CZESTOCHOWA UNIVERSITY OF TECHNOLOGY
FACULTY
OF INFRASTRUCTURE AND ENVIRONMENT

Adsorption pilot plant investigations and possibilities of large scale application

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EU – Australian workshop,
Oslo, Norway, 13th-14th September 2017

Czestochowa University of Technology

Czestochowa University of Technology is the largest state university in the region, with a 60-year tradition

CUT Academic Staff:

- **153 professors (43 full professors and 110 associate professors)**
- **467 doctors**
- **150 lecturers**

IAET team

IAET Academic Staff

Director

Izabela Majchrzak-Kucęba

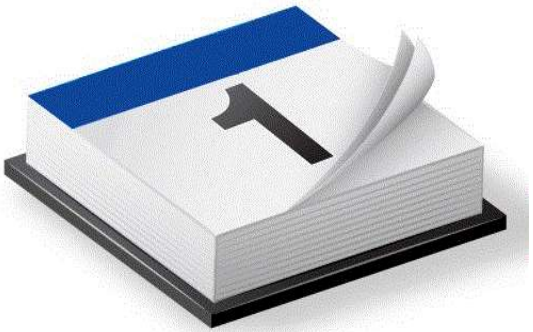
- 5 professors
- 5 doctors
- 3 others
- PhD students

Institute of Advanced Energy Technologies
fields of investigtion

- combustion (oxy-fuel, chemical-looping)
- biomass and renewables
- CO_2 capture and storage
- hydrodynamics
- heat transfer
- energy storage
- optimisation
- experiment, modelling and simulations

plans

- low emission – technologies for pollution reduction
- alternative fuels
- thermal and potential energy storage
- CO_2 utilization
- development of new types of adsorbents and catalysts
- chemical energy storage
- hydrodynamics, combustion and emission of pollutants in the CFB, CLC and CaL systems



Main research projects

A novel method of gas and petrochemical pollutants removal using adsorbents based on fly ashes (SORBENT)

Developme of high efficiency CFB technology to provide flexible air/oxy operation for power plant with CCS (FLEXI BURN CFB)

Utilizing waste from coal fired power production to produce solid fly ash based sorbents for CO2 and mercury (Ashsorbent)

Economically efficient and socially accepted CCS/EOR processes (PRO_CCS)

Innovative Idea for Combustion of Solid Fuels via Chemical Looping Technology (NEWLOOP)

Advanced Technologies for Energy Generation: Development of Technologies for High-efficient zero-emission coal-fired power plants integrated with CO2 capture units (PS1)

Advanced Technologies for Energy Generation: Development of oxy-combustion technology for PC and FBC boilers with CO_2 capture (PS2)

Budget ≈ 20 mln€

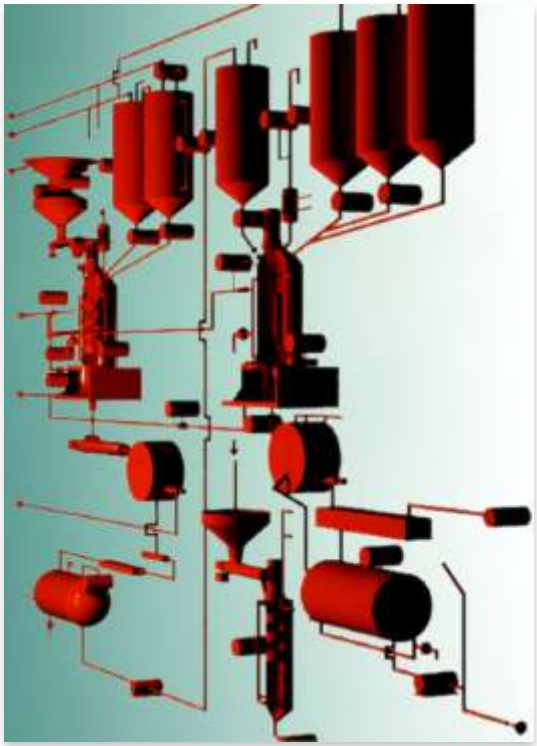
PARTICIPANT

COORDINATOR

2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

Sorbents for CO_2 capture

LABORATORY INVESTIGATIONS	SYNTEZIS IN HIGH-PRESSURE REACTOR	CONCEPT OF INDUSTRIAL SCALE
GRAMS OF SORBENT	KILOGRAMS OF SORBENT	TONS OF SORBENT

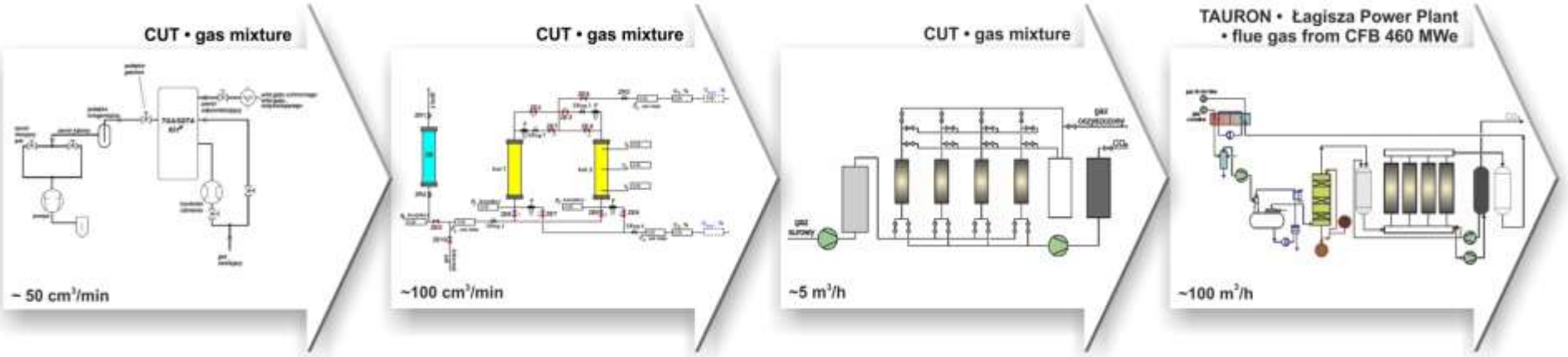


Sorbents for CO_2 capture

- commercial adsorbents
- fly-ash derived adsorbents
- metaloorganic frameworks structures
- amine impregnated sorbents

- carbon dioxide utilization in concrete production

Experimental facilities



laboratory scale → bench scale → pilot scale

Pilot scale investigations

✓ **decision of built two-step CO_2 separation installation in pilot scale based on dual-reflux vacuum pressure swing adsorption (DR-VPSA) technology**

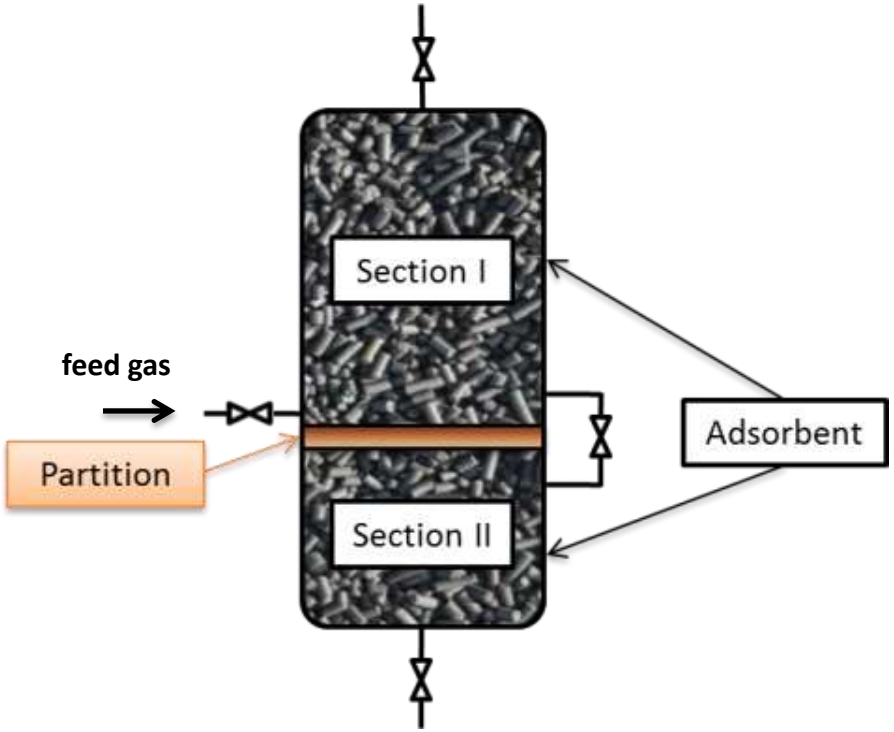


Fig. 1. Scheme of adsorption column in DR-VPSA technology

- ✓ two-section adsorber (two stage of CO_2 separation)
- ✓ the additional (second) section of the adsorber enriched the product obtained from the first section
- ✓ the possibility of obtaining high recovery of carbon dioxide and a high CO_2 concentration in the product
- ✓ **the World's first DR-VPSA investigations in pilot scale at real (industrial) conditions**

Pilot scale investigations

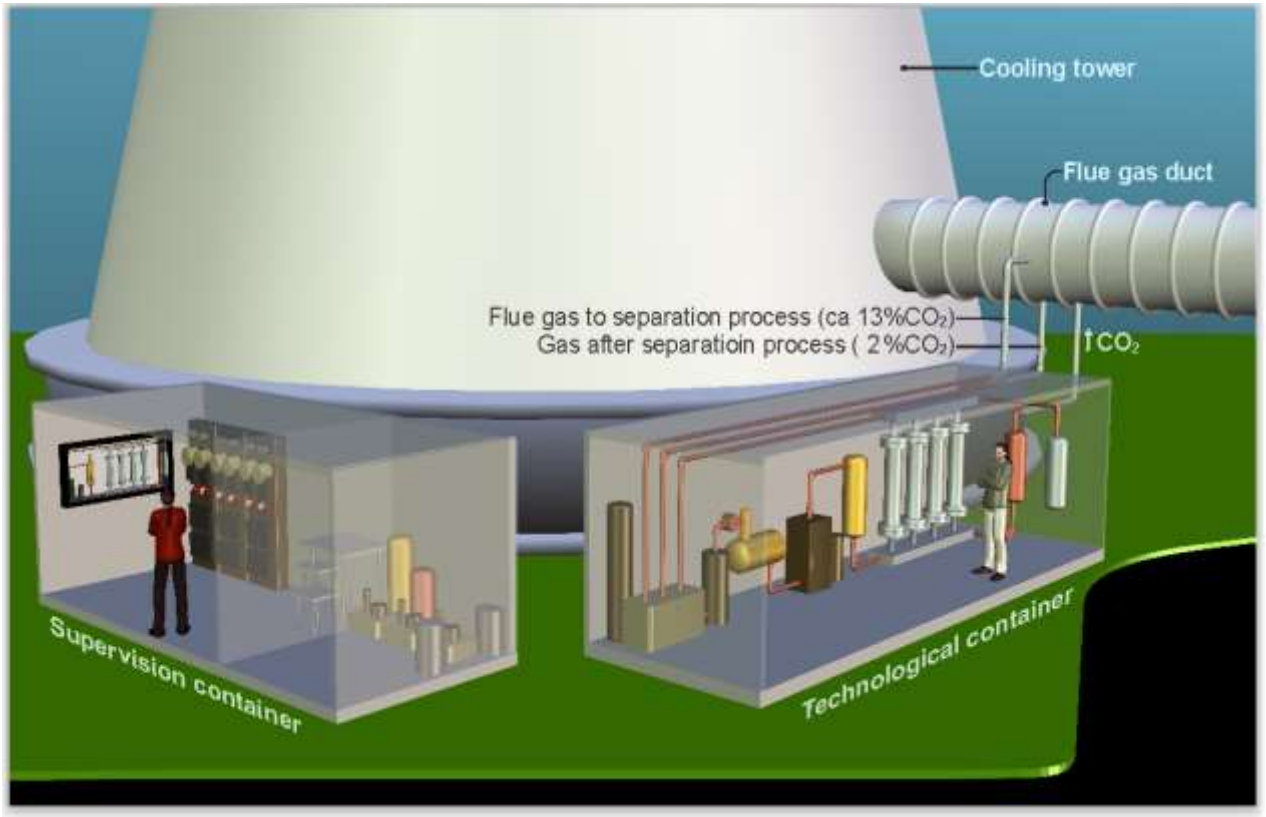


Fig. 2. Location of vacuum-pressure swing adsorption CO_2 capture pilot installation in Lagisza Power Plant, Bedzin (TAURON Wytwarzanie S.A.)

Location

next to cooling tower and flue gas duct

Design

two containers:
technological
& supervision

Technical parameters

productivity: 100 m^3/h

adsorption pressure:
160kPa abs

desorption pressure:
10kPa abs

Pilot scale investigations

- ✓ different kinds of adsorbents (activated carbon & zeolite)
- ✓ influence of process parameters (volume flow, time of adsorption, purge gas stream)
- ✓ different configurations of the process

Fig. 3. View on the pilot plant installation located at Lagisza Power Plant

Process design

- ✓ the necessity of purification of the flue gas before introduction to carbon dioxide adsorption separation section due to contaminants

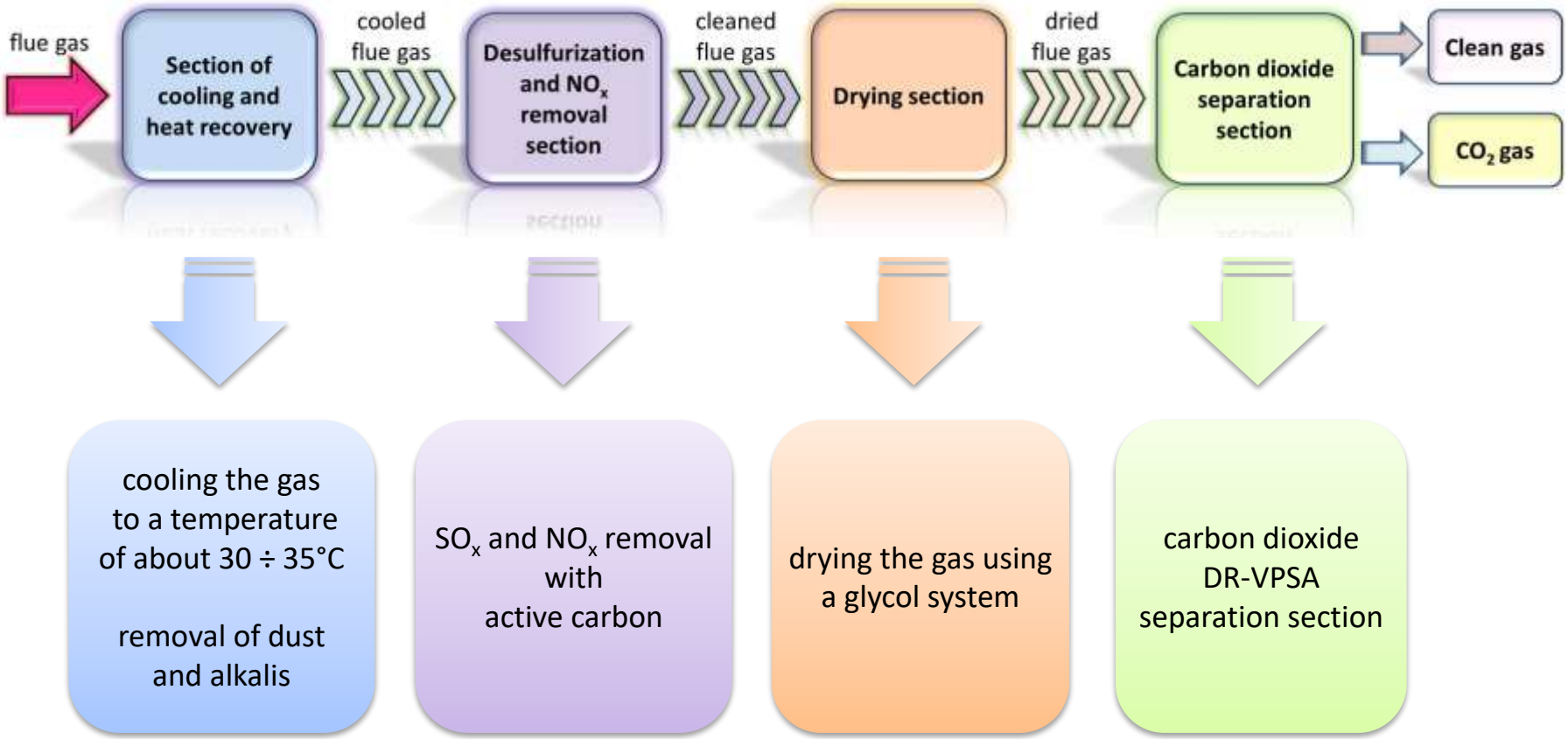


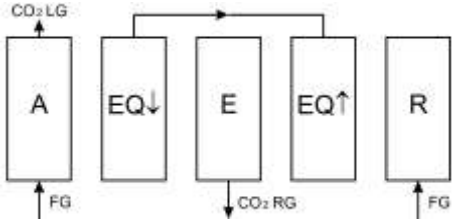
Fig. 4. Technological scheme of pilot DR-VPSA installation

Pilot scale investigations

- **Total operating time of installation**
  - startup and systems tests, leackage tests, research campaigns: over 1100h
  - research campaigns: over 800h

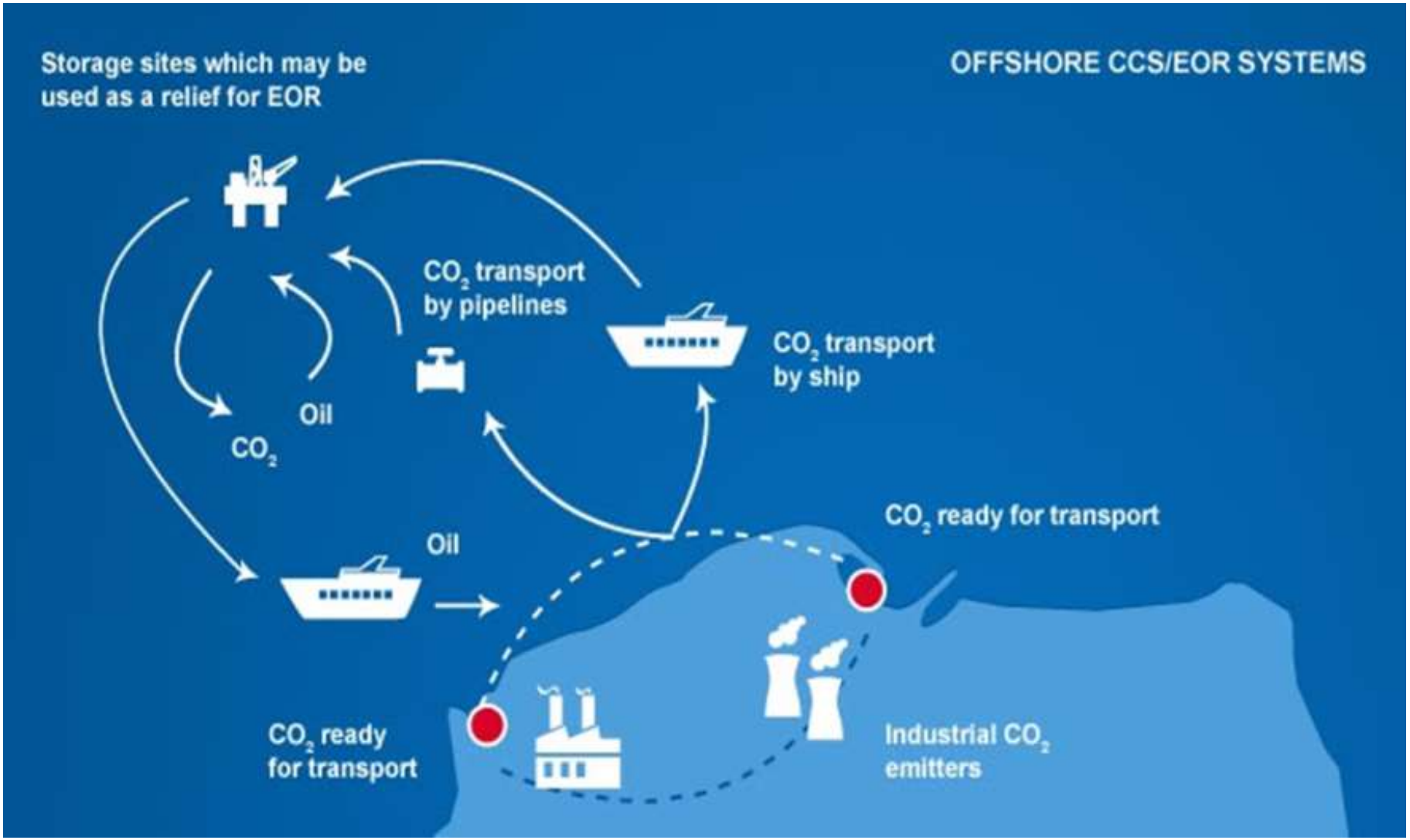
- **Investigated adsorbents:**
  - two kinds of activated carbons
  - zeolite and activated carbon

- **Configurations**
  - five different configurations



- **Parameters**
  - from three to five diffenent feed gas flowrates
  - three different purge gas flowrates (depend on configurations)
  - five different times of adsorption step

PRO_CCS project



Summary

- ✓ tests carried out with the filling of the beds by zeolite and activated carbon showed better results compared with the test performed only on the activated carbon

- ✓ conducted studies showed the possibility of using adsorption method for CO_2 capture on a larger scale, but some demonstration tests should be conducted

- ✓ it seems more perspective to looking for any other applications for separated CO_2 than sequestration

- ✓ measured energy demand for adsorbent regeneration by vacuum was low - not exceeded 1 MJ_e/kg_{CO2}

Further research directions

- reduction of the energy intensity of the capture process for power plants or other energy-intensive industries (steel, lime and cement and petrochemicals)

  (HORIZON 2020: LC-SC3-NZE-1-2018: Advanced capture technologies)

- demonstration tests on CO_2 capture on large scale

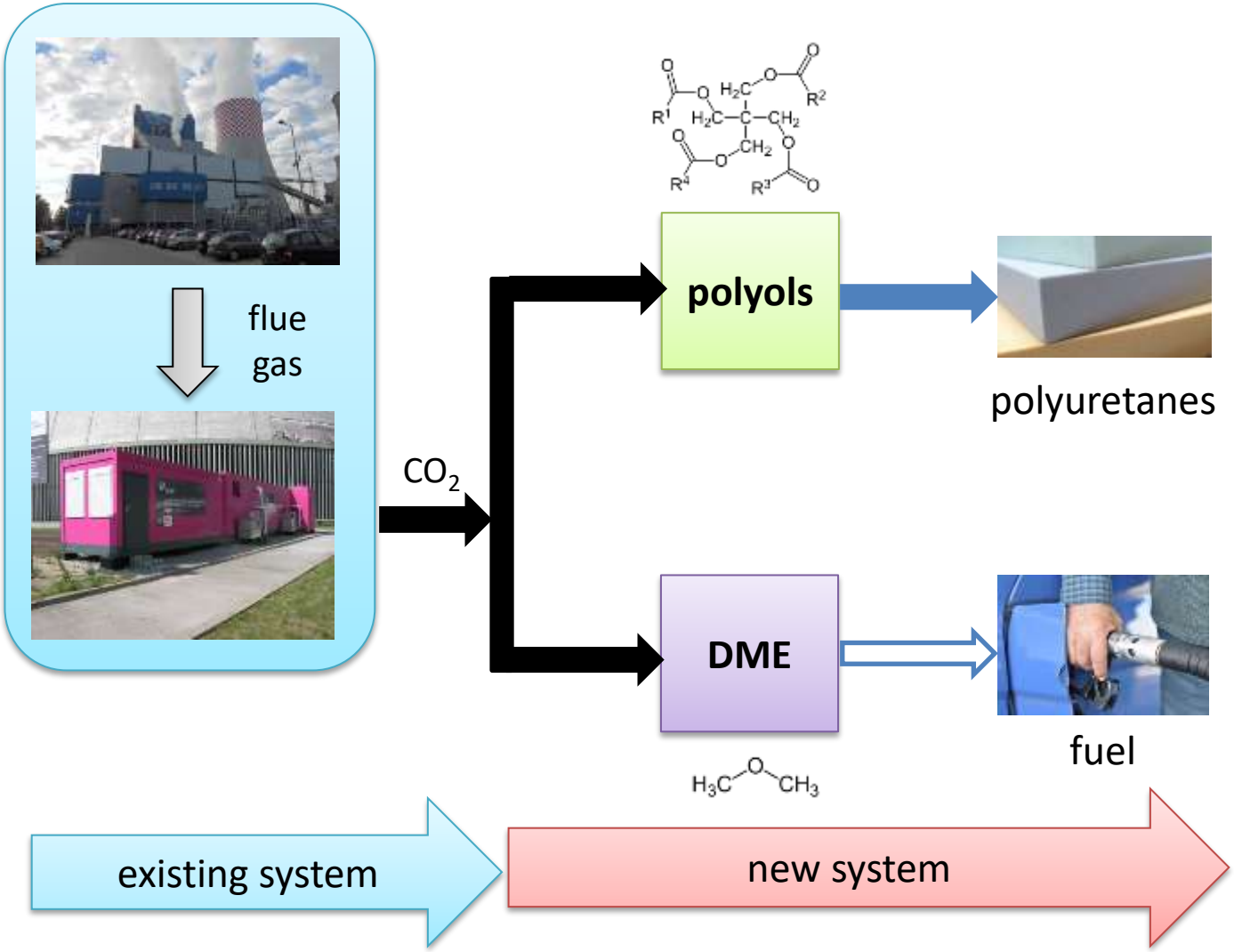
  (THE BLUE BOOK of EEA and NORWAY GRANTS 2014-2021)

- demonstration of full CCS chain at industrial conditions with CO_2 offshore geological storage to overcome lack of business and public acceptance **(HORIZON 2020: *LC-SC3-NZE-3-2019: Demonstrating the full CCS chain at commercial scale)***

- development of energy-efficient CO_2 utilisation technologies for chemical energy storage or displacement of fossil fuels

  (HORIZON 2020: CE-SC3-NZE-2018: Conversion of captured CO_2)

Possibilities of application



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