GRACE project, 2002-2003
Chemical-Looping Combustion

- Development of oxygen-carrier particles of sufficient reactivity and life-time.

- Study of reactor system to establish possible conditions for fluidization and solids recirculation.

- Demonstration and evaluation of this new combustion technology in a 10-kW prototype unit.

- Assessment of the feasibility of a full-scale plant and prediction of cost.

Participants

CSIC, Zaragoza
particle development

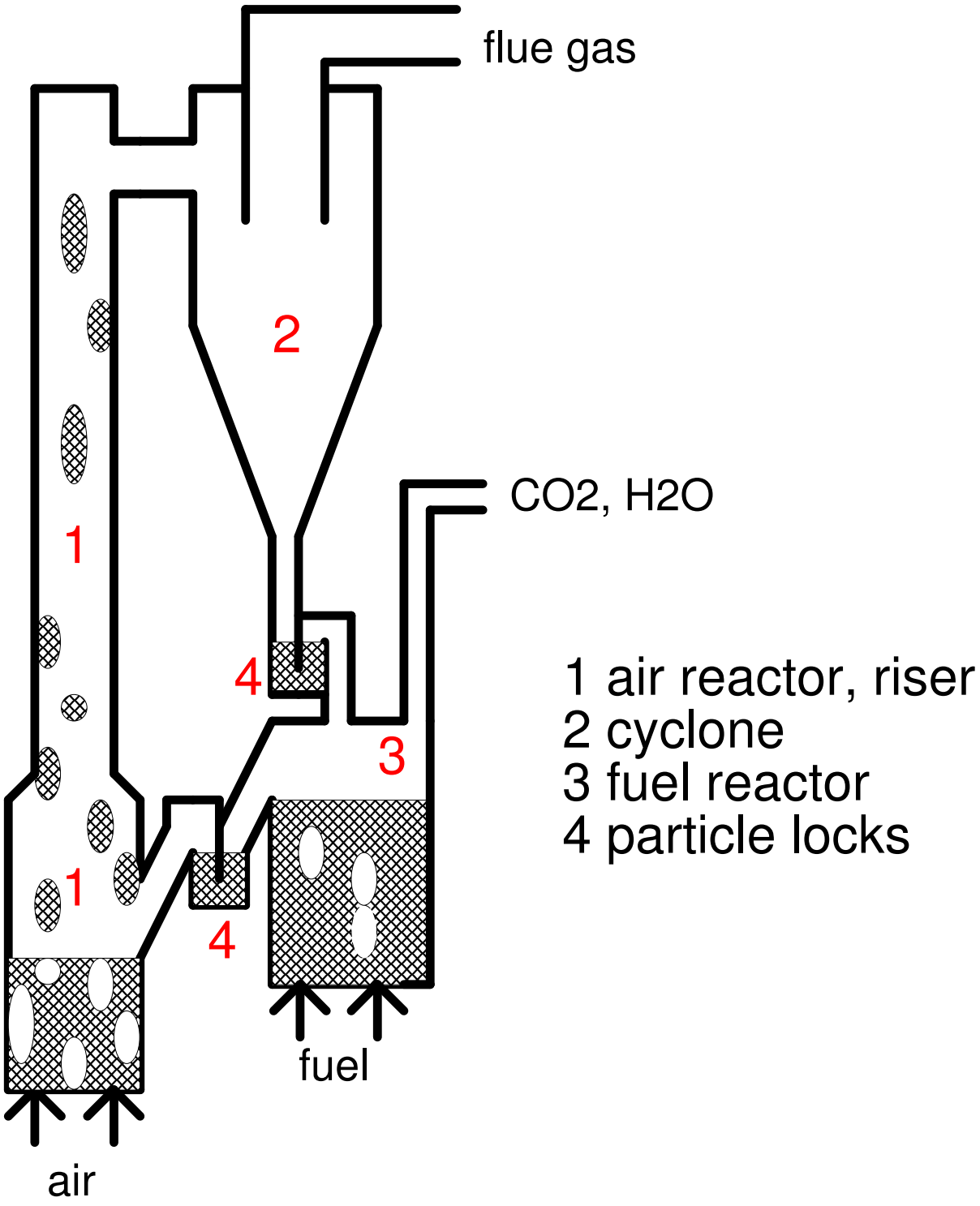
Technical University of Vienna
reactor system

Chalmers University of Technology
development, construction and operation of 10-kW unit, particle development

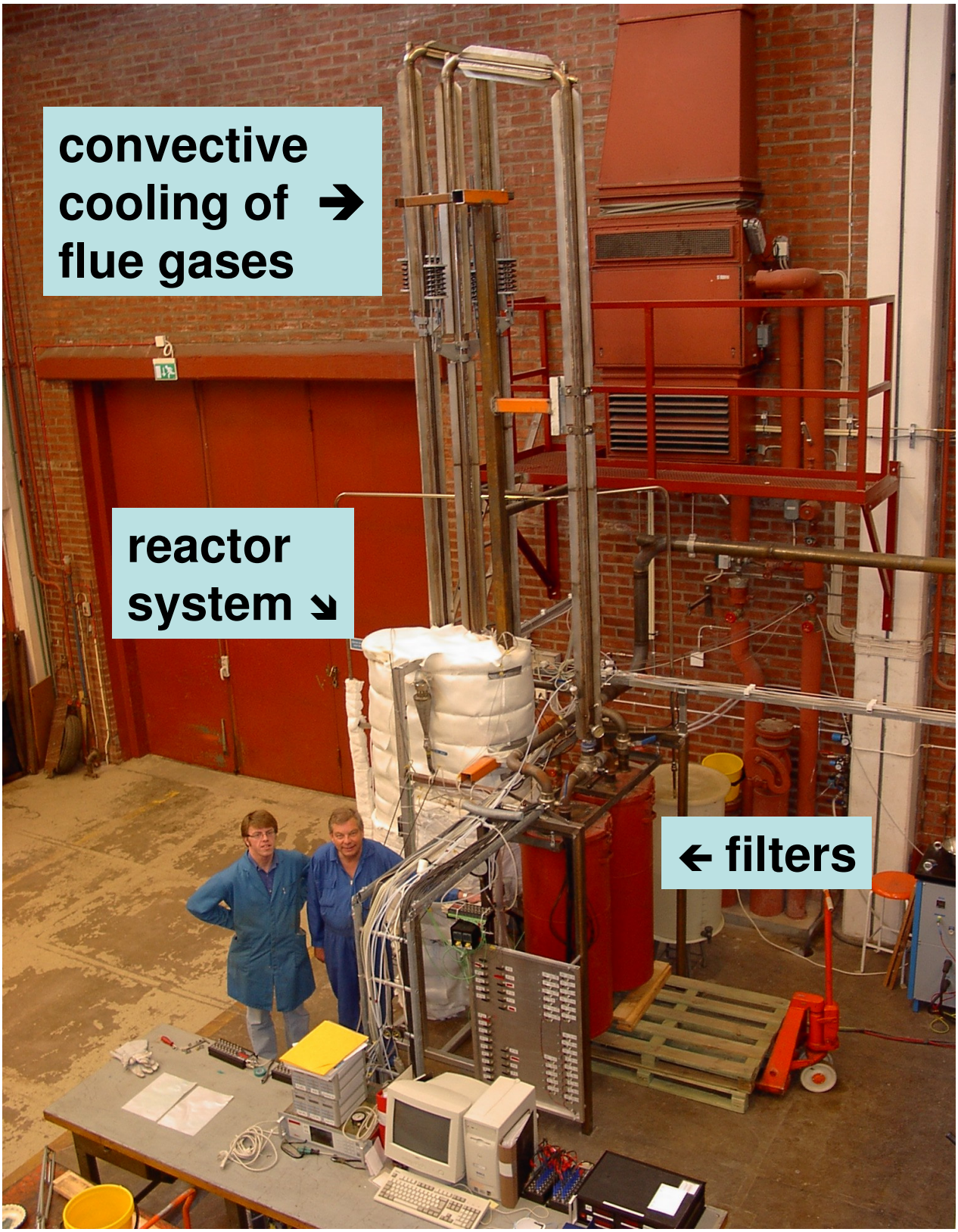
Alstom Power Boilers
full-scale plant feasibility

BP, coordinator
settings for full-scale plant

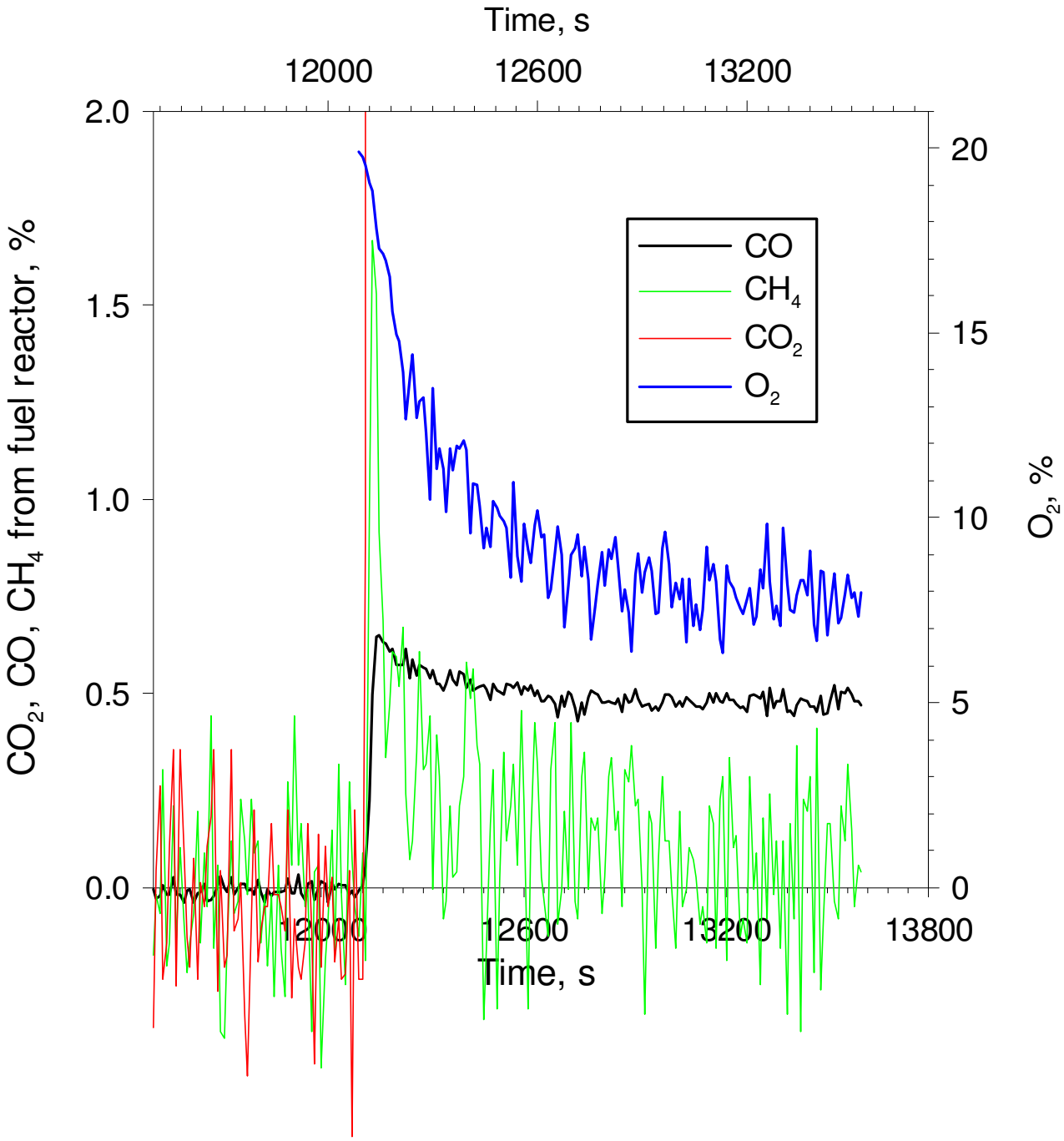
Financing: EU and CCP



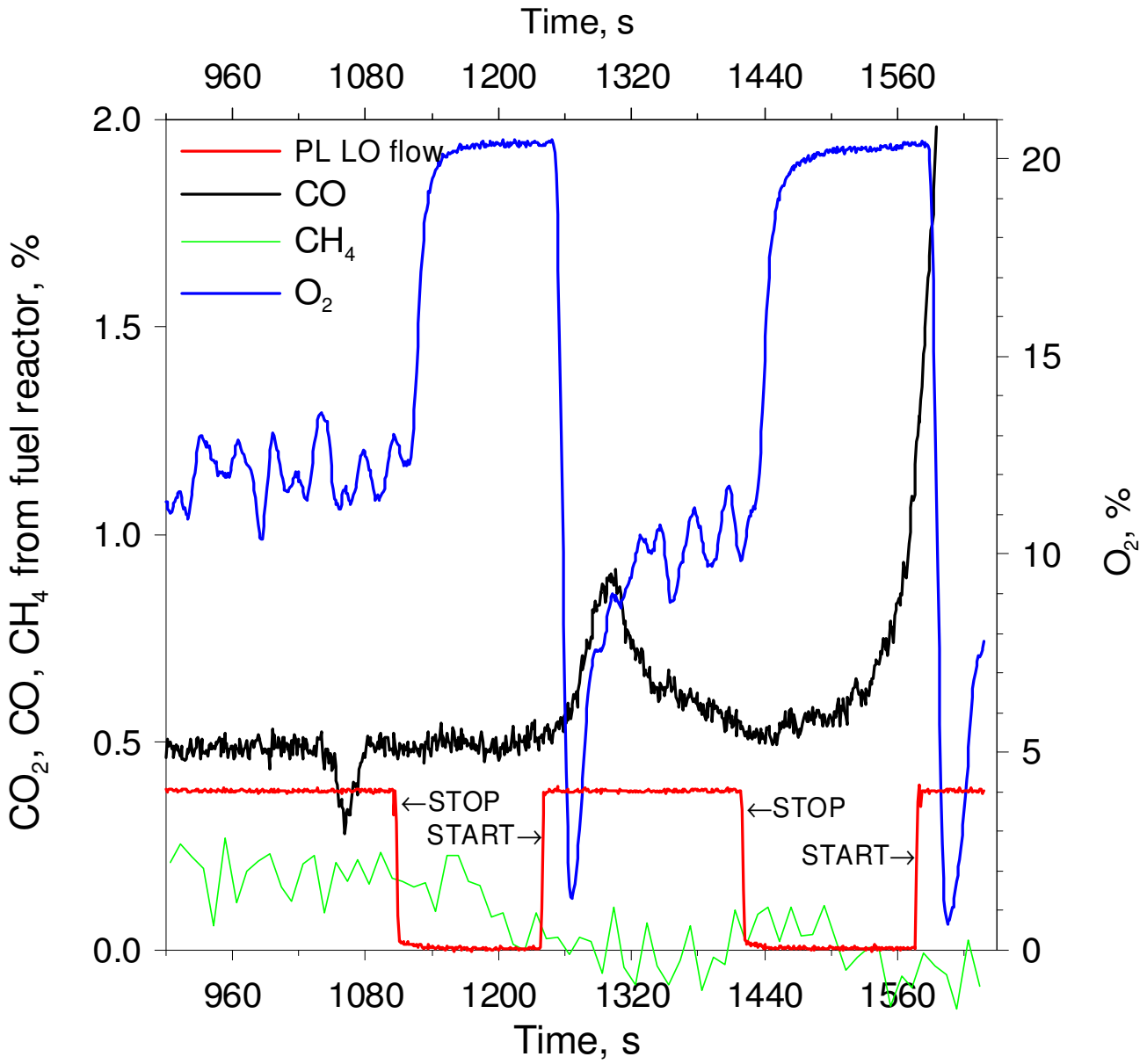
1 air reactor, riser
2 cyclone
3 fuel reactor
4 particle locks



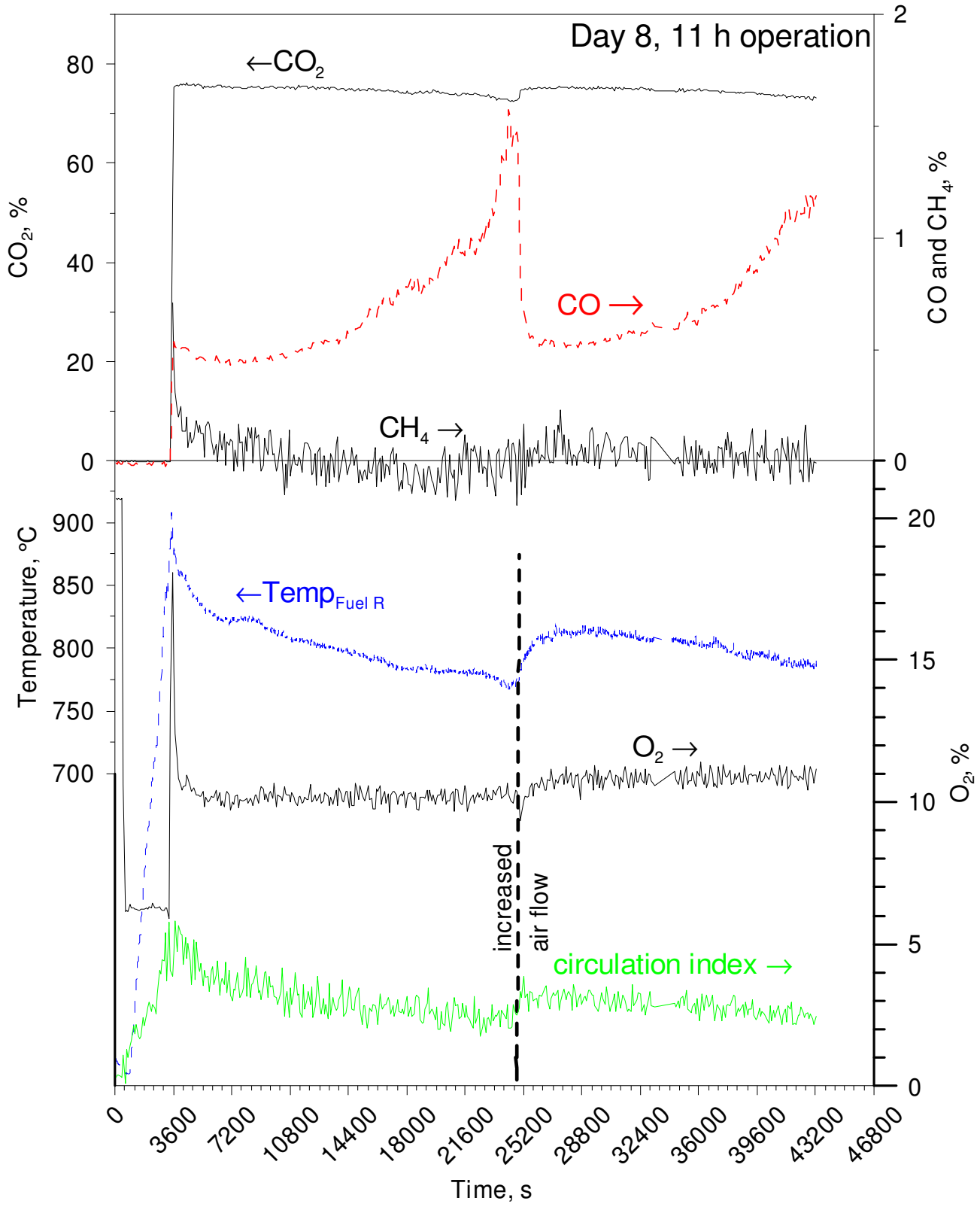
Chalmers 10 kW chemical-looping combustion prototype

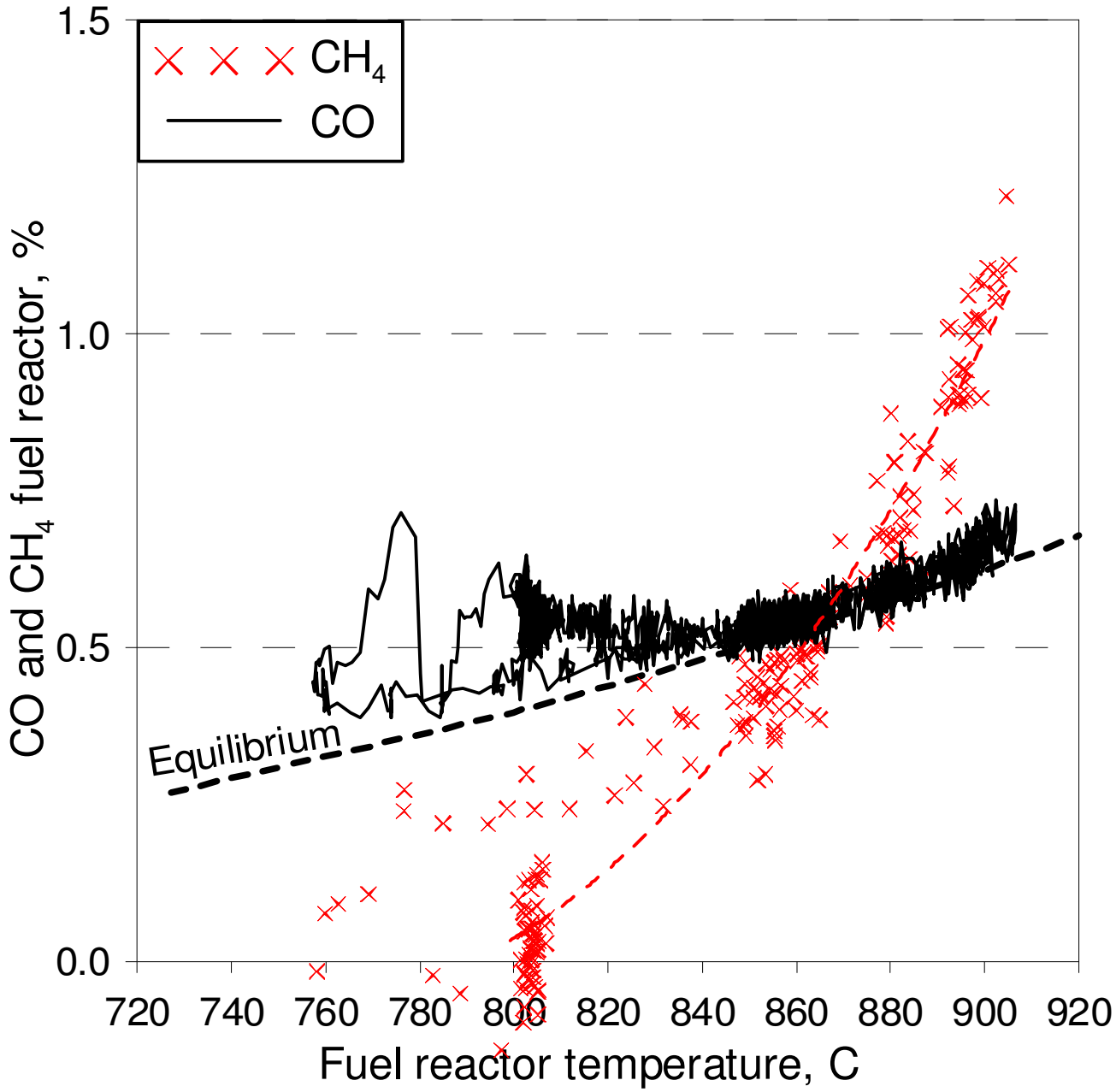


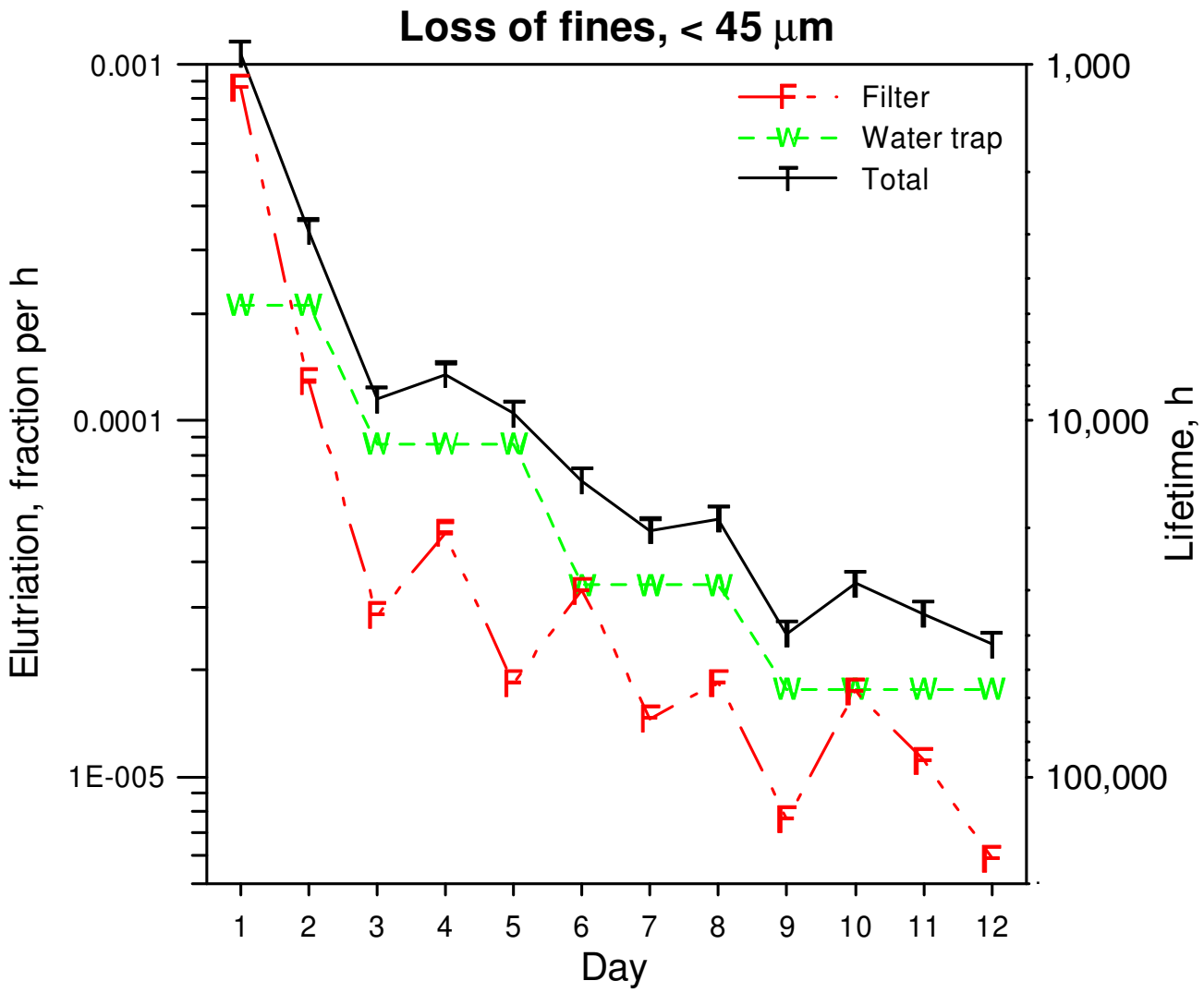
Start of fuel



stop in circulation (on purpose)


Day 8, 11 h operation
←CO2
CO →
CH4 →
CO2, %
CO and CH4, %
Temperature, °C
←TempFuel R
O2 →
O2, %
increased air flow
circulation index →
Time, s
0
3600
7200
10800
14400
18000
21600
25200
28800
32400
36000
39600
43200
46800


1.5
1.0
0.5
0.0
CO and CH4 fuel reactor, %
CH4
CO
Equilibrium
720
740
760
780
800
820
840
860
880
900
920
Fuel reactor temperature, C


Loss of fines, < 45 μm
Filter
Water trap
Total
0.001
0.0001
1E-005
1,000
10,000
100,000
Elutriation, fraction per h
Lifetime, h
1
2
3
4
5
6
7
8
9
10
11
12
Day

Conclusions:

No CO_2 from air reactor:

- No leakage between reactors
- No significant carbon formation
- → 100% CO_2 capture

Sand tests verify no leakage from air to fuel reactor:

- Almost pure CO_2 possible
  (1.2% H_2, 0.6% CO)

Conversion of fuel:

- 99.5% at 800

Operation

- Stable and easy to control
- 105 h operation CLC (13 days) without change of particles
- ~300 h circulation

Investigation of particles after 105 h

- No loss in reactivity
- No loss in particle strength

Loss of fines very low:

- Particle lifetime >40,000 h (?)

Low particle cost:

- <1 €/ton CO_2 (lifetime 4,000 h)

Chemical-Looping Combustion

Reactor system (fluidized beds):

- well established
- commercially available
- simple
- moderate costs

Oxygen-carrier particles:

- very encouraging results
- scale-up of particle manufacture
- raw materials
- long-term testing needed

Energy production from oxidation of hydrocarbons

respiration	~2 000 000 000 BC
fire	~500 000 BC
fuel cell	1839
chemical-looping combustion	2003