Piloting CO_2 Post-Combustion Capture

CO2NET East workshop, 3-4 March 2009, Bratislava, Slovakia

TNO | Knowledge for business

Mohammad Abu-Zahra

Senior process engineer Energy/CO_2
TNO Science & Industry

E: mohammad.abuzahra@tno.nl
T: +31 15 269 2861

Overview

- Introduction
- CCS in the Netherlands
- Rotterdam Climate Initiative
- TNO post-combustion capture pilot plant
- Solvent/process benchmarking
- The way forward

TNO profile and core areas

CCS Expertise

Quality of Life

Defense, Security & Safety

Science & Industry

Built Environment & Geo-Sciences

ICT

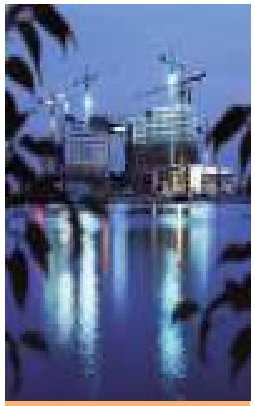
FY2007 Key Figures

- € 579 million turnover
- 2/3 market, 1/3 government supported research
- approximately 4600 employees

Getting CCS Technologies to Work

- R&D and Engineering - Lab → Bench → Pilots & Demos
- Building the Chain - Capture →Transport → Storage
- Support - Corrosion, Risk Management, Policies

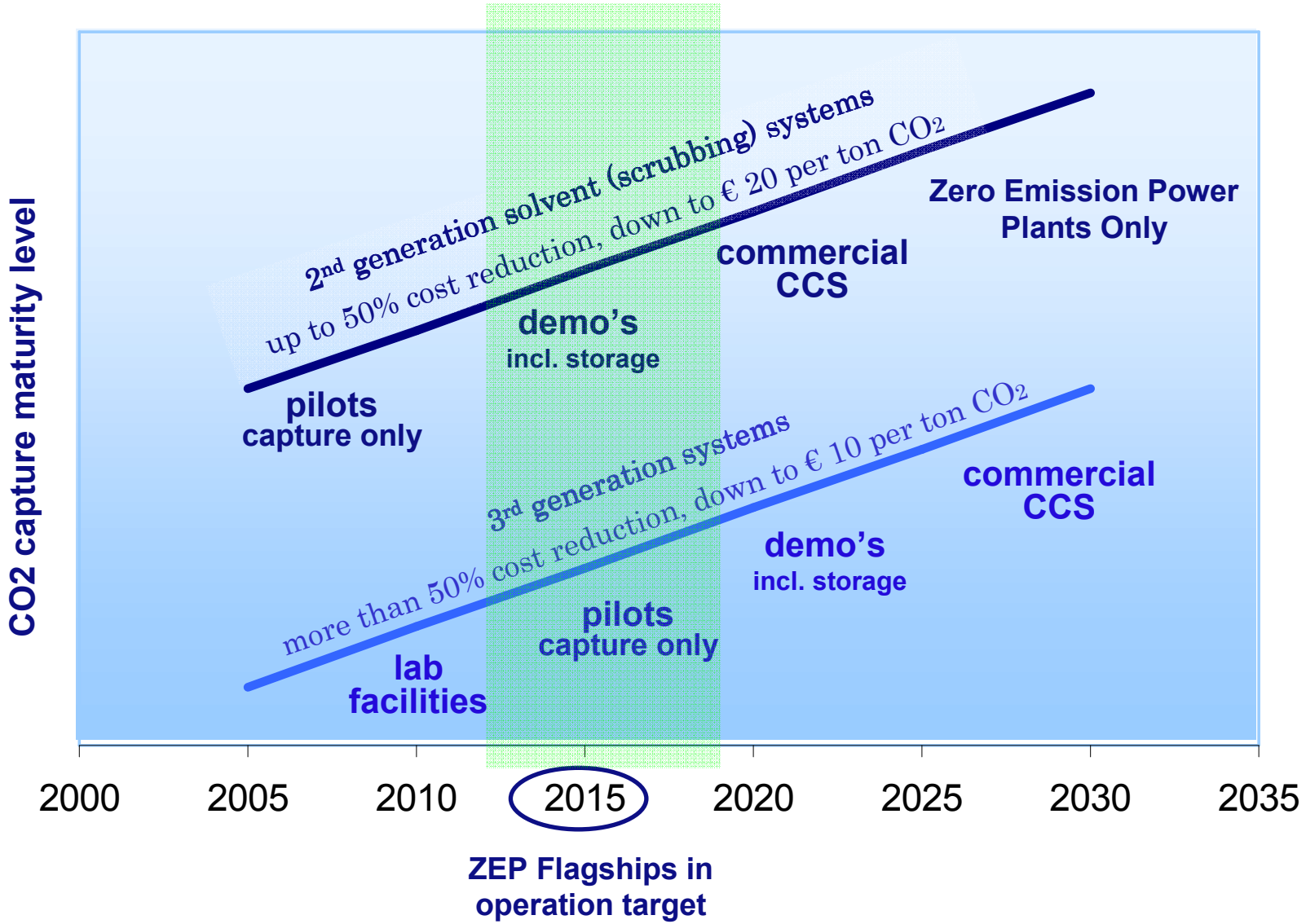
Science & Industry



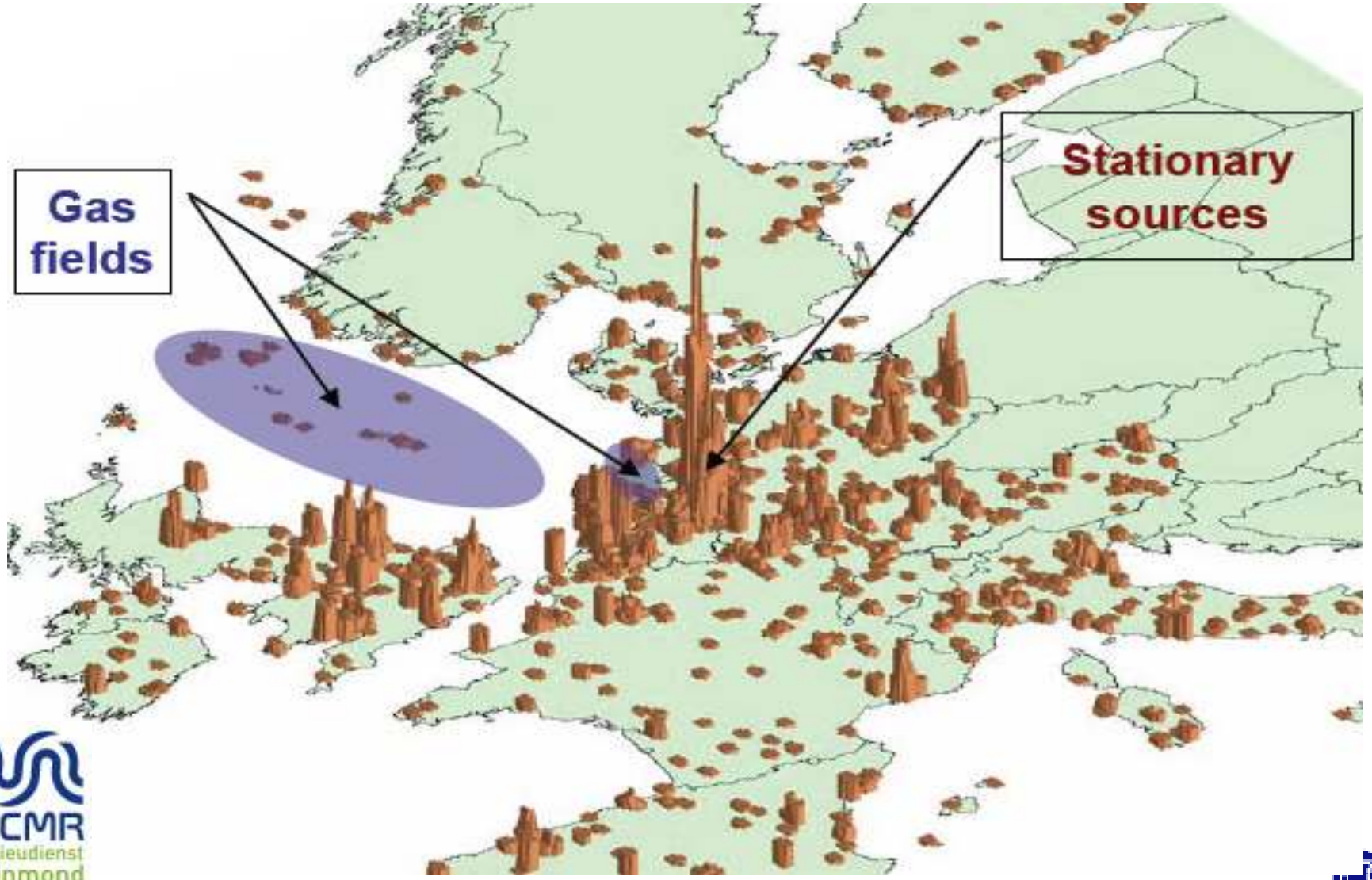
Built Environment & Geo-Sciences

- 50+ Employees working in the CCS field
- EU and national programmes
- Joint development projects
- Industrial bilateral projects

CCS – Capture Implementation Roadmap



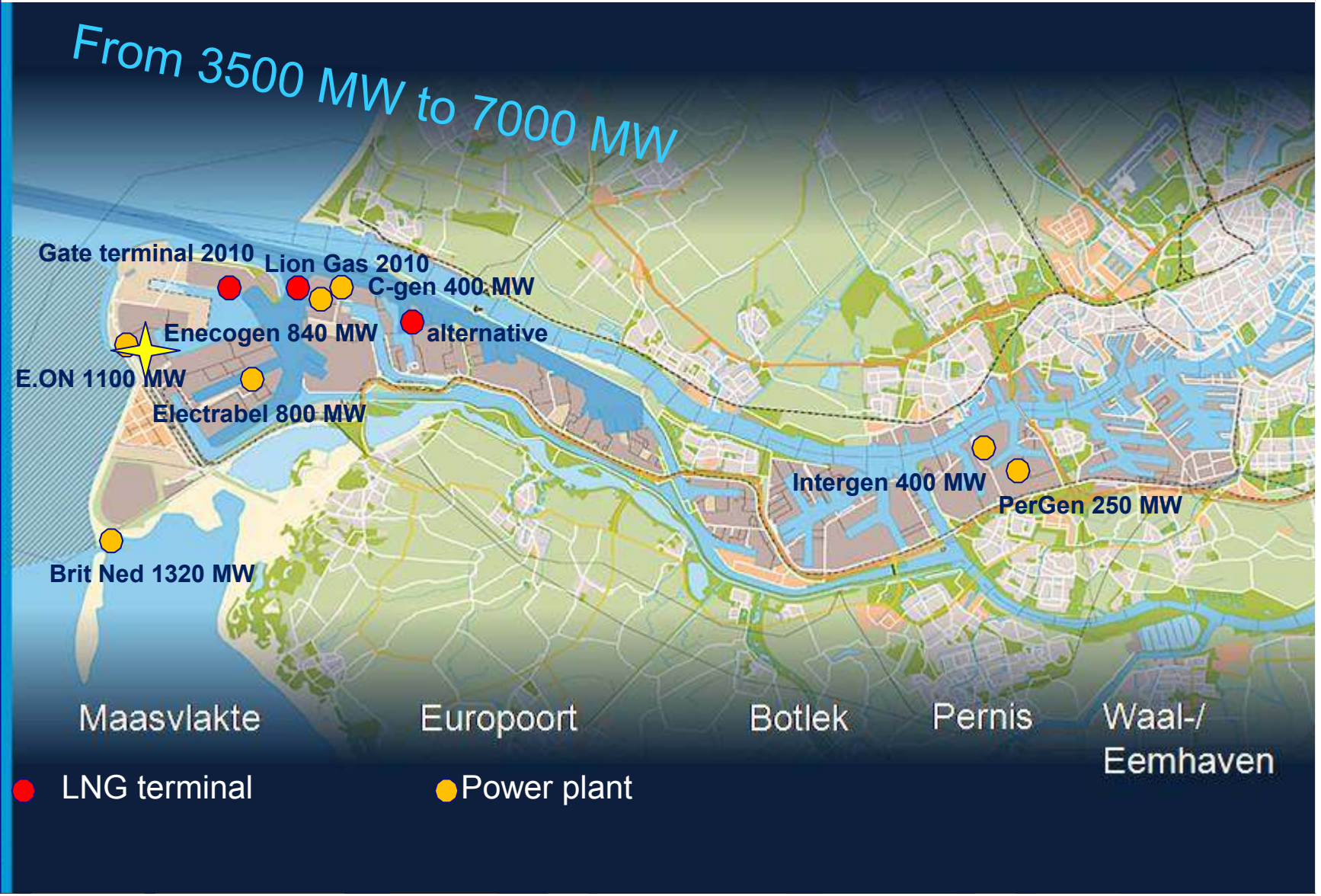
CO_2 sources in Europe



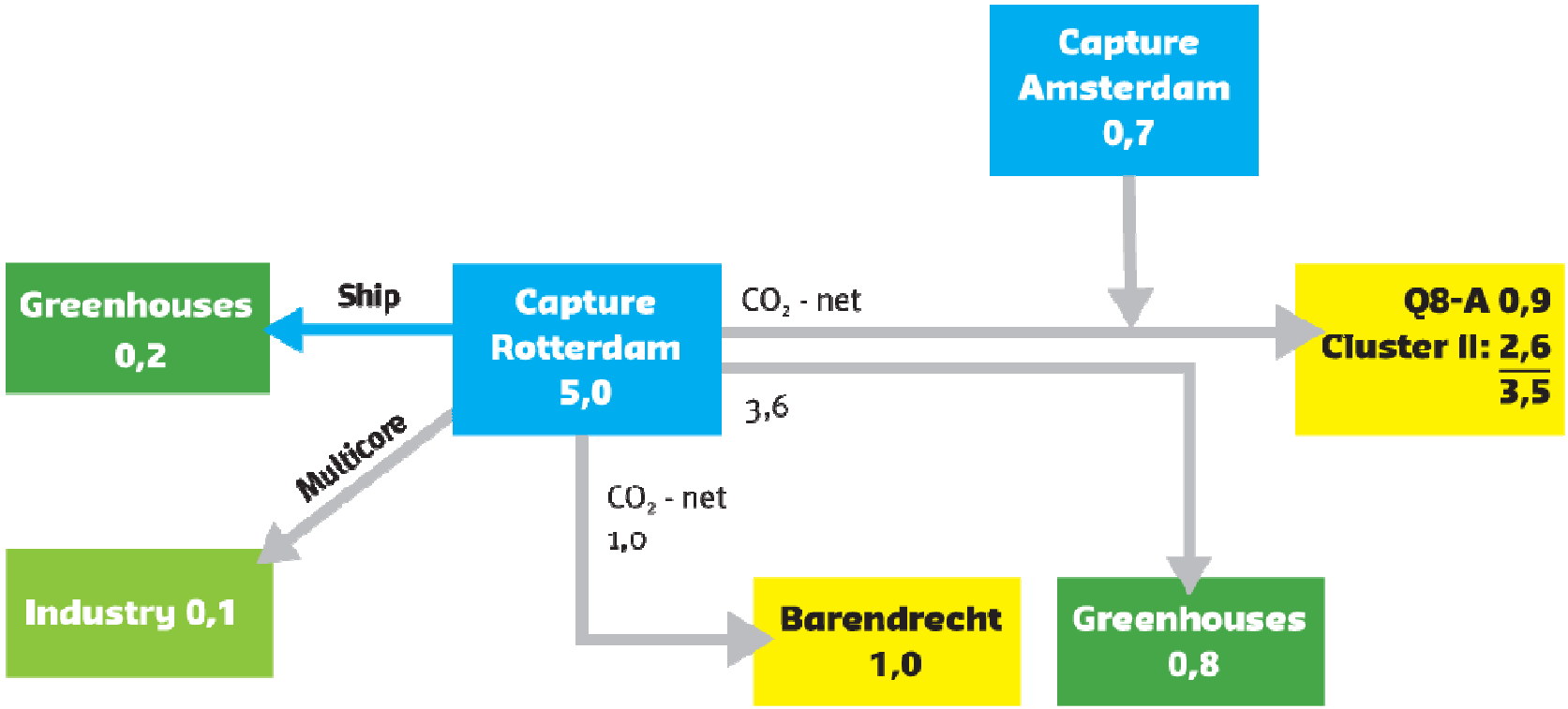
DCMR milieudienst Rijnmond

Rotterdam Climate Initiative

Rotterdam Energy port



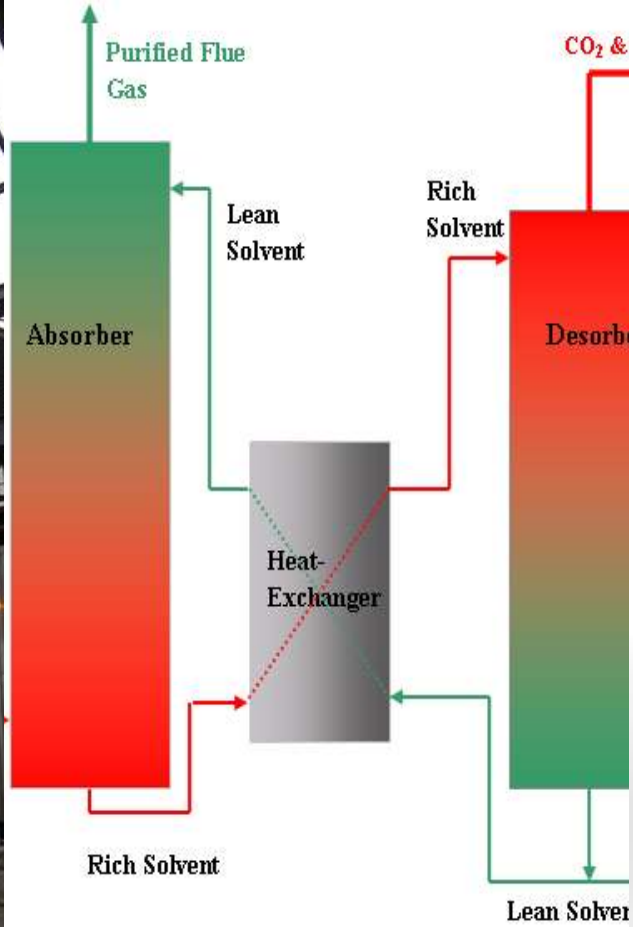
First businesscase: 5 Mton in 2015

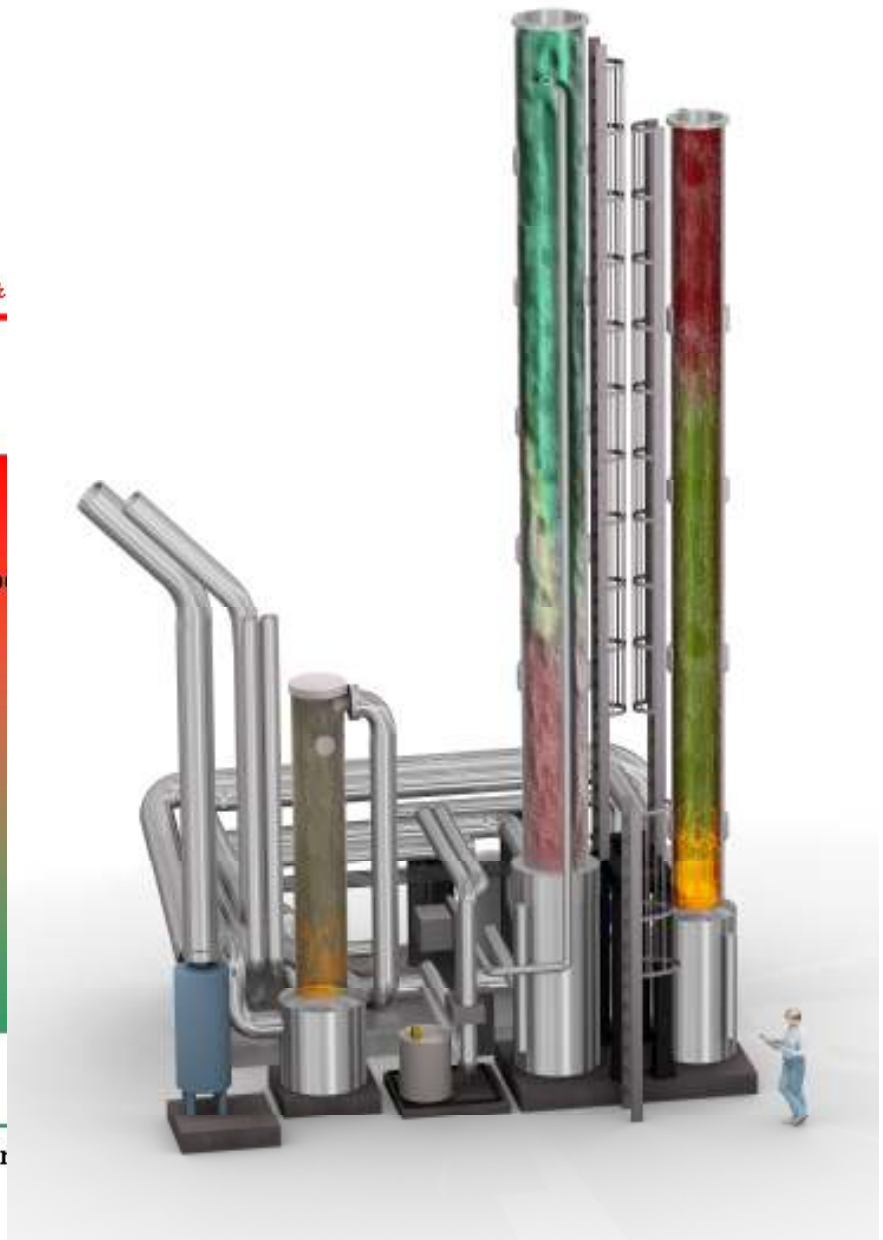


CATO CO_2 Catcher - Main Facts

- First CO_2 capture pilot plant in the Netherlands
- First flexible multi-purpose pilot plant in Europe:
  - testing/benchmarking CO_2 absorption solvents
  - different types of gas/solvent contactors
  - validating and developing process models
- Developed & operated by TNO in cooperation with E.ON and CATO partners
- Investment € 2 million, about 1/3 financed by Ministry of Economic Affairs via CATO
- Real flue gas conditions at power plant of E.ON, Rotterdam

CO_2 capture process





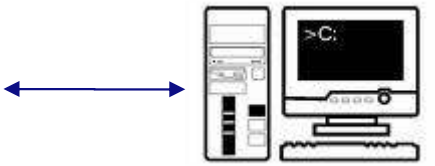
Solvent Testing Workflow - From Lab to Pilot

Lab tests

Solvents screening
Thermo data
Basic characteristics

Micro & Mini plant

System performance
Model validation



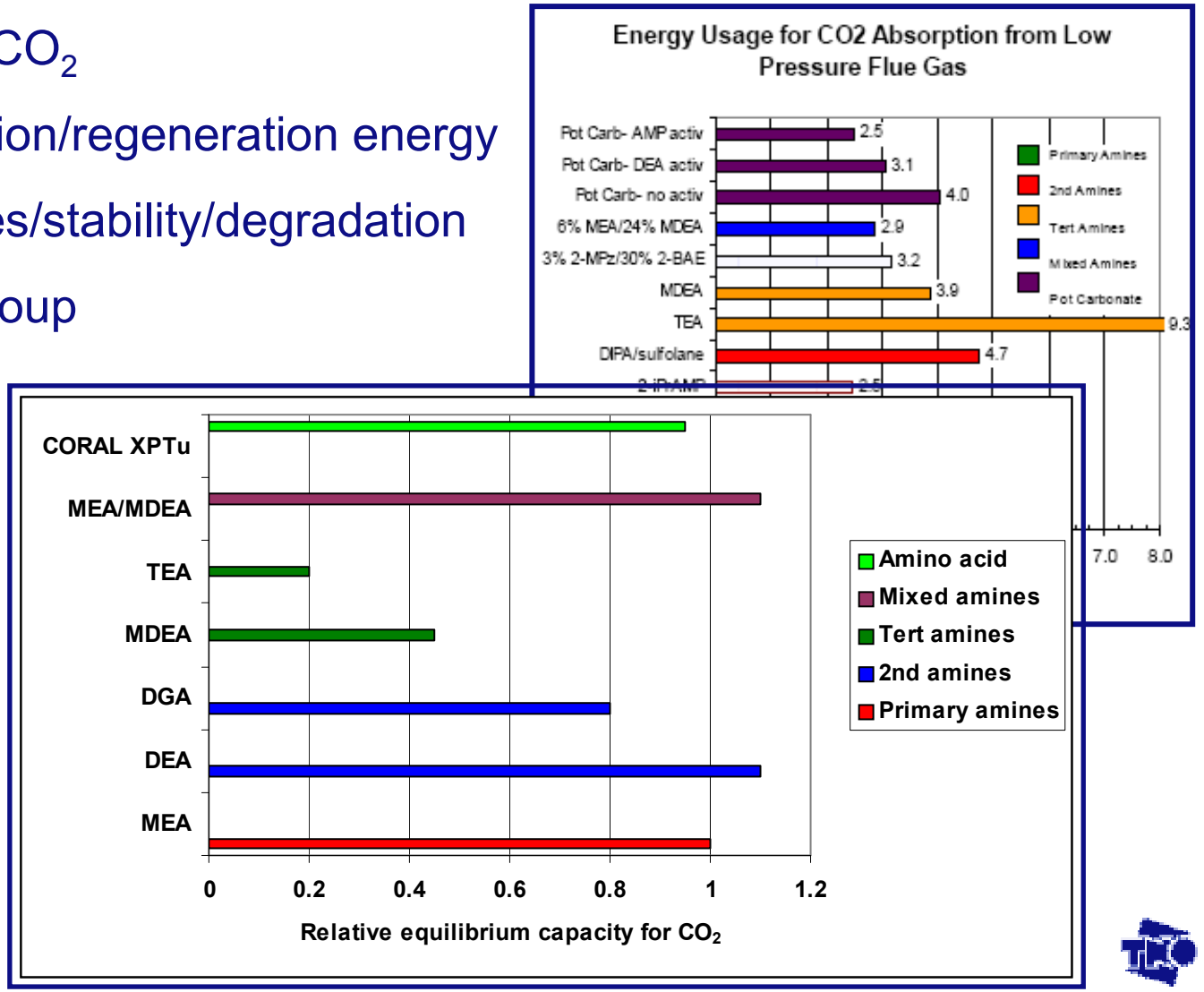
Modelling
System design

Pilot plant

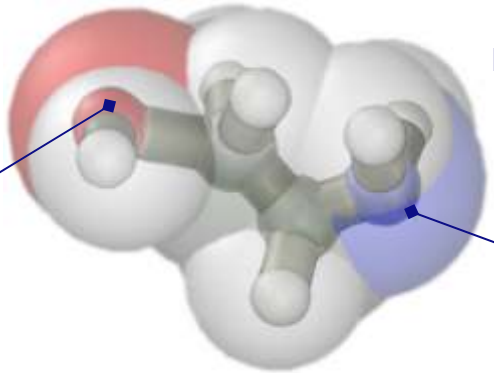
Scale up effects
Industrial conditions
Model validation
Long term effects

Solvent benchmarking parameters

- Capacity for CO_2
- Heat of reaction/regeneration energy
- Solvent losses/stability/degradation
- Functional group
- Toxicity
- Environment
- Cost



Amino acids and MEA chemical structure



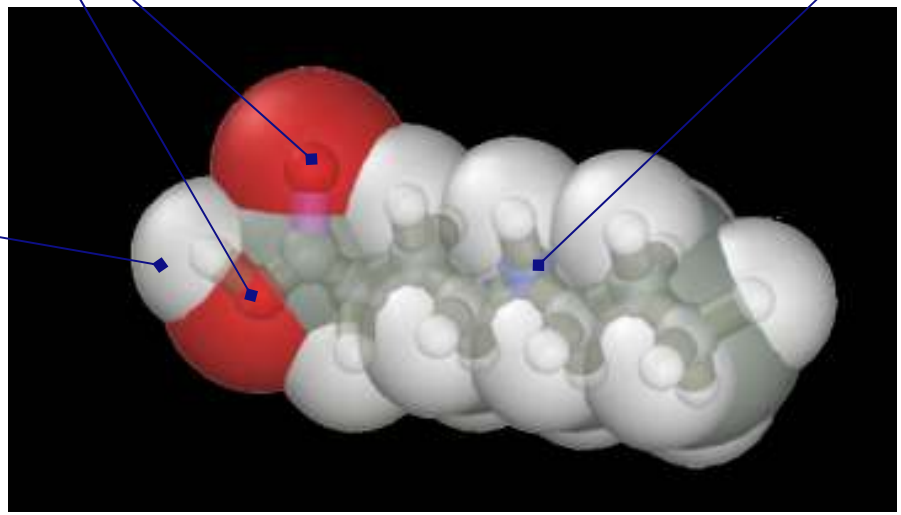
MEA (conventional amine)

Oxygen molecule

Amine functional group (reacts with CO_2)

Hydrogen molecule

Replaced by Ion +



Chemically stable

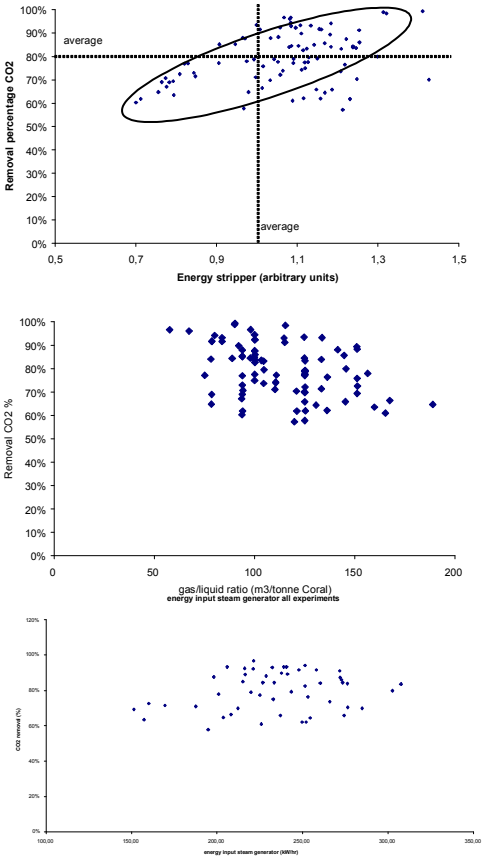
Biologically degradable

No vapour pressure

An example of amino acid salt (CORAL family)

Solvents benchmarking methodology

➔**Pilot**

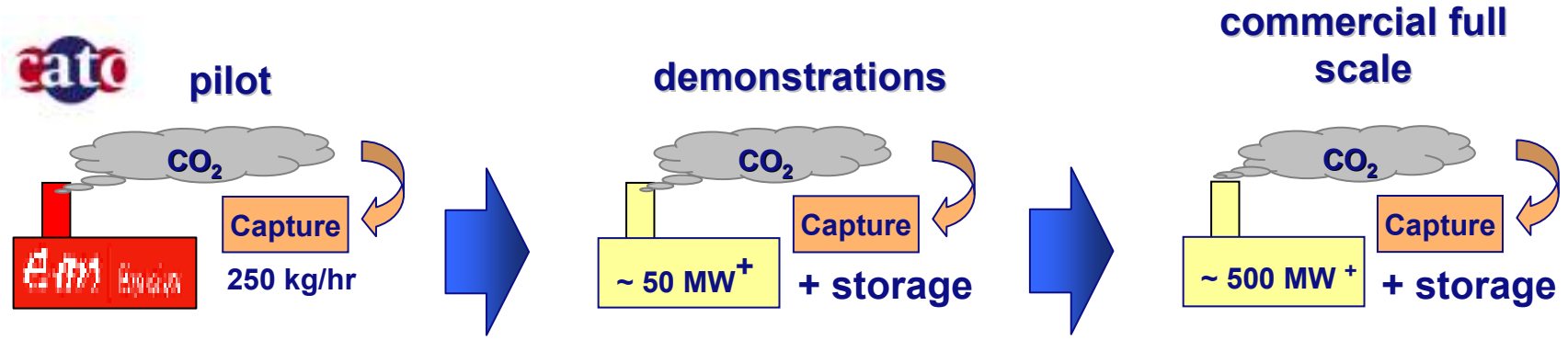


➔**Translation**

Energy requirement
Gas/liquid ratio
Stability solvent
Loading solvent

Techno-
Economic
Evaluation

Scale-Up & Improvement Strategy



In operation

40 → 30 EUR/ton*

2010 - 2015

30 → 20 EUR/ton*

2015 - 2020

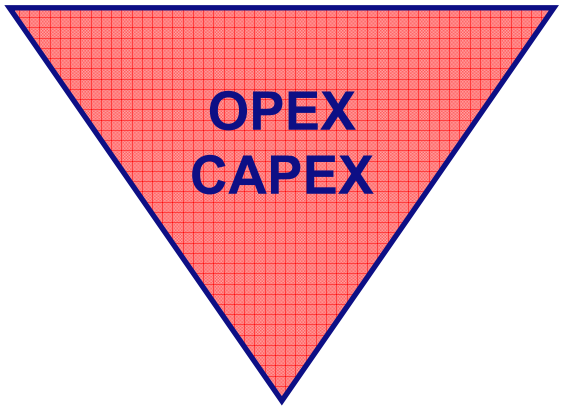
20 EUR/ton*

* Indicative targeted CO_2 avoidance cost including compression up to 110 bar, excluding storage

Improving capture cost efficiency

Novel Solvent

- Capacity
- Enthalpy
- Stability
- kinetics



Equipment development

- Scale-up
- Compact contactors
- Process conditions

Process integration and optimization

- Heat recovery
- Split flow
- Process conditions

Way Forward

- **CORAL solvent family** – Promising replacement for MEA
- Support in **benchmarking** and **testing for third parties**
- CATO-2 important national platform to prepare basic design packages for **large scale demonstration**
- CESAR/CLEO new industrial sponsors **(open running programme)**.
- Further 2nd generation development:
  - **Solvent, contactors** and **Process** development and optimization
- Development of 3rd generation processes:
  - combined CO_2/SO_2 removal (e.g. DECASOX)
  - multi-phase solvent systems (e.g. DECAB)