Securing the Underground

Managing the Risks of Carbon Storage through Effective Policy Design

Martin Cames | Berlin | 24/09/2024

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Background

- Growing interest in carbon dioxide removal (CDR) such as BioCCS and DACCS
- CDR technologies with geological storage of CO_2 are contentious
  - IPCC: most scenarios involve contributions of CDR to achieve climate neutrality
  - UBA: climate neutrality can be achieved with nature-based removals only
  - IPCC & UBA: the later emissions are reduced, the more CDR will be required
- CDR must not postpone emission reduction (mitigation deterrence)
- CDR should only be applied for residual and negative emissions
- Geological storage received little attention in current discussions

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and with the Advisory Board (CAN-E, EEB, NABU, WWF-EPO)

Scope

- Geological storage and CO_2 transport but not capture
- EU Offshore (Germany)
- Technological, geological, environmental, socio-economic risks
- Positions of stakeholder
- Existing policy landscape
- Governance challenges
- Conclusions and recommendations

- Authors
  - Dr. Martin Cames
  - Dr. Florian Krob
  - Hauke Hermann
  - Stephan Kurth
  - Dr. Laura von Vittorelli
- With contributions from
  - Laura Veit
  - Mateo Flohr-Reija
  - Dr. Vanessa Cook

Risk profile for carbon storage projects

- Risk profile increases and peaks after injection begins
- After operation risk potential decreases significantly
- After well closure risk potential wanes constantly throughout post-operational phase

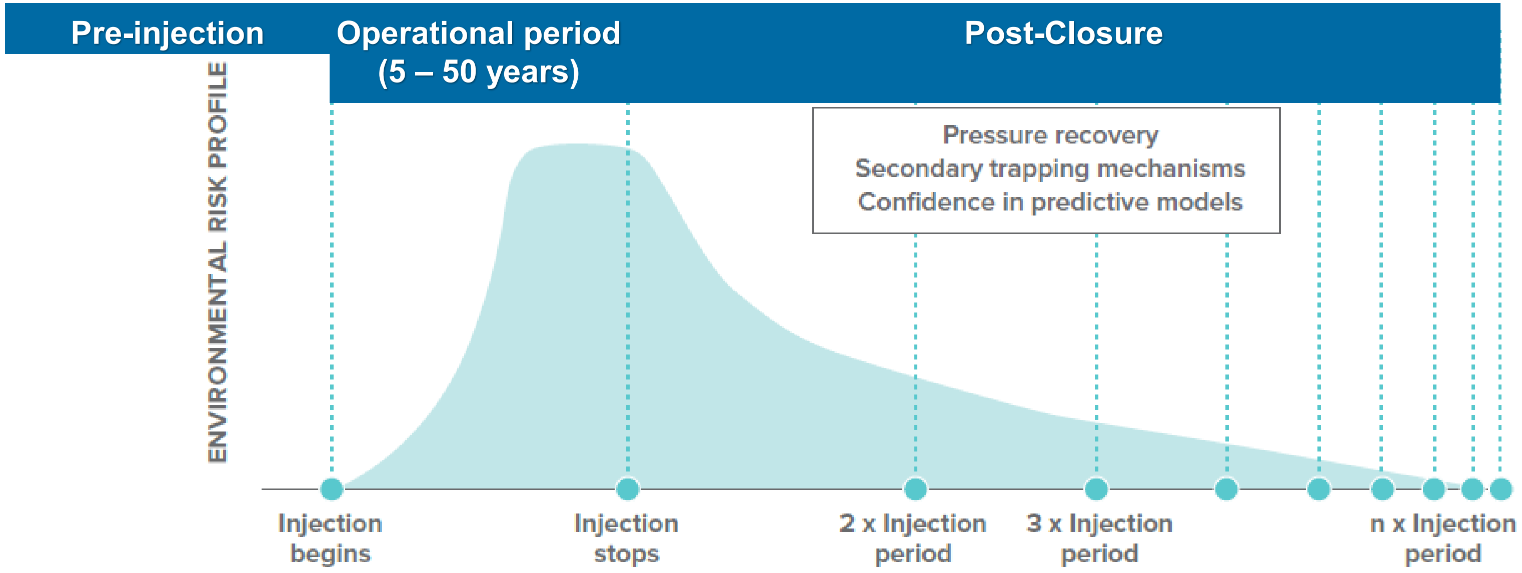


Figure: Based on GCCSI (2019)

Main challenges

- Pre-injection site characterisation
  - Site performance characterisation (e.g., reservoir properties & conditions, and capacity)
  - Pressure management (e.g., determination of reservoir fracture pressure and injectivity)
- Injection
  - Monitor and intervene
  - Pressure management to avoid blowouts and overpressurisation

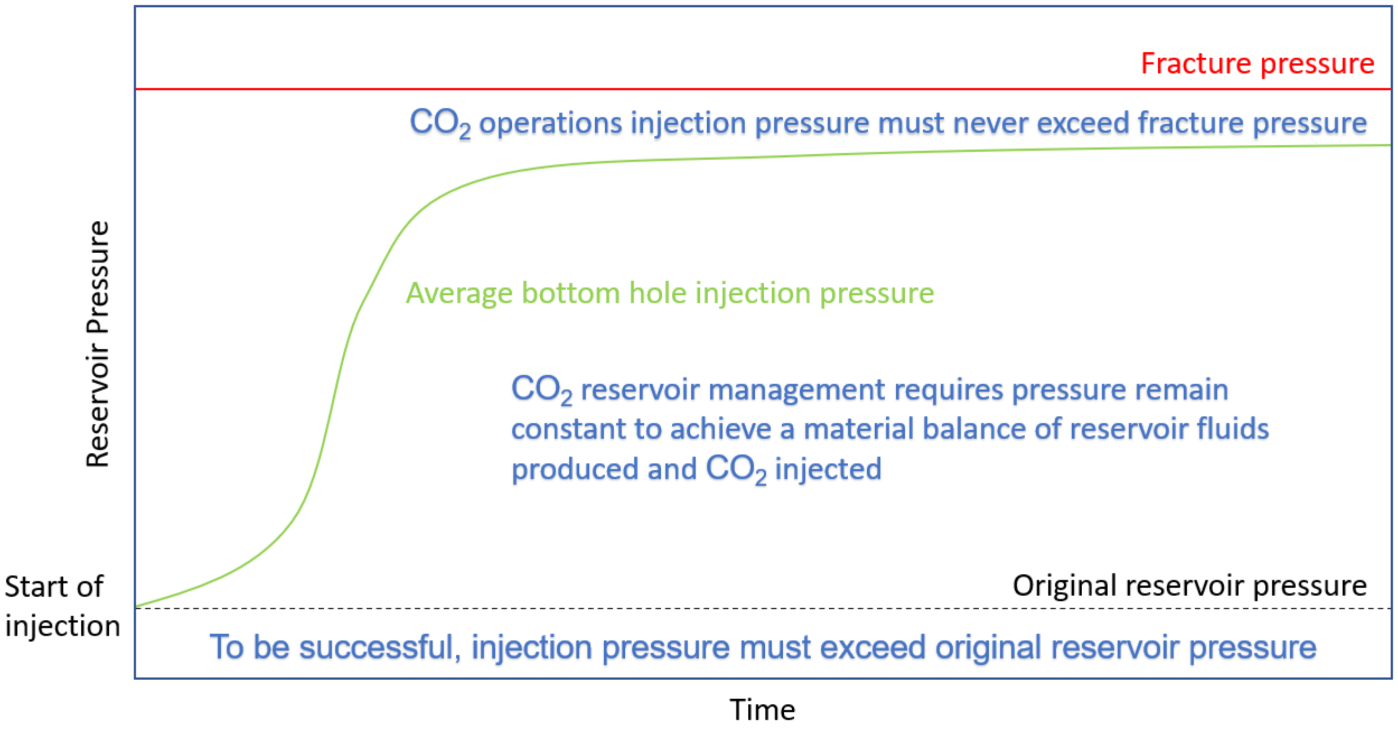


Figure: Based on Marston (2023)

Example: Snøhvit, Norway

- Offshore CS project, operational since 2008
- Materialised risk: Unexpected subsurface storage behaviour
- Effect: Geological formation unable to accept predicted amounts of injection
  - Fast unexpected rise of CO_2 injection site pressure
  - Immediate emergency well intervention
  - Target Formation turned out to be significantly less porous
  - Wells were plugged and abandoned

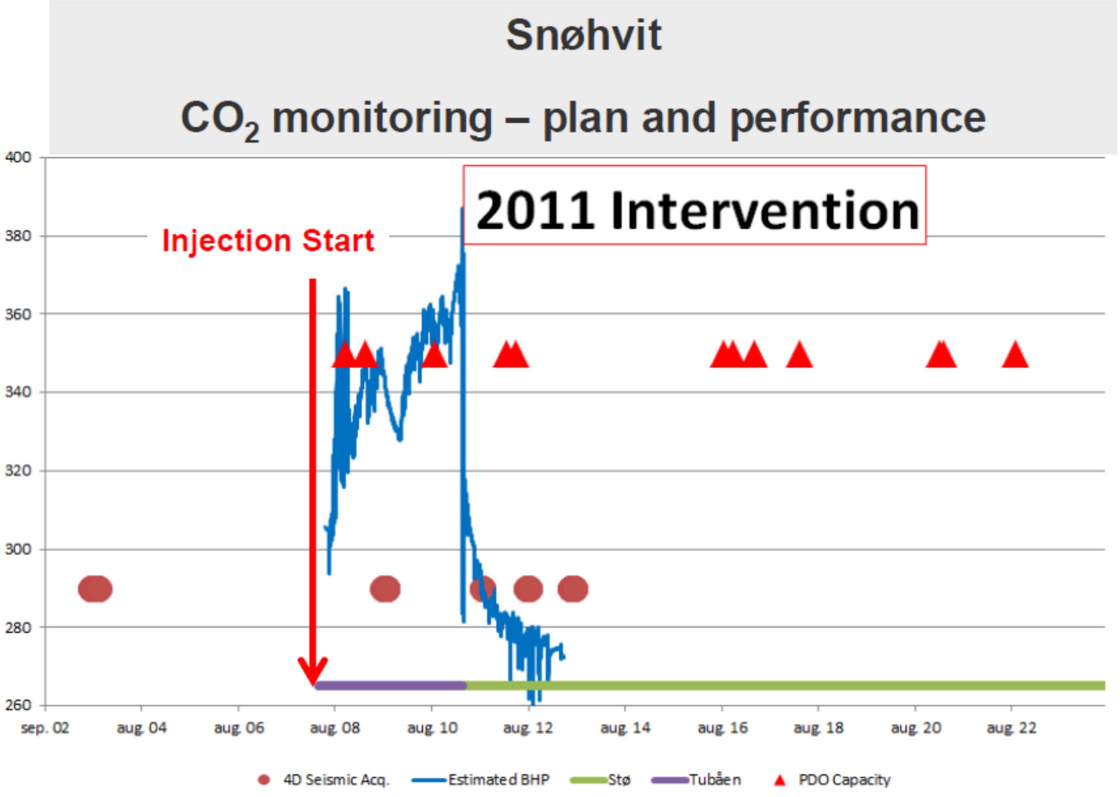
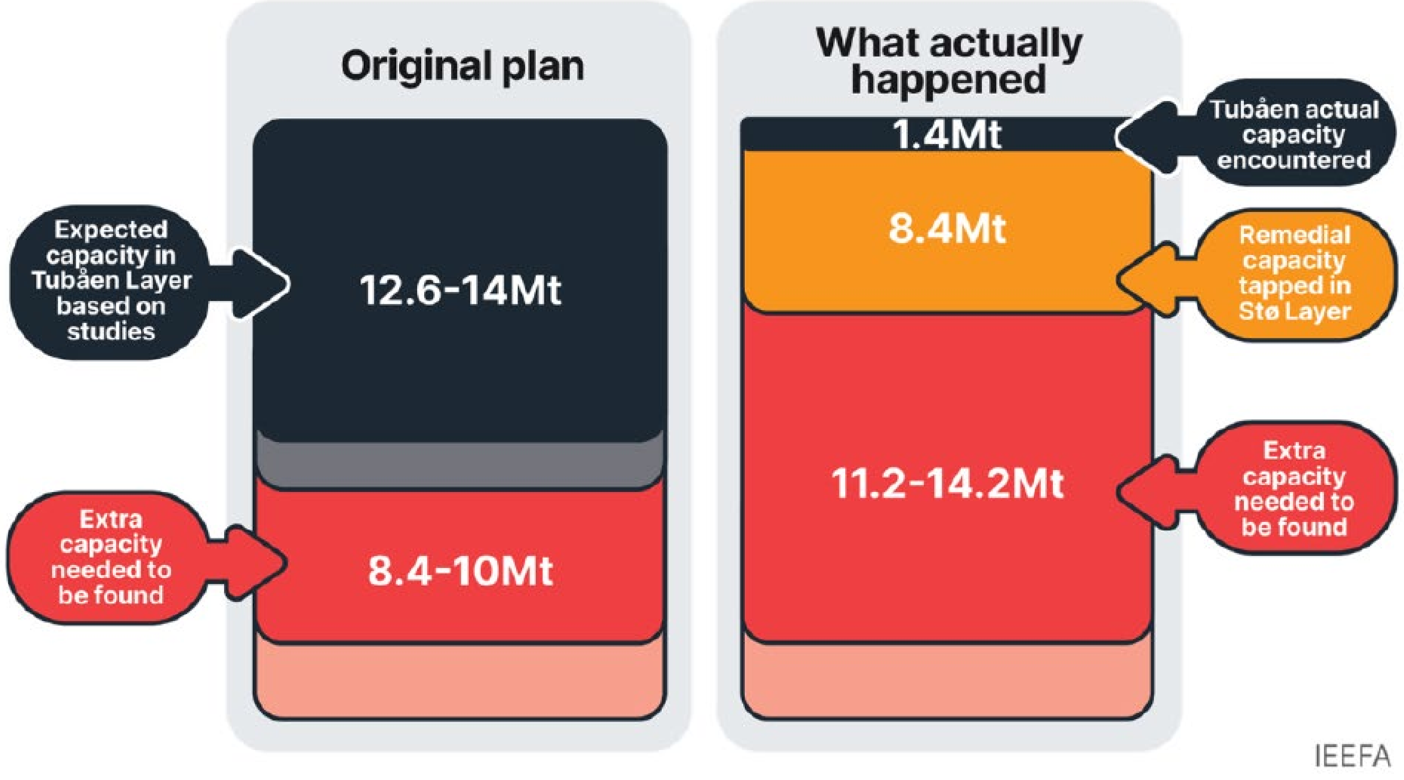


Figure: Ringrose et al, 2013b

Snøhvit: Consequences

- Switched to shallower formation (Stø Fm) on the same well bore
- Stø formation turned out to provide significantly less storage capacities and obtain other risks
- By now, Equinor switched to a third storage site (future Snøhvit)
- Besides explosion of financial costs for remediation measures and intervention, no further effects are known so far



Take Away Messages

- As with any technology, various risks & challenges exist
- Every storage site has its own unique geology and technical set up: Risk factors must be avoided or mitigated
- No characterisation methods is fool proof: Unforeseen storage behaviour should be expected at all times
- Comprehensive monitoring and remediation is imperative to track deviations
- Safe, industrial ramp-up to achieve climate goals might be the biggest challenge

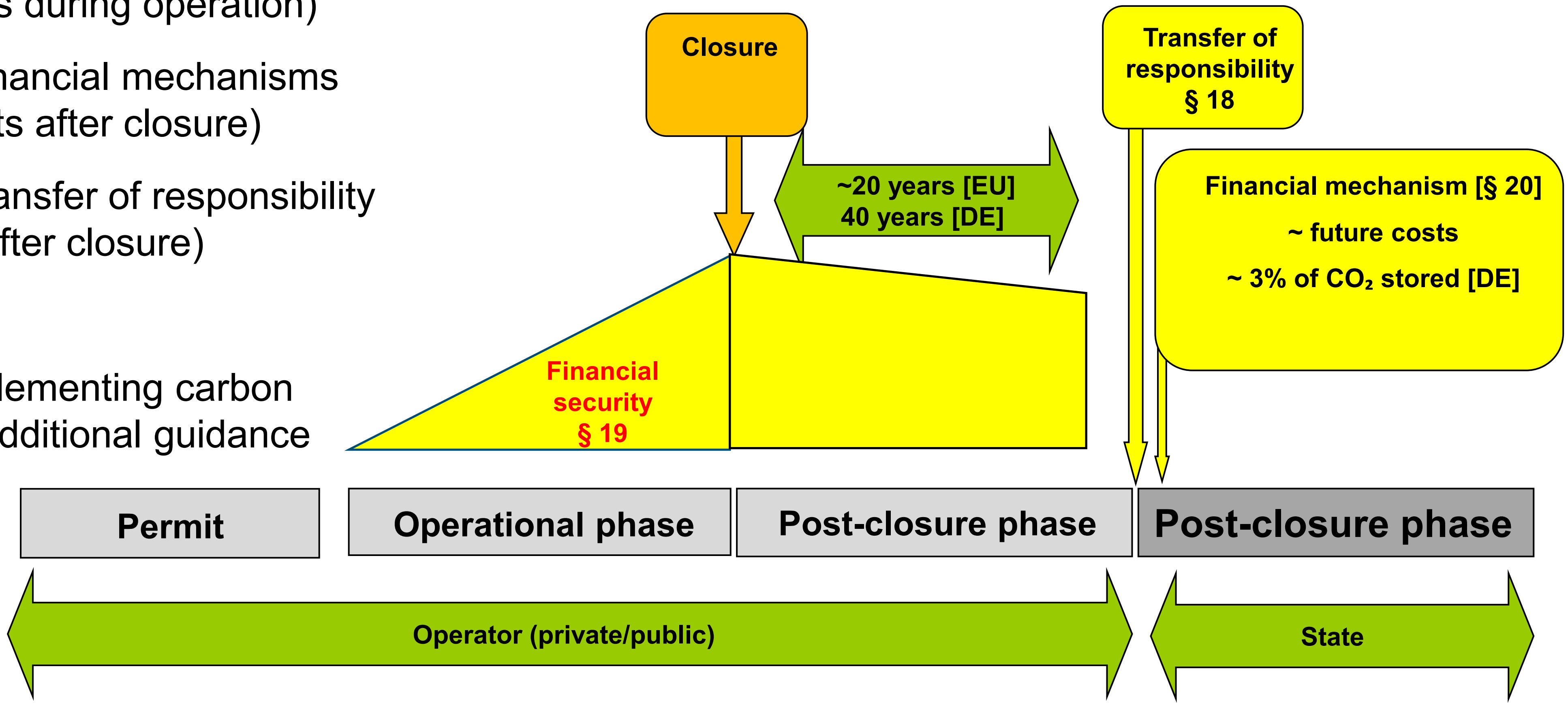
- Not a zero-risk technology but a comparatively low-risk technology overall
- Decades of experiences with CO_2 injection wells were being made
- Challenges can be addressed through efficient pre-injection site characterisation, monitoring, and remediation
- Examples have shown that interventions minimize risks efficiently

Overview of important current governance mechanism

International	European	National e.g. Germany
• UNCLOS • London Protocol	• CCS Directive • ETS Directive • EIA Directive • Environmental Liability Directive	• Federal Carbon Storage Law • Immission Control Law • Transport of Hazardous Goods Law

CCS Directive (2009/31/EC): How is liability regulated?

- Article 19: Financial security
  (to cover risks during operation)
- Article 20: Financial mechanisms
  (to cover costs after closure)
- Article 18: Transfer of responsibility
  (> 20 years after closure)
- Basis for implementing carbon storage but additional guidance required



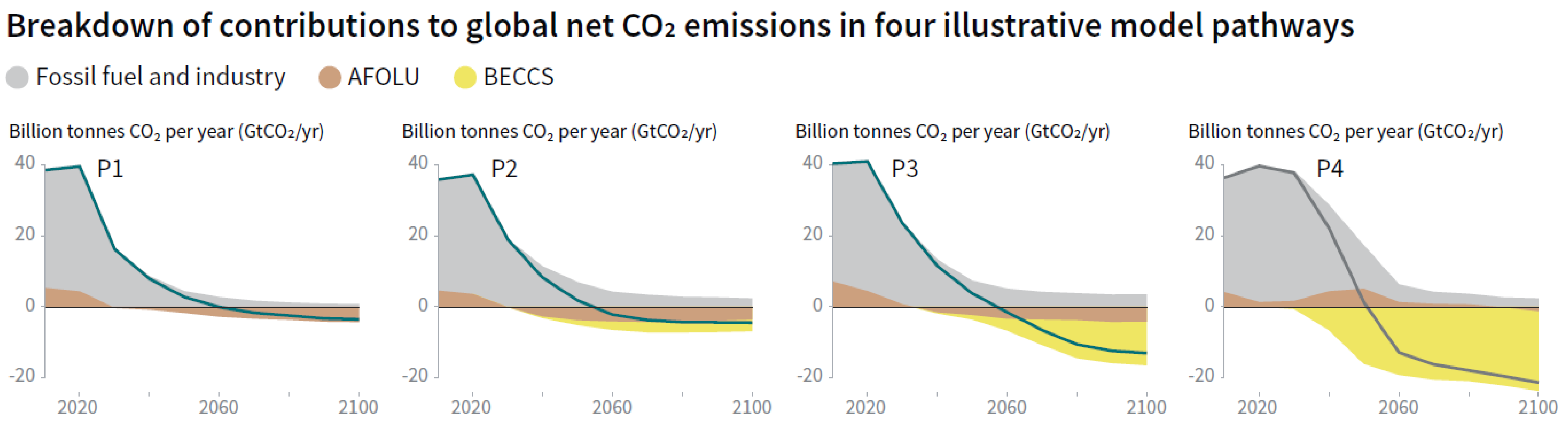
Bird’s eye view on the governance of carbon storage
Governance challenges: Trust

- Unlike renewables, geological carbon storage a highly complex industrial technology that can only be implemented at large scale
- Know how for storing CO_2 is with existing oil and gas industry, implementation of carbon storage impossible without oil and gas industry
- Existing oil and gas industry contributed to a large extent to the climate change, they made large profits from business models with caused the climate crisis
- Many ask whether these companies can be trusted to contribute to solving the climate crisis
- Should they again make profits from addressing the crisis?

Governance challenges: Experience with long-term risks

- Eternity costs of hard coal mining: operators → governments (RAG-Stiftung 2007)
- Nuclear waste: operators → governments (DEU 2017)
- Insufficient liability (e.g. lignite mining): operators → governments
- CS after 20/40 years: operators → governments
- In the long run, the risks are anyway with governments

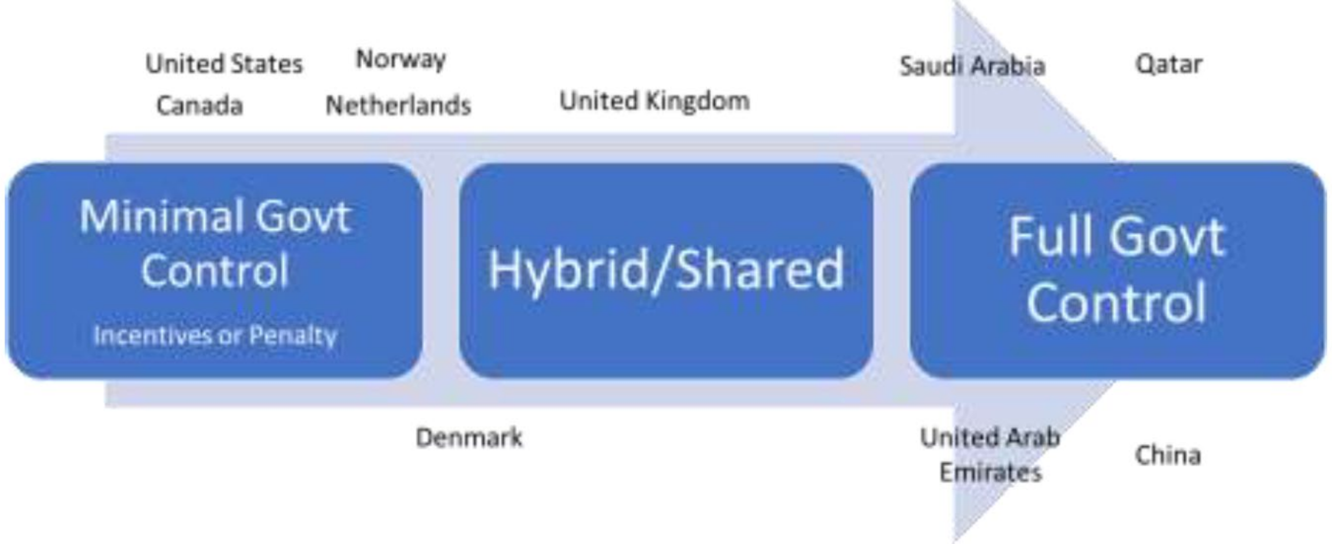
Governance challenges: polluter pays principle



- Long-term demand for carbon storage
  - <50%: Offset residual remissions
  - >50%: Address overshoot (negative emissions)
- Overshoot can hardly be allocated ex-post to individual entities, needs to be financed from government budgets

C.3.3. Pathways that overshoot 1.5°C of global warming rely on CDR exceeding residual CO_2 emissions later in the century to return to below 1.5°C by 2100, with **larger overshoots requiring greater amounts of CDR** (Figure SPM.3b) (high confidence).

Varying degree of government involvement in CCS



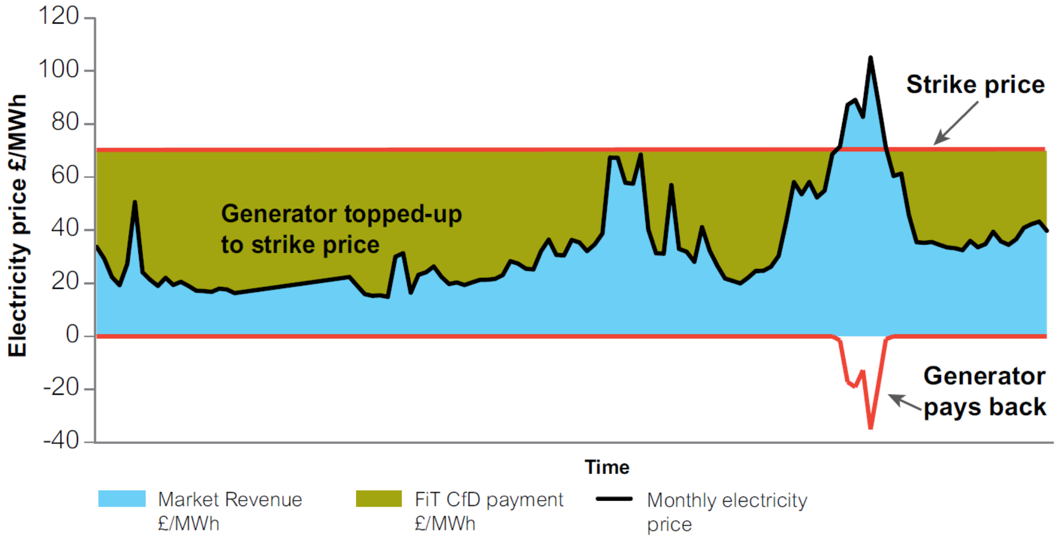
- **Minimal**: Utilize incentives and/or penalties to influence and nudge the private sector to invest in CCS projects without taking ownership of any segment in the supply chain
- **Hybrid**: For capital-intensive activities with uncertain revenue streams, governments may share costs and risks with the private sector
- **Full**: Countries leverage their state-owned and/or national oil companies to invest in and potentially operate CCS projects

OIES (2024) Capture Carbon, Capture Value: An Overview of CCS Business Models

Larger involvement of EC or Governments

- Should the EU or governments therefore take the risks right away?
- Establishment of an EU or national bodies for managing CO_2 storage
- Storage sites operated by private companies (likely from the oil and gas industry)
- Geological CO_2 storage may partly be financed through subsidies allocated through contracts for difference (CfD) in a bidding procedure

Contracts for Difference (CfD)



DECC (2011) Planning our electric future, A white paper for secure, affordable and low-carbon electricity (p. 38)

Provide subsidies to investors in a way which ensures **efficient use of the subsidies while eliminating windfall profits** and mitigating price risks for investors at the same time

Cames et al. (2023) Climate protection in aviation and maritime transport: Roadmaps for achieving the climate goal (p. 157-159)

Conclusions

1. **Regulatory and technical framework**
   - Harmonized CO_2 purity standards
   - Confidential reporting of irregularities

2. **Operational challenges**
   - Proper site selections and injection protocols
   - Reuse of existing infrastructure bears risks

3. **Environmental and human safety**
   - CO_2 leakage, noise, increased traffic
   - Relatively low but not must not be ignored

4. **Monitoring and long-term liability**
   - Continuous monitoring during & after operation
   - Financial provision for remediation and maintenance

Recommendations

- **CO_2 purity rules**: A common set of standards reduces uncertainties, operational costs, foster cross-border collaboration
- **Independent monitoring**: Third-party verifiers ensure transparency, real-time monitoring for risk mitigation
- **Expanded environmental assessments**: Include indirect effects to minimize unintended impacts
- **Integrated spatial planning**: Avoid land-use conflicts, define no-go zones in sensitive areas
- **Post-Closure financial liability**: Ensure financial provisions for post-closure costs, evolving risks and remediation
- **Government involvement**: Build public trust, manage CO_2 storage demand, align with climate goals
- **Policy evolution**: Adaptive governance to address emerging challenges in carbon storage

While reducing GHG emissions remains the top priority for achieving climate neutrality, geological storage of CO_2 can contribute by offsetting residual emissions and achieving negative emissions

Öko-Institut e.V.

Thank you for your attention!

Dr. Martin Cames
Head Energy & Climate (Berlin)

Öko-Institut e.V.
Borkumstr. 2
13189 Berlin
Germany

Telephone: +49 (30) 40 50 85-383
e-mail: m.cames@oeko.de