CO_2-EOR relevant to CCS?

CO_2-EOR relevant to CCS?

- Safeguards needed to ensure permanence of the CO_2 storage after commercial operation of the EOR ceases
- Is there likely to be a large potential for CO_2 EOR in future
- CO_2 EOR meeting the criteria for CCS

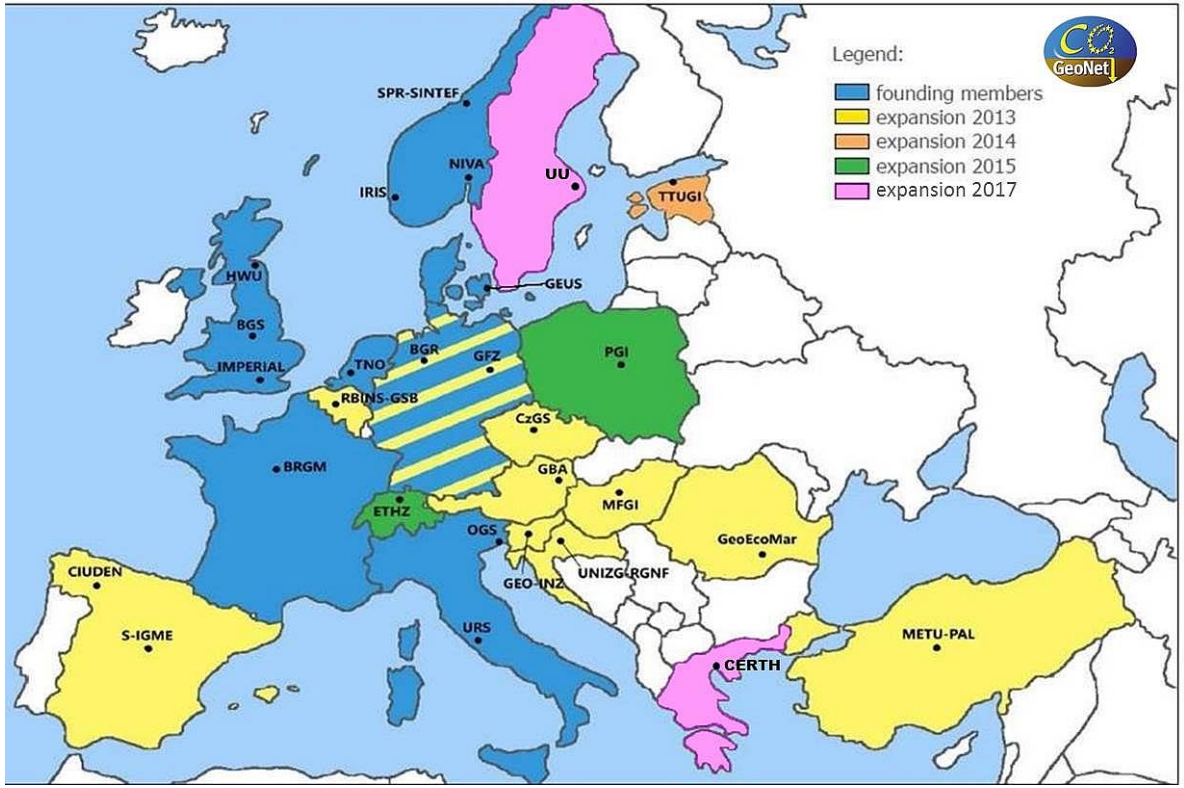
By Niels E. Poulsen, CO_2GeoNet

CO_2GeoNet, the European Network of Excellence on the geological storage of CO_2

A UNFCCC-accredited Association (Research NGO)

GEUS

CO_2GeoNet



CO_2GeoNet continues to expand both in terms of geographical coverage and expertise, benefitting Members and the scientific community where CCS is viewed as a key part of a low carbon future.

- ✓ Created as a EU **FP6 Network of Excellence** in 2004
- ✓ Became an **Association** under French law in 2008
- ✓ Founding Members: 13 research institutes over 7 countries
- ✓ Expansion thanks to CGS Europe FP7 project (2013-14)
- ✓ Now comprises 28 research institutes from 21 countries

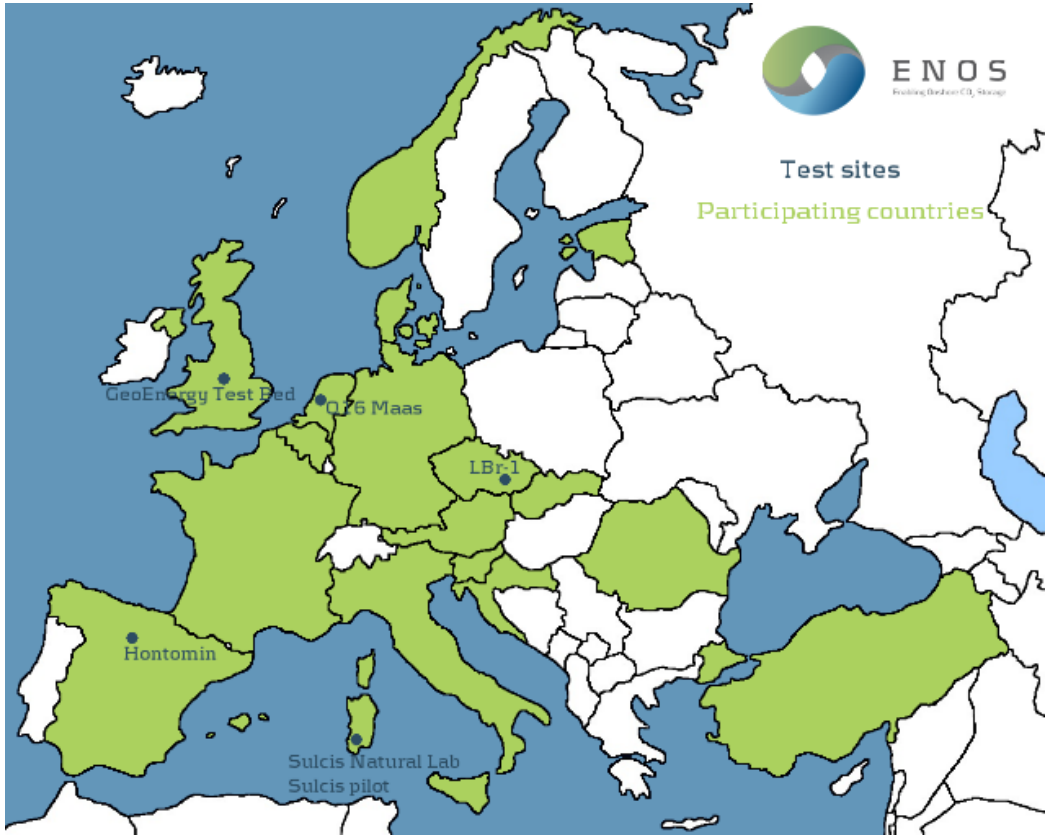
ENOS
Enabling Onshore CO_2 Storage

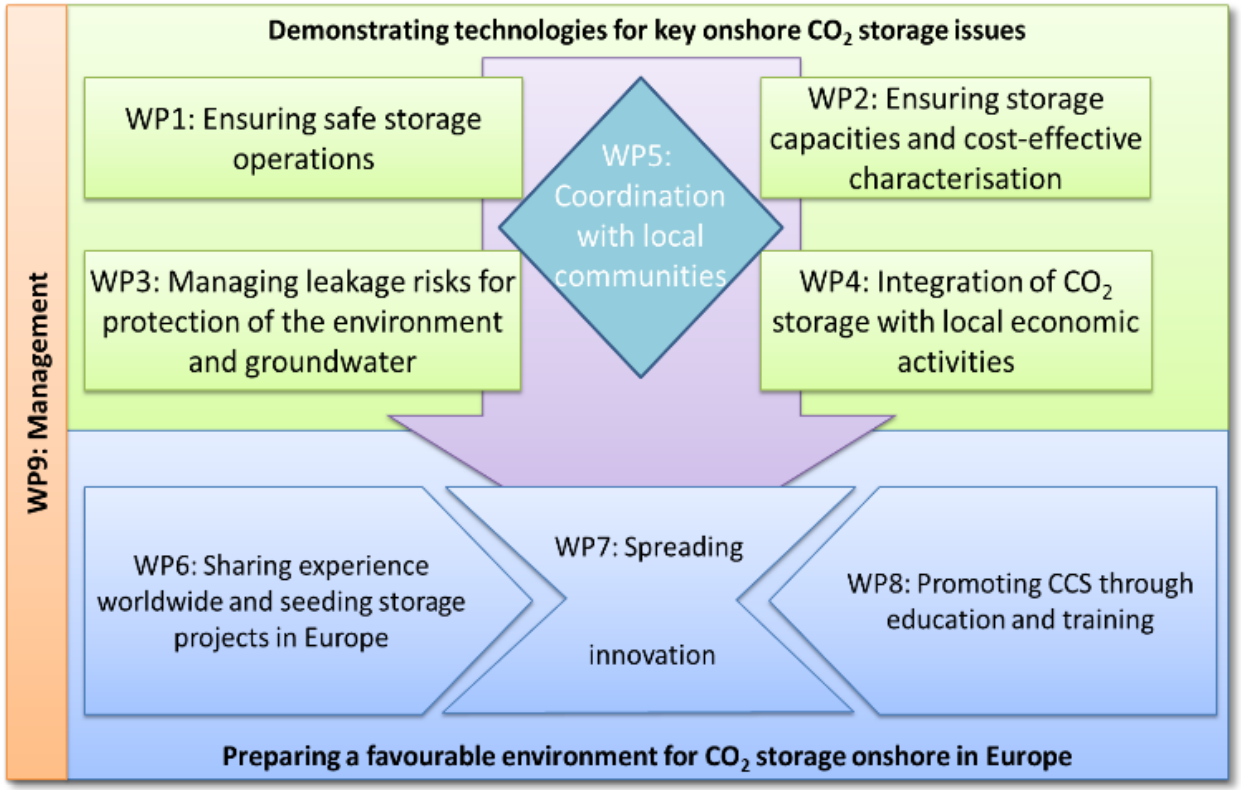
ECO2BASE
Enhanced oil recovery with storage

Cooperation with international bodies:

ieaghg · carbon sequestration leadership forum · GLOBAL CCS INSTITUTE · ISO International Organization for Standardization · United Nations Framework Convention on Climate Change · CTCN CLIMATE TECHNOLOGY CENTRE & NETWORK

ENOS - Enabling Onshore Storage in Europe





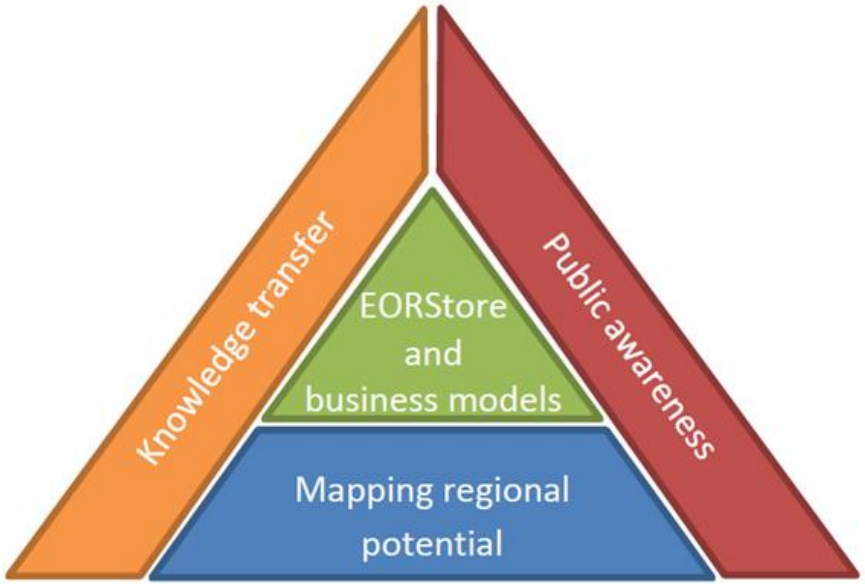
The project is a CO_2GeoNet initiative

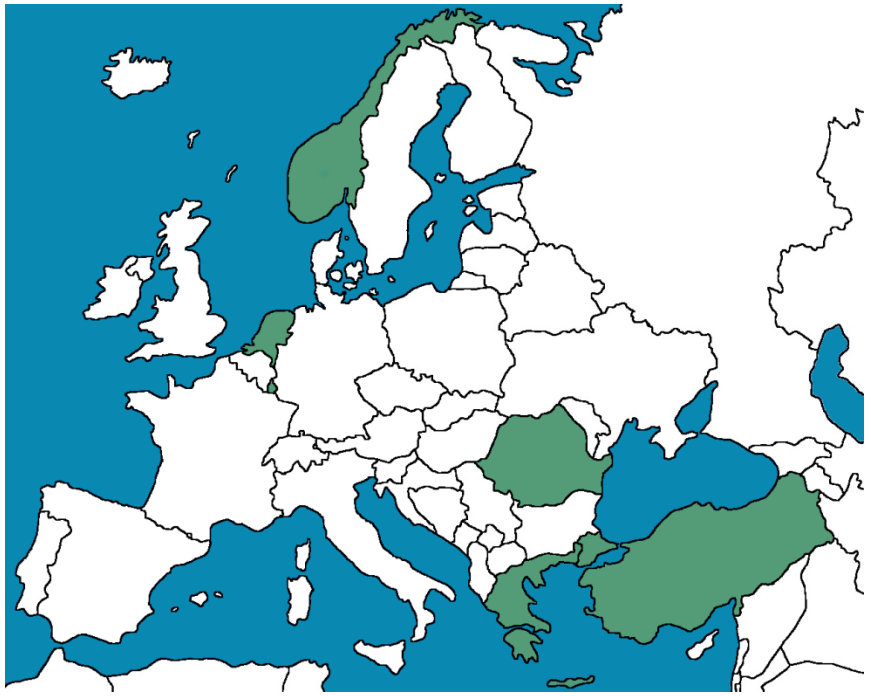
www.enos-project.eu

ECO2BASE

Enhanced oil recovery with storage

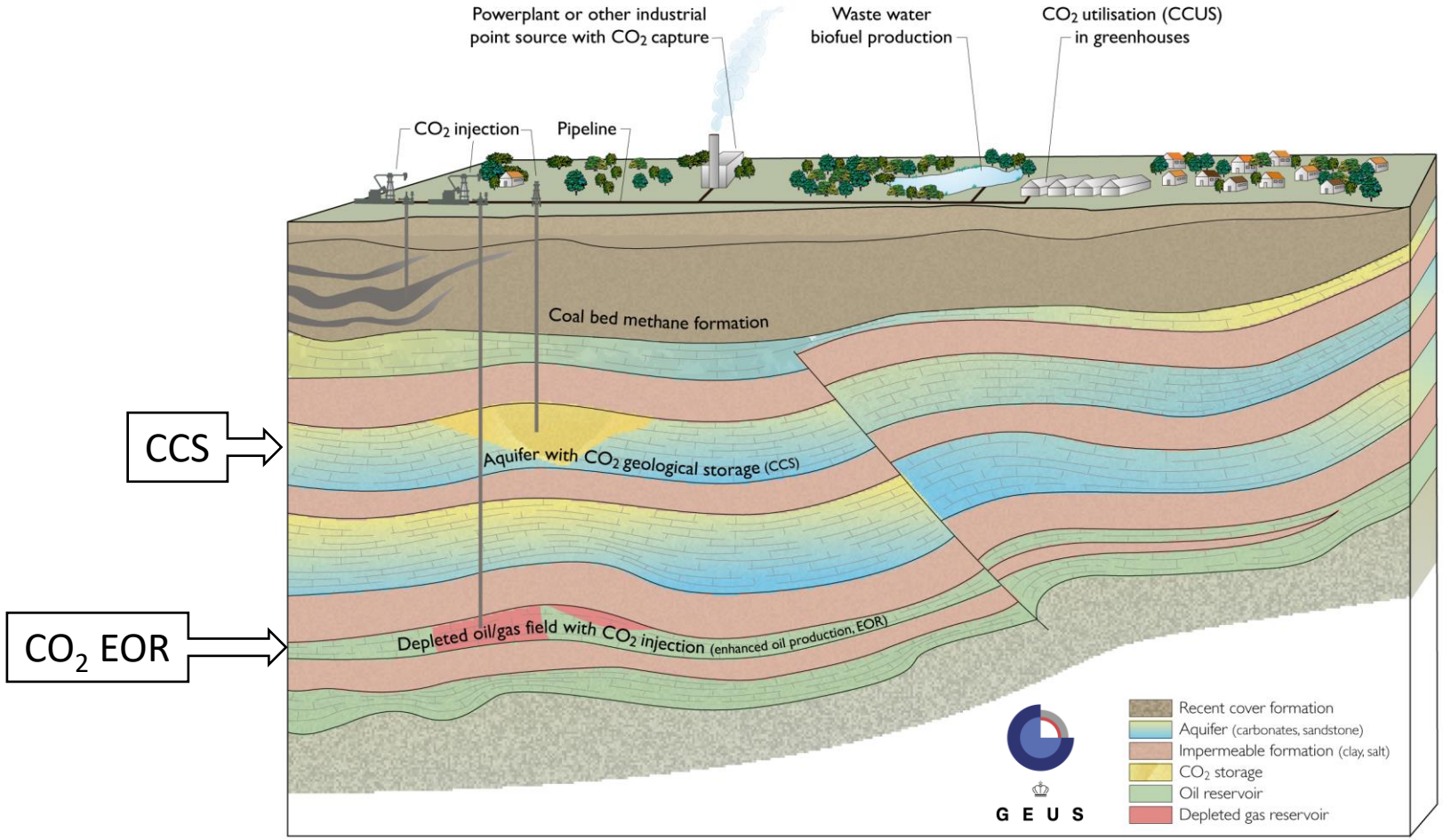
- Establishing CO_2 enhanced Oil recovery Business Advantages in South Eastern Europe





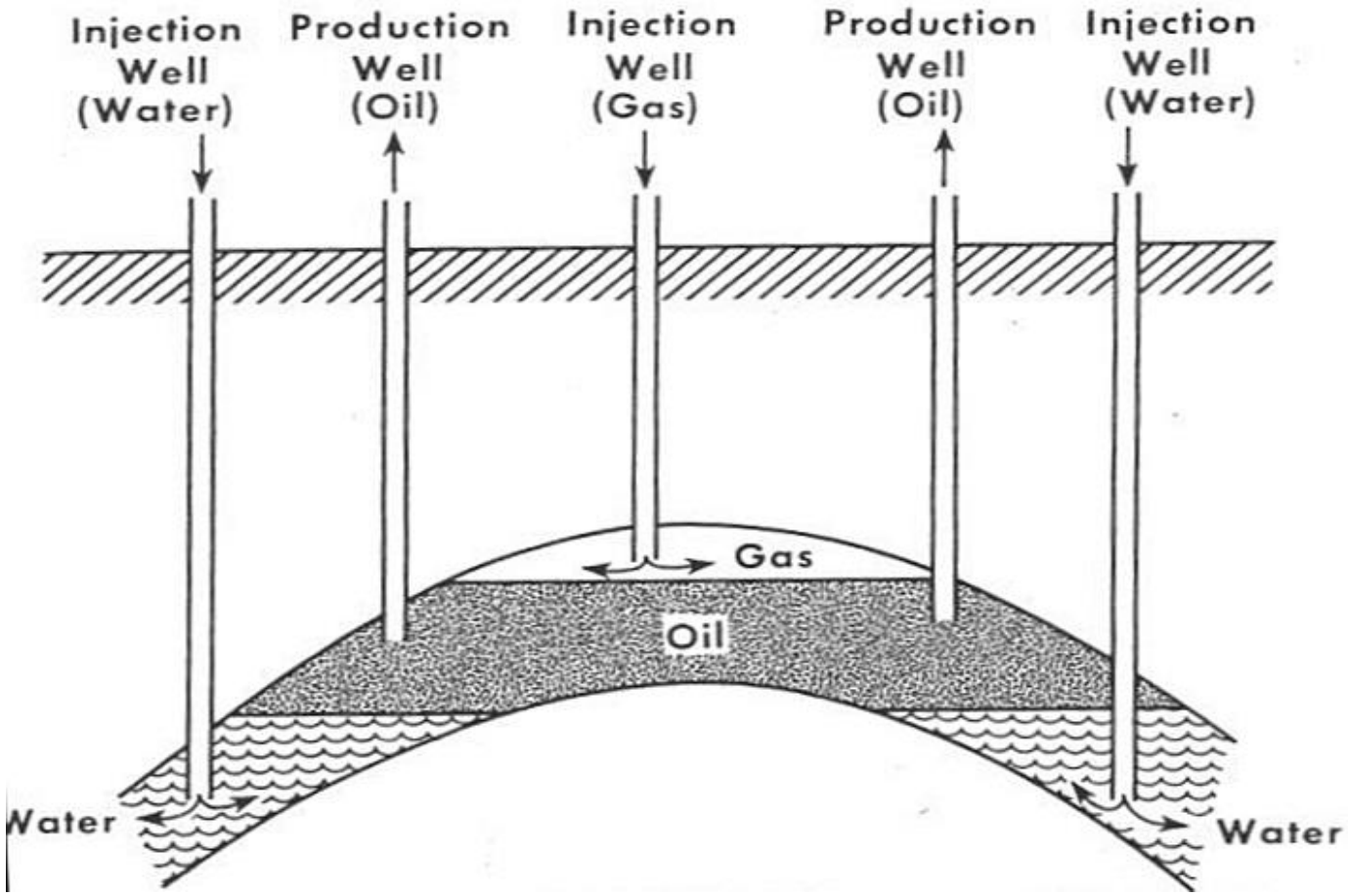
The project is a CO_2GeoNet initiative

CO_2 Geological storage sites



Secondary and tertiary EOR techniques

- Water or gas injection

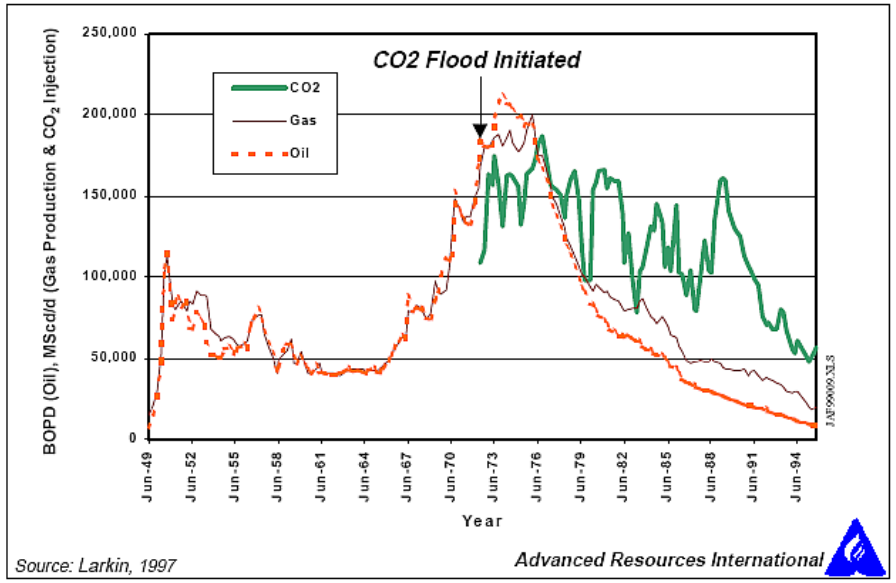


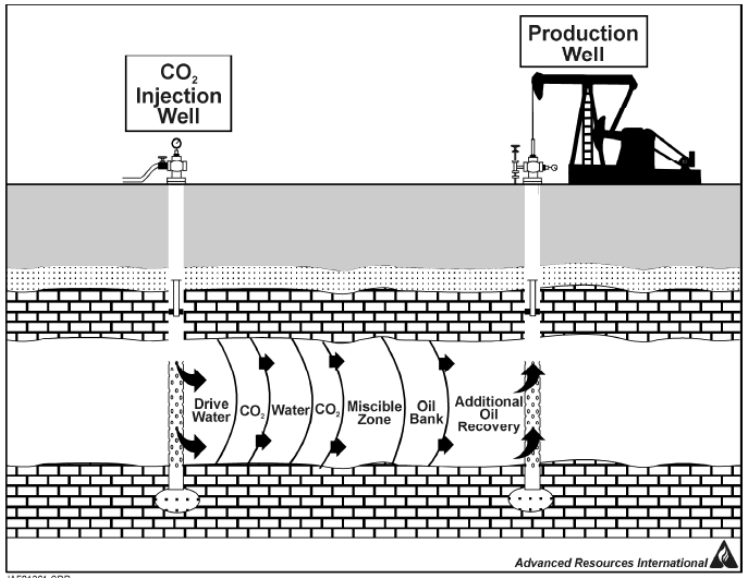
Tertiary EOR techniques

- Chemical
  - Polymer
  - Surfactant
- Gas injection
  - N_2
  - **CO_2**
  - Foam
- Thermal
  - Hot water
  - Steam
  - Steam foam
- Other, e.g. low salinity brine injection, bacterial flooding

EOR using CO_2 flooding

- Water flooding started 1961
- CO_2 flooding started early 1970'ies
- Commercial since 1984





- Breakthrough generally between 0.5 and 2 yrs

CO_2 EOR technology

- CO_2 EOR is mature technology (>40yrs, currently >200 000 bbl/d globally)
- Mainly CO_2 from natural sources
- Adding oil recovery methods adds to the cost of oil — in the case of CO_2 typically between 0.5-6.0 € per tonne of CO_2.
- Onshore EOR has paid in the range of a net 7 -12 € per tonne of CO_2 injected for oil prices of 11- 15 €/barrel current price 60 $/barrel = 62 €/barrel

Where?

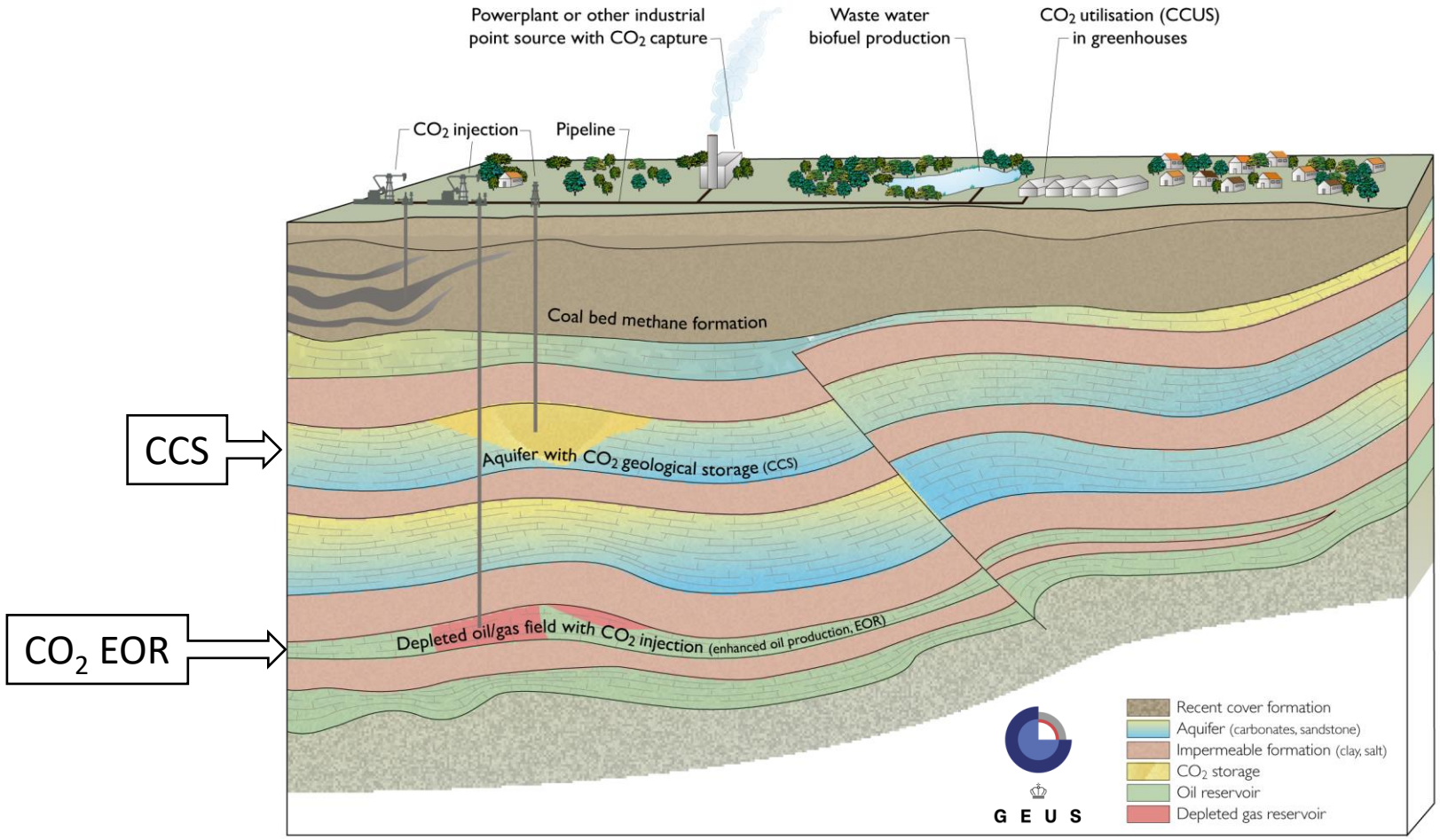
- USA (North Dakota, Wyoming, Colorado, Arizona, New Mexico, Texas, Louisiana, Mississippi)
- Turkey
- Canada, Weyburn, (industrial CO_2)
- Hungary
- Croatia
- China, Shengli oil field, Eastern China

CO_2-EOR Projects

Producing CO_2-EOR Projects in US (from Global CCS Institute, 2017; Moritis, 2008)

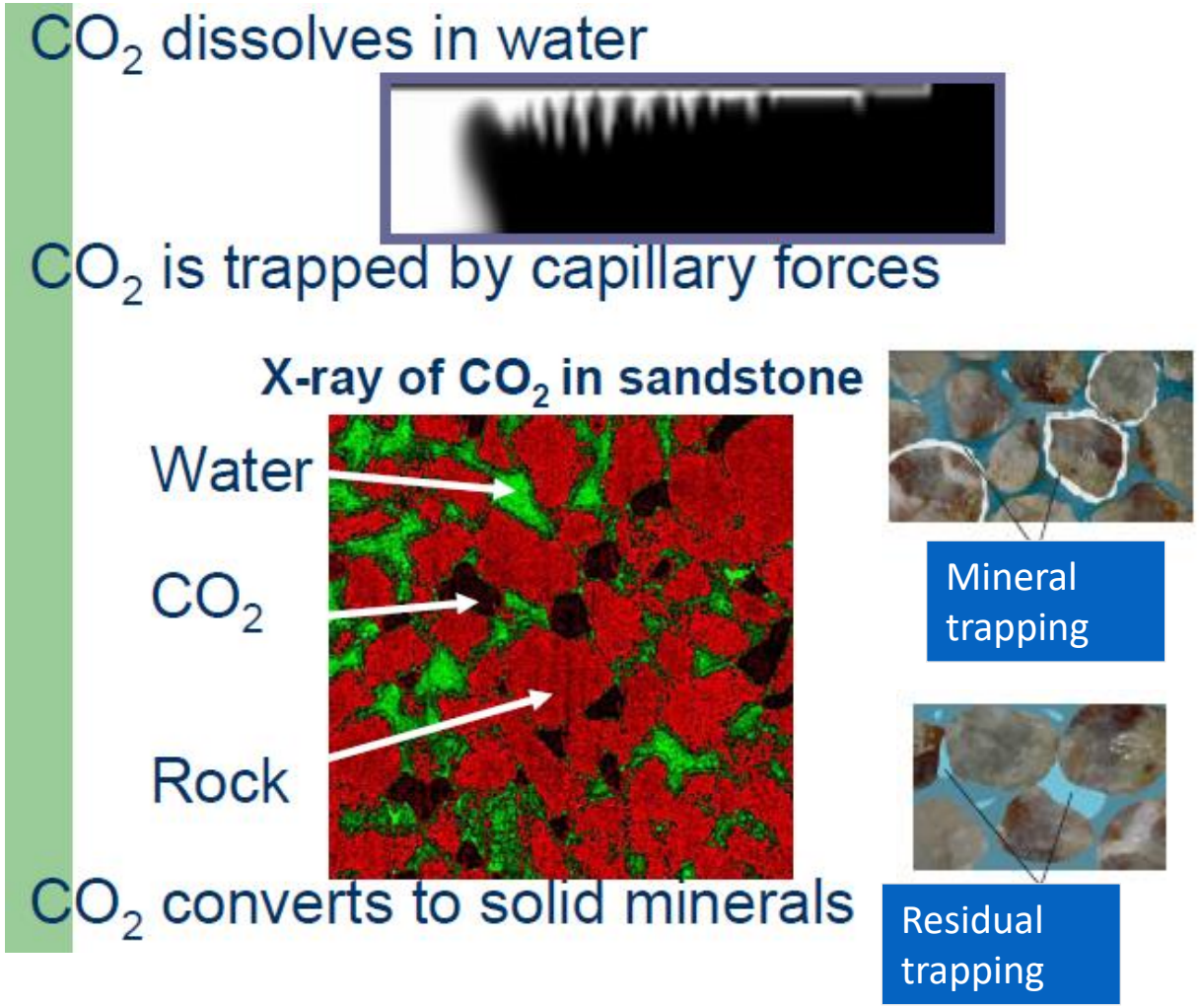
Project/ targeted reservoir	Leader	Location	Start	Recovery factor/production increment	Additional information
Slaughter	Apache	Texas	June 1989	Increment of 636 m^3/d	
Slaughter Sundown	Chevron	Texas	January 1994	Increment of 755 m^3/d	
Vacuum	ConocoPhillips	New Mexico	February 1981	Increment of 827 m^3/d	
Seminole Unit-Main Zone	Hess	Texas	July 1983	Increment of 3100 m^3/d	
Rangely Weber Sand	Chevron	Colorado	October 1986	Increment of 1844 m^3/d	
West Mallalieu	Denbury Resources	Mississippi	1986	Increment of 986 m^3/d	
Postle	Whiting Petroleum	Oklahoma	November 1995	Increment of 715 m^3/d	It was expected that production would reach 1351 m^3/d
Salt Creek	Anadarko	Wyoming	January 2004	Increment of 954 m^3/d	
Lost Soldier	Merit Energy	Wyoming	May 1989	Increment of 723 m^3/d	

Safeguards needed to ensure permanence of the CO_2 storage after commercial operation of the EOR ceases



What keeps CO_2 underground?

- Natural gas and CO_2 are miscible and form one single fluid phase
- CO_2 (gas or supercritical) and water are immiscible
- CO_2 dissolve in water
- CO_2 and oil are miscible or immiscible depending on oil composition and thermodynamic conditions
- CO_2 and coal: very complex interaction in which adsorption also plays a role



Setting the scene: CO_2 utilization and storage

Humanity produces CO_2 which is a greenhouse gas

If an industrial unit is emitting CO_2 and not capturing it:

CO_2 is stored in the atmosphere

This is our default and **worst** way of storing CO_2!!

Any other storage solution is **a lot** better

Even if CO_2 will be reproduced (by EOR CO_2 breakthrough) it will be better than doing nothing!

CCS Directive (2009/31/EC)

- Legal framework for the environmentally safe geological storage of CO_2
- Capture and transport related through amendments of existing legislation and at national level
- Removes barriers to CCS in existing legislation
- Member States determine whether and where CCS will happen on their territory

Key elements of CCS Directive

- Site selection and exploration
- Storage permits
- CO_2 stream composition
- Monitoring and reporting
- Closure and post-closure obligations
- Transfer of responsibility
- Financial security and financial contribution
- Emissions captured and stored recognized as not emitted under EU-ETS

CCS Directive – Guidance Documents (GD)

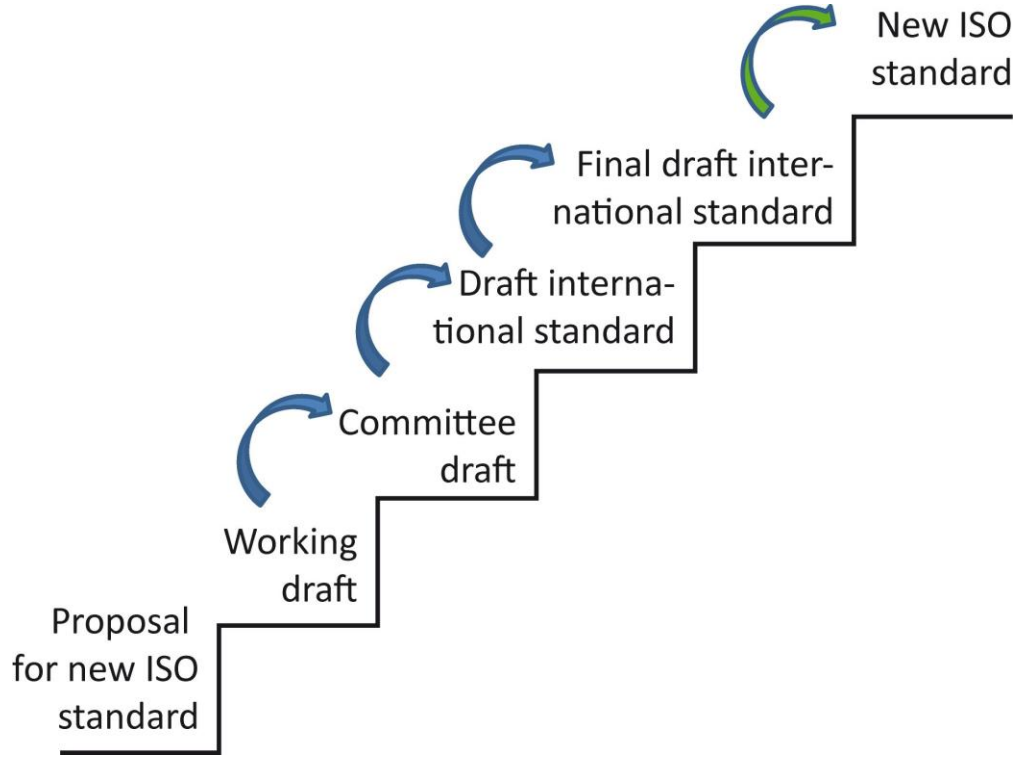
- GD support coherent implementation of CCS Directive across EU
- GD published on CCS website on 31 March 2011
  - GD1 – CO_2 Storage Life Cycle Risk Management Framework
  - GD 2 – Characterization of the Storage Complex, CO_2 Stream Composition, Monitoring and Corrective Measures
  - GD3 – Criteria for Transfer of Responsibility to the Competent Authority
  - GD4 – Financial Security and Financial Mechanism

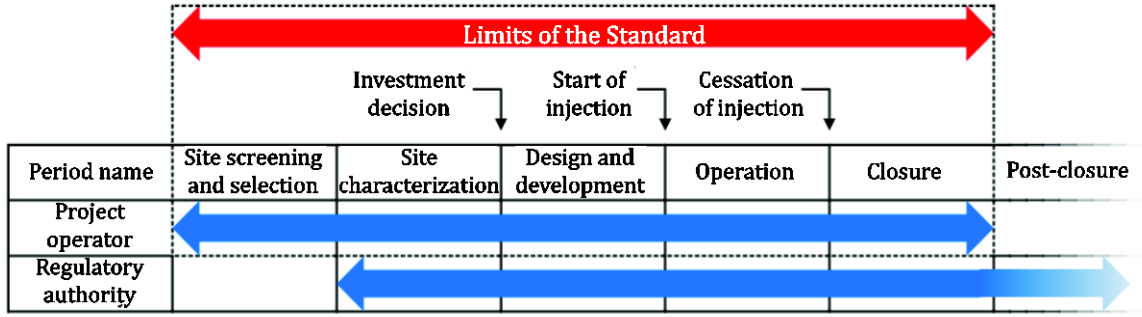
- Enhanced Hydrocarbon Recovery (EHR) refers to the recovery of hydrocarbons in addition to those extracted by water injection or other means.
- EHR is not in itself included in the scope of this Directive.
- However, where EHR is combined with geological storage of CO_2, the provisions of this Directive for the environmentally safe storage of CO_2 should apply.

ISO TEC265 CCS

- WG1 *Capture*
- WG2 *Transport*
- WG3 *Storage*
- WG4 *Quantification & verification*
- WG5 *Crosscutting issues*
- WG 6 *Enhanced Oil Recovery*

ISO 29716 addresses enhanced oil recovery (CO_2-EOR). The document is supplemented by recommended practice manuals for CO_2 storage





Conclusions on safeguards to ensure permanence of the CO_2 storage after operation of the EOR ceases

- CCS Directive established the legislative framework for CCS implementation, introduced the concept of CO_2 storage permit
- CCS Directive integrated into national legislation in EU
- CCS Directive draws some limits for CCS implementation
- Environment protection areas (Natura 2000) – no injection facilities, exploration and transport activities might overlap
- Groundwater resources not to be affected with an exception of the deep potable aquifers.
- Hydrocarbon production might rather benefit than suffer from CO_2 storage activities,
- Exploration for hydrocarbons is a matter of priorities
- The use of low enthalpy geothermal resources and CO_2 storage could be in a conflict.

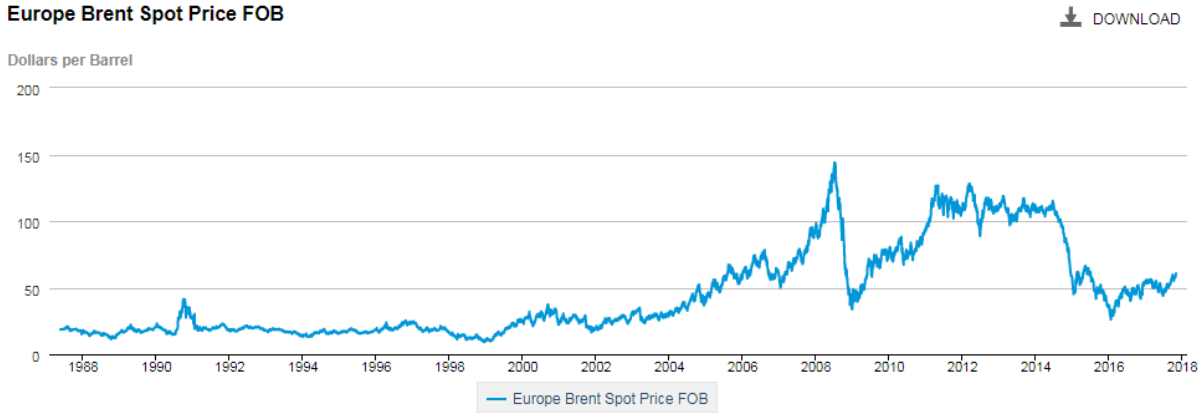
Is there likely to be a large potential for CO_2 EOR in future

The EU Emissions Trading System (EU ETS)

ETS price from 2009 to 2017

CO2 EUROPEAN EMISSION ALLOWANCES IN EUR - HISTORICAL PRICES

Brent Oil Price from 1988 to 2017



Quota system, objections?

CO_2 prices

EU ETS failing to failing to provide an incentive for CCS

Scepticism about the quota system expresses: The Quota system does not work

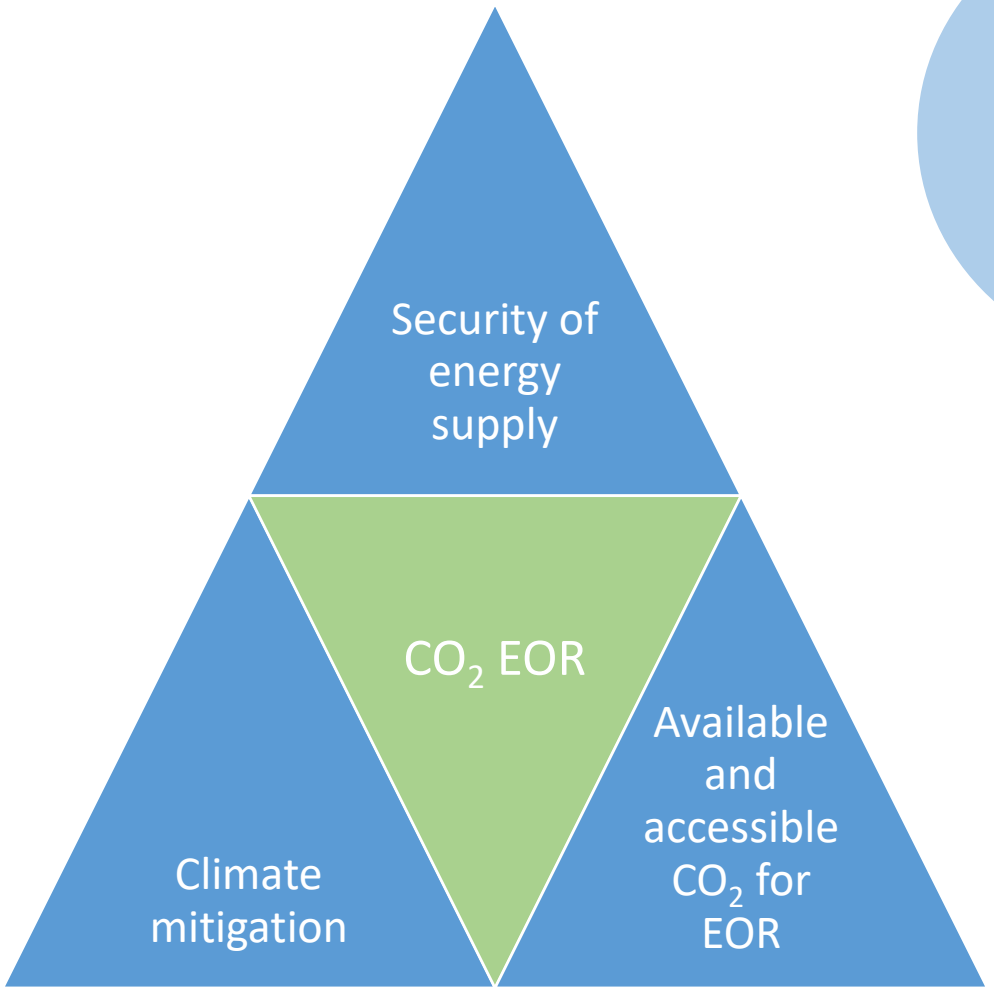
- The quota system consists of a (politically) amount of allowances traded between the various distributors who have to submit quotas corresponding to their emissions.
- If the quota market works efficiently - as the research suggests - it ensures that emissions reductions are made where is cheapest. That's how the quota market works and it works well. Therefore, this statement is wrong (Lars Gårn Hansen, Danish Economic Councils)

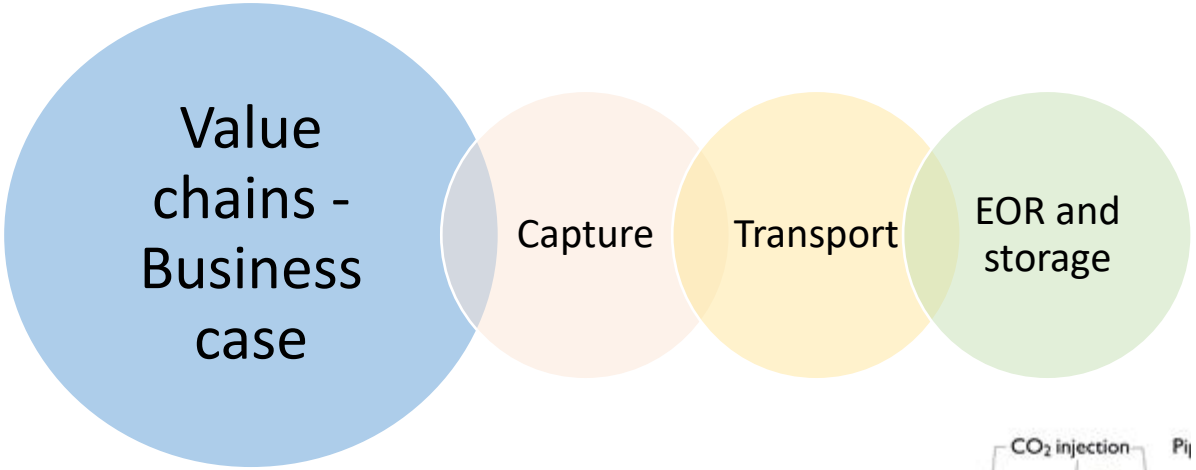
The quota price is too low to ensure investments

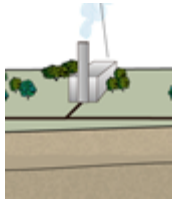
- There is a large quota surplus on the market and the price of quotas is very low. This means that the incentive to invest in renewable energy, CCS, EOR and others ways to reduce greenhouse gases are very small. Thus, the quota market today is not driving for the green change. The statement is therefore right (Lars Gårn Hansen , Danish Economic Councils).
- The big quota surplus and the low price also seem to be true, the credibility of the quota system in the long term and the weakened credibility is a problem in itself (Lars Gårn Hansen , Danish Economic Councils).

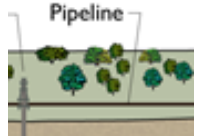
Trilemma

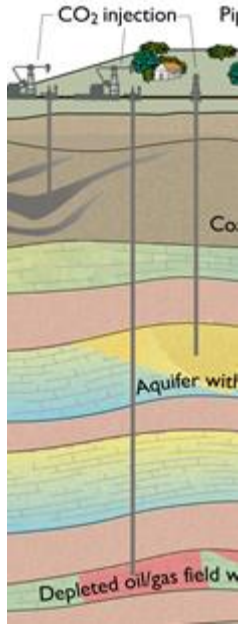
CO_2 EOR in a wider perspective











Enhanced hydrocarbon recovery (EHR)

Extending field lifetime and utilizing existing infrastructure: saving on materials and energy use

In short: we would need hydrocarbons (fossil fuels) at least till 2050 according to IEA.

Why don't make them greener with EHR (EOR) and help reduce the costs for CCS technologies and pay at least part of the bill to inject CO_2?

09/11/2017

EU Emissions Trading System: landmark agreement between Parliament and Council delivers on EU's commitment to turn Paris Agreement into reality

The European Parliament and Council have today (09/11/2017) reached a provisional agreement to revise the EU Emissions Trading System (EU ETS) for the period after 2020. This revision will contribute to put the EU on track to achieving a significant part of its commitment under the Paris Agreement to reduce greenhouse gas emissions by at least 40% by 2030.

- Significant changes to the system in order to speed up emissions reductions and strengthen the Market Stability Reserve to speed up the reduction of the current oversupply of allowances on the carbon market;
- Additional safeguards to provide European industry with extra protection, if needed, against the risk of carbon leakage;
- Several support mechanisms to help the industry and the power sectors meet the innovation and investment challenges of the transition to a low-carbon economy.

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