CO2 Storage Possibilities in Hungary

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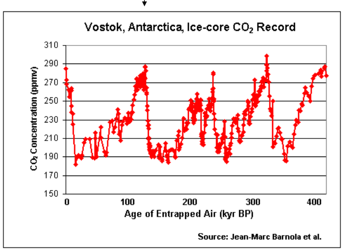
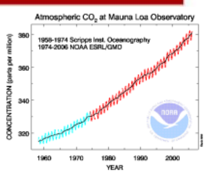
Climate Change…Results of the Vostok project

During glacial-interglacial transitions, the atmospheric concentrations of **CO2** alternated between **180 to 290 ppm**





In the **last 50 years** the changing is shocker. CO2 concentration increased from **315 to 380 ppm**.

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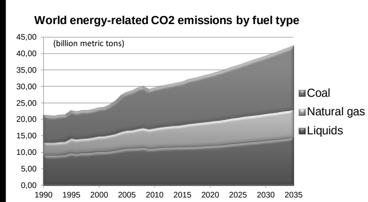
World energy related CO2 trends 1990 - 2035

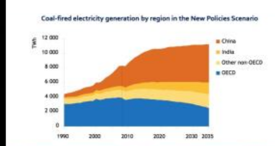
Global Energy Trends

Global energy needs grow steadily

World Energy Outlook's Reference Scenario –

the world's energy needs 50% higher in 2030 than today





A drop in coal-fired generation in the OECD is offset by big increases elsewhere, especially China, where 600 GW of new capacity exceeds the current capacity of the US, EU & Japan

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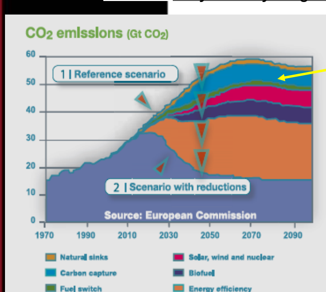
Climate Change – How to mitigate the effect

Methods: They can only mitigate the climate change together :



Key to the diagram: Growth of CO_2 emissions: 1) assuming no change of lifestyles (extrapolation of the current situation); 2) assuming a reduction of emissions and compatible with a temperature rise of no more than 2 °C.

- **Natural sinks**
- **CCS**
- **Fuel switch**
- **Solar, wind and nuclear power**
- **Biofuel**
- **Energy efficiency**

These methods are **not competitors** but **supplementary of each other.**

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Carbon Capture and Storage (CCS)

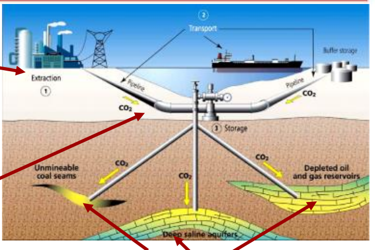
Carbon Capture

CO2 separated from the flue gas

CO2 stream is liquefied and dried

Transportation

by **pipeline** or **ship**



CO2 Storage

Alternative **geological formations** :

- depleted **oil and gas fields**
- deep saline **aquifers**,
- unmineable **coal beds**

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Geological storage of CO2 in Hungary

Carbon dioxide can be found in **geological formations in natural reserves**, same way as natural gas.

The available alternatives for storing carbon dioxide in geological formations :

•depleted oil and gas fields
•deep saline aquifers,
•unmineable coal beds

In 2009 our R&D study presented answers in the following issues:

- **CO2 storage possibilities**
  - in deep saline aquifers
  - coal beds
- **CO2 storage potential** of the depleted hydrocarbon reservoirs of MOL

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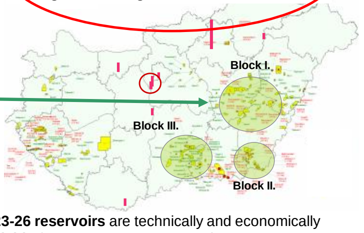
Storing in depleted oil and gas fields

ELGI-MOL R&D study:

180 oil or gas reserves were investigated

Most prosperous reservoirs are in **Block I.** with **30 Mt CO2** capacity

Hydrocarbon fields hold oil and gas over millions of years.
They have **great potential to serve as long-term storage** sites for carbon dioxide



23-26 reservoirs are technically and economically **viable for CO2 storage** purpose in Hungary.
with **maximum 150 Million ton CO2 capacity**

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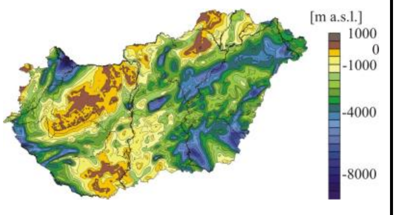
Storing in deep saline aquifers

The exact **location** and the real volume of the saline aquifers are **partly known**

Huge **exploration cost** needed for **3D seismic surveys and Exploration wells**

Deep saline aquifers – in Hungary



Suitable aquifers for storage are typically located **at least 800 meters underground** and **contain water that is not drinkable**.

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Storing in aquifer - Szolnok Formation

Criterion:

- **proven regional seal**
- **more than 800m depth**
- **sufficient CO2 storage capacity**
- **Effective petrophysics properties**

Estimation of the storage potential

Storable CO2 quantity (by Prof. Pápay, 2007):

$$M_{CO2}=\varphi \times c \times V \times \Delta p \times \rho_{CO2}$$

where:

M_{CO2} – storable CO2 mass in the aquifer (kg)
φ - aquifer porosity
c - effective compressibility (1/bar)
(rock and the water in the rock pores)
Δp - over-pressure; value: $\Delta p 0.2 p_i$ (bar)
V - aquifer rock volume (m3)
ρ_{CO2} - CO2 insitu density (at actual p, T) (kg/m3)

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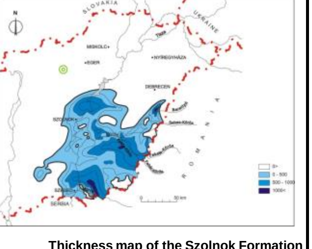
Storing in aquifer - Szolnok Formation

Theoretical maximum amount of 2510 Million t CO2

Area	Storage capacity (Million t)
Újfalu Formáció	**424**
Szolnok Formáció elemei:	
Jászság Basin	183
Makó Trough	197
Pusztaföldvár Horst	120
Békés Basin	204
Transdanubian part of Szolnok Form. (thickness 500m)	1380
Együtt Szolnok Formáció	**2090**
Összesítve	**2510**



Thickness map of the Szolnok Formation

Only areas with proven regional seal and more than 800m depth are considered.
Potential source (Mátra pp. - green concentric circles) is also shown.

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Risks of storing CO2

Risks:

CO2 leakage from the reservoir to the upper layers and to atmosphere

Reactivation of fractures

Ground movement

Displacement of brine

Leakage is the most significant risk of CO2 storage:

- ►CO2 leakage can occur in case of the inability of the cap rock
- ►CO2 can escape through the old wells if they are not plugged in the proper way
- ►through aquifer flows in the reservoir.

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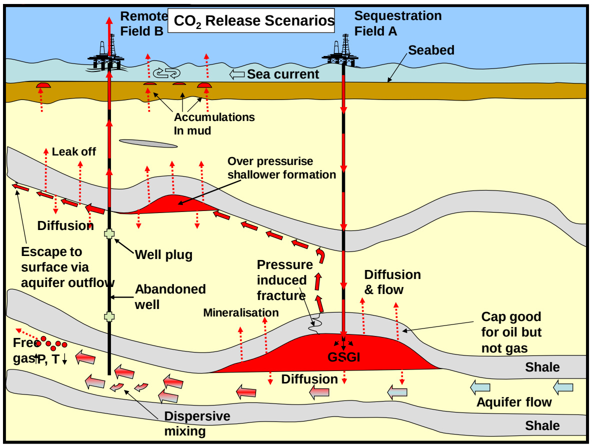

Risk management of CO2 storage: 1. Site selection

Good reservoir parameter is the main succes factor for mitigating risks

Good storage parameters

- High porosity
- Big storage volume
- High permeability
- Low temperature
- Appropriate cap rock with good sealing
- Geologic and Hydrodynamic Stability

Preparation of site selection in deep saline aquifers:

1. Re-evaluation of old 2D seismics
2. Re-evaluation of drilling data of old wells
3. Making pre-estimated geology maps with cap rocks
4. Evaluate candidate areas
5. Determine the best candidate
6. Execute 3D surveys
7. Evaluate 3D surveys
8. Exploration wells drilling with core samples
9. Geology study and Evaluation

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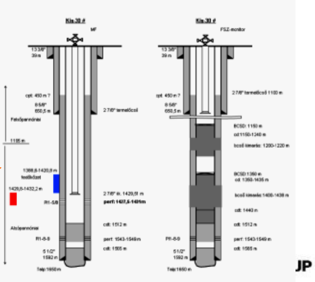
Risk management of CO2 storage: 2. perfect well conditions

Most of the wells do not have CO2 resistant cement and casing, it is a must to drill new wells for the purpose of injection

Avoiding the leakage problems we have to abandon most of the existing wells.

Old wells can be used if only they have:
- CO2 resistant cement,
- perfect cement measurement
- good casing



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Risk management of CO2 storage: 3. Monitoring

Aim of monitoring:

The stored CO2 quantity and the trapping mechanism have to be verified,

and this system can provide early warning of storage failure.

Examples of monitoring techniques

Monitoring group	*Monitoring technologies*	*Compartment*
Engineering	**Pressure, temperature**, well tests	Wells
Geophysical	**Seismics (3D)**, micro seismicity, gravimetry, electro-magnetic, self-potential, physical well logging	Reservoir and back-ground system, wells
Geochemical	Production **water & gas analysis**, **tracers**, overburden fluids, direct measurements	Reservoir and surface system
Geodetic	Geodetic, tilt measurements, **satellite interferometry**, airborne sensing	Surface system, space
Biological	Microbial, **vegetation changes**	Surface and background system

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Monitoring CO2 by InSAR

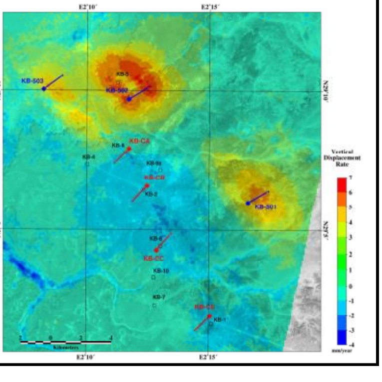
Most interesting Novel tool:

Satelit Imaging

InSAR:

Changing of 2 mm surface displacement can be measured

4D seizmiks
&
InSAR
show the same picture



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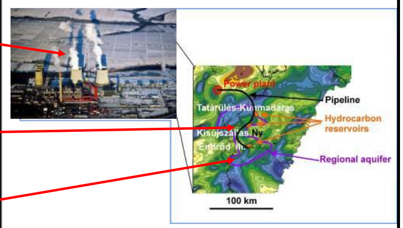
Matra CCS project – Case Study

- Consortium established in 2009 for preparing feasibility studies for a possible **EU tender** of **a demonstration CCS project in Hungary**
  - MOL (oil company)
  - Mátra Power Plant (lignite)

CO2 capture from the flue gas of Mátra Power Plant

Transport via pipeline

Storage in depleted gas fields of MOL and saline aquifers



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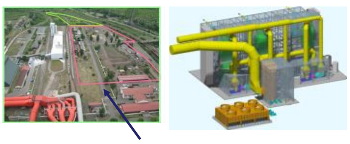
Data of Capture in Mátra CCS Project

Post combustion based on chemical absorption (amine) in combination with heat induced CO2 recovery.



Capture area

POWER GENERATION

New lignite-fired power plant
Capacity: 500 MW
Net efficiency: ≥ 42% (elec.)

CAPTURE	
Technology:	post combustion
CO2 absorber:	MEA
Capture efficiency:	min. 85%
Efficiency with CCS:	32-33%
Outlet CO2 pressure:	100 bar
Status:	feasibility study

Captured CO2: 2.5-4 Million t/y

Costs of electricity without CCS: 4,8 EUR ct./kWh
Costs of electricity with CCS : 9,2 EUR ct./kWh

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Transport and Storage Data of Mátra CCS Project

First storage phase will use depleted hydrocarbon reservoirs

STORAGE

Formation: Depleted hydrocarbon (gas) reservoirs

- field Kisújszállás Ny.
- field Endrőd III.

CO2 capacity:	**ca. 15 Mt**
Depth:	1200-2000 m
Reservoir rock:	sandstone

Second storage phase CO2 will be injected in the regional aquifer.

Formation: Aquifer (Szolnok Fm)

Depth of top:	> 800 m
Porosity:	15-25%
Permeability:	40-80 mD
Thickness:	800-1000 m
Storage capacity:	**ca. 250 Mt**

TRANSPORT

CO2 transportation via pipeline

Length:	116 km
Diameter:	350 mm
Pressure:	120 bar

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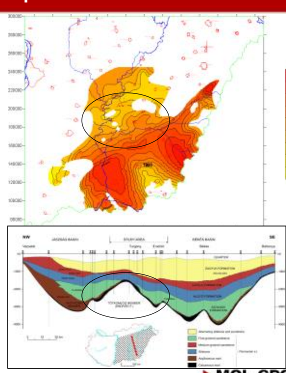
EXPLORATION PLAN of aquifer

Exploration program:

1. Preliminary regional geology model by re-evaluation of past 2D seismic data, and rock parameters
2. Implementation of 3D seismic on 2000 km2
3. Assessment of 3D data
4. Evaluation of 3d Data
5. Exploration drillings with catching core samples
6. Evaluation of drilling data
7. Implementation of a reservoir-geology model
8. Determining positions of injection wells

COST ESTIMATION:
total is cc. EUR 50 Million



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Economics

<u>In case of 2.5 Million t/year Matra CCS project</u>

Specific costs of Transportation & Storage 25-30 EUR / tCO2
Specific costs of Capture is about 30-50 EUR / t CO2

Specific costs of the CCS project is 55-80 EUR / tCO2

For NPV= 0 the needed income of 1 ton CO2 should be cc. 90-120 EUR !!!

↕

Carbon price of the market is less than 10 EUR/t

If the energy prices are increasing
the specific costs will be increasing as well…
negative costs spiral!!!

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Thanks for your kind attention!