Carbon Storage and Management

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CO2 Storage Capacity from the Resource Management, Investment and Certification Criteria

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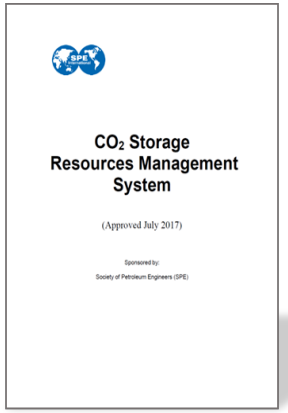
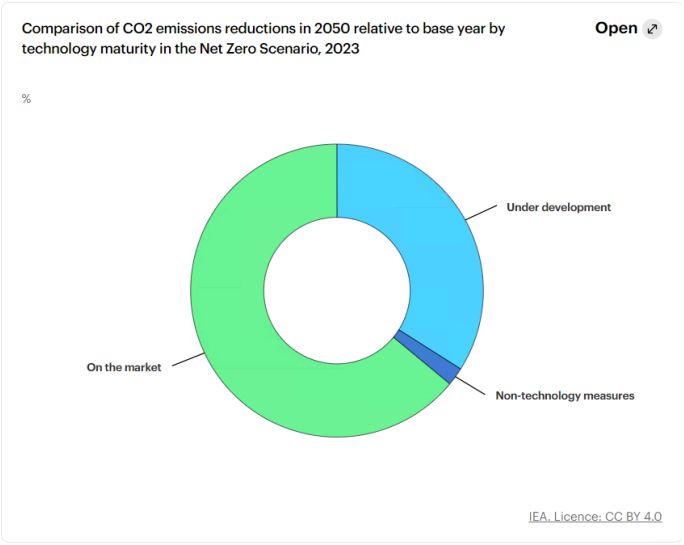
SPE Storage Resource Management System (SRMS)

- In 2017 the Society of Petroleum Engineers (SPE) published the SRMS at a time when regulators were still assessing their response to a future need for CCS.[1]
- Technologies already available in the market to reach 65% of the Net Zero target by 2050, and regulators developing legislative frameworks to attract USD4.5trillion by 2030 to reach Net Zero target by 2050[2]
  - North America and Europe have already created policy incentives
  - In 2017 there were 24 CCS projects operating, in 2021 there were 27 and in 2024 there are 41[2].
- Clearly our desire for CCS is out pacing our experience but the international community will rely on us to assess, and compare, CCS opportunities
- The SRMS is a useful tool to calibrate expectations, uncertainty and maturity of carbon storage projects for investors and stakeholders

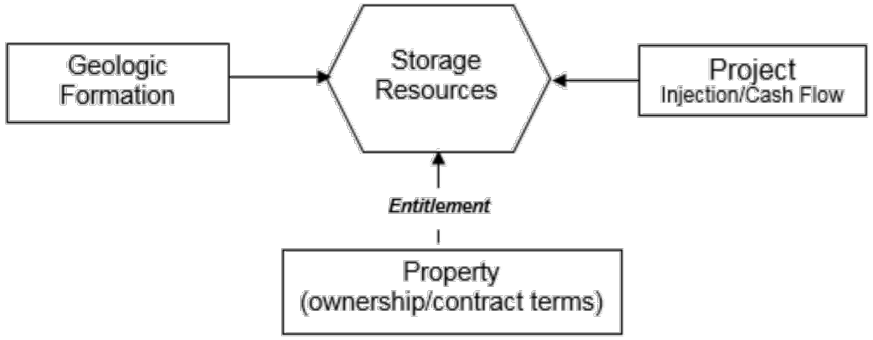




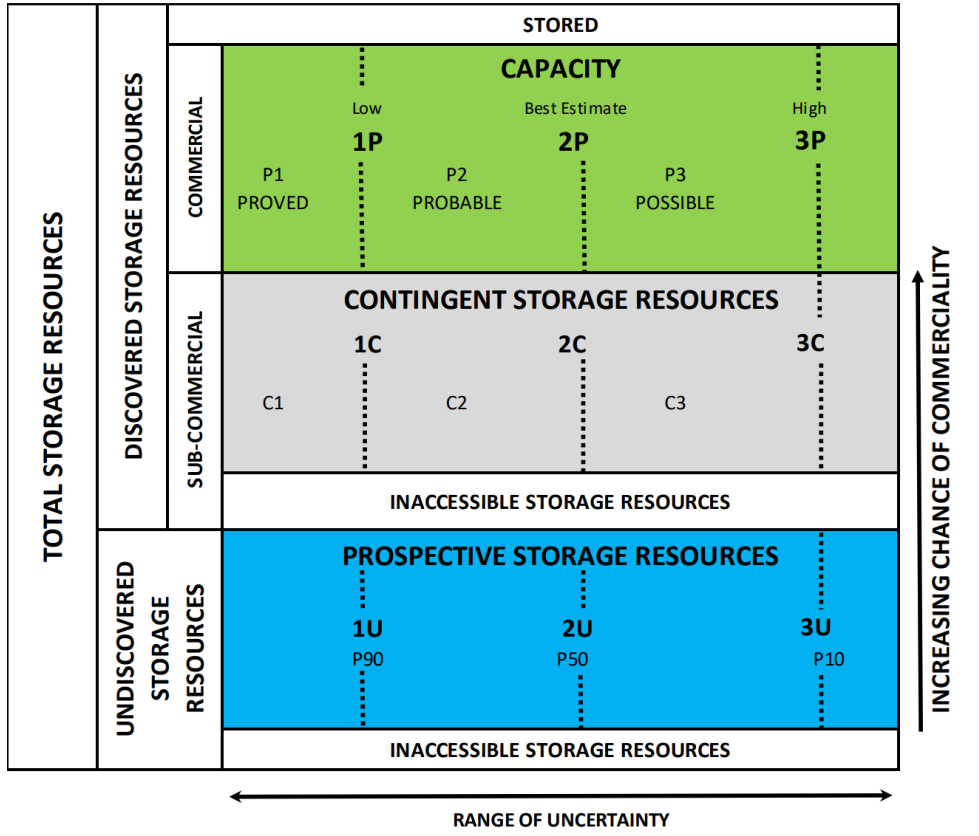
1 - Aug 2022 update
2 – International Energy Agency Net Zero Report

Basic criteria for classification

- Can a classification be made?
  - Ownership
  - Geological characterization
  - A project concept



SPE PRMS Resources evaluation data sources



SPE SRMS Resources classification framework

Storage types

The principal storage options that are widely available are different in some key areas

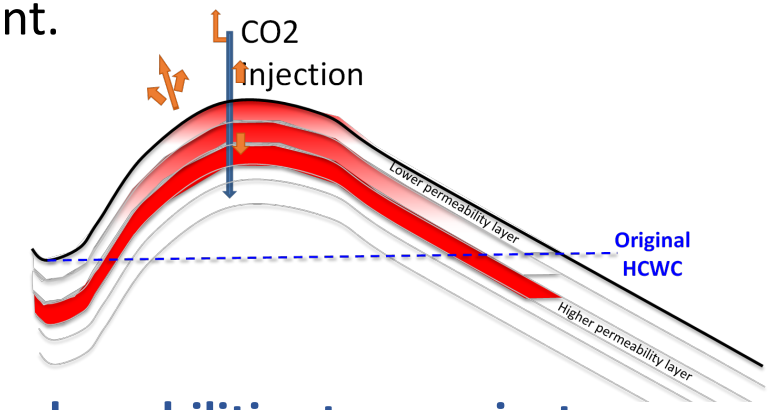
- **Depleted fields**
  - Most likely that contingent resources will be defined without prospective resources as a precursor
  - Extensive database, infrastructure and confirmed trap
  - Time to start up could be minimal
  - Useful for competing strategies (H2 or CH4 storage)
- **Saline aquifers**
  - Prospective resource identification more likely
  - Appraisal and data acquisition cycle common
  - Time to start up extended
  - Storage potential considerably larger than depleted fields
  - CO2 migration a principal concern

Uncertainty in depleted petroleum fields

Existing data can be used to calibrate uncertainty and projects can typically enter the SRMS as contingent resource

- Mobile CO2 replaces petroleum removed from the trap
- Advantages
  - Extensive database
  - Existing wells
  - Demonstrated trap
  - Speed of implementation
- Initial resource estimates can be determined by converting the produced petroleum volume to a CO2 volume at the storage conditions

- Limitations
  - CO2 migrating below the original trap due to heterogeneity
  - Formation breakdown pressure
  - CO2 reacting with cap rock, reservoir and legacy oil field equipment.
    - Well integrity
    - Trap integrity

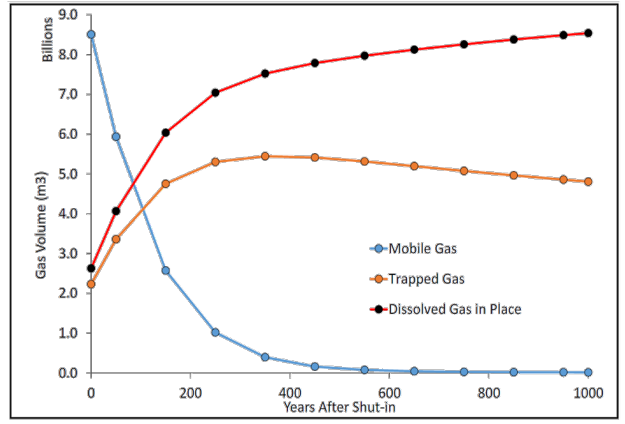


Although legacy equipment offers a speed advantage it introduces potential vulnerabilities to a project

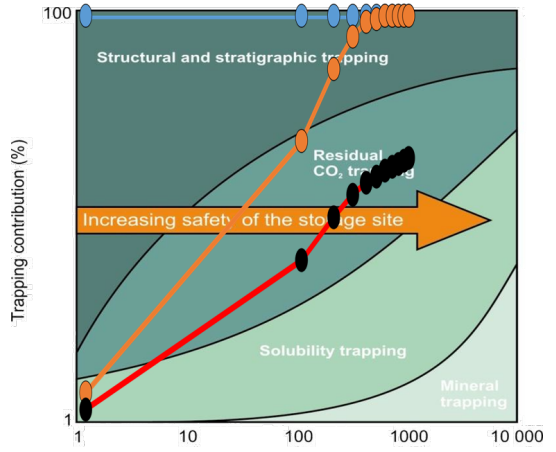
Uncertainty in aquifers

Aquifers have the potential for much larger storage volumes but the Trapping mechanisms are more complex and rely on capillary pressure, solubilisation and mineralisation.

- **How far does the mobile plume migrate until it is trapped?**
  - Can not migrate to the surface, potable aquifers or off permit
  - Modelling and monitoring commitments (jurisdictionally sensitive)
    - Australia requires wells to be permanently abandoned
    - The Californian Carbon Capture and Sequestration Protocol requires monitoring of up to 100 years



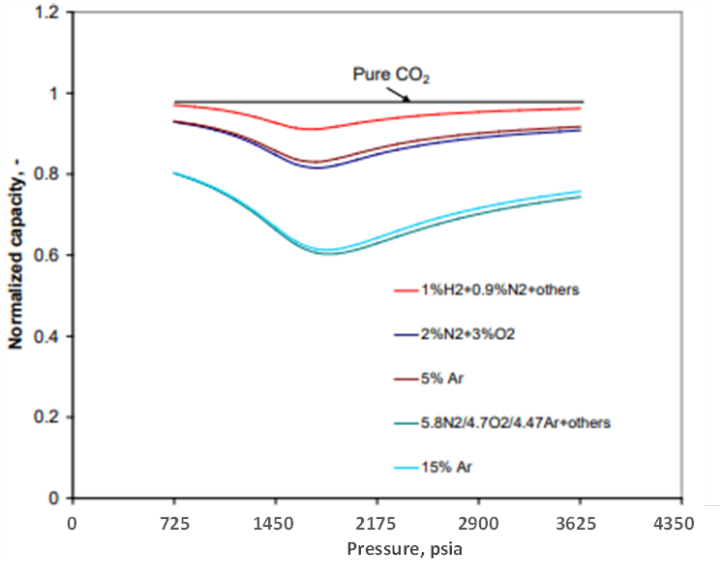
Ref: SW Hub Carbon Storage; Dynamic modelling Final report WAPIMS W21531A27



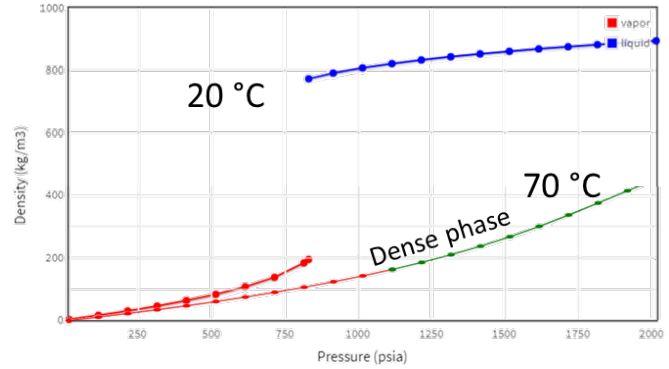
Notable CO2 Phase behaviour

CO2 phase behaviour contains some characteristics that can be problematic to model

- Inert gases can increase the pressure required to reach the dense phase and reduce the storage capacity of CO2.
- At surface temperatures CO2 goes through a dramatic phase change at ~ 850 psig
- Vapourisation of CO2 at the surface or downhole could be problematic and disrupt the process



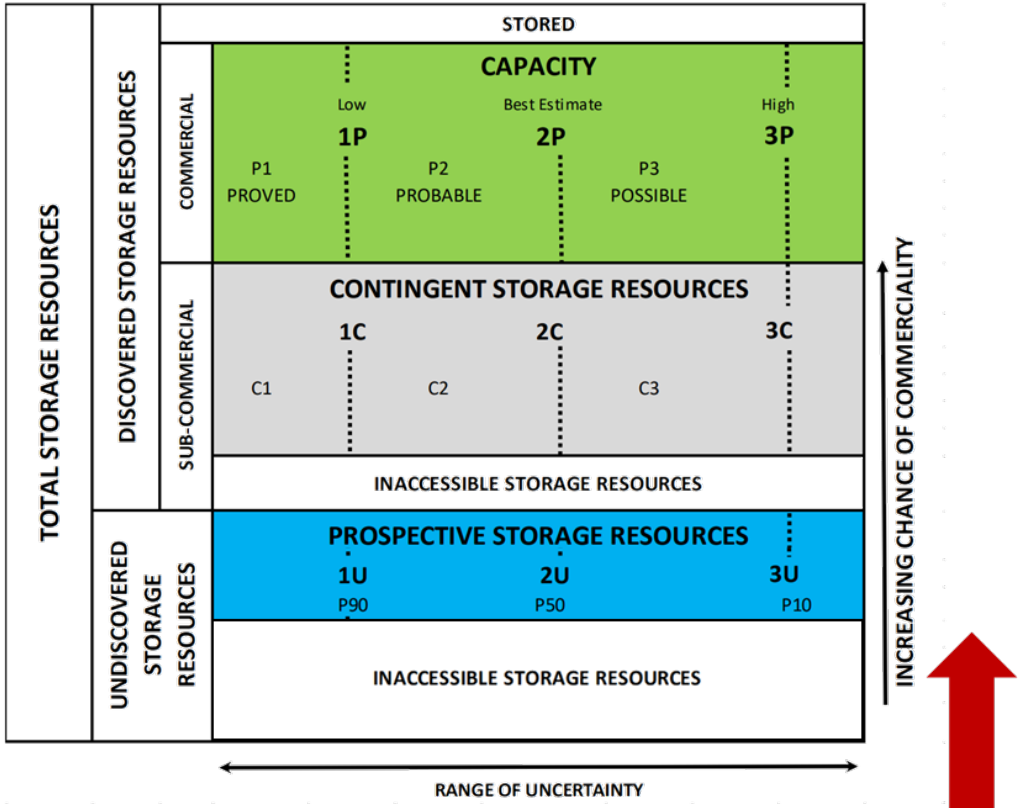
Ref: Effect of impurities on geological storage of carbon dioxide, Global CCS Institute, June 2011



Establishing a prospective resource

An awareness of the market for the project is important if evaluating a saline aquifer prospective resource

- Need entitlement, a level of geological characterisation and a project concept
- In the absence of detailed modelling an estimate of 1.5% to 4% aquifer contact could be suitable
- An awareness of the available market

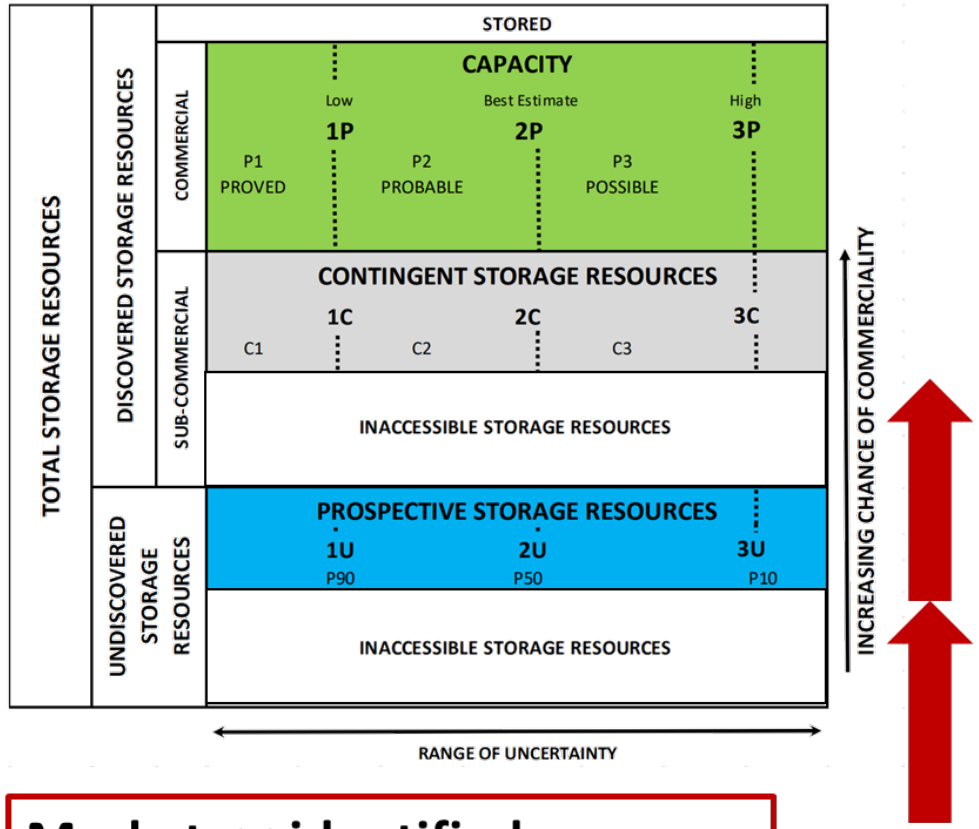


Market << potential resource

Maturing to a contingent resource

The principal measure of maturing contingent resources is developing the technical and commercial understanding.

- At least one well must have penetrated the storage formation
- Sufficient data to estimate the storage potential
- Ideally injection testing if not good local analogues
- The formation must have been mapped to some degree
- If the market is materially smaller than the total resource some should be declared inaccessible[1].
- The nature of the market should feature more closely in the evaluation and interdependencies investigated when required.



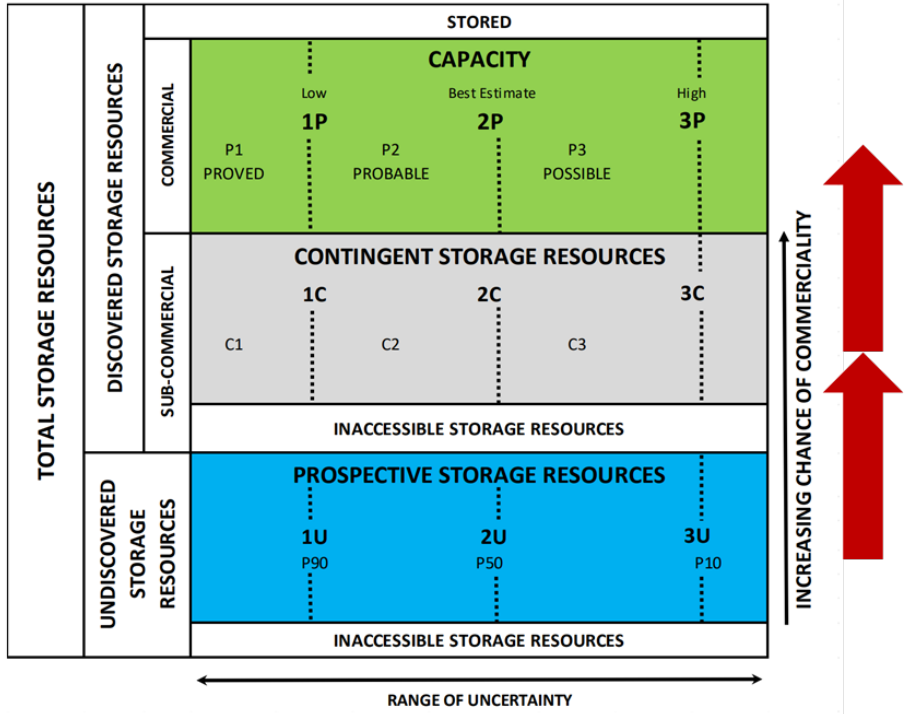
Market << identified resource

1 – this is deliberately provocative and designed to enable realistic contingent volumes being reported to investors

Maturing to capacity

Also known as a commerciality test

- Evidence to support a reasonable timeframe for development
- A reasonable assessment that the future economics of such development projects meet defined investment criteria
- Evidence that the necessary injection facilities are available or can be made available
- Evidence that legal, regulatory, contractual, environmental, and other social and economic concerns and approvals will allow for the actual implementation of the storage project being evaluated



In Summary

- To be in line with the Net Zero target by 2050, total investment needs to reach USD4.5 trillion by 2030.
- CO2 storage projects have geological similarities with petroleum projects.
- Trap definition and fluid behaviour are important exceptions.
- CO2 markets are required to be considered at the prospective resource stage.
- In some circumstances a deeper understanding of commercial terms is required to determine capacity.