# Chemical looping technology research activities at IFE

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# Chemical looping research activities

- CL activities at IFE arise from broad experience in the last 15 years with Sorption-Enhanced Reforming (SER) and Calcium Looping (CaL) looping cycles
- Focused on material development with emphasis on
  - Low cost materials
  - High multi-cycle performance in relevant process conditions
  - From chemical synthesis (micro-powder) to granulated materials

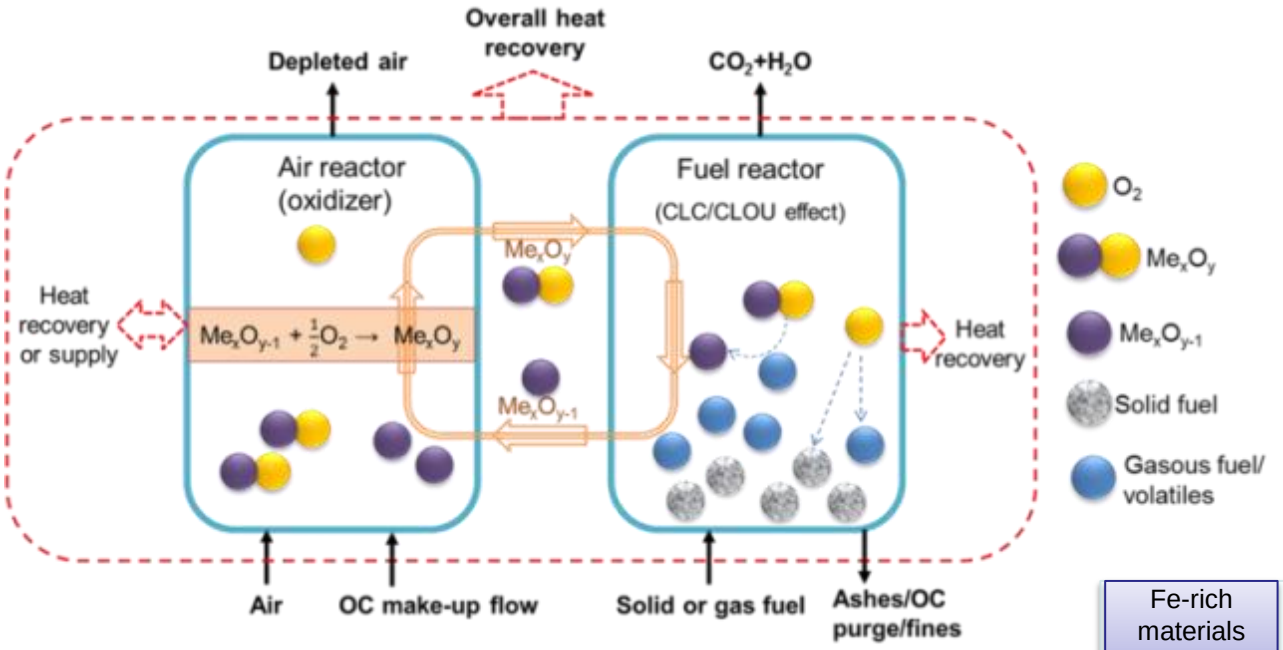
- Cu and Mn based materials produced from low cost raw materials and industrial tailings for application in
  - Chemical Looping combustion of solids fuels with Oxygen Uncoupling (CLOU)
  - Chemical Looping Air Separation (CLAS) for oxy-fuel retrofitting of coal power plants (or new plants)
- Ca and Cu based combined materials for hydrogen production via the Sorption-Enhanced Reforming process (SER) and integration with NGCC plants

# On-going and new CL projects

- **NewLoop**
  - Innovation for Combustion of Solid Fuels via Chemical Looping Technology
- **ASCENT**
  - Advanced Solid Cycles with Efficient Novel Technologies
- **6Cs**
  - Innovative materials for $CO_2$ Capture by Combined Calcium-Copper Cycles

# CLOU

NewLoop




NewLoop collaboration outputs:

- 1 patent application filed-2015
- Work on scientific papers in progress
- 3 abstracts sent to international conferences
- Collaboration with Polish and Norwegian potential CLC materials suppliers

CLC reaction:

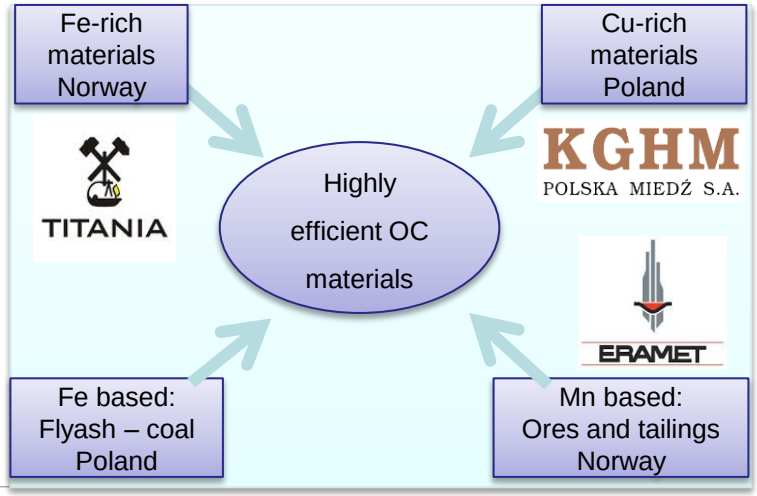
$(2n + m)M_xO_y + C_nH_{2m} \rightarrow (2n + m)M_xO_{y-1} + mH_2O + nCO_2$

CLOU effect: $2M_xO_y \rightarrow 2M_xO_{y-1} + O_2\ (g)$

$C_nH_{2m} + (n + m/2)O_2\ (g) \rightarrow nCO_2\ (g) + mH_2O\ (g)$

Oxidation in air reactor

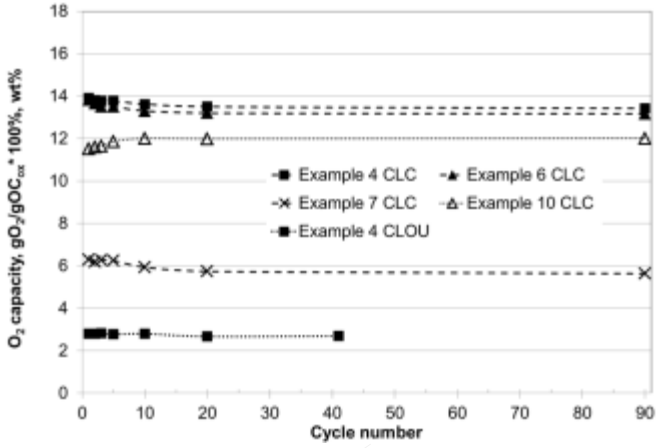
$2M_xO_{y-1} + O_2 \rightarrow 2M_xO_y$



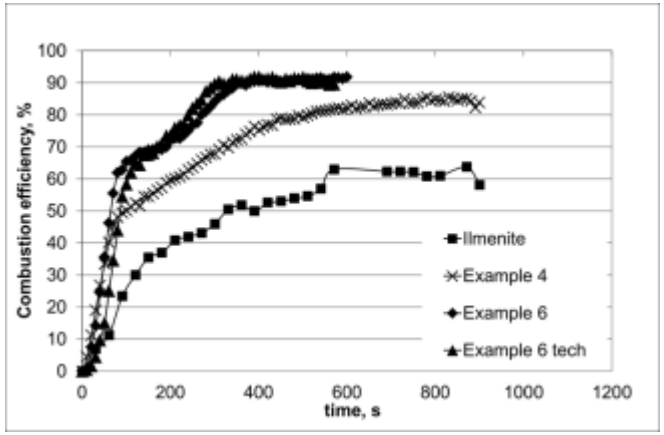
# CLOU

NewLoop

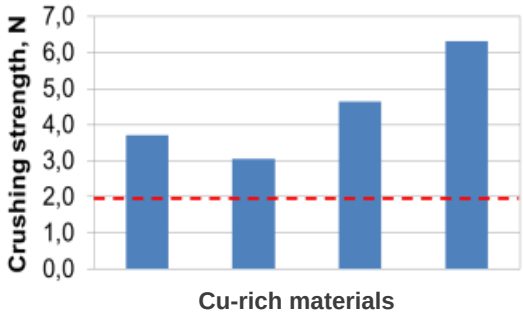
- Low cost oxygen carrier materials based on natural ores and industrial waste (tailings)
- Oxygen uptake capacity for low-cost Cu-rich materials remains stable over cycles
- Improved fuel conversion compared to Ilmenite
- Satisfactory crushing strength for use in fluidized bed




Biomass combustion




NewLoop target for mechanical strength ≤ 2 N



# Ca-Cu concept

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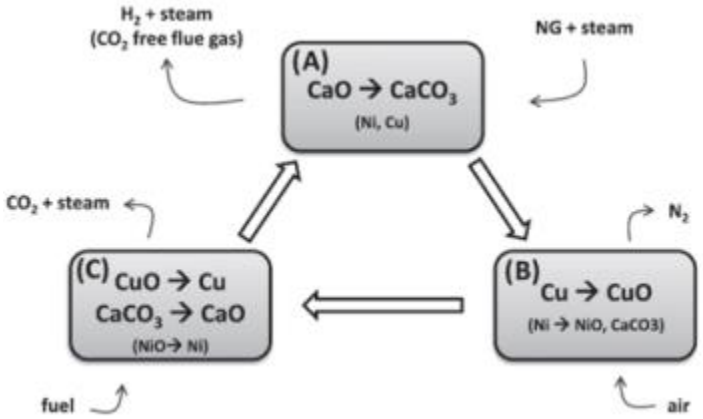


*Ref. J.R. Fernandez, J.C. Abanades, R. Murillo, G. Grasa. Conceptual design of a hydrogen production process from natural gas with $CO_2$ capture using a Ca–Cu chemical loop. International Journal of Greenhouse Gas Control 6, 2012.*

- **Fixed bed reactor system**

- **Advanced combined materials for the Ca-Cu process**
- Combination of the $CO_2$ sorbent and $O_2$ carrier in one single material
- Reduce the amount of inert material in the reactors
- Optimize the efficiency of the heat transfer between the sorbent and the oxygen carrier

- Combined materials produced using a hydrothermal method where CuO is added in the synthesis
- Mayenite based material (inert phase)
- Pelletization by compaction or agglomeration by high shear granulation

# Ca-Cu concept

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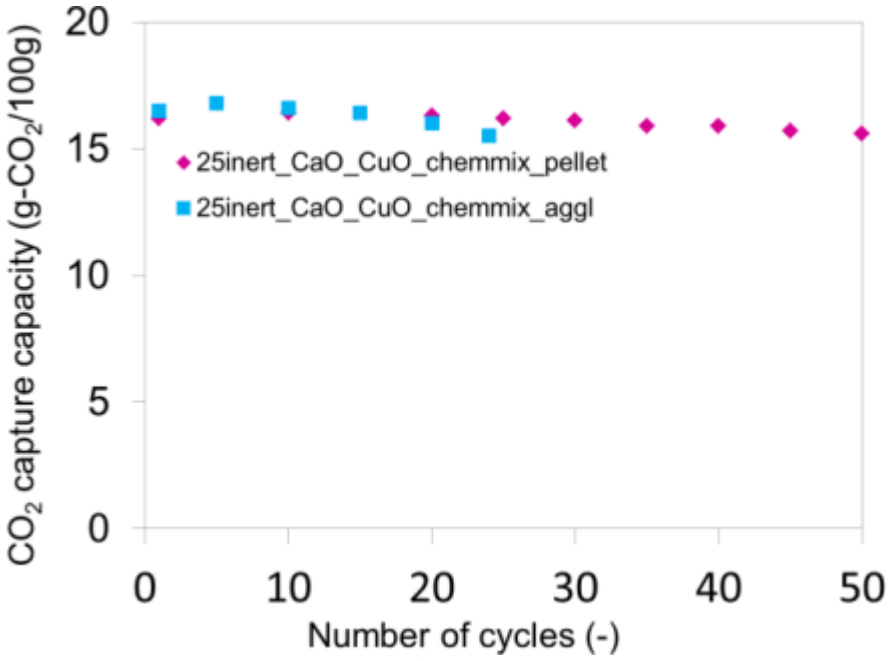
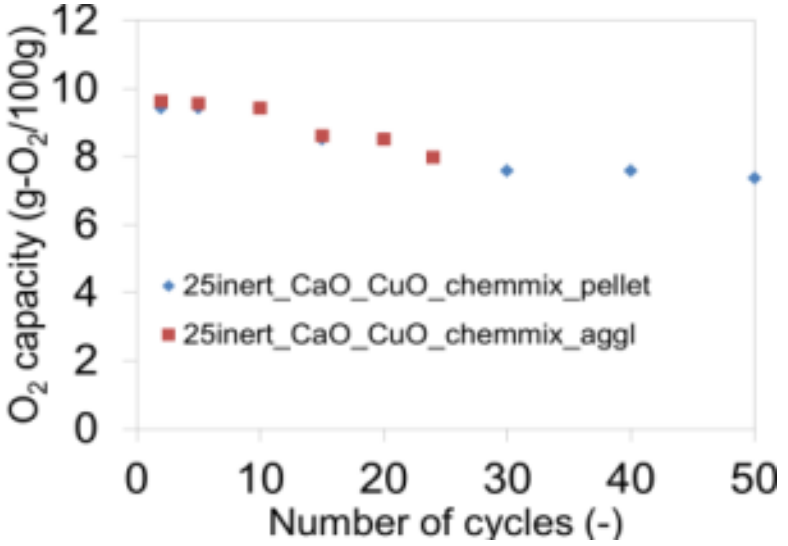



- Mayenite based combined CaO-CuO material (25 wt% inert)
- Pelletized vs agglomerated
- Pelletized material with 25 wt% inert gives the best results so far



# New projects and further plans

- **6Cs project (Project start: August 2016)**
  - Further development and optimization of Ca-Cu combined sorbent-O2 carrier
  - Modeling of the heat transfer at nano-scale

- Planned activities on chemical looping gasification (CLOU) with European partners (H2020 proposal delivered in February 2016)

# Experimental facilities

- Autoclaves for synthesis methods
  - Co-precipitation, Sol-Gel, Hydrothermal

- Advanced material characterization methods
  - TGA, SEM, XRD, PSD, BET

- Crushing strength gauge

- Agglomeration techniques
  - Fluid bed agglomerator, shear agglomerator, disc pelletizer
- Chemical reactors of different sizes
  - Fixed and fluidized bed