Can vessels contribute to economic cross border CO$_2$ transport systems?

Presentation at the Berlin Conference on Energy and Electricity Economics (BELEC 2015)
Cross-Border Coordination for Sustainable Energy Security – Theory and Policy Lessons from Different Sectors

29 May 2015 | Joachim Geske
Introduction

- CCS: CO$_2$ emission goals + avoid expensive adjustment of technological processes
- optimization of the transport infrastructure + transport modes
- potential offshore CO$_2$ storage sites: expensive, acceptance, EOR.
- Transport modes suitable for million tonnes of CO$_2$ to offshore storage sites: pipelines and vessels (Svensson et al, 2004)
- cost models for pipelines are common practice (Knoope et al., 2013).
- cost effectiveness of the transport by vessel is addressed in specific cases of distance, total transport volume, vessel capacity and fleet size.
- determination of vessel capacities is missing. Except: (Nilsson, 2010)
  $\rightarrow$ little is known about the size of optimally dimensioned vessels and cost savings potential
Introduction

1. Preparation:
   a. a cost model including all elements of the vessel CO₂ transport chain
   b. parameters
   c. optimization of the vessel capacity and fleet scheduling

2. Application
   a. comparison of vessel and pipeline transport for transport distance and capacity
   b. case I: cost assessment of transport options from the Iberian Peninsula to the North Sea (EOR)
   c. case II: embedding the vessel and pipeline cost models in a multimodal CO₂ transport optimization model
      i. Portugal
      ii. Morocco
      iii. Iberian Peninsula - North Sea

3. Conclusion

“COMET: Integrated infrastructure for CO₂ transport and storage in the west MEdiTerranean (2010-2012)”.

Vessel transport CO$_2$: liquid phase, 5 bar, -50 °C.

**Liquefaction**
compression, cooling and expansion. prevent hydration, freezing, corrosion. contamination $\rightarrow$ dry ice formation.

**Storage**
discontinuous sea transport, intermediate storage required. storage tanks operated for LPG storage.

**Loading**
pumps and pipelines, a loading arm. loading time; fees are generally charged.

**Vessel / Fleet**
Fleet size, vessel capacity, transport volume, transport distance, velocity of vessel and the time for un/loading

**Unloading**
unloading procedure varies: complex offshore CO$_2$ compression – less expensive onshore unloading
1. Preparation: b. Parameters

**Loading time**: 10 h

**Construction cost**: $500 \text{ €/t } C_{Ship} + 30 \text{ Mio €}$
1. Preparation: c. Optimization

Example:
- \( \text{TOTEX}_{vt}(4\text{Mt/y}, C_{Ship}, 200\text{Km}) / (4\text{Mt/y}) \)
- red curve: + harbor fee
2. Application: a. vessel/pipeline

Iso vessel capacity curves
2. Application: b. Case I/North Sea

- **Storage sites:**
- **Transport to the North Sea:**
- **Transport modes:**
- **Volume Mt/y,**
  - Scenario:
    - 2020: 11
    - 2030: 57
    - 2040: 101
    - 2050: 142

- **Cost:** 4-9 €/t (on average 7 €/t)
- **EOR revenues:** -11 to 21 €/t (on average 6 €/t, IPCC, 2005)
- it cannot be excluded that EOR revenues exceed transport costs.

**CO₂ Europipe** (2011)
- **1300-2300 Km**
- offshore, on/offshore, vessel
2. Application: c. Case II/System

COMET: Scenarios Spain, Portugal and Morocco
- Storage/Geology: saline aquifers, hydrocarbon fields, on-/off-shore; storage capacity, injection rate, # wells → cost of exploration, implementation and operation
- Capture: Identification of emission clusters, capture costs
- Transport: Transportation routes, costs, GIS
- Cost minimal combination in a spatially dispersed energy system model.

Design of multimodal CO₂ transport infrastructure
- unsteady vessel transp.- steady on an. level
- segmentation of the grid – linearity
- addition of a second (modal) layer
2. Application: c. Case II/System

- **10% cost decrease to 9€/t S42; (S03 : 12€/t)**
- breakeven
2. Application: c. Case II/System

Potential Infrastructure

- 2050: 0.8 Mt/y
- vessel transport option → 36 €/t (-20%)

- transboundary CO₂ transport to Portuguese S42: Costs -56% (S42: 10 €/t, lower storage cost) at equal 360 Km H67-S42 to 20 €/t
2. Application: c. Case II/System

2050: 42 Mt/y
vessel Option: system cost 260 Mio €, 31 Mt/y, transported to the North Sea, storage cost -7.1 €/t
3. Conclusion

- Cost savings potential of optimized CO$_2$ vessel transport can reach up to 40%
- A reliable cost estimation should account for the dimensioning of vessels
- Vessel transport is advantageous for long distances and small volumes
- Vessels connect the West Mediterranean region and the North Sea cost-effectively
- It could be profitable if CO$_2$ is used for Enhanced Oil Recovery
- Definition of a multimodal (vessel and pipeline) CO$_2$ transport optimization model
- Vessel transport can save up to 20% points of total cost in the West Mediterranean region
- Savings are achievable by substitution and complementarity
- CO$_2$ transport from the West Mediterranean region to Europe could be profitable, however, a crowding out is likely
- Value of vessel transport limited but: Option Value!
3. Conclusion

Published as:
3. Quantifying the Option Value of Vessel transport (?)

Thank you!