THE SRMS: SOLVING THE VOLUMETRIC VS DYNAMIC CO_2 STORAGE CAPACITY DILEMMA

TOTAL Views on the SRMS

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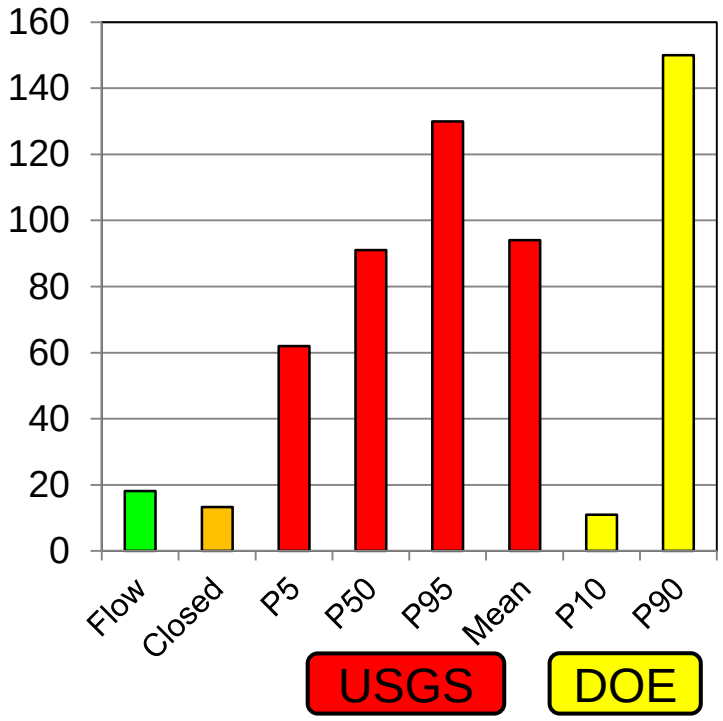
THE CHALLENGE

- Volumetric estimates and flow simulation methods have been developped to estimate CO_2 storage resources in regional aquifers
  - Discussions on open vs closed aquifers
  - Large impact on CO_2 storage resources

- Mont Simon Sandstone example [1]
  - Volumetric estimates 11 – 150 Gt
  - Flow simulation 18 Gt

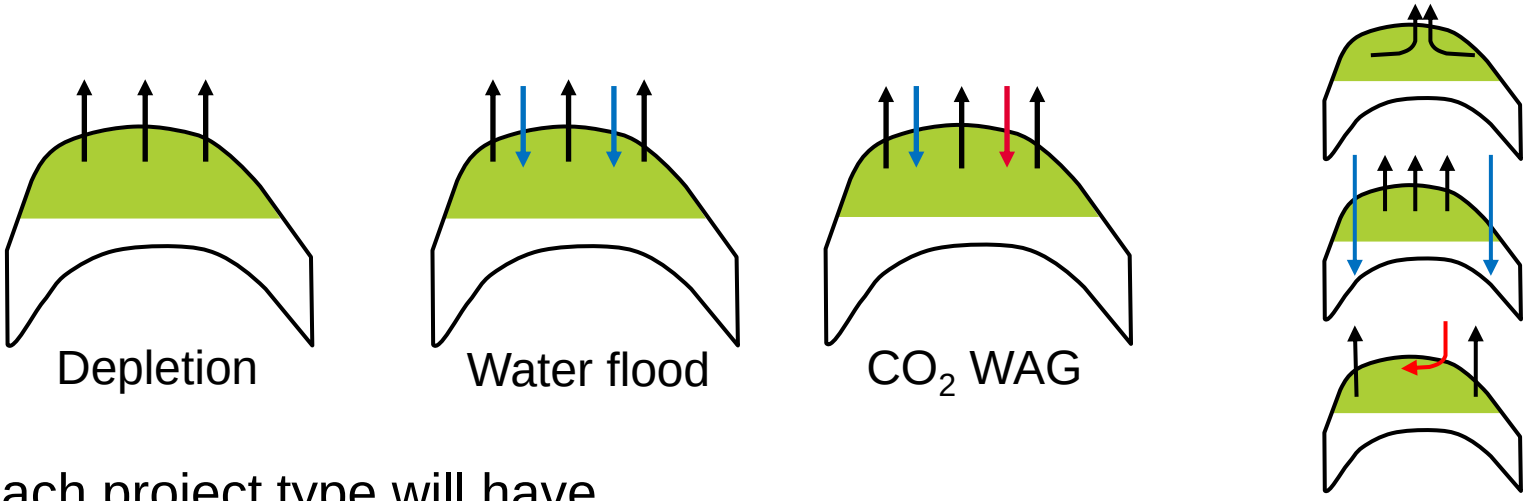
- Similar situation in UK, France, Norway, Canada, …



[1] Thibeau, Bachu, Birkholzer, Holloway, Neele, Zhou, Energy Procedia 63 (2014) 5294 – 5304

THE OIL & GAS APPROACH TO RESOURCE EVALUATIONS

- Estimate the total resource and its range
  - Petroleum Initially In Place
  - Can be discovered or undiscovered
- Estimate which project type is appropriate to develop the resource



- Each project type will have
  - Specific recovery factors (and range)
  - Specific technico-economic characteristics (#producers ; #injectors; water and gas management, well costs, …)

THE OIL & GAS APPROACH TO RESOURCE EVALUATIONS

- The recoverable volumes are largely dependent on the applied project

- Project choice is a technico-economic optimization, based on
  - Geological properties
  - Water management issues; CO_2 availability
  - Well costs
  - Onshore vs offshore

- The quantity relevant for project implementation is the recoverable quantity, not the Petroleum Initially In Place

- How are recovery factors evaluated?
  - Range derived from analogue historical developments
  - Range estimated from flow simulation
  - Remaining recoverable volumes estimated from production performance

IMPLICATIONS FOR CO_2 STORABLE QUANTITIES EVALUATIONS

- Is there an analogue to the Petroleum Initially In Place?
- What is the maximum CO_2 quantity that could ever conceivable be stored in the formation?
- What about considering the various trapping mechanisms set to their maximum?

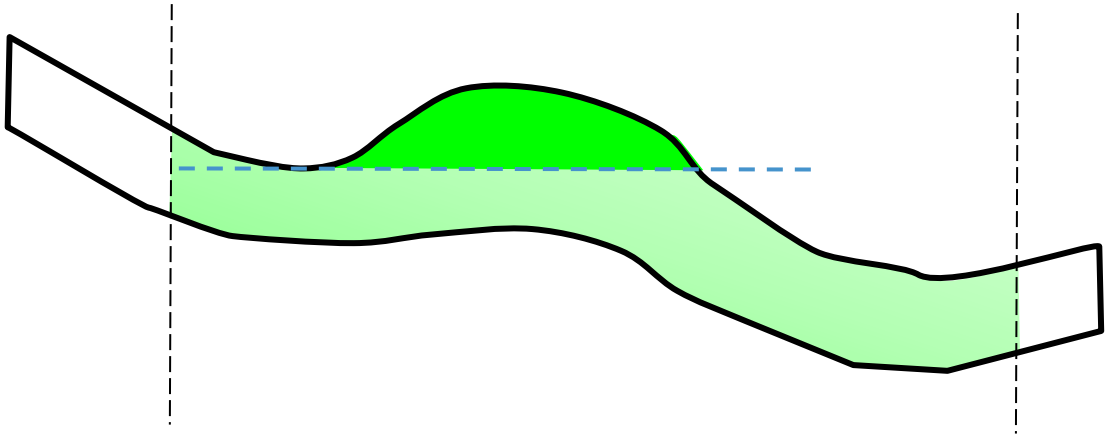


Illustration for aquifer storage

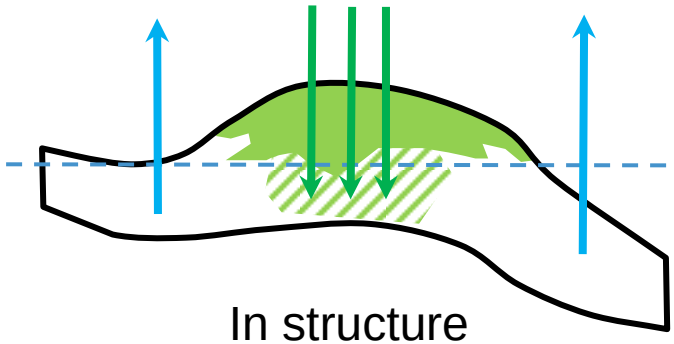
In structural trap, CO_2 saturation can reach 1-Swirr

Outside any structural trap, CO_2 can reach Connate gas saturation

Residual water can be saturated with CO_2

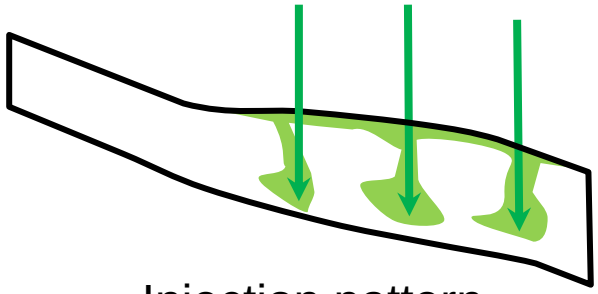
IMPLICATIONS FOR CO_2 STORABLE QUANTITIES EVALUATIONS

- If a storable quantity is the application of a project (or future project) on Total Storage Ressources, how to define a CO_2 storage project?
- Many possible settings depending on the Total Storage Resource type, as

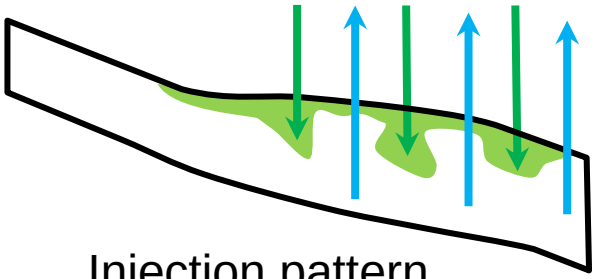


In structure

Injection cluster



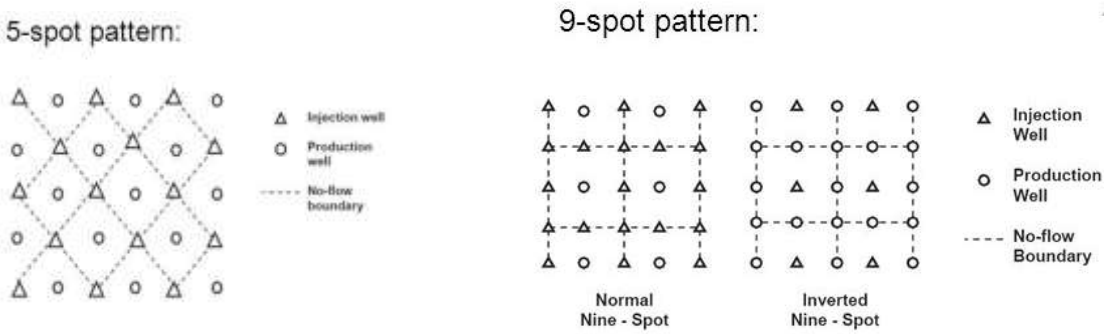
Injection pattern



Injection pattern
with water extraction

IMPLICATIONS FOR CO_2 STORABLE QUANTITIES EVALUATIONS

- How to evaluate the range of storage efficiency of these projects?
  - Limited CO_2 storage analogues
  - Possibility to estimate storage coefficients for a pattern approach using flow simulation
    - Standard activity in the Oil & Gas industry
    - Requires no-flow boundary conditions to ensure a repeatable pattern
    - Valid for injection only (pressure controled) or injection with brine extraction (CO_2 breakthrough management)

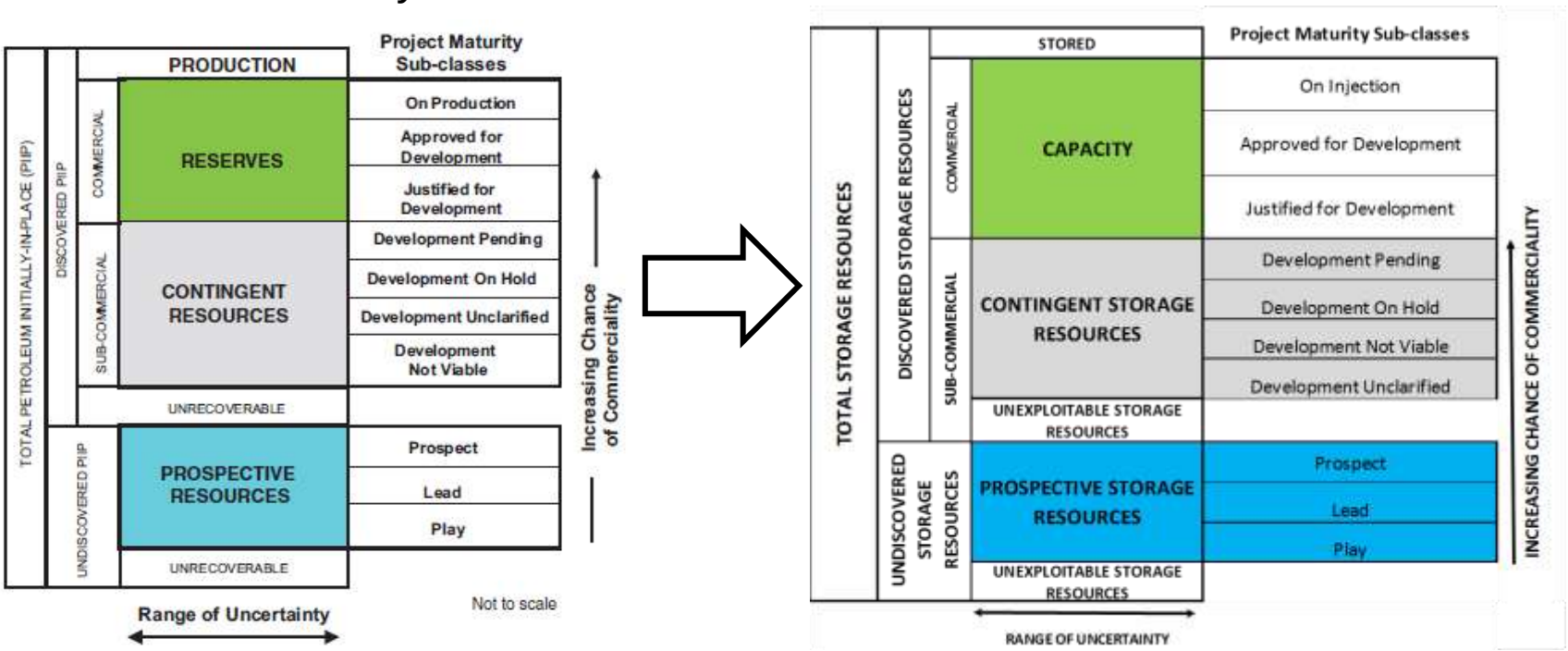


https://slideplayer.com/slide/10369263/35/images/37/Different+Well+Patterns.jpg

  - Flow simulation for injection clusters (with or without pressure management)

THE SRMS (STORAGE RESOURCE MANAGEMENT SYSTEM), A FRAMEWORK FOR RESOURCE REPORTING

- SRMS derived by SPE from the long-life SPE PRMS for oil and gas
- Two axis classification
  - Horizontal: uncertainty range
  - Vertical: Maturity classes



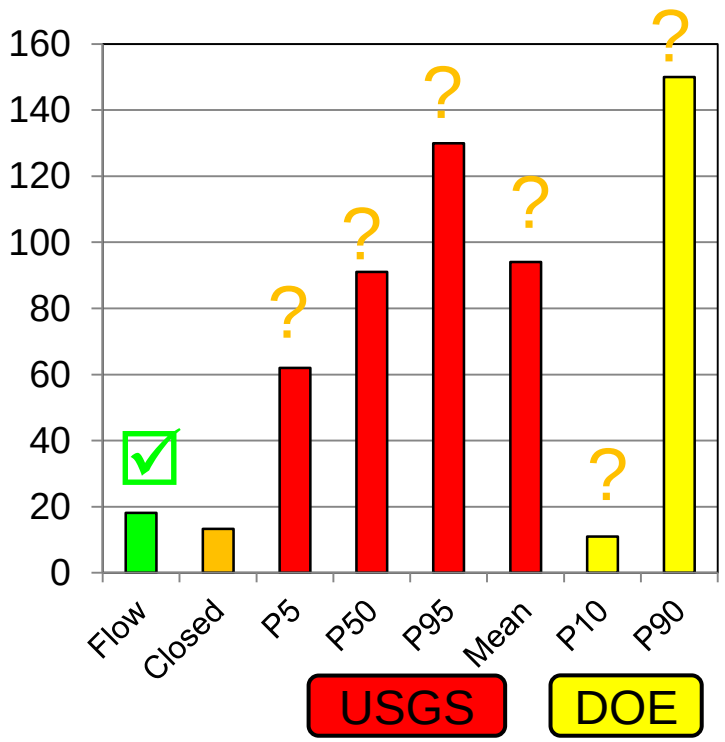
https://www.spe.org/industry/CO2-storage-resources-management-system.php

IMPLICATIONS FOR CCS COMMUNITY

- Evaluating storable quantities is required in order to ensure CO_2 storage can be implemented at scale of Climate Change
- Storables quantities
  - require the definition of project / project types
  - may be orders of magnitude lower than Total Storage Resources (practical impossibility to saturate all formation water or to fill all pore space to connate gas saturation)
- Storage coefficients are required to estimate storable quantities attached to a specific project type
  - Methods remain to be developped
  - Can be evaluated through flow modeling
  - Pattern approach can be used to simplify the flow modeling

RETURNING TO MOUNT SIMON SANDSTONE RESOURCE EVALUATIONS

- The flow modeling approach is a sound approach to evaluate storable quantities
  - Future project is defined, together with number of wells and possible locations, injection rates and duration
  - Resource is valid for an injection cluster approach ; other project types could lead to other resource range
  - Uncertainty should be quantified in addition to a Base Case approach
- Volumetric approaches lack key informations to be labeled as storable quantities
  - No project type associated with resource estimation
  - Possible proxy for Total Storage Resources?



TOTAL

Thanks a lot for your attention