2013 IEA Conference
Bio-Energy with CCS

Lessons Learned - An Investor's Perspective

Sao Paulo, Brazil
13 June 2013

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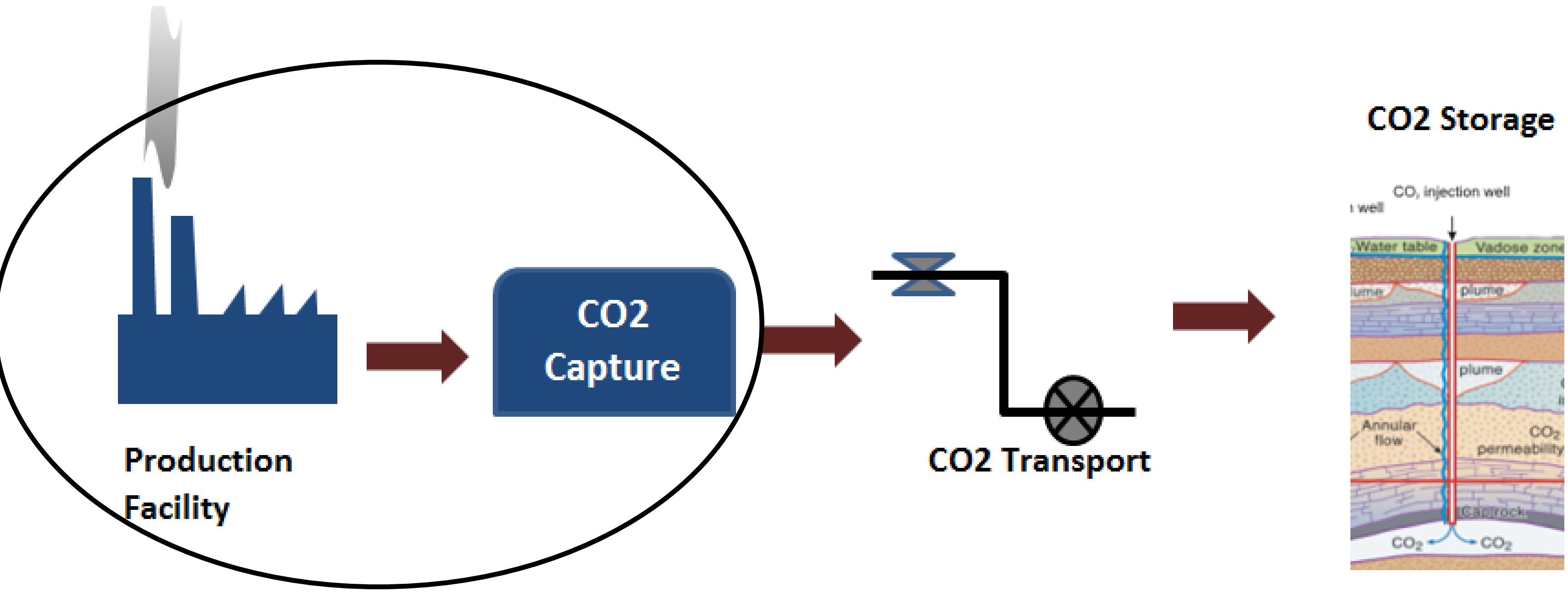
Scope of Presentation

- Lessons Learned
- CCS Development Roadmap
- Differentiating Storage (S) and CO_2 Capture (CC) risks & uncertainties
- Management of Integrated CCS projects
- Investment decision making & due diligence
- Exploration strategy & programs for CO_2 Storage
- Review processes

CCS Supply Chain

- Project developers often focus on the value added industrial link (Production Facility) in the CCS chain



- Capture & transport are easy to study and evaluate
- **But without a cost effective, rate matched storage resource there is no CCS**

But many CCS projects have done just this ….

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- **ZeroGen - Australian CCS Flagship Case Study:**

  Coal fired power generation with CCS – commenced 2008.

  - ► Power plant & CO_2 capture technology
    - – Scale to be full industrial commercial (400 MW Net)
    - – IGCC with pre-combustion capture
  - ► CO_2 storage
    - – specified acreage granted (**not yet explored or characterised**)
    - – No alternative resources for contingency
    - – Regulations still to be developed
  - ► General
    - – Schedule – fully operational in 2015.

– **Project abandoned after investing ~ $100 M because of <u>insufficient suitable storage</u> and high Capex (Plant)**

Lessons Learned from Coal Power Coal Power with CCS Demonstration

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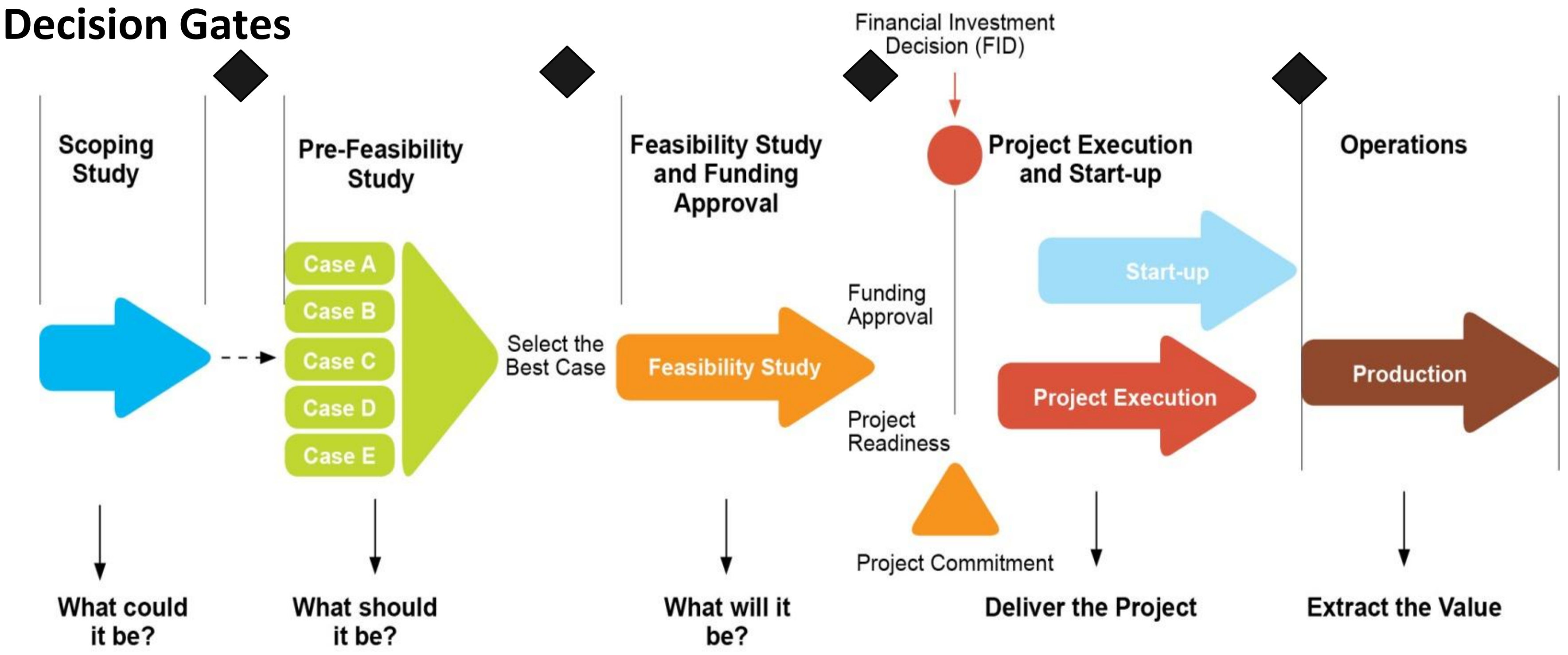
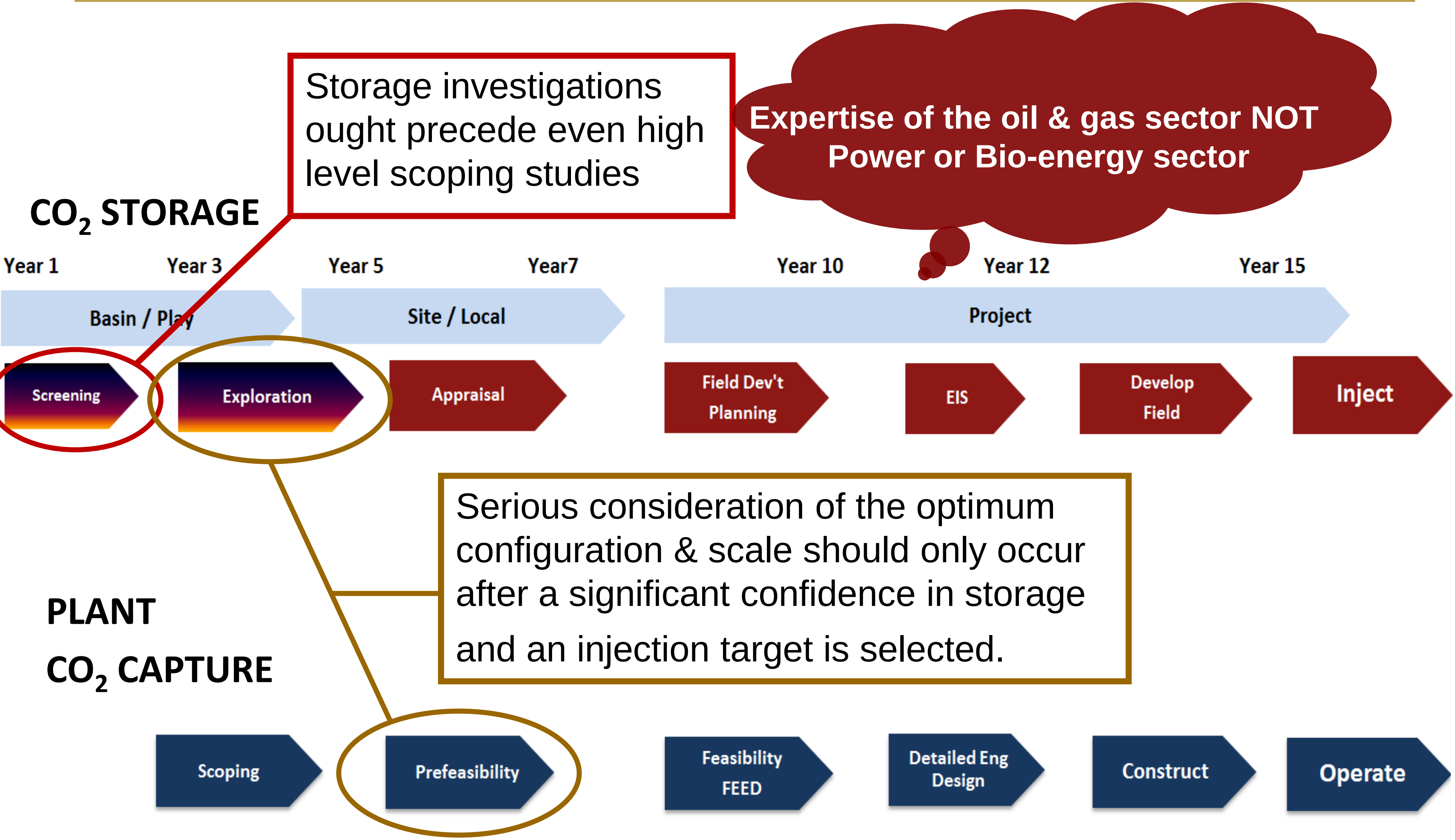
- CO_2 Storage is a natural resource, a **portfolio exploration and appraisal approach is needed**
- Measured management of pace (stage-gating) of “first-mover” projects is critical to success and wider deployment
- **Pre-FEED and feasibility risks and costs are heavily weighted to the search for storage**
- When defining storage resources requirements it is essential to understand the linkage between **injection <u>rate</u> requirements** versus **cumulative volume estimates**.
- High front-end engineering loading is needed for first-of-a-kind – CO_2 capture technology applied to coal fired power is immature
- Industrial-scale, coal fired power with CCS is not currently economic (absent a significant carbon price) and requires government support.

Project Development
2 common systems for phasing



BUT CCS development needs to synchronise with the search for STORAGE



Integrated CCS Projects
From Sequencing to Investment Decision Framework

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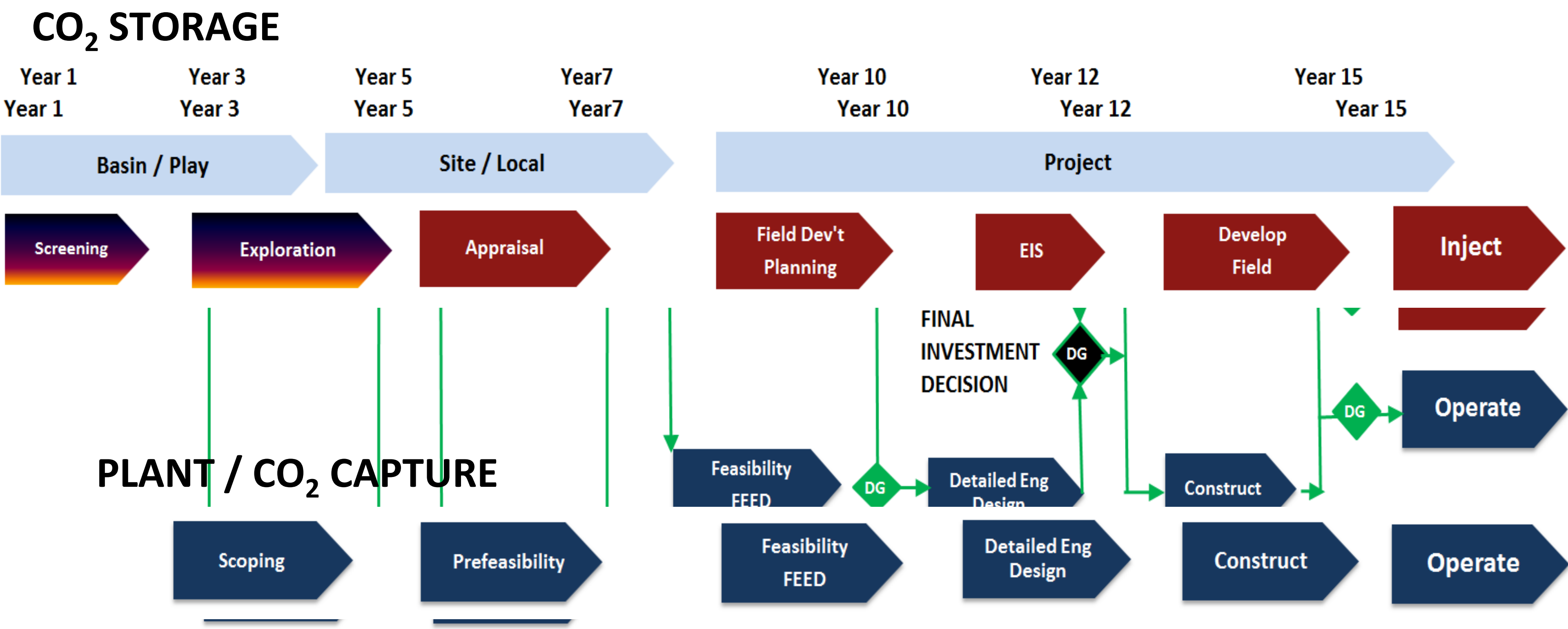


Each Decision Gate should be informed by competent, rigorous independent review

Storage Exploration & Appraisal Estimation Method Overview

Static model

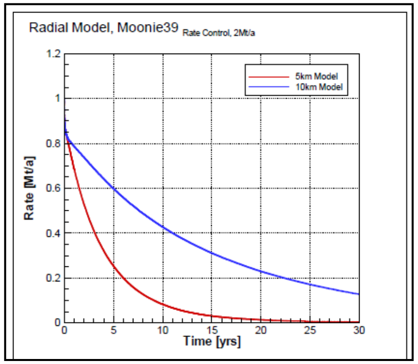
Well & seismic Data

Regional geology

Illustrative, regional static model reflecting key aerial and depth trends

Estimates distribution of reservoir parameters and key features consistent with regional trends.

Inform PDFs



Dynamic models

probabilistic

deterministic

Monte Carlo analysis of steady state injectivity

Informs ranges of initial, steady-state rates.

Inform PDFs

Selected sector models of different regions & tenements

Informs estimates and ranges of lateral migration and rates in an heterogeneous system

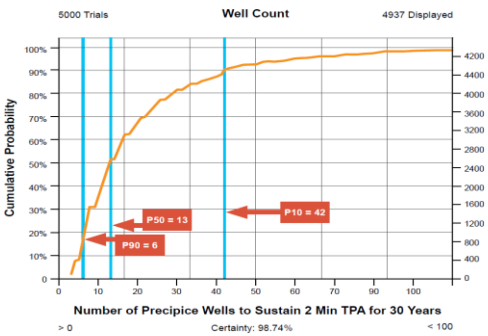
Single well models representing range of reservoirs

Informs estimates of injection decline rates.

PDF of Io

Ranges of I(t)

Economic model



Informs confidence in required injection performance.

Set of outcomes Injection rates over time and uncertainty.
$I(t) = PDF(I_o) * PDF\ I(t)$

Range and uncertainty in well-count and $/t

Informs confidence in required cost performance.

Implications for Investment

- Need to establish confidence that in all cases X million tpa and 30 X million tonnes total can be injected for less than $C /tonne – **Critical to establish rates and decline** early on … and where !.
- Main 2 technical uncertainties on economics
  - Absolute (in-situ) permeability including the 'upscaling' effect of local and far-field heterogeneity
  - Pressure build up (injection decline) as a function of time.
- Injectivity data acquisition must focus on:-
  - DYNAMIC (*water*) TESTS
    - Calibration of absolute, in-situ, k
    - Calibration of contributing net (NTG & h_{gross}) e.g. PLT/spinner
    - Extended Well Tests - detecting barriers out to approximately 3-4km.
  - CALIBRATION
    - Acquisition of complimentary core & log to form calibration set with tests and
      - Calibrate the non-tested intervals
      - achieve a reduction in future expensive dynamic testing.

Summary

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- **CCS Projects require a stage gated development** in which effort and dollars are invested to reduce risk and uncertainty so as to justify investment in future stages
- **Storage resources must underpin any CCS project** – Finding and characterising storage represents the highest risk & investment prior to FID for an integrated CCS project.
- **Storage, capture and transport studies must be synchronised** to a logic such that each informs investment decisions about the other.
- Main 2 technical uncertainties on storage economics
  - Insitu **permeability** incl. local and far-field **heterogeneity**
  - Pressure build up (**injection decline**) as a function of time.
- Storage capacity **probability distribution of injection rate & cost** over time cannot be determined without exploration wells over the target site, production (or injection) tests and dynamic modelling.