
ENCAP SP4

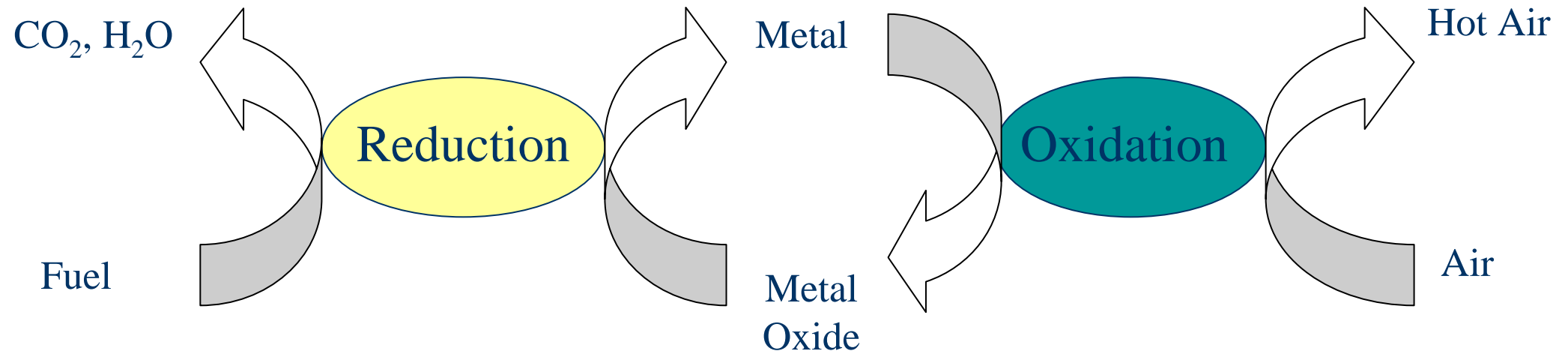
Chemical looping combustion

ENCAP – CASTOR Workshop

Billund, 16 March 2006

E. Lebas

Chemical Looping Combustion principle



Chemical looping combustion features

- Process characteristics
 - > 98% CO₂ capture
 - No Air Separation Unit for oxygen production
 - No energy penalty for oxygen production and for CO₂ separation
 - One of the best candidates for 20 €/tCO₂ target
- Process design requirements for Circulating Fluidized Bed CLC
 - Reactive and mechanically resistant oxygen carrier
 - Sufficient solids flow, typical of CFB hydrodynamics
 - No gas mixing between the two reactors

Chemical looping combustion features

- Background experience from past EU FP5 GRACE chemical looping combustion on natural gas (>100 hours continuous operation)
- CFB technology well suited to CLC application with already proven components allowing to build very large boilers (400 MWe)
- Possibility to retrofit conventional air blown CFB to CLC CFB with limited modifications

ENCAP - SP4 - Objectives

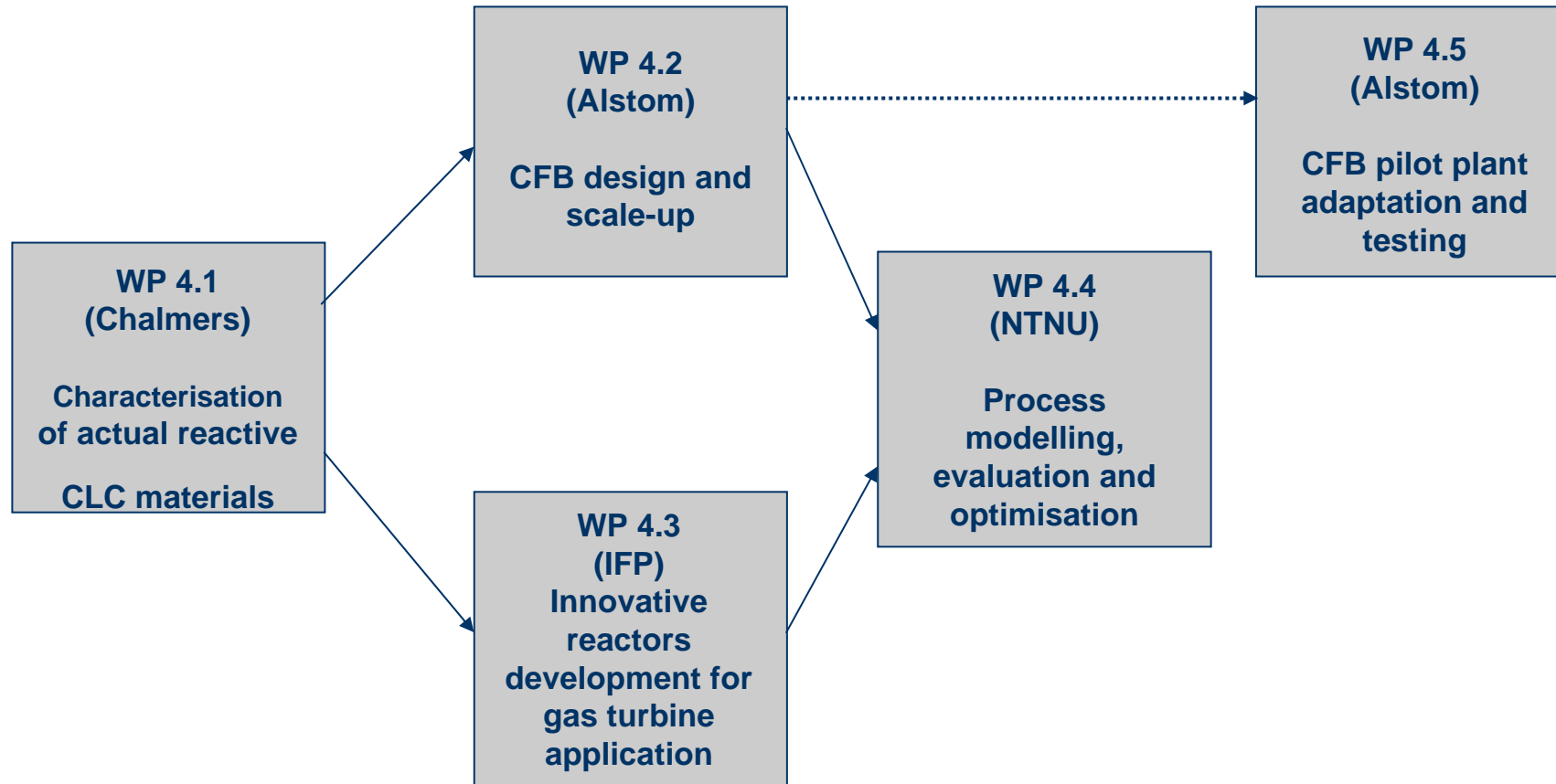
- Make available validated technologies, materials and process concepts for chemical looping combustion.
- Develop 400 MWe SC CFB boiler for solid fuels CLC application.
- Develop new concepts of CLC reactor adapted to gas turbine operation using natural gas.

ENCAP SP4 Partnership

- Coordinator : IFP

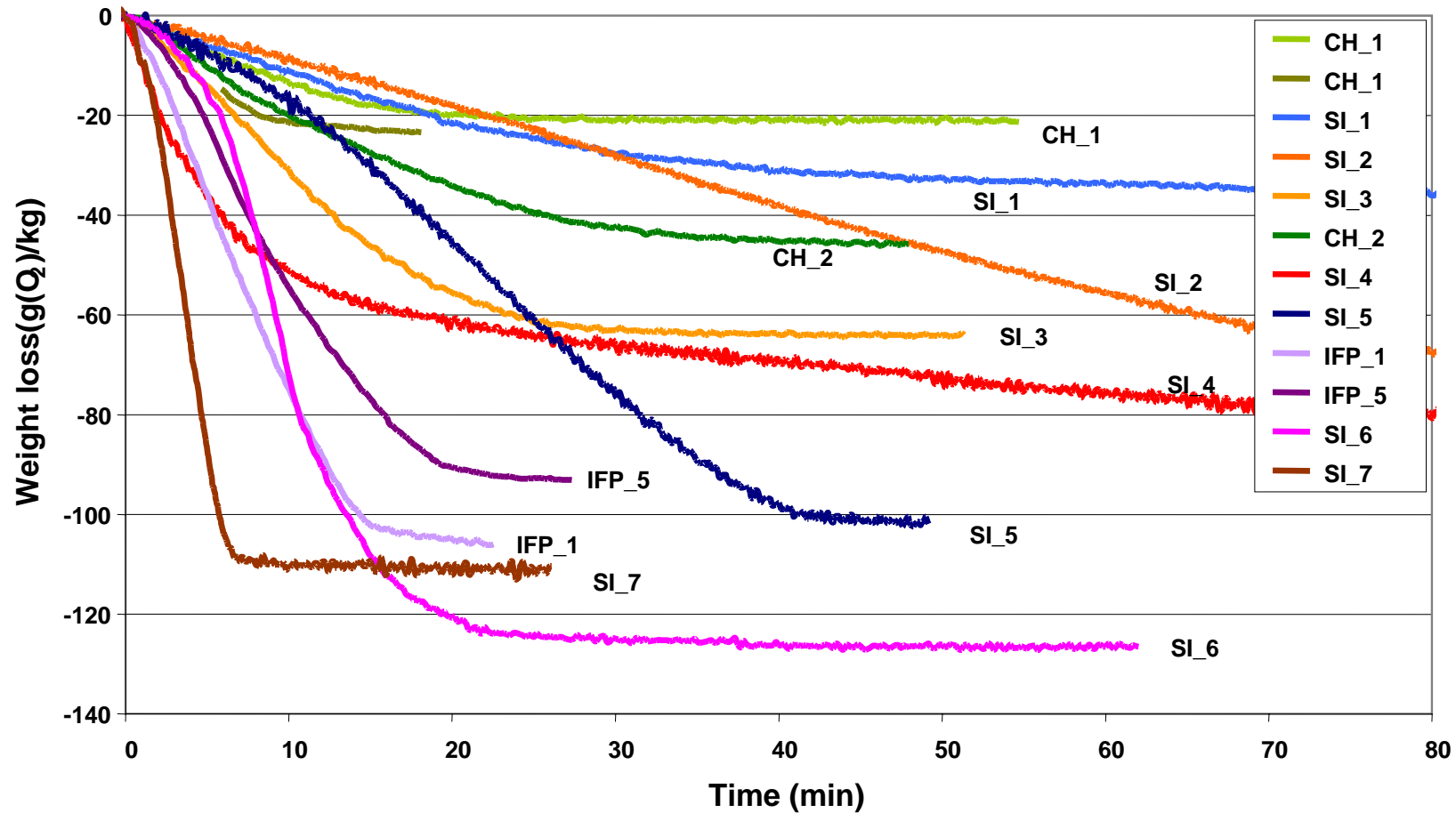
- Partners :
 - ALSTOM Power Boilers
 - ALSTOM Power Centrales
 - Siemens
 - SINTEF
 - Chalmers
 - TNO
 - NTNU

SP4 Structure



WP4.1 : Comparison of various CLC particle formulations

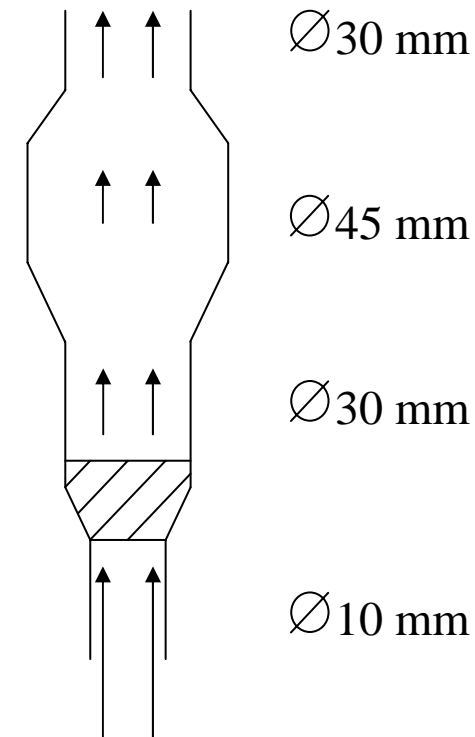
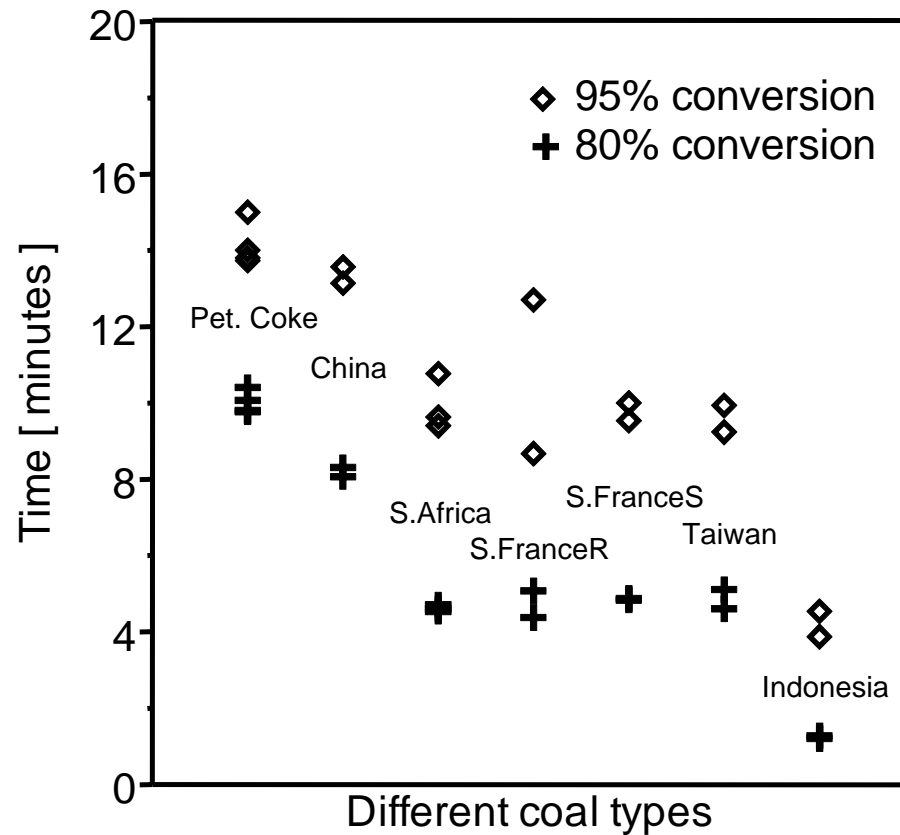
TG experiments : Oxygen capacity compared for systems at 800°C in Ar containing 10% CH₄ and 25%CO₂



WP4.1 : Solid fuel reaction with oxygen carrier

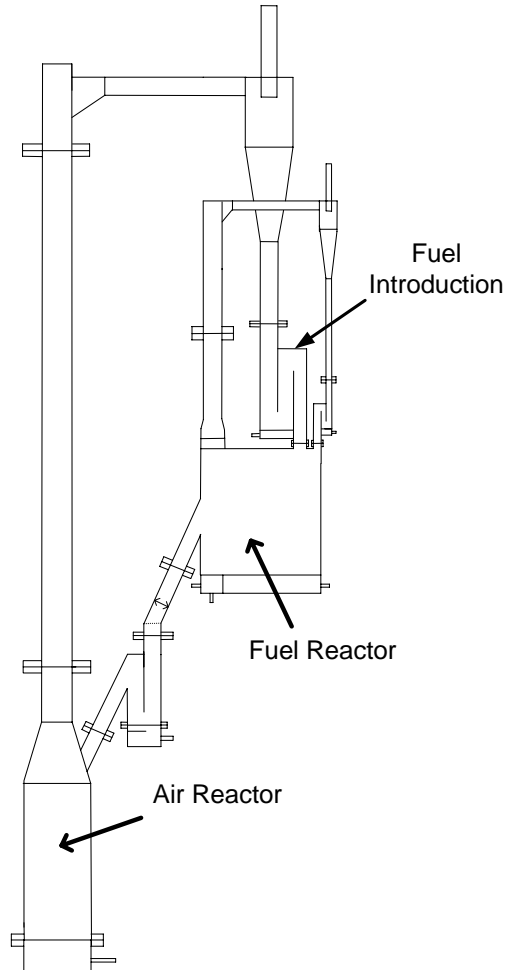


Time to convert 0.2 g of different coal types
in 40 g of natural mineral (Ilmenite)

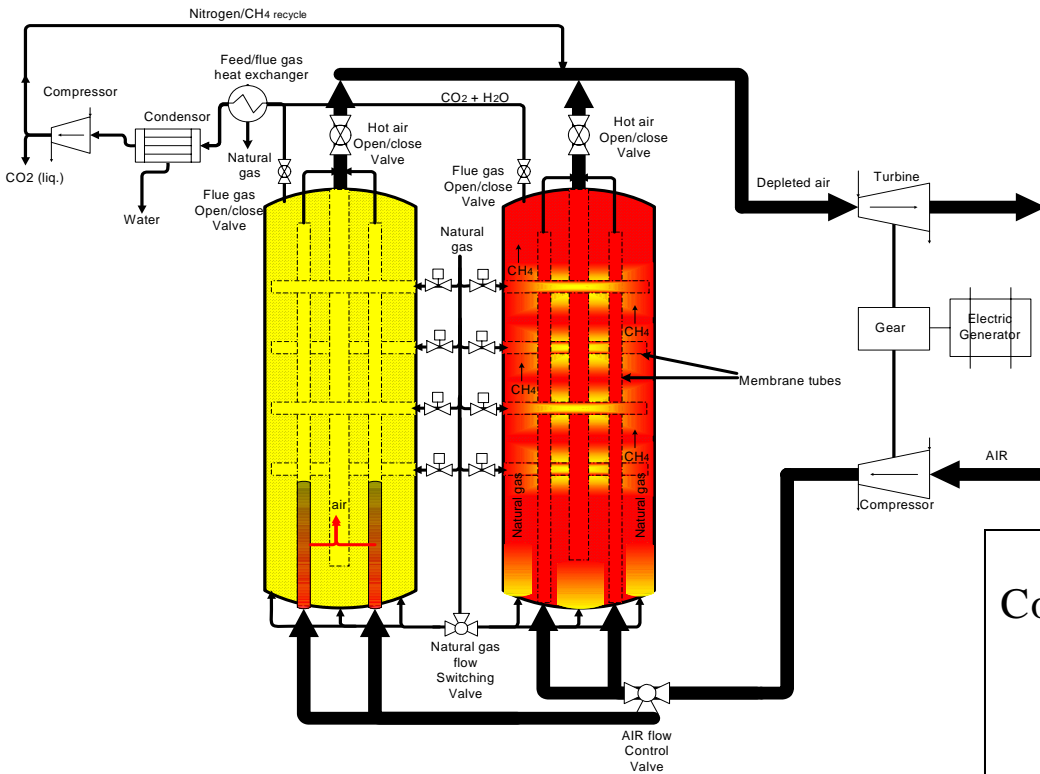


Solid fuel reactor

WP4.2 : Chalmers CLC CFB prototype 10 kWth

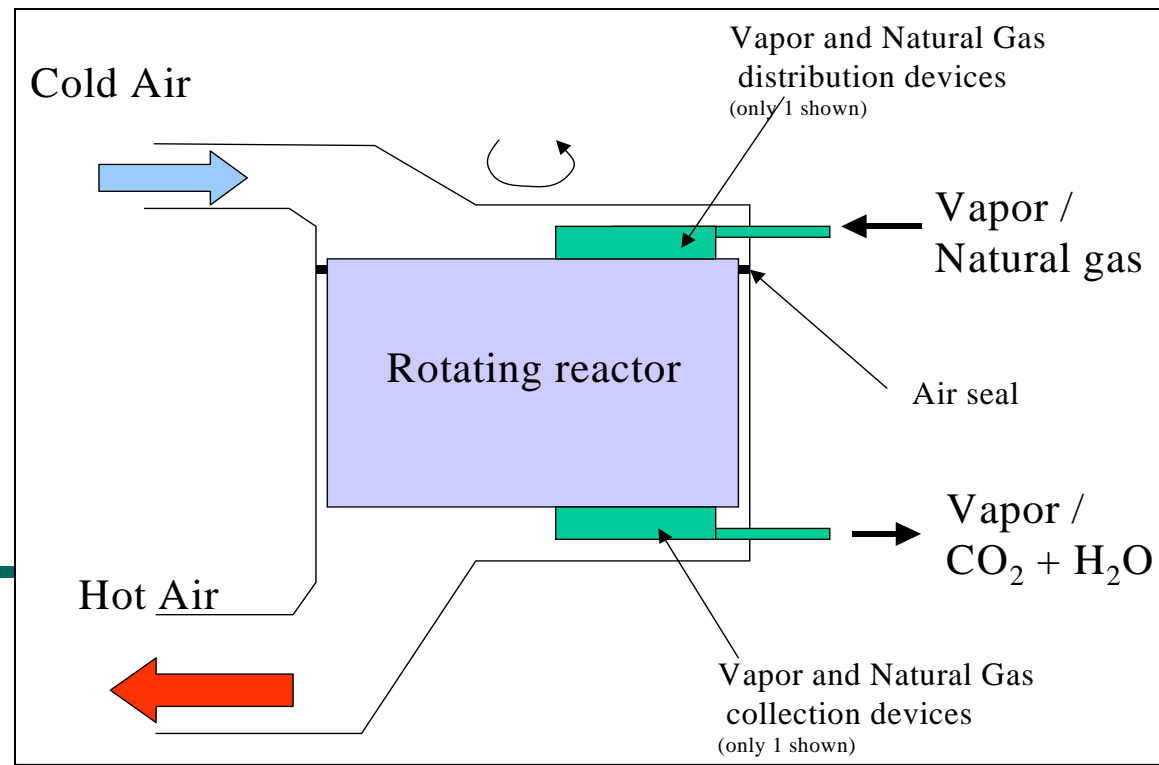


WP4.3 : Innovative CLC reactors development



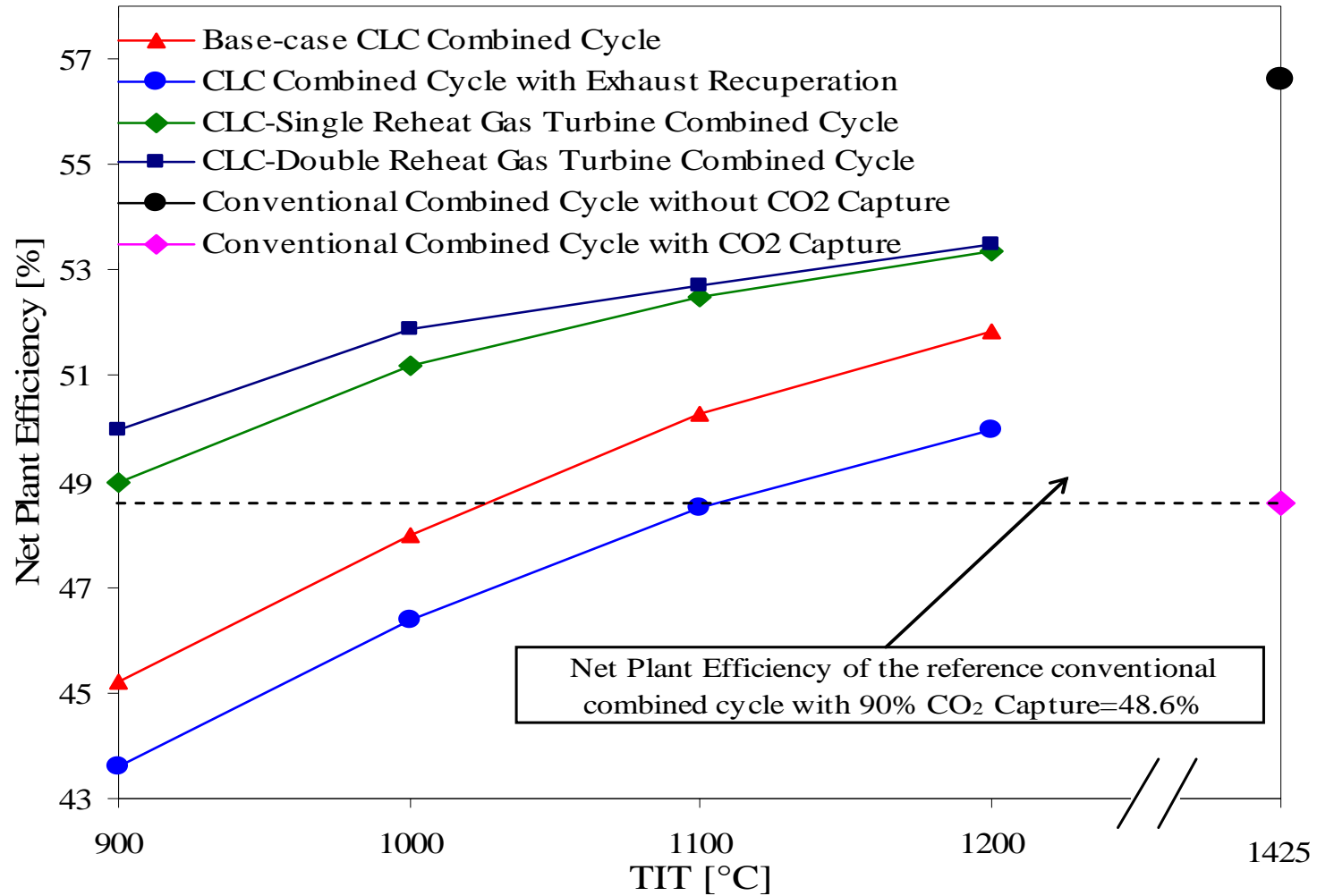
- Concept selection
- First sizing provided

IFP rotating reactor



TNO membrane reactor

WP4.4 : CLC GT cycle optimisation



ENCAP SP4 achievements February 2006

- Solid fuel conversion with oxygen carrier successful
- Suitability of low cost materials, e.g. natural ores, confirmed
- Chalmers fluidized bed reactor system (10 kWth) for solid fuels ready for operation
- **Design concept for solid fuels CFB boiler 445 MWe**
 - **Low cycle efficiency penalty (2%, mainly CO₂ compression)**
 - **CO₂ mitigation cost lower than 10 €/tonCO₂**
- Feasibility of innovative reactors for gas turbine application in progress
- CLC combined cycle efficiency 52 % with double reheat gas turbine