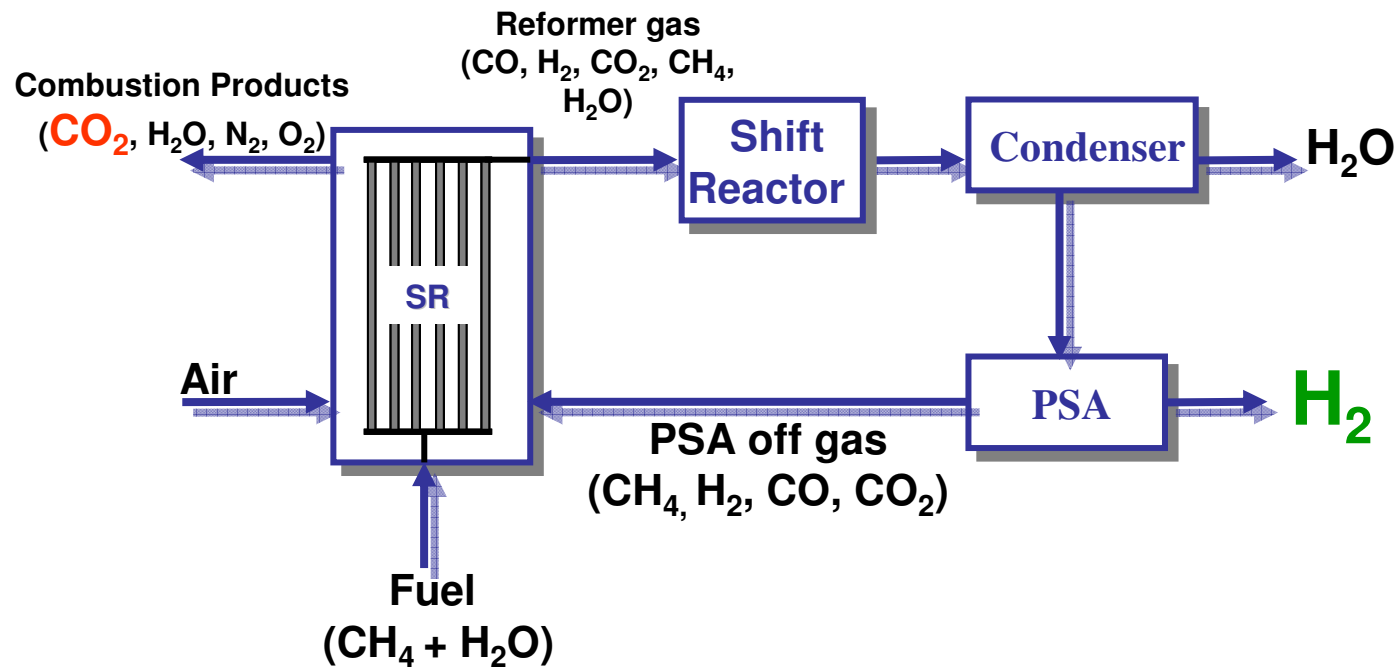
Options to reduce transport CO₂ emissions

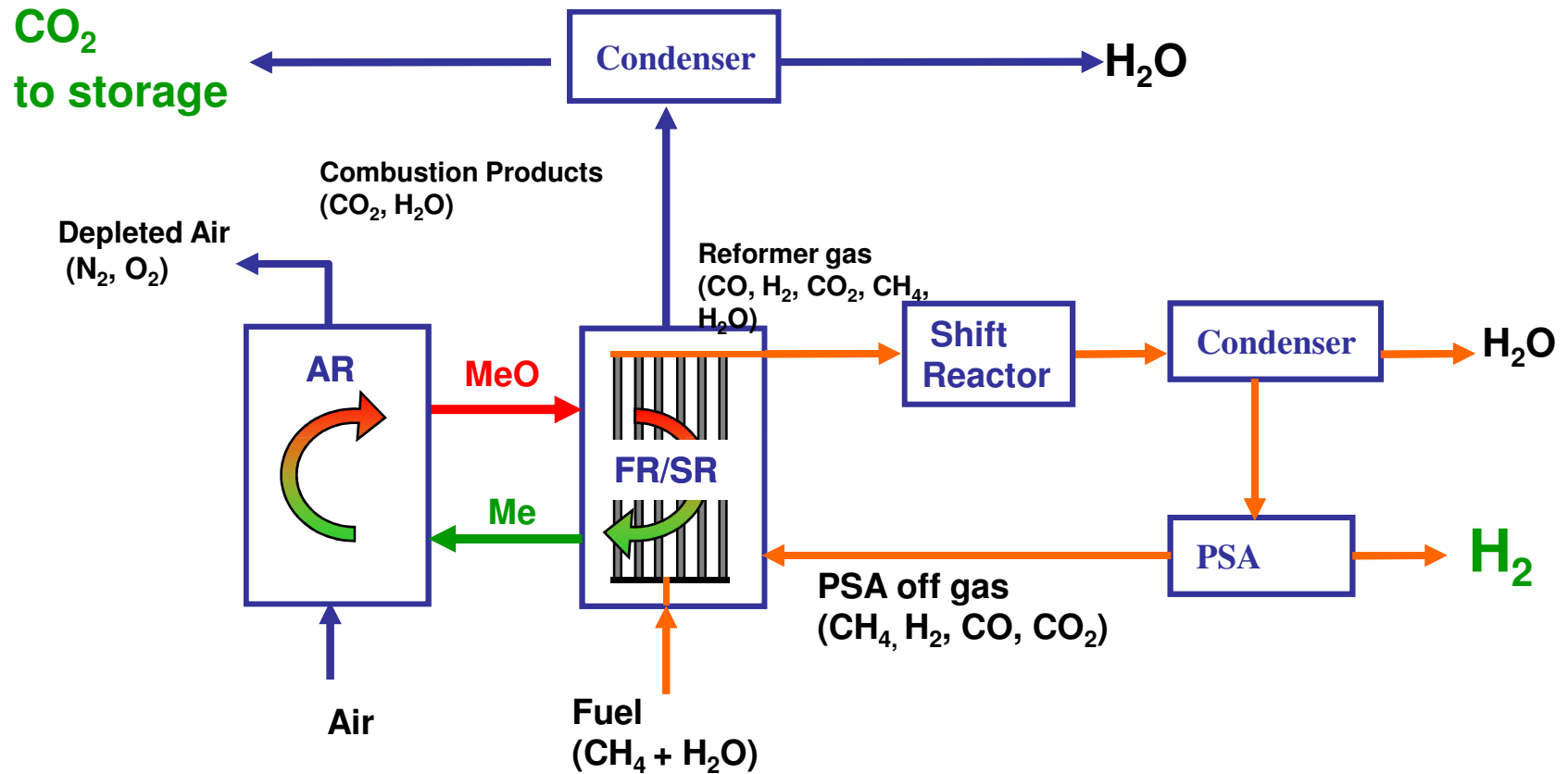
- ❑ Improvement of fuel combustion
- ❑ Electric or Hybrid-electric vehicles
- ❑ Low-carbon fuels
- ❑ No-carbon fuels



ii Hydrogen is an energy carrier that must be produced from a primary energy source !!

Steam reforming (SR)





- 100% CO₂ capture without energy penalty or O₂ needs
- No formation of thermal NO_x

- Development of an oxygen carrier that can fully convert a **PSA-offgas** fuel.
- Analysis of the behaviour of mixtures of Fe-based and Ni-based oxygen carriers in a continuous CLC pilot plant using different fuels.
- To study the effect of different operating variables on the combustion of CH_4 and a PSA-offgas fuel.

Fe-based oxygen carriers

Advantages

- Cheap
- Non toxic
- No thermodynamic limitations ($\text{Fe}_2\text{O}_3/\text{Fe}_3\text{O}_4$)

Disadvantages

- ↓ Low reactivity with CH_4
- ↓ Agglomeration problems if the final reduction state is FeO or Fe

Ni-based oxygen carriers


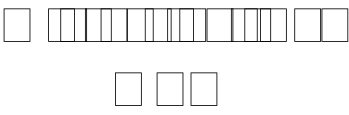
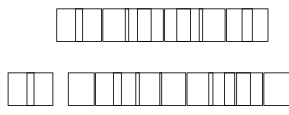






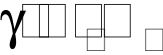
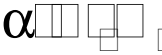
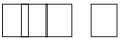








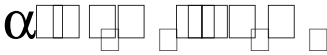
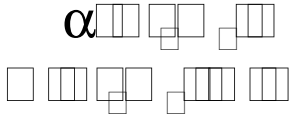
Advantages

- High reactivity
- No agglomeration problems
- Catalyze CH_4 reforming

Disadvantages

- ↓ Toxic
- ↓ Expensive
- ↓ Thermodynamic limitations

A mixture of Fe-OC and Ni-OC will take advantage of favourable characteristics of each metal.

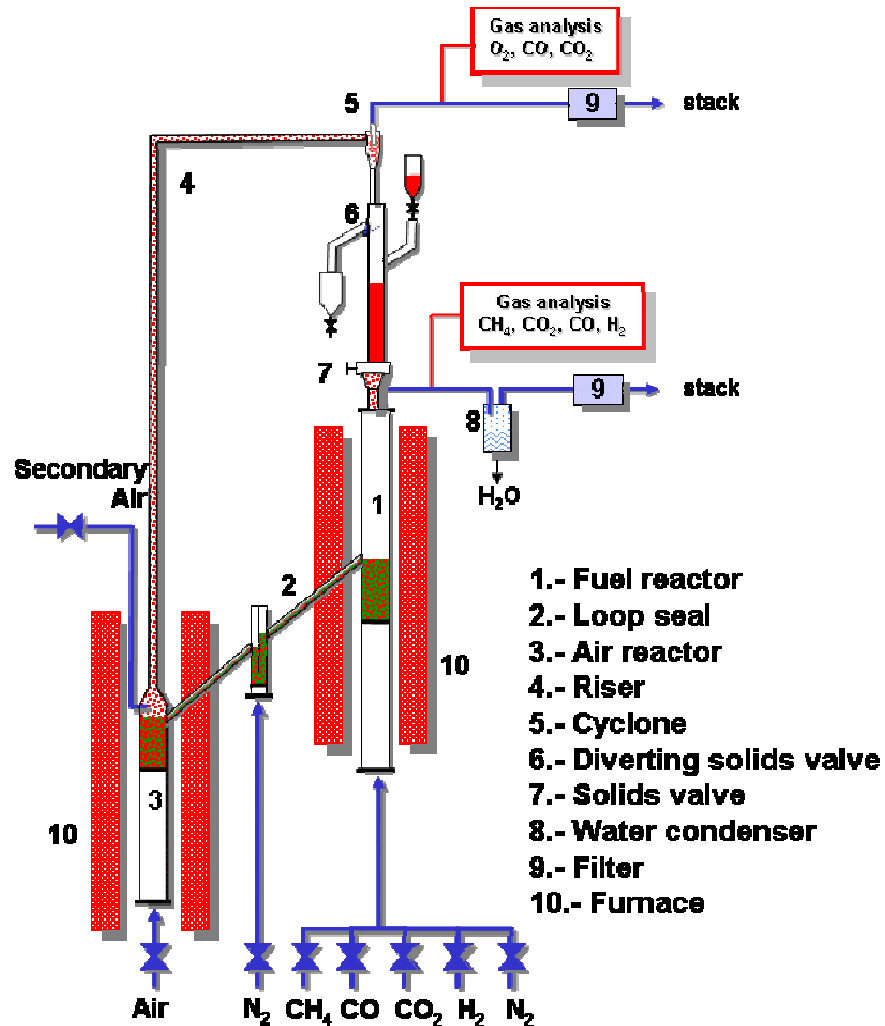
	Fe-OC	Fe-OC+ Ni-OC	Ni-OC
Preparation Method			
wt% Fe₂O₃			
wt% NiO			
Support	γ 		α 
dp 			
			
	α 		α 

Oxygen transport capacity, R_0

$$R_0 = \frac{m_o - m_r}{m_o}$$

□ 2% Fe ₂ O ₃ □ % inert	herodina i itation	Fidiation ehaio r
$Fe_2O_3 \square Fe_{1-2}O_{1-2}$	2	Co plete o o itation
		No a o eration

Experiments in a continuous CLC plant



Operating conditions

- PSA-off gas composition
12 vol.% CH₄, 18 vol.% CO, 25 vol.% H₂, 45 vol.% CO₂
- Power output: 150 W_{th} to 900 W_{th}
- Effect of FR temperature 830-880°C T_{AR}=950°C
- Effect of oxygen carrier to fuel ratio: ϕ from 1 to 6
- Total solids inventory ~ 1.5 kg oxygen carrier
- Solids circulation rate 12 kg/h
- u_{FR} : 10 cm/s (u_{mf}=3 cm/s) u_{AR}: 45 cm/s

- During more than 70 hours of operation it was **not detected**:
 - Carbon deposition
 - Agglomeration problems
 - Leakages between the reactors
- The OCs were physically and chemically characterized **before and after** operation and no important changes were found.

ERROR: rangecheck
OFFENDING COMMAND: .buildmap

STACK:

-dictionary-
/WinCharSetFFFF-V2TT9BF4ACCAT
/CMap
-dictionary-
/WinCharSetFFFF-V2TT9BF4ACCAT