“CARBON CAPTURE AND STORAGE, A REAL POSSIBILITY?”

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Definitions

• Carbon Dioxide – CO₂
• CCUS – Carbon Dioxide Capture, Utilisation and Storage
• Sequestration – the capture and storage of CO₂
• EOR – Enhanced Oil Recovery
• LCA – Life Cycle Assessment
Outline

• Why bother?
• Capturing – the very basics
• Storing or Utilising
  – Economic
  – Environmental
• Conclusions – will this work in Cyprus?

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Why Bother?

- First – my position – I am a believer in Climate Change
- We are engaged in a massive experiment with the atmosphere – with our success in the past in major geo-engineering experiments, why would we succeed this time?
- The evidence overwhelmingly points to change – the rapidity of change will be the problem
  - We have seen rapid changes geologically and the result is extinctions
  - As occupants of Earth, we are not prepared for rapid change
- In Saskatchewan, we will certainly feel the impacts more strongly than many places
Options for CO₂ Capture

Industrial CO₂ sources

Post-combustion
- Combustion
- Air

Pre-combustion
- Gasification/reform
- Air / O₂ + steam

Oxyfuel
- Combustion
- O₂

Separation
- Product
- CO₂

Heat & Power
- Other Products
- H₂

Fossil fuels, biomass
Why Compress?

- **CO₂ as a gas**
- **CO₂ as a supercritical fluid**

- Depth (km):
  - Ground level
  - Critical depth (approx)

- Density of CO₂ (kg/m³):
  - 0.32
  - 0.28
  - 0.27
What Keeps the CO₂ Underground?

- Physically trapped beneath seals
- CO₂ dissolves in water
- CO₂ is trapped by capillary forces
  - X-ray of CO₂ in sandstone
- CO₂ converts to solid minerals

Ground Surface
- Sand
- Shale
- Sandstone
- Shale
- Sandstone
- Shale (seal)
- Sandstone (storage formation)
Weyburn CO₂ Source: Great Plains Synfuel Plant

- 12,500 tonnes CO₂ by-product of coal (lignite) gasification
  - approx. 8000 tonnes/day suitable for EOR
- CO₂ purity 95% (approximately 1% H₂S)
- 180 mi pipeline (14 in & 12 in) built & operated by Dakota Gasification

From PTFC/Cenovus
The Weyburn Example

The Weyburn Total Oil Production at Weyburn

- Around 30,000 bbl/day: a 35 year high
- 20,000 bbl/d are due to the CO₂ flood

CO₂ stored equivalent to removing more than 8 million cars off the road for a year

From Cenovus
Life Cycle of CCS

- Energy (+)
- Electricity production (+)
- Energy for CO₂ capture (-)
- Coal mining
- Power plant operations
- CO₂ trapping
- Power plant construction
- Pipeline construction
- Oil field operations
- Oil trapping
- Refinery
- CO₂ stored
- Energy (-)
- Use
- System boundaries

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LCA: Energy Output

Net energy output (GJ) over project life

- **1-a**, **1-b**, **1-c**
- **2-a**, **2-b**, **2-c**
- **3-a**, **3-b**, **3-c**

- **Coal**
- **Crude oil**

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Conclusions

• There is a need to do something
  – Renewables cannot be brought on fast enough
  – Renewables have their issues – storage, land use, projects in your backyard, etc
  – Nuclear has its issues as well, Fusion is not here
• Responding with geo-engineering is a mistake
  – Fertilising oceans
  – Space shields, dust in atmosphere (acid rain)
  – CO₂ from air – feasible but costly
• There is a cost to doing nothing, it is just difficult to calculate, particularly on an annual basis – statistically, we can expect costs.
• CCUS/Sequestration is not the whole answer
  – It can store large volumes safely
  – There is a cost, but how does it compare to other options?
  – There is a value in EOR, this is the starting point
  – EOR certainly has resource management benefits and environmental
Conclusions / Can this work in CYPRUS?

- Supporting the tests of CO₂ capture and utilisation/storage
- Canada/US global leaders in spite of criticism
- Continue to provide economic support to early ventures
- Do not ignore renewables
- Conserve – always the cheapest, not necessarily the easiest
- Cyprus – electrical generation, expanded industrial use of natural gas, LNG etc – all produce CO₂
- Being on the ocean, easy to export by ship (over 500km, ship cheaper than pipeline).