Financing existing CCS projects. How has it been done?

François KALAYDJIAN
IFP

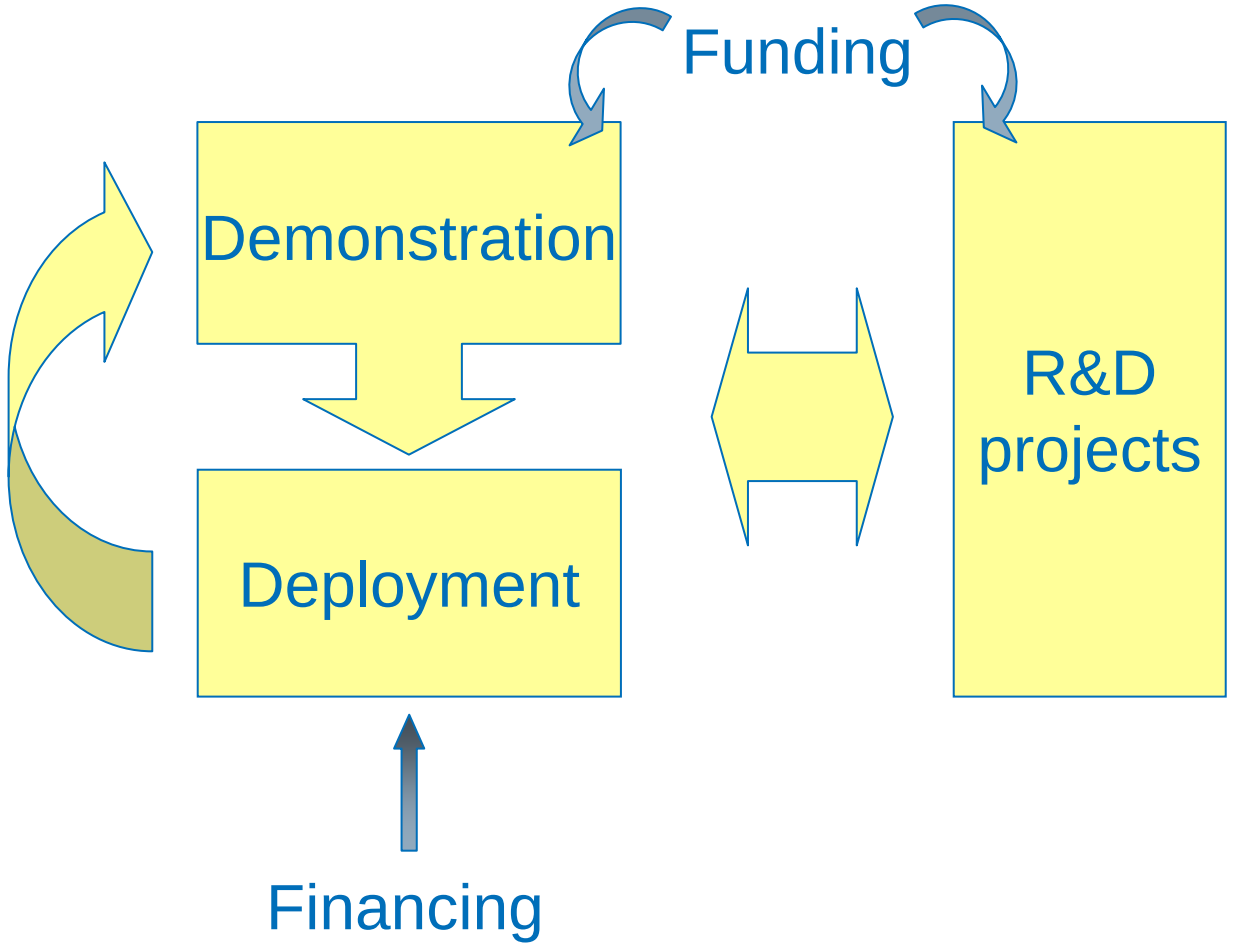
Financing mechanisms

- Key issues
  - **include CCS in an international cap-and-trade system**
    - Trades in the worldwide market amount to USD 30B in 2006 with USD 24B for the EU EU Emission Trading System only
  - **recognize CCS as a CDM to develop exchanges with emerging countries**
    - Allows for the development of more efficient technologies
  - **develop technologies (R&D) and financing mechanisms suitable for emerging countries**
    - Improve the energy efficiency
    - Reduce the energy penalty
    - Implement appropriate financing mechanisms

Financing CCS for a worldwide deployment

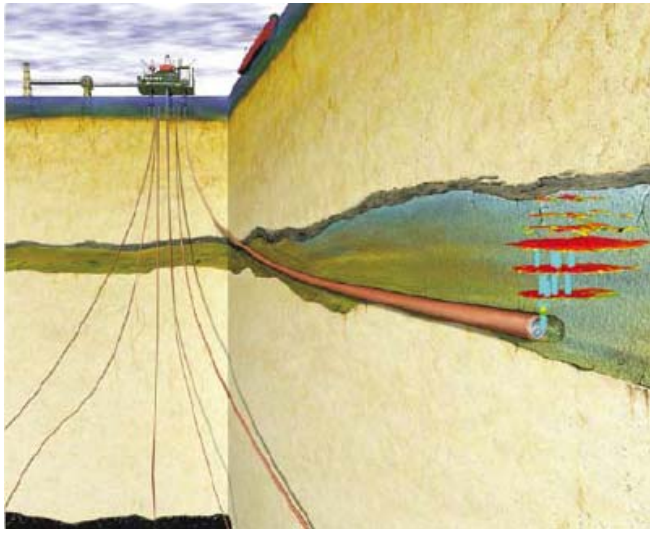
- Establish a clear legal and regulatory framework
- Funding & Financing
  - funding R&D project and demonstrations
  - develop financing mechanisms that can create a global market
- Create consistent emission reduction rules and tools to create an international CO2 market
  - Cap and Trade, Emission Trading Scheme
- Some issues to address
  - CCS Capex and Opex (in particular for CO2 capture)
  - Efficiency reduction and Energy penalty

Deploying CCS
From R&D to Deployment



Sleipner

Tax regime : US$ 40/tCO2



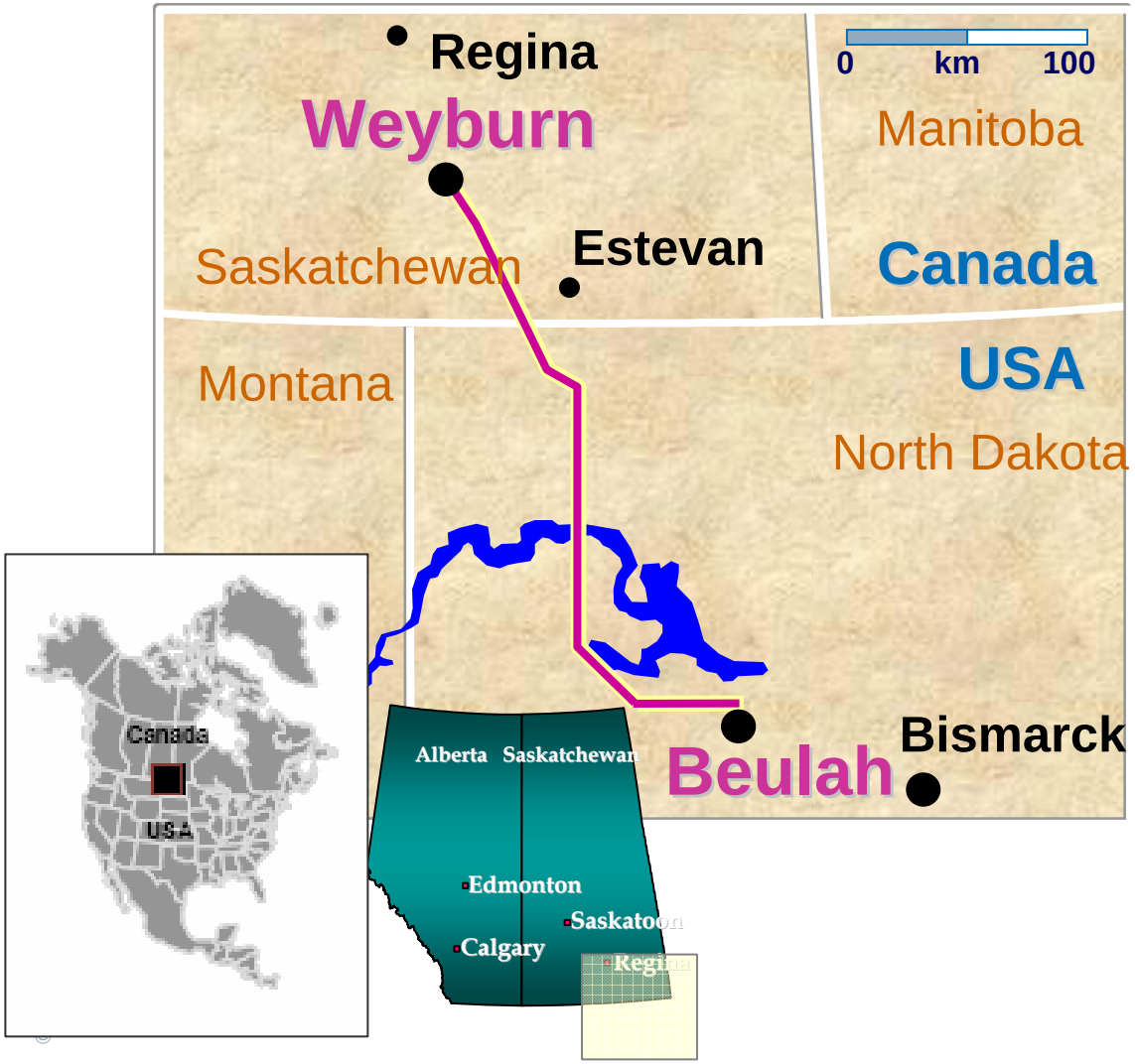
- **Capture**
  - amine gas treatment
- **Compression & Reinjection**
  - Utsira formation (saline aquifer): 50-100km wide; 50-250m thick; 1000m below the sea floor
- **Storage**
  - 1MMtCO2 / yr
  - 25 MMtCO2 over 25 years

started in 1996

Sleipner
Cost breakdown

Costs	US$ (1996)	%
■ preparation	2 MM	2
■ compressors	79 MM	82
■ injection well	15 MM	16
Investments	**96 MM**	100
Operations *(marginal fuel consumption + tax on CO2 emissions)*		
■ per year	**7 MM**	
■ per tonne		

Weyburn



- **Capture**
  - coal gasification plant located in the US (DGC)
- **Transport**
  - pipeline, over 330 km
- **Storage**
  - 1MMtCO2/yr in a the mature Weyburn field (CO2 EOR)
- *155 MM added barrels*
- *23 MMtCO2 stored while EOR*
- *55 MMtCO2 stored afterwards*

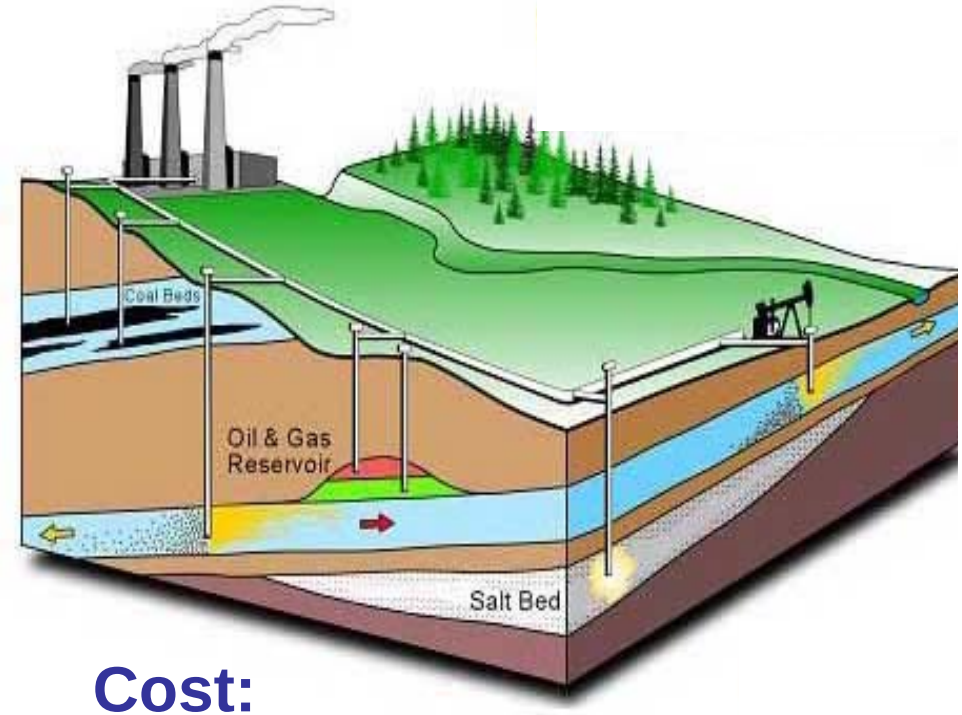
Weyburn – cost breakdown
(T. Torp and K. Brown, 2006)

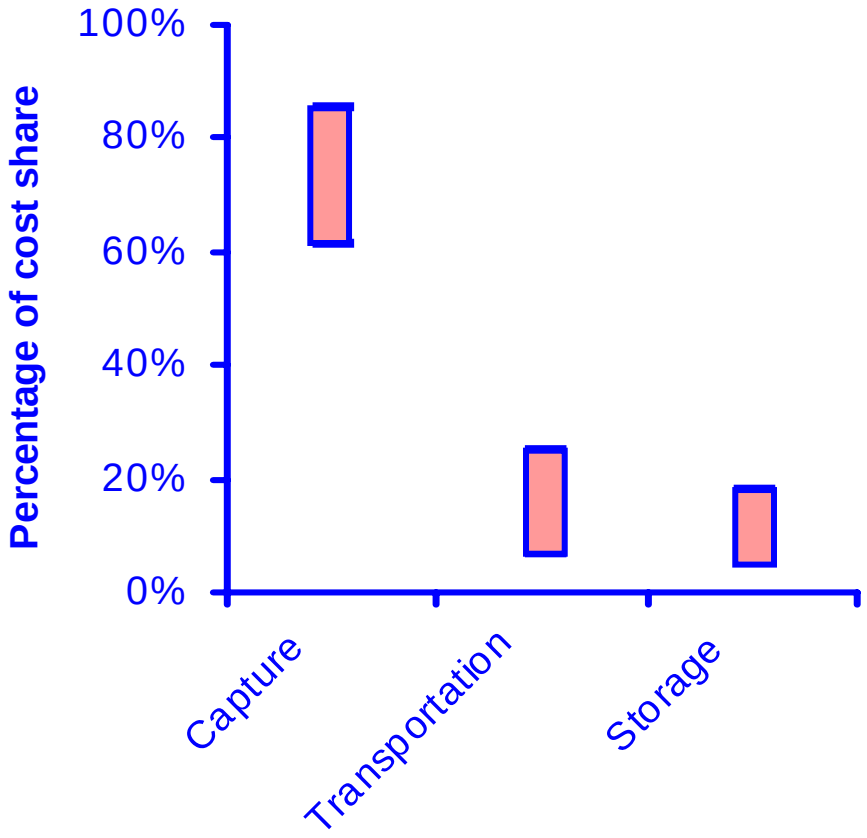
- Plant + Compression + Pipeline
  - US$ 100MM
- CO2 injection facilities (existing)
  - US$ 270M/yr
- The IEA GHG R&D Weyburn CO2 Monitoring & Storage project
  - US$ 27MM
  - Phase 1 completed in June 2004

Costs	US$ (2000) per tonne	%
■ preparation ■ compression ■ injection	EOR	
Investments	10.19	51
Operations ■ per year ■ per tonne	9.85	49
TOTAL	20.04	100

Innovation Energy Environment

Weyburn
Summary of main costs



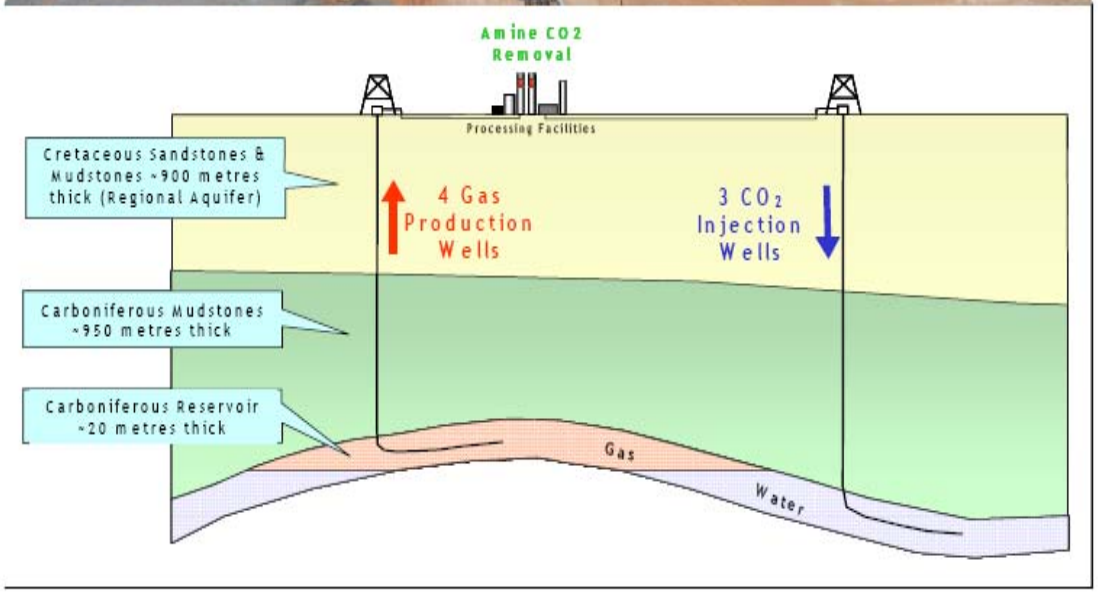


Cost:

- **Capture: $40-60/t CO_2 avoided**
- **Pipeline: $0.02-0.06/t .km**
- **Transportation mileage: 300 km**
- **Storage: $5-10/t CO_2**
- **Break even: $20 bbl**

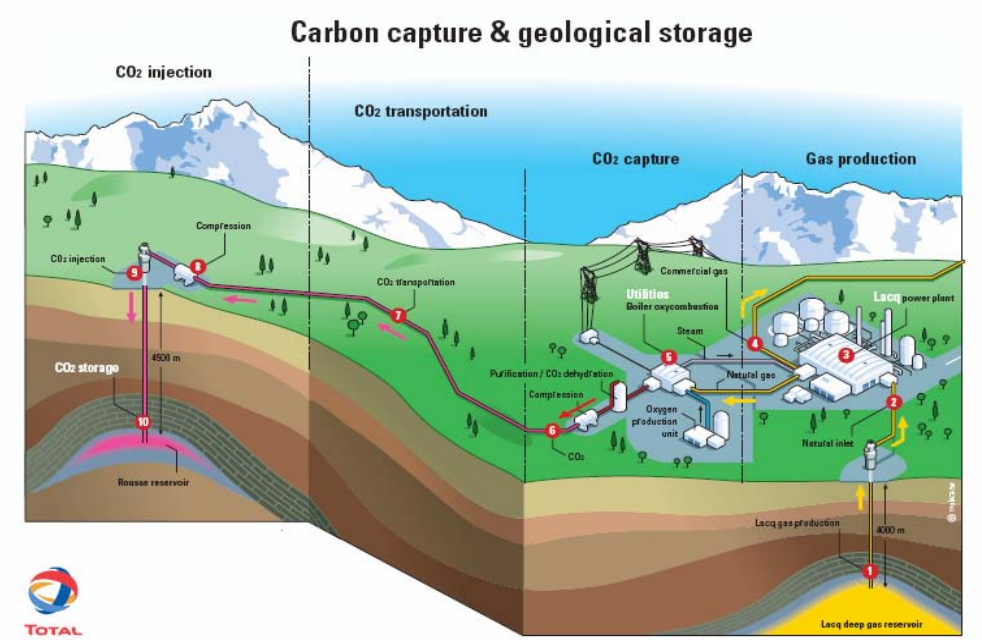
source: ABB

In Salah CO_2 storage operation



- ✓ Industrial scale demonstration of CO2 geological storage
- ✓ Started August 2004
- ✓ 1 MM tCO2 /yr
  - 17 MM tCO2 lifetime
- ✓ $100MM incremental cost (US$6/$tCO_2$)
  - no commercial benefit
- ✓ Test-bed for CO_2 monitoring technologies

Lacq CCS pilot project *(TOTAL)*



- revamping of a 30MWth boiler with oxycombustion
- 150 ktCO2 captured over 2 years
- compression, then transport and storage in a depleted gas reservoir close to the Lacq field
- start: end of 2008

An integrated CCS project, from capture to storage

Funding R&D projects
Two EU funded projects

- **CASTOR**

- **COACH**

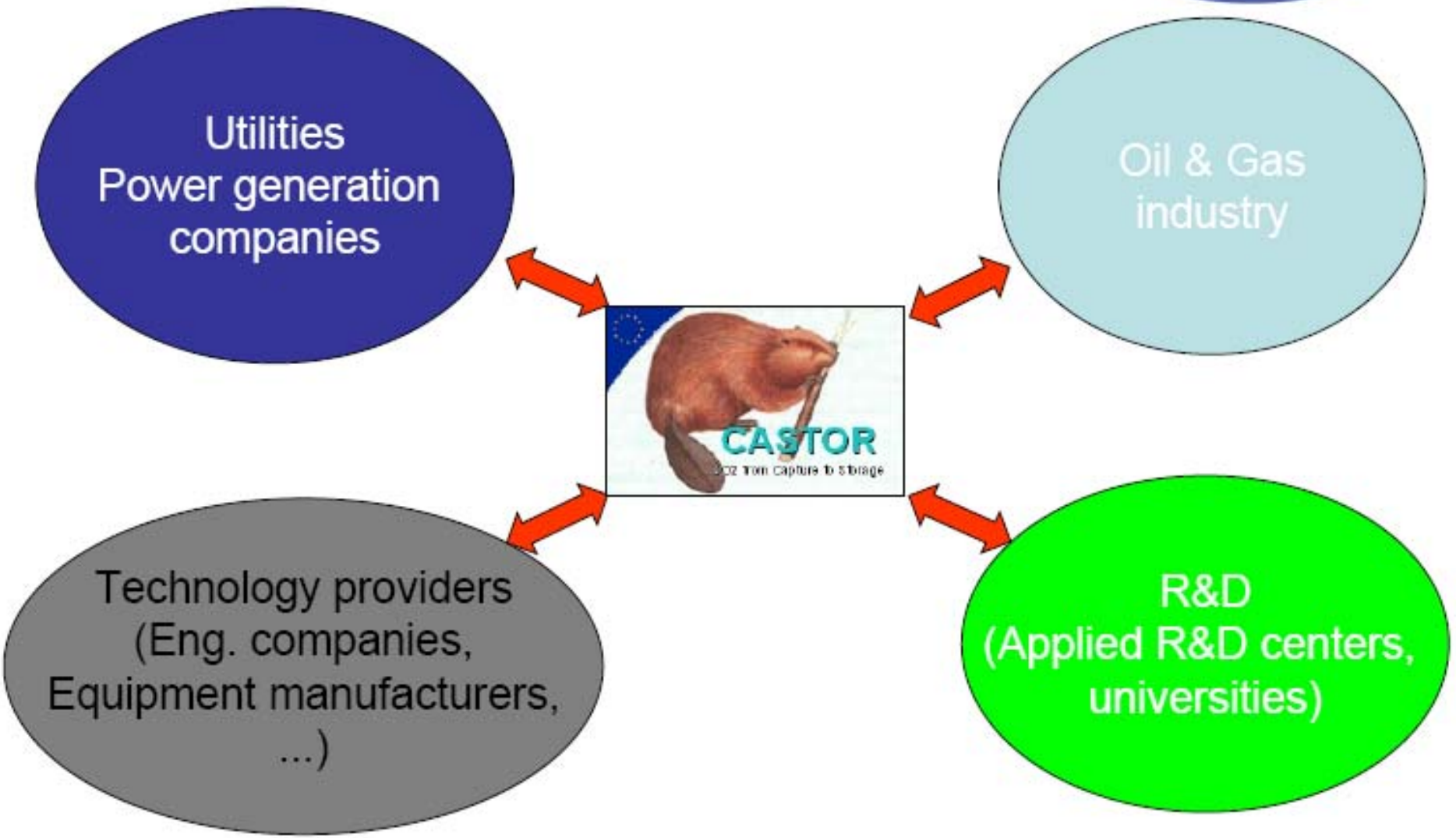
CASTOR targets

- Develop and validate innovative technologies needed to capture 10% of CO_2 emitted in Europe (30% of CO_2 emitted by power and industrial plants)
  - Reduce the cost of CO_2 post-combustion capture,

    ⇒ *from 50-60 € to 20-30 € / ton of CO_2 avoided*
  - Contribute to the feasibility & acceptance of the geological storage concept

    ⇒ *study 4 new European storage sites*
  - Start the development of an integrated strategy connecting capture, transport and storage options for Europe

A wide representation of European actors



CASTOR at a Glance (1)

Funded by the European Commission under the 6th Framework Program

R&D	Oil & Gas	Power Companies	Manufacturers
IFP (FR)	STATOIL (NO)	VATTENFALL (SE)	ALSTOM POWER (FR)
TNO (NL)	GDF (FR)	ELSAM (DK)	MITSUI BABCOCK (UK)
SINTEF (NO)	REPSOL (SP)	ENERGI E2 (DK)	SIEMENS (DE)
NTNU (NO)	ENI (IT)	RWE (DE)	BASF (DE)
BGS (UK)	ROHOEL (AT)	PPC (GR)	GVS (IT)
BGR (DE)		EON-UK (UK)	
BRGM (FR)		SUEZ-ELECTRABEL (BE)	
GEUS (DK)			
IMPERIAL (UK)			
OGS (IT)			
TWENTE U. (NL)			
STUTTGARTT U. (DE)			

Co-ordinator: IFP

Chair of the Executive Board: Statoil

31 partners from 12 European Countries

Duration: 4 years **Feb. 2004 – Feb 2008**

CASTOR at a Glance (2)

- **Total Budget: 15,8 M€**

- **Funding of the project:**
  - ✓ **EU funding: 8,5 M€**
  - ✓ **Industrial funding: 2,7 M€**
    - ⇒securing the pilot plant and operating costs
    - ⇒necessity to have the pilot ASAP available for the project
  - ✓ **Own funding from partners: 4,6 M€**

CASTOR at a Glance (3)

- **Budget for the pilot plant:**
  - **Building of the pilot: 1,9 M€**
  - **Operations & maintenance: 0,4 M€**
  - **Testing (2 years): 0,5 M€**

  2,8 M€

- **Funding of the pilot:**
  - EC funding: 1,2 M€
  - Industry funding: 1,2 M€
  - Pilot owner contribution (DONG): 0,4 M€

CASTOR main components

Strategy for CO_2 Reduction (Lead SINTEF)

WP1.1 Development of CO_2 reduction strategies

WP1.2 Geological storage options for CO_2 reduction strategy

Budget: 0,9 M€

Management Dissemination

WP0.1 Project Management

WP0.2 Dissemination & Training

Budget: 0,75 M€

CO_2 Post-Combustion Capture (Lead TNO)

WP2.1 Evaluation, optimisation & integration of post-combustion capture processes

WP2.2 Identification of most promising liquids

WP3.3 Designed of membrane based processes

WP3.4 Advanced processes

WP3.5 Process validation in pilot plant

Budget: 10,3 M€

CO_2 storage performance & risk assessment studies (Lead SINTEF)

WP3.1 Field case "Casablanca"

WP3.2 Field case "Atzbach"

WP3.3 Field case "K12b"

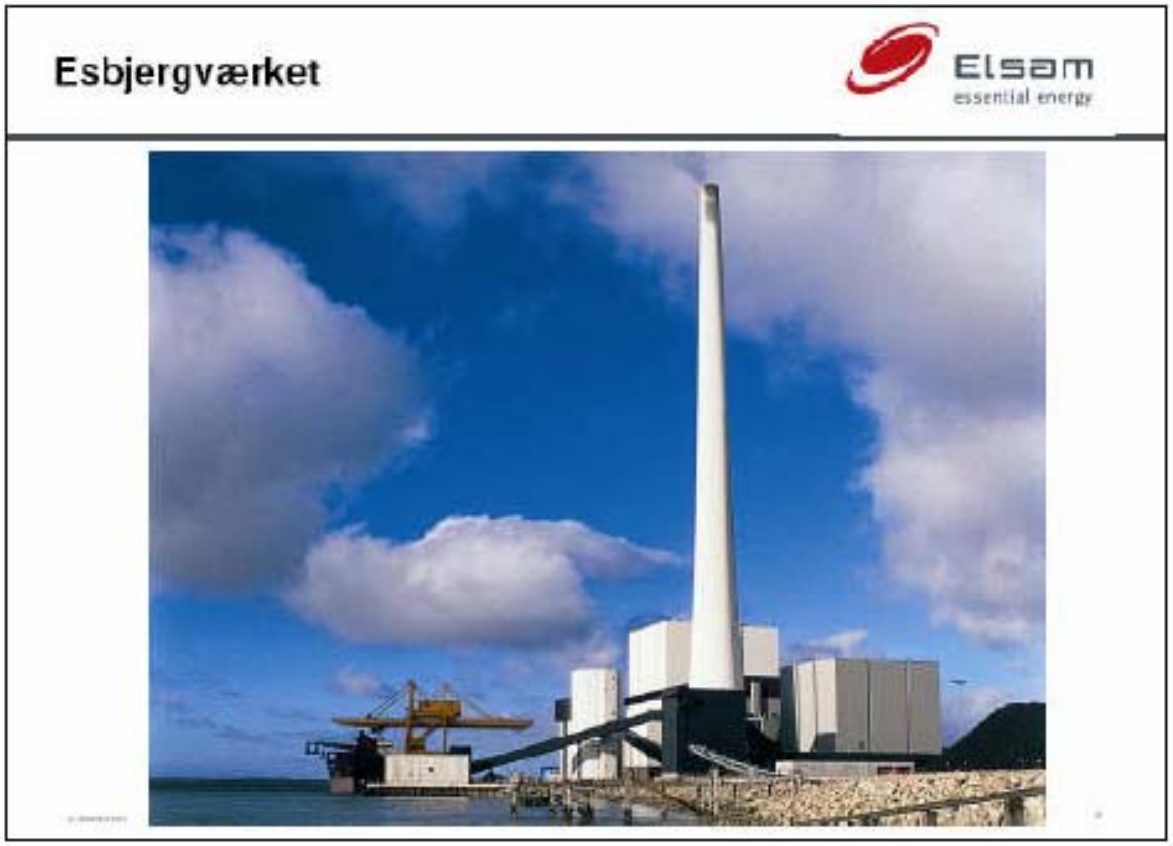
WP3.4 Field case "Snohvit"

WP3.5 Preventive & corrective actions

WP3.6 Criteria for site selection and site management

Budget: 3,8 M€

European post-combustion test facility: the CASTOR pilot plant



Capacity: 1 t CO_2 / h

5000 Nm3/h fluegas
(coal combustion)

In operation since early 2006

Technical achievements

- **To prepare the implementation of large-scale polygeneration energy facilities, with options for**
  - ✓ Coal based electric power generation
  - ✓ H2 & synthetic fuels production
  - ✓ Heat integration with surrounding industries
  - ✓ CO2 capture and geological storage, including use for EOR/EGR

A THREE PHASE PROGRAMME

Time schedule

- **Phase 1 / COACH /** 2006 – 2009
  - Feasibility, benchmarking of technologies, recommendations for site selection and technologies
- **Phase 2 /** 2010 – 2011
  - Design
- **Phase 3** / 2012 – 2015
  - Implementation

Partners

IFP, co-ordinator

SINTEF, GEUS, BGS, KTH,

BP, STATOIL, SHELL,

SCHLUMBERGER, ALSTOM, AIR LIQUIDE, ATANOR

ACCA21

Tsinghua Univ.

Zhejiang Univ.

Inst. of Engng Thermophysics

Thermal Power Research Inst.

IGG CAS

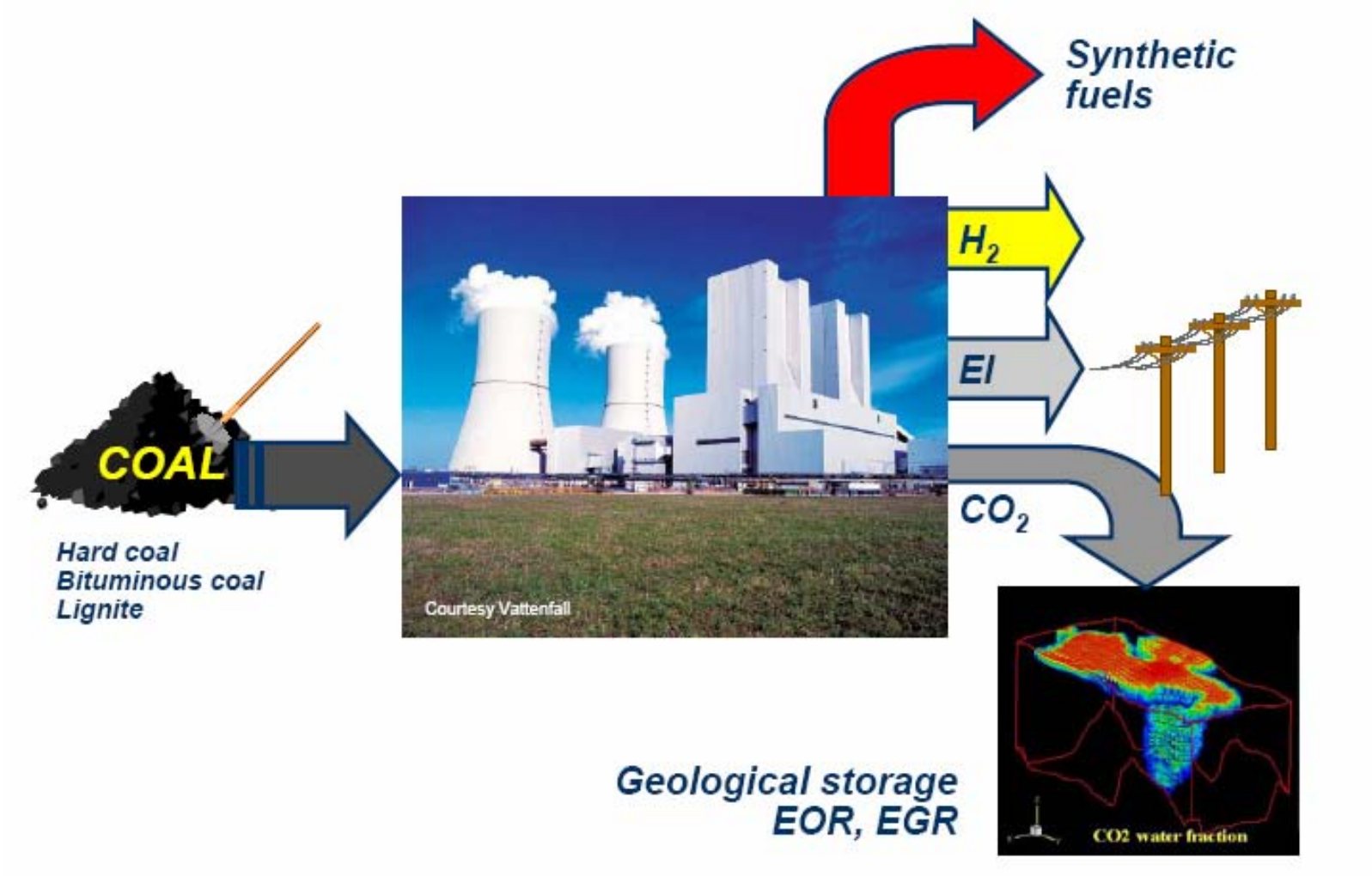
RIPED

GreenGen, Huaneng Group

Main objectives

- Enhance Knowledge sharing and capacity building
- Prepare the ground for
  - preparation of a demonstration of CCS in China by 2015
  - implementation of large scale clean coal energy facilities by 2020
  - Coal-based polygeneration schemes including CCS
  - as well as production of H2
  - options for synthetic fuels
- Address cross-cutting issues
  - societal anchorage
  - legal, regulatory, funding and economic aspects

General workflow



Budget 2.6 M€ / EU funding 1.5M€

Workpackage	Budget *(kEuros)*	%
WP1 - Knowledge sharing & capacity building	412.0	16
WP2 - Capture technologies	843.9	32
WP3 - Geological storage and large scale use of CO2	794.0	30
WP4 - Recommend. & guidelines for implementation	416.5	16
WP5 - Project Management	106.8	4
WP6 - Overview, managt & reporting of MOU activities	47.0	2
Total	**2620.2**	**100**

Potential impacts

- **To mobilize Chinese and European proficiency** to facilitate strategically important cooperation initiatives with China
- **To contribute to the future practical implementation** of European carbon capture and storage technologies in China
- **To stimulate cooperation** through established international cooperation frameworks
- **To enable the implementation of clean coal power technologies with option for hydrogen production**

Deploying CCS worldwide
A number of challenges

- A Legal and a regulatory framework
  - at national level as well as international level
  - recognizing CCS as a relevant mitigation option
- Fiscal / Financial mechanisms to provide incentives for giving a value for CO2
  - develop visibility for long term investment structure
  - inclusion of CCS in trading schemes (CDM, ...)
- Develop International cooperation
  - large scale CCS demonstrations by 2015
  - scientific cooperation
  - technology development and technology transfer
  - rising public awareness and support

Innovation
Energy
Environment

Innovating for energy

Innovation
Energy
Environment