CO_2 Storage Resource Catalogue Cycle 4 Report

AMERICAS

August 2024

OIL AND GAS CLIMATE INITIATIVE

GLOBAL CCS INSTITUTE

HALLIBURTON

International Association of Oil & Gas Producers

Amounts of CO_2

Stored
0.014 Gigatonnes

Commercial
0.056 Gigatonnes

Sub-commercial
394 Gigatonnes

Undiscovered
7919 Gigatonnes

Appendix A : The Americas

Brazil
Canada
Mexico
USA

Document Summary	
Client	Oil and Gas Climate Initiative (OGCI)
Title:	CO_2 Storage Resource Catalogue – Appendix A: The Americas
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Important notice

TABLE OF CONTENTS

Figures

Tables

1 Brazil

1.1 Summary

Brazil was assessed during Cycle 1, and not updated in Cycle 2 or Cycle 3 or 4. The CSRC identified a CO_2 storage resource for Brazil as follows:

Classification	CO_2 storage resource (Gt) Project and no project	CO_2 storage resource (Gt) Project specified only
Stored	0.0006	0.000
Capacity	0.000	0.000
Sub-Commercial	2.47	0.000
Undiscovered	0.000	0.000
Aggregated*	2.47	0.000

* The aggregated resource represents the summed storage resource across all maturity classes and as such should not be viewed as representative of the potential of the country.

Table 1-1: Storage resource classification summary for Brazil

The aggregated storage potential in Brazil is 2.47 Gt and is entirely held within oil and gas fields. These are classified as Discovered but Inaccessible due to the lack of cessation of production dates, an EAD date, or a CCS specific regulatory and legal framework.

The CSRC has identified 17 oil and gas fields in the Campos Basin with a storage potential evaluation, plus the summed evaluation of hydrocarbon fields in a further 10 geological basins.

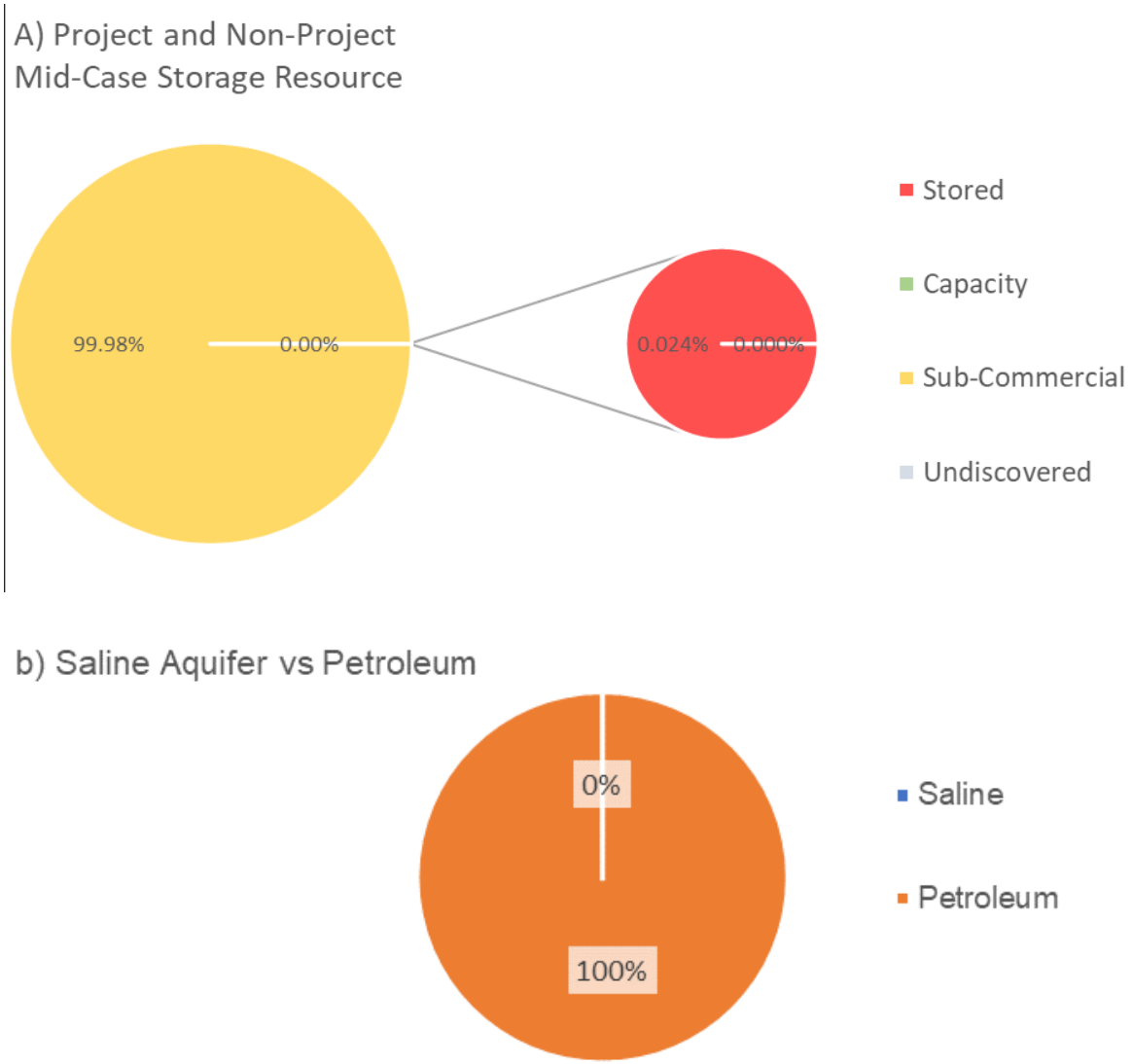


Figure 1-1: Brazilian spread of Storage Sites

*Note: None of the Brazilian sites have an associated project specified.

a) Spread of storage resource in all Brazilian sites (28) across SRMS classifications. b) Split of Brazilian storage resource between saline aquifers and hydrocarbon fields, both project specified and not.

1.2 Resource Statement

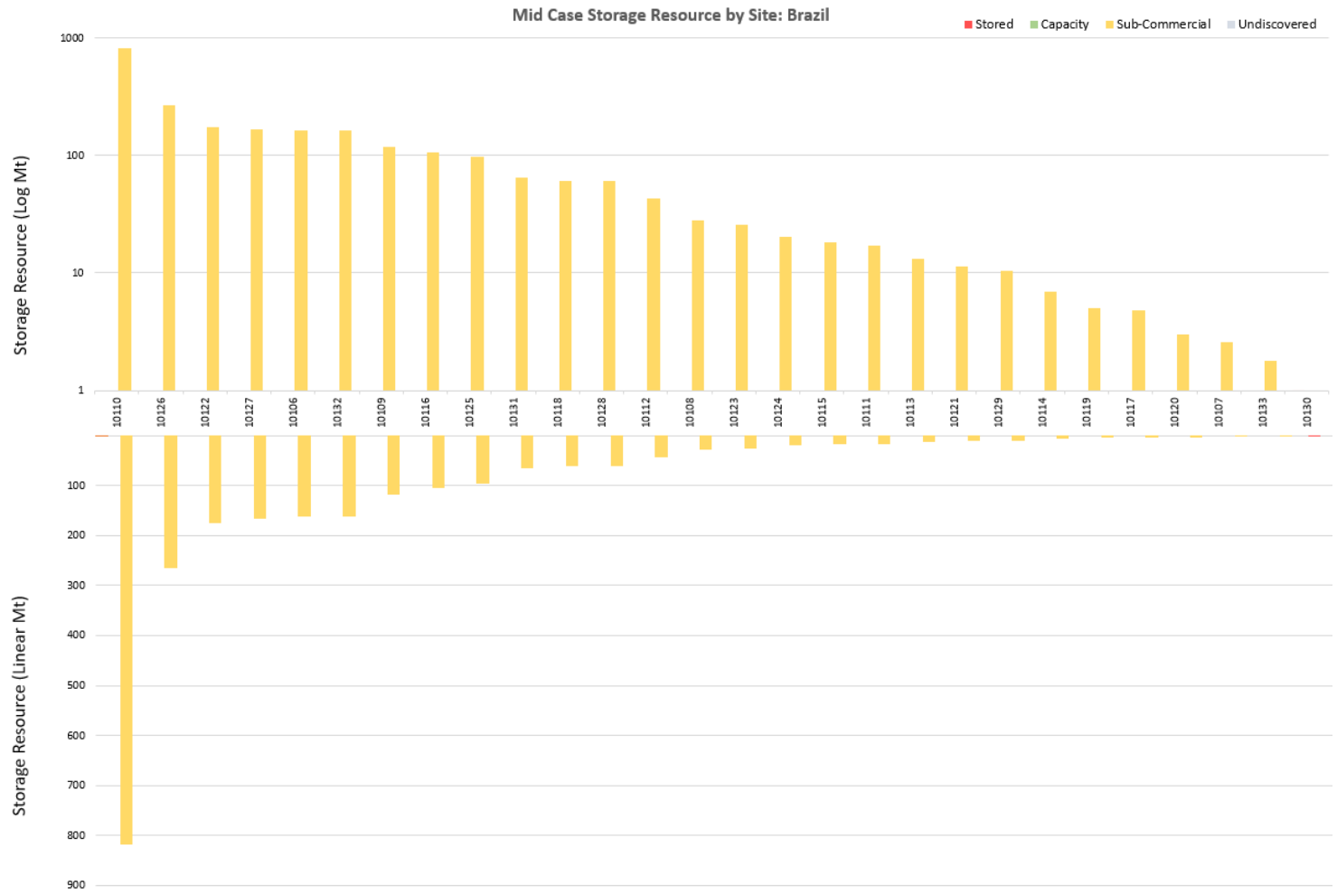


Figure 1-2: Storage resource summary for Brazil compiled in the CSRC.

Graph above is log scale and graph below is linear. No project specified sites were identified.

1.3 Evaluation History

Brazil's storage resources were reviewed, and a preliminary assessment carried out, during Cycle 1. The assessment draws from three documents which currently provide the only information on CO_2 storage resource potential in Brazil.

The first is the 2016 Brazilian Atlas of Carbon Capture and Storage. This document is based on research by the Centre of Excellence in Research and Innovation in Petroleum, Mineral Resources and Carbon Storage (CEPAC) and was funded by the Global Carbon Capture and Storage Institute (GCCSI). The Brazilian Atlas evaluated the storage potential in oil and gas fields, both onshore and offshore, however quantitative evaluations were only available for fields in the Campos Basin. In addition, coalfields and basalts were evaluated but do not form part of this assessment [1].

The second is the Brazilian Carbon Geological Sequestration Map (CARBMAP) Project [2], an effort to create a geographic information system (GIS) to facilitate matching of CO_2 sources and sinks. Here the storage potential of Brazilian oil and gas fields in 11 basins was evaluated using the hydrocarbon reserve volumes.

The final source, published in 2013, evaluated the storage potential in 17 of approximately 50 hydrocarbon fields in the Campos Basin, using a voidage replacement method by Bachu et al (2007) [3].

1.4 Resource Review

1.4.1 Major Projects

No major carbon storage projects were identified that could be assessed against the SRMS, during Cycle 1. The presalt oilfields in the Campos and Santos offshore basins contain high levels (8-12%) CO_2 in the produced fluids (Iglesias et al., 2014). Petrobras operate an active project which captures CO_2 from the hydrocarbon processing facilities and re-injects the CO_2 into the supergiant Lula field in the Santos Basin. This operation is utilising a 'hub and cluster' development which, uniquely, deploys 10 FSPO's. The primary focus is on CO_2-EOR however the reported aim is to cumulatively inject 40 Mt by 2025. By January 2019, 10 Mt had successfully been injected. Future assessments should re-visit this operation.

1.4.2 Depleted Oil & Gas Fields

The Campos region potential storage resource is estimated to be 0.95 Gt [3] but the published resource only represents a subset of 17 fields out of 50 in the basin and excludes the large pre-salt oilfields.

The CARBMAP Project identified a further 1.52 Gt in hydrocarbon fields across Campos and a further 10 basins [2].

All storage resources are classified as Discovered as they are oil and gas fields, however the

absence of both a Cessation of Production (COP) date, or an EAD, indicating when the resource may become accessible for CO_2 injection, and the lack of a CCS-specific regulatory system limits them to "Inaccessible Storage Resources". It should be noted that even though a CCS regulatory framework is lacking, CO_2 continues to be injected underground for enhanced oil recovery under the existing petroleum regulatory system. For example, in the Reconcavo Basin, a CO_2 storage pilot project, has evaluated the impact of 20 years CO_2 injection into the onshore Buracica oilfield where a small 600,000t inventory has been injected for enhanced oil recovery 1.

1.4.3 Saline Aquifers

The CSRC found no specific published details of CO_2 storage potential in saline aquifers. A 2009 pilot project in which 12,000 t CO_2 was injected into the Rio Pojuca saline aquifer represents the only reported carbon storage [4].

1.5 Regulatory Framework

Brazil is classed as a 'moderately performing' nation by the 2018 GCCSI CCS Readiness Index with moderate scores for both CCS Readiness and Inherent Interest. Although Brazil's energy mix is 90% renewables, due to a large share of hydropower in the country, it is supportive of CCS and recognizes it as an important energy technology in its energy strategy. The government National Energy Plan 2030 was issued in 2007 and identifies CCS technology as one of the tools to reduce CO_2 emissions from fossil fuels. CCS is also recognized as a technology capable of boosting Brazil's energy security. As of May 2024, Brazil's Ministry of Mines and Energy approved a bill (Bill 1425/2022) which is aimed at building a legislative framework for CCS development in the country. This is exemplified by the Santos Basin CCS facility which has developed into a commercial-scale operation through implementation of CO_2-EOR, not carbon storage.

1.5.1 Issues for the Assessment

Both the Brazil Atlas and CARBMAP provide an early high-level overview of the potential storage resource and links basins to emissions centres to minimise transportation burden. However, the overall resource potential remains unquantified due to the lack of saline aquifer storage resource, and as such, the CSRC is significantly incomplete with regards to the classification.

1.6 Future Updates

1.6.1 Future evaluations

Future evaluations should focus on the potential for saline aquifer storage which is likely to be significant but is not represented currently in the CSRC. As the Pre-salt operations develop in the Campos and Santos offshore basins, additional resource potential may be identified. As regulatory developments progress, an update of Brazil's storage resources from Inaccessible to a more mature commercial classification should be undertaken.

2 Canada

2.1 Summary

The CSRC has identified the following CO_2 storage resource for Canada. It has been updated in Cycle 2, Cycle 3 and 4 to reflect continued injection of CO_2 in active projects.

Classification	CO_2 storage resource (Gt) Project and no project	CO_2 storage resource (Gt) Project specified only
Stored	0.01	0.01
Capacity	0.05	0.05
Sub-Commercial	43.64	6.17
Undiscovered	104.30	24.60
Aggregated*	148.00	30.83

* The aggregated resource represents the summed storage resource across all maturity classes and as such should not be viewed as representative of the potential of the country.

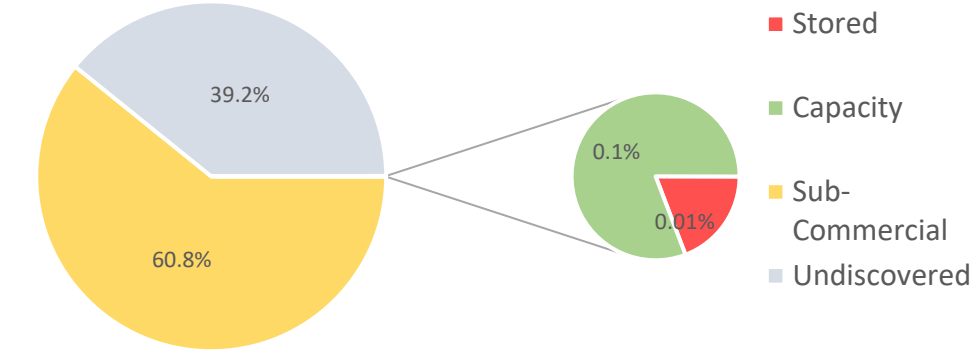
Table 2-1: Storage resource classification summary for Canada

Storage resource potential is present in both saline aquifers and oil and gas fields.

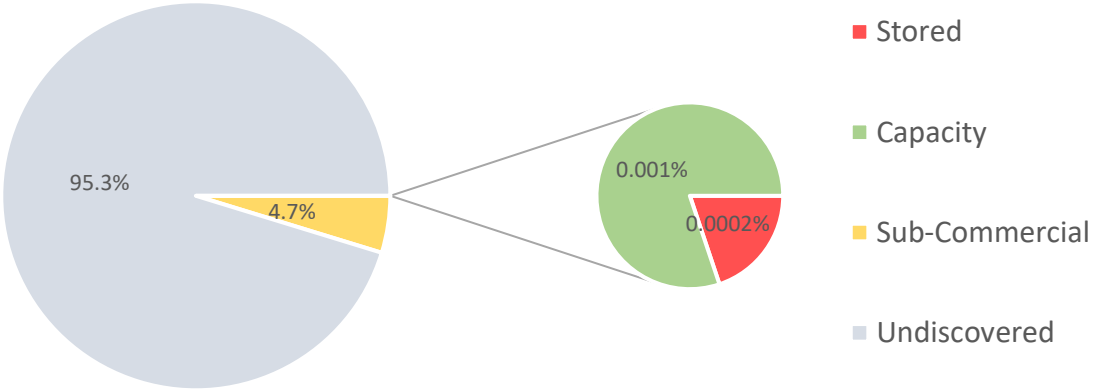
- Potential storage resource has been identified in 4 geological basins with 67 sites or regional locations identified.
- Altogether, 11 projects have been defined. High level, province-scale resource estimates are also included in the Assessment for those provinces where a more detailed break-down of the storage resource is unavailable.
- As of May 2024, 8.2 Mt of CO_2 has been reported injected and stored by two CCS projects operating in Canada: Quest (7.7 Mt) and Aquistore (0.5 Mt).
- Five site characterisation projects have been undertaken over the past decade, but these have not been progressed since completion.
- Most published information on potential storage resource is geographically centred on the provinces of Alberta and Saskatchewan within the Western Canada Sedimentary and Williston basins, with additional potential identified in British Columbia, Ontario, and Quebec. The current regulatory system is moving towards a CCS specific framework with most progress at the provincial level. Alberta and Saskatchewan have both approved CO_2 injection legislation to support the active Quest and Aquistore projects.
- There are currently no well-publicised plans for any future large-scale CCS project in the pipeline, although opportunity exists with the Alberta Trunk Line (ACTL) CO_2 pipeline project. This 240km pipeline, capable of transporting up to 14.6 Mt CO_2/annum across Alberta, became operational in June 2020.

- A significant update to Cycle 4 has been ammendement to the Basal Sandstone record (Cambro-Ord Saline System (COSS)). Recent research [14] on this aquifer considered its resource potential from a notional project perspective. By considering the pressure response from injection this effectively halved the storage resource of this site. This research has not only made significant changes to the whole Basal Sand aquifer resource estimate but has consequentially revised the aggregated estimate for all of Canada. At cycle 3 the aggregated estimate was around 404 Gt. The revised study to the vast resources in the Cambro-Ord Saline System (COSS) has now changes the aggregated resource for Canada to 148 Gt. Discussion on this project is in section 2.4.5 *Basal Sandstone Aquifers.*

A) Project
Mid-Case Storage Resource



B) Project and Non-Project
Mid-Case Storage Resource



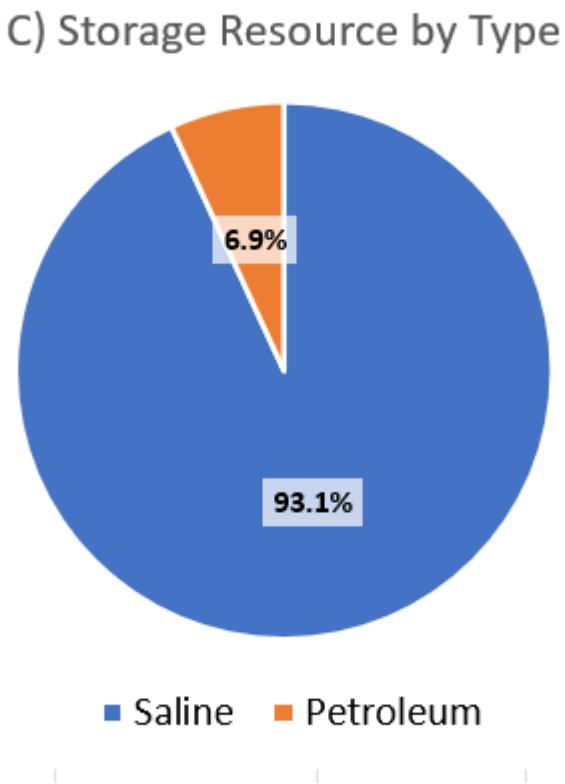


Figure 2-1: Canadian spread of Storage Sites

a) Spread of storage resource in Canadian sites (67) across SRMS classifications, where a project has been specified. b) Spread of storage resource in all Canadian sites across SRMS classifications; both project specified and not. c) Split of Canadian storage resource between saline aquifers and hydrocarbon fields, both project specified and not.

2.2 Resource Statement

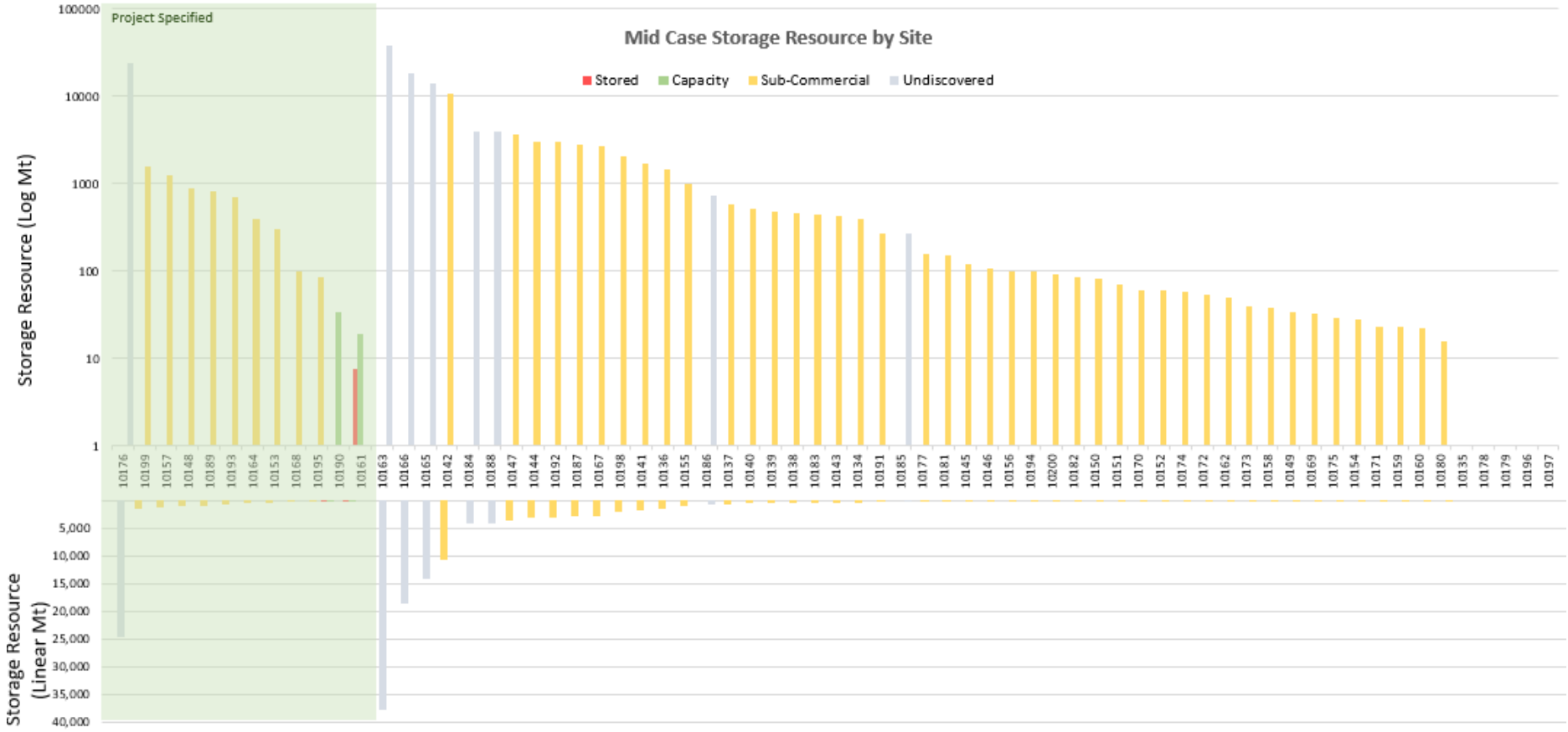


Figure 2-2: Storage resource summary for Canda compiled in the CSRC.

Graph above is log scale and graph below is linear. Green box highlights sites where a project has been specified.

2.3 Evaluation History

Canada was selected as the priority country for review during the Cycle 1 Assessment. The approach taken was to review the published national and regional evaluations of storage potential, followed by a more detailed study of specific projects at the basin and local scale. As a starting point, both the North American Carbon Storage Atlas [5] and the 2015 DOE Atlas V [6] were used to derive high level estimates of the storage resource at the Country and Province level. US-DOE-funded projects, through the Regional Carbon Sequestration Partnerships (specifically the Plains CO_2 Reduction Partnership; PCOR), provided additional data and information. The storage potential in unmineable coals seams (Enhanced Coalbed Methane, or ECBM), basalt deposits, and organic-rich shale units has also been investigated by both the country-level atlases and the regional studies, but has not been included in this Assessment, as these resource types do not fall within the current SRMS.

2.4 Evaluation History

2.4.1 Major Projects

In 2006, Canada's National Round Table on the Environment and Energy, a now defunct independent advisory board to the Canadian Government, reported that CCS technology had the potential to offer up to 40% of the required reductions in CO_2 emissions in Canada. In the following decade, various task forces created a case for CCS implementation in Canada, leading to over $3 billion in government and provincial support for CCS through a range of programs. As a result, several large-scale CCS demonstration projects, designed to inject at least 1 Mt CO_2/ year, were advanced. These included:

- Boundary Dam Carbon Capture project: a coal-fired electricity-generation project (SaskPower, Saskatchewan).
- Alberta Carbon Trunk Line (ACTL): a CO_2 pipeline project (Enhance Energy, Alberta).
- Quest CCS: Scotford oil sands upgrader (Shell, Alberta).
- Pioneer project: coal-fired electricity generation (TransAlta, Alberta).
- Swan Hills project: underground coal gasification and syn-gas electricity generation (Alberta).
- Fort Nelson CCS: shale gas processing plant (Spectra Energy, NE British Columbia).
- Weyburn: commercial CO_2 -EOR (Whitecap Resources (formerly owned by Cenovus Energy), Saskatchewan).
- Midale: commercial CO_2-EOR (Apache Energy, Saskatchewan).

Of these, only Boundary Dam, Quest, and Weyburn-Midale are actively either capturing or

injecting CO_2; albeit predominantly for EOR, using CO_2 captured from the Boundary Dam site, or piping CO_2 from the Dakota Gasification syn-fuels plant in North Dakota (Weyburn-Midale fields).

As of the Cycle 2 Assessment, only the Quest CCS project (5 Mt by mid-2020) and the Aquistore project (325,000t by October 2020), which acts as a 'overflow' store for CO_2 captured at Boundary Dam, are currently injecting CO_2 into saline aquifers as part of fully integrated and monitored CCS projects. The Fort Nelson project completed initial site characterisation studies and is currently on-hold. The Pioneer CC project collapsed in 2012 for economic reasons related to the absence of either a national carbon trading market, or a method for capturing value from emissions credits. Swan Hills Syn-Fuels ran a demonstration project (the ISCG project) in 2009 but has since shifted the company focus.

2.4.2 Site Studies

Several saline aquifer site characterisation projects were carried out during the period 2004 – 2014. These attempted to identify or technically progress potential storage sites:

- WASP
- HARP
- Athabasca area
- St Lawrence Lowlands basin, Quebec (Becancour project)
- Michigan Basin, Ontario
- PCOR (Plains CO_2 Reduction Partnership Basal Cambrian System

These are included in the Cycle 1 assessment.

2.4.3 Application of the SRMS in North America

National atlases [6] and [5] have been used as a starting point for reviewing the resource potential of Canada and the USA. These publications report state-wide or province-wide resource estimates for USA and Canada. These estimates are generally large numbers for which there is no detail explaining source or geographic distribution of the data inputs. Both atlases do, however, provide an explanation of how the resource estimate was calculated, including providing low/mid/high values for the storage efficiency factors applied to saline aquifers.

The Cycle 1 used the 2015 DOE Atlas V [6] resource estimates in preference to the earlier 2012 NASCA [5] data. According to the Atlas V, the data presented is derived from the DOE-funded Regional Carbon Sequestration Partnerships. These partnerships have distinct study areas which are defined by geological basins, i.e., not state or province boundaries, and therefore there is often no clear alignment between the state and province-level reporting by the Atlases,

and the Regional Partnership evaluation reports.

The CSRC Cycle 1 reviewed studies undertaken by the PCOR and Big Sky Regional Partnerships. The PCOR study area crosses the USA/Canada national boundary and covers those parts of British Columbia Alberta, Saskatchewan and Manitoba which sit within the Alberta and Williston basins. The partnerships also include several USA states: Montana (North-Central and Williston Basin), North Dakota, South Dakota, NE Wyoming (Powder River Basin) and NW Nebraska (Denver Basin).

For saline aquifers, the Regional Partnerships provide two levels of storage resource evaluation: DOE Phase I and II studies which provide high level resource estimates at the formation-level, and DOE Phase III studies which evaluated specific sites as detailed site characterisation studies or demonstration projects. As per the SRMS guidelines, formation level resource estimates have been classified as Undiscovered: Prospective Sequence Play due to the generally large area covered by the resource, and the lower level of confidence in the resource estimate. Site specific or demonstration studies have been classified as Discovered and then further classified based on their level of development (e.g., Not Viable).

These saline aquifer resource evaluations have been handled according to the level of published data available:

1. Where the Sequence Play resource estimates are considered to fully represent the State- or Provincewide resource estimate provided by the Atlas V, the CSRC Cycle 1 has nulled the State- or Province-wide resource estimate and a note has been attached to the assessment.

2. Where there is insufficient data available to fully supersede the State- or Province-wide resource estimate, the Atlas-derived estimate has been held and classified as Undiscovered: Prospective Basin Play.

3. If a resource estimate for a Sequence Play can be shown to only partly contribute to the State- or Province-wide resource estimate, the Sequence Play estimate is subtracted from the Basin Play estimate to avoid double counting within the Undiscovered SRMS maturity class.

4. Where no resource estimate is available in the 2015 DOE Atlas, the 2012 NASCA report has been used (this applies to the eastern Canada provinces which are not covered by the DOE Regional Partnerships).

5. Where storage resource estimates are available and classified as Discovered, the resource estimate has not been subtracted from the Sequence or Basin Play resource estimate to avoid aggregation across SRMS maturity classes. This has been noted in the 2019 Assessment notes for that site.

This approach has highlighted some issues:

- Mismatch of resource estimate values between different Atlases, e.g., the Atlas V estimate is significantly different to the equivalent NASCA estimate. This occurs for both oil and gas fields, and saline aquifers. Where possible the DOE Atlas has been used in preference to the NASCA Atlas to provide consistency of data inputs and volumetric calculations.

- Multiple evaluations of the same saline aquifer formation reporting quite different resource estimates. This is particularly true for the Cambro-Ordovician Basal Sand for which there are 3 different static volumetric estimates which use mid-range storage efficiency factors (E) of 2%, 9.1% and 14%. In this case, preference has been given to estimates derived from 3D static models which use the lower value of E, which here is 9.1% as opposed to 14% (while 14 % is used by PCOR for clastic lithologies where all net-to-gross terms are known [7], a more recent study [8] suggests that on a 50-year injection time-scale values of E greater than 2% may be overly optimistic). The alternative estimates are noted in the Assessment.

- Resource estimates are provided for a geological basin, i.e., they are not sub-divided by federal nation, or state/province. For the Basal Sand, which covers an international boundary, the approach taken is to use a percentage value of the resource estimate derived from a 2D model which did apportion the resource between USA and Canada and apply to the 3D static estimate.

- Aggregated Sequence Play resource estimates for a region do not equal the Basin Play resource estimates for that region. This suggests that either the Basin Play resource estimates contain additional data, which is not apparent from the regional studies available, or that the range of storage efficiency factors applied are quite different. This highlights the need for a consistent approach to storage resource calculation.

- Studies which use a simulation to evaluate the impact of pressure on the storage potential of a formation indicate that the storage resource is up to 1 magnitude lower than the equivalent volumetric estimate. Where this occurs, it is noted in the assessment and the country report and suggests that the volumetric resource estimate is likely to be invalid.

2.4.4 Depleted Oil & Gas Fields

The aggregated depleted field resource identified by the Cycle 1 Assessment is 11.2 Gt. This Sub-commercial resource

is assumed Discovered but is classed as currently Inaccessible due to a lack of information on abandonment dates for the fields. 7.1 Gt storage potential sits within identified oil and gas fields with the remaining 4 Gt derived from high level, province-scale studies which do not provide any level of detail on data source or distribution.

The 2012 NASCA report [5] states that over 50,000 oil and gas reservoirs, plus oil reservoirs with a gas cap, existed at the time of reporting in north-eastern British Columbia, Alberta, Saskatchewan, and Manitoba. Additional fields are also present in Ontario (below Lake Erie), Northwest Territories, and in the Canadian offshore (Nova Scotia and Newfoundland). Twenty-three (23) depleted fields have been included in the Cycle 1 Assessment. Inclusion was based on a few key criteria: a published evaluation of storage potential for an individual field or pool, having greater than 20 Mt reported storage potential, and appearing in a publicly available, searchable reserves database. None of the oil or gas fields in the Cycle 1 Assessment have an abandonment date or an EAD (Earliest Accessibility Date) assigned as the necessary information is not available in the public domain. A significant number of oil fields in Canada are currently, or have previously undergone, secondary or tertiary recovery and are flooded with the water or natural gas injected to enhance oil production, leaving little available pore volume for CO_2. These are typically not included in published storage resource estimates.

Most of the identified storage resource is in oil pools (5.9 Gt) which are located predominantly in Saskatchewan and Manitoba. Oil pool size in Alberta is generally small. Of nearly 8500 oil reservoirs under primary production in 2004 only 98 have a calculated storage resource > 1Mt [9], and only 1 oil pool was identified as having a resource greater than the 20 Mt cut-off applied by this study. Similarly, gas pools in Canada are typically small. Out of nearly 25,800 fields studied in the published literature, only 9 fields in Alberta and 7 in British Columbia qualify for the >20Mt cutoff; Saskatchewan and Manitoba do not contain any identified resource potential in gas fields. The total storage resource reported for gas pools is 1.2 Gt.

Regarding commercial readiness of the depleted field resource identified, no projects with a stated aim of injecting CO_2 directly into depleted fields for storage have been identified. CO_2-EOR is taking place in several locations but these projects and injected volumes do not form part of the SRMS at this stage. At the province level, British Columbia is least commercially mature with most of the stated storage resource sitting within the Undiscovered Province-wide classification.

Additional data included in the SRMS database were taken from online reserves data maintained by each province. In some cases, *e.g.,* Saskatchewan, these publications are not exhaustive and only provide data from a selection of active projects (i.e., high activity, new projects/pools, or changes to existing projects/pools).

2.4.5 Saline Aquifers

Most of the saline aquifer resource (3 Gt; 93%) is within Undiscovered resource, split between Sequence Play (83%) and Basin Play (10%). Sub-commercial resources make up a much smaller proportion (25.6 Gt: 6.6%) of the summed saline storage resource. Storage projects form only 15% (3.9 Gt) of the Sub-commercial resource however the only reported, non-EOR stored CO_2 in Canada is within the Cambro-Ordovician Basal Sand formation saline aquifers at the Quest and Aquistore projects in Alberta and Saskatchewan respectively where a total of 61

Mt is either already Stored or is permitted for injection (On-Injection).

Saline aquifers identified as holding storage potential in Canada include the diachronous Cambro-Ordovician Basal Sand clastic formation in the Williston and Alberta basins, and its temporal equivalent, the Mt Simon Sandstone in Ontario, Devonian carbonates located predominantly within the West Canadian Sedimentary Basin, and the Lower Cretaceous Viking Formation in the Alberta Sub-basin.

In terms of commercial maturity of saline aquifer storage potential, Alberta is significantly more advanced than other provinces, with identified potential resources at several stages of maturity. Saskatchewan is dominated by storage resource estimates for the Basal Sand, but only the Aquistore project is currently demonstrating successful injection. In comparison, British Columbia, Manitoba, and the eastern provinces of Ontario and Quebec contain significantly lower resource volume and are less commercially (and technically) advanced, except for the Fort Nelson CCS site in British Columbia.

Basal Sand Storage Potential. The Cambro-Ord Basal Sand (or Basal Aquifer) is one of the most widely studied aquifers. As such there are several different estimates of storage potential for the unit; all of which use different values for storage efficiency:

- Province-wide estimates of storage potential provided by the DOE Atlas V using a mid-range storage efficiency factor of 2.0%.

- A 2013 PCOR 2D static volumetric estimate which provides a split between the Canadian (75.2%; 85 Mt) and US (24.8%) portions of the Williston and Alberta basins and uses a P50 storage efficiency factor of 2.4%.

- Two (2014 and 2015) PCOR 3D static (geocellular) models for the combined USA & Canada area (373 Mt) which use P50 values for storage efficiency of 9.1% and 14% to calculate a volumetric estimate of storage (note: as discussed above, 14% is considered an unrealistically high storage efficiency factor on a 50-year injection timescale and so is not used in this assessment).

- Two numerical simulation studies which both look at injecting a set volume (63 Mt and 94 Mt) of CO_2 into the Basal Sand over a period of 50 years. Both use the 3D geocellular static model (or equivalent using the same dataset) developed for the 2014 volumetric case. By optimising injection location in areas of highest modelled transmissivity within Saskatchewan and eastern Alberta, the model was able to successfully able to simulate injection of 3100 Mt (63 Mt/year) without exceeding set pressure constraints using 5 injection locations (including the Quest site). It should be noted that the pressure map of the Basal Sand model indicates that there is little pressure space remaining in the high transmissivity areas of the aquifer following injection of this volume of CO_2 and, as such, may represent a near-capacity resource value. The alternative (94 Mt/year) simulation

attempt focussed injection at the Duffield-Warburg power generation facility (Alberta) but only achieved a maximum injected volume of between 298 Mt and 1280 Mt over the 50-year period. Detail is limited in both studies, but it appears from maps of the simulated subsurface pressure increase that the 2 study areas do not overlap as the 63 Mt/year study discarded the Warburg site as it failed to achieve the injection volume of 23 Mt/year set in that model for the Warburg site.

- Active injection operations which target the Basal Sand are currently operating at the Shell Quest CCS project (Alberta) and the Aquistore project (Saskatchewan)

At Cycle 3, the Basal Sand is classified as a Sequence Play (Undiscovered) and assigned a summed storage resource estimate of 75.2% of the 2014 3D static model volumetric calculation (284 Gt). It was noted that this is a very high estimate of storage resource potential given the numerical simulations which achieved almost one order of magnitude lower injection volumes.

The recent publication [14] on a Basal Cambrian site (Cambro-Ord Saline System (COSS)) has made a significant change to the resource estimates for both this site and consequentially the resource estimates for all the Basal Sand project sites. The study evaluated the resource as a notional project by using both a consistent volumetric and flow modelling approach. The notional project had the following specifications: vertical CO_2 injectors with a maximum injection well pressure of 50% above hydrostatic pressure, pressurizing the regional formation by two values during a 50-year injection period without formation water extraction and using maximum injection rate per well of 2 Mt/yr. The project also considered only a single geologic formation (i.e. The Basal Aquifer) and the geographic area north of Canada-United States border. The flow modelling approach used a pressure limit of both 30 and 15%. Comparison of the volumetric approach to the flow modelling approach provided similar results confirming that a volumetric approach can provide a robust first pass approach to storage estimates. Storage efficiencies from a combination of both volumetric and flow modelling results range form 0.46-0.52%. These are considerably lower than previous dynamic storage efficiency estimates that ranged from 7.4- 24% given by [15]. The previous studies did not take into account pressure limitations; either by the assumption that storage would continue for much longer than reasonable timescales (i.e. above a realistic injection period of ~50 years) or the assumption that pressure can be reduced by large-scale formation water extraction. The results of this study by [14] provided a base case estimate of 18.6 Gt, a mid-case of 24.6 Gt and a high case of 32.0 Gt for the Cambro-Ord Saline System (COSS). For the mid case this is 256 Gt less than estimates by [15] as cited in Cycle 3. These studies demonstrate the importance of having a project-based approach to resource calculations to provide a more realistic insight into resources based on potential project parameters, but also the significant effects that pressure limitations can have on a resource.

The Basal Sand project sites are classed as Discovered Sub-commercial: Contingent (Development Not Viable) resources for those where no current project evaluation is occurring,

or Commercial: Capacity (Stored or On Injection) where CO_2 injection is taking place or permitted. By carrying the Prospective, Contingent and Capacity resource estimates in the database, there is a degree of 'double counting', however this to date only amounts to 6500 Mt (6.5 Gt). It also raises the question of whether any credence should be given to the static volumetric resource estimate given the issue of available pressure space for a 50-year injection project.

Devonian Aquifers Potential. The mid-upper Devonian section of the foreland basin is best developed in the Alberta sub-basin of the West Canadian Sedimentary Basin. At the basin scale, the section has been evaluated by the PCOR group with a summed storage resource of 14.2 Gt. The Devonian aquifers have also been targeted by several studies including the Athabasca area identifying possible storage resource associated with the oil sands operations in the area, large reefal build-up structures (HARP) and regional carbonates (WASP).

Lower Cretaceous Aquifer Potential: The Viking Formation, which sits within the Alberta Basin, has been evaluated by PCOR as having some storage resource potential. No storage projects have been identified within the formation.

The Cycle 1 Assessment carried an assumption that the DOE Atlas V (2015) province-wide estimates for saline aquifers represent the sum of any reported regional evaluations (e.g., by PCOR). As per the discussion in Sections 3.2-3.6, the SRMS entries at the province-level for Alberta, Saskatchewan and Manitoba have therefore been assigned a null value.

2.5 Regulatory Framework

Canada is the top-ranking nation in the GCCSI CCS Readiness index, meaning that it has been identified as a leader in promoting and deploying CCS. It is only lacking a strong policy to help drive investment for rapid deployment on a commercial scale. The regulatory competence for developing CCS legislation in Canada is shared between several national and provincial bodies. Regulatory development, in the form of design and implementation of CCS-specific legislation, has principally occurred at the provincial level in Canada. Several provinces have undertaken reviews and scoping studies to consider their existing regimes potential to manage CCS activities and, in some instances, this has resulted in the promotion of CCS-specific frameworks. The provincial governments of Alberta, Saskatchewan, and Nova Scotia have all made attempts towards the deployment of CCS-specific legislation in recent years, however it is the province of Alberta that has developed the most comprehensive CCS-specific model.

2.6 Issues for the Assessment

2.6.1 Data Validation

While the 2012 NASCA [5] report provides a useful early snapshot of storage resource potential in Canada, it has been superseded by province-wide resource statements published in the 2015 DOE Atlas V. In addition, the NASCA Viewer and website which provided web-based access to all NASCA data is no longer live. Information is provided on the method of calculation of storage

potential in both reports, however there is little to no supporting detail as to the source of the data. However, the DOE Atlas also has significant shortcomings for application to the SRMS. The data presented as state-wide storable quantities are derived from studies carried out by the DOE Regional Partnerships. For Canada, this only includes information from the PCOR group (the WestCarb group does not appear to have published any studies for the west coast of Canada). For example, PCOR studies provide back-up for the overall,

basin-wide storage potential reported for the Cambro-Ord Basal Sand, but this not reported at the province-level.

2.6.2 Probabilistic Assessments

The data available for the Cycle 1 Assessment suffer from a lack of probabilistic analysis; most studies do not provide a range of estimates of storage resource. For studies which provide a storage resource estimate derived from a volumetric methodology, a range of storage efficiency factors may be used but these are applied to a single static model pore volume. Numerical simulations are rarely available for the sites reviewed by this report, and often only give a single storage resource value, assessing whether the site meets the stated benchmark resource.

Projects (sites with dynamic simulations which specify an injection volume and a development plan) may only report a single 'base case' resource value. At the only actively injecting projects, Quest and Aquistore, the resource classified as Stored or On-Injection refers to the permitted injection volume, not the maximum storage potential which is not reported.

2.6.3 National Atlas Data Discrepancy

There is a significant discrepancy between the storage resource figures provided in the 2015 DOE Atlas V and the 2012 NASCA report. For example, the Alberta saline aquifer storage resource in the NASCA report is given as 28 Gt, but the DOE report gives a mid-estimate value of 76.74 Gt, over 2x greater. Similarly, the values for Saskatchewan saline aquifer storage vary between 75 Gt in the NASCA report but greatly increase to 285.22 Gt (mid estimate; 149.72 Gt as the low estimate) in the DOE report.

The discrepancies cannot be wholly attributed to differing methodologies for calculating storage resource as both studies use the same volumetric equation and efficiency factors for saline aquifers. Discussion with the DOE-NETL team responsible for generating the Atlas V numbers suggests that the regional PCOR study data are not included in the NASCA numbers, as NASCA Canada generated their own estimates. It is suggested here that any figure for saline aquifers derived from the 2012 NASCA study should be considered a low estimate for those provinces which are covered by the DOE Regional partnerships.

By contrast, the depleted field storage resource estimates are higher (for each province) in the NASCA report relative to the DOE Atlas, for example, the Alberta depleted field resource is 12 Gt in NASCA but only 1.49 Gt in the DOE Atlas. The reasons for the discrepancies are not clear, NASCA states that the CSLF approach of using original oil or gas in place plus a recovery factor

(and an efficiency factor based on local experience or simulations) was applied. The DOE Atlas applied two methods depending on the available data. Either an efficiency factor to convert produced volumes to CO_2 storage volumes, or a straight replacement (on volume-for-volume basis) of hydrocarbon by CO_2 was used [6]. Given the fact that only 3 years separates the publication of each report, the difference in values for storage resource at the province-scale should be used with caution.

In all cases, the 2015 DOE Atlas V data are used in preference to the 2012 NASCA data as they are the most recent storage estimate available. NASCA data are used if the Atlas V does not report for a province (this mainly applies to the eastern provinces).

2.6.4 Data Mismatch for Oil and Gas Fields

There is also an issue with data mismatches between the high level, province scale resource estimates, and the estimates based on site-specific resources, e.g., in Saskatchewan the province-wide total of 960 Mt reported is significantly less than the 4857 Mt resource reported in depleted fields in the public literature. In such cases, the province-wide resource has been entered as a null value in the database.

2.6.5 Availability of Resource Estimates

Storage resource potential in oil and gas reservoirs is only quoted for British Columbia, Alberta, Saskatchewan, Manitoba and Ontario as, while oil and gas reservoirs are present outside of these provinces, they are considered by the major reports to be too distant from major emissions sources and therefore not reported.

2.1.7 Future Updates

2.6.6 Future CSRC cycles

Required updates in future Assessment cycles should include:

- Annual adjustments to account for continued injection and any model updates at Quest and Aquistore. Annual reports are released for both projects (end-first quarter) and should be reviewed when released for database update.

- Update following any future release of DOE Carbon Storage Atlas, or equivalent publication. This should include any further information as to the source of the data used to generate the high, Province-level, estimates of storage potential. According to the team at the US DOE responsible for the Atlas, an updated edition is currently in-progress, but no release date was provided (M Sullivan, pers. comm, January 2020).

- Additional release of information on depleted field availability and storage resource calculations. All depleted field resource data are currently classes as Discovered - Inaccessible due to the absence of a published field abandonment date.

3 Mexico

3.1 Summary

Mexico was assessed during Cycle 2. The CSRC has identified a CO_2 storage resource for Mexico as follows:

Classification	CO_2 storage resource (Gt) Project and no project	CO_2 storage resource (Gt) Project specified only
Stored	0.0	0.0
Capacity	0.0	0.0
Sub-Commercial	89.5	0.0
Undiscovered	11.3	0.0
Aggregated*	100.8	0.0

* The aggregated resource represents the summed storage resource across all maturity classes and as such should not be viewed as representative of the potential of the country.

Table 3-1: Storage resource classification summary for Mexico

- There are currently a total of 76 sites across nine basins in Mexico.
- There are no project-specified sites in the Mexican dataset.
- There are no active CCS projects operational in Mexico, however pilot capture plants have been proposed.
- The Mexican Government has recognised the requirement for CCS in meeting its commitments to the Paris Agreement, yet lacks a developed CCS policy to allow projects to progress.

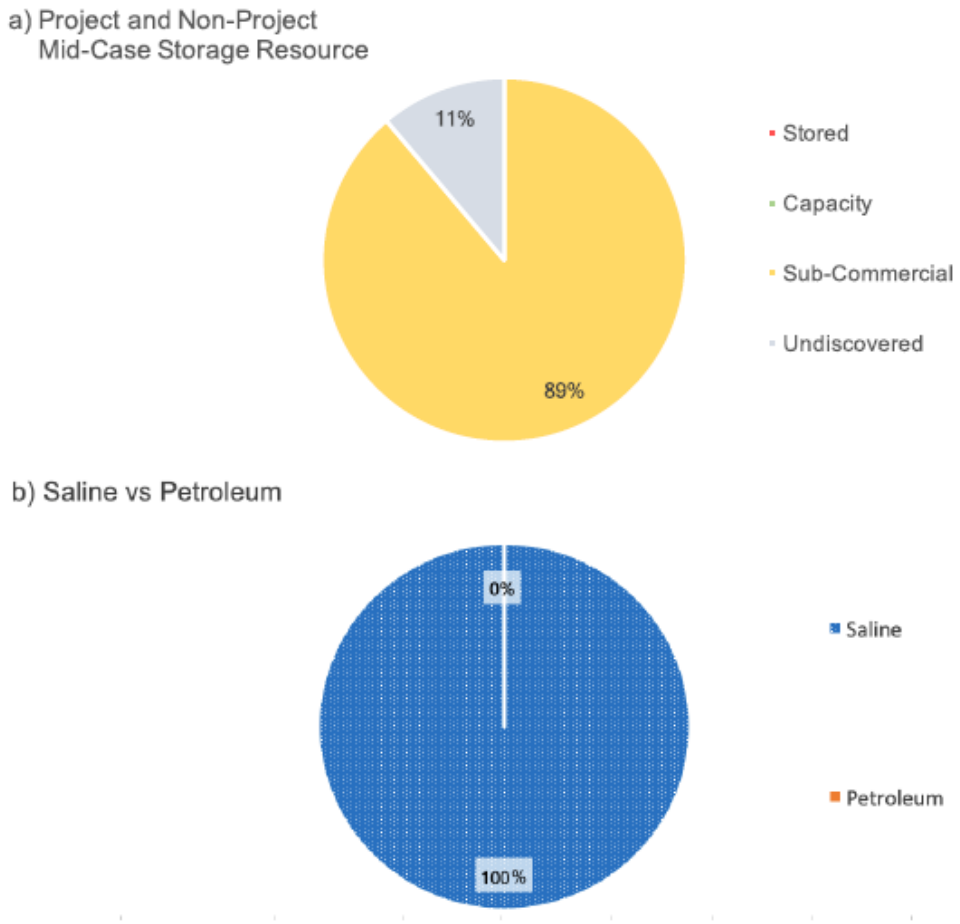


Figure 3-1: Mexican spread of Storage Sites

a) Spread of storage resource in Mexican sites (76) across SRMS classifications, where a project has been specified. b) Spread of storage resource in all Canadian sites across SRMS classifications; both project specified and not. c) Split of Canadian storage resource between saline aquifers and hydrocarbon fields, both project specified and not.

3.2 Resource Statement

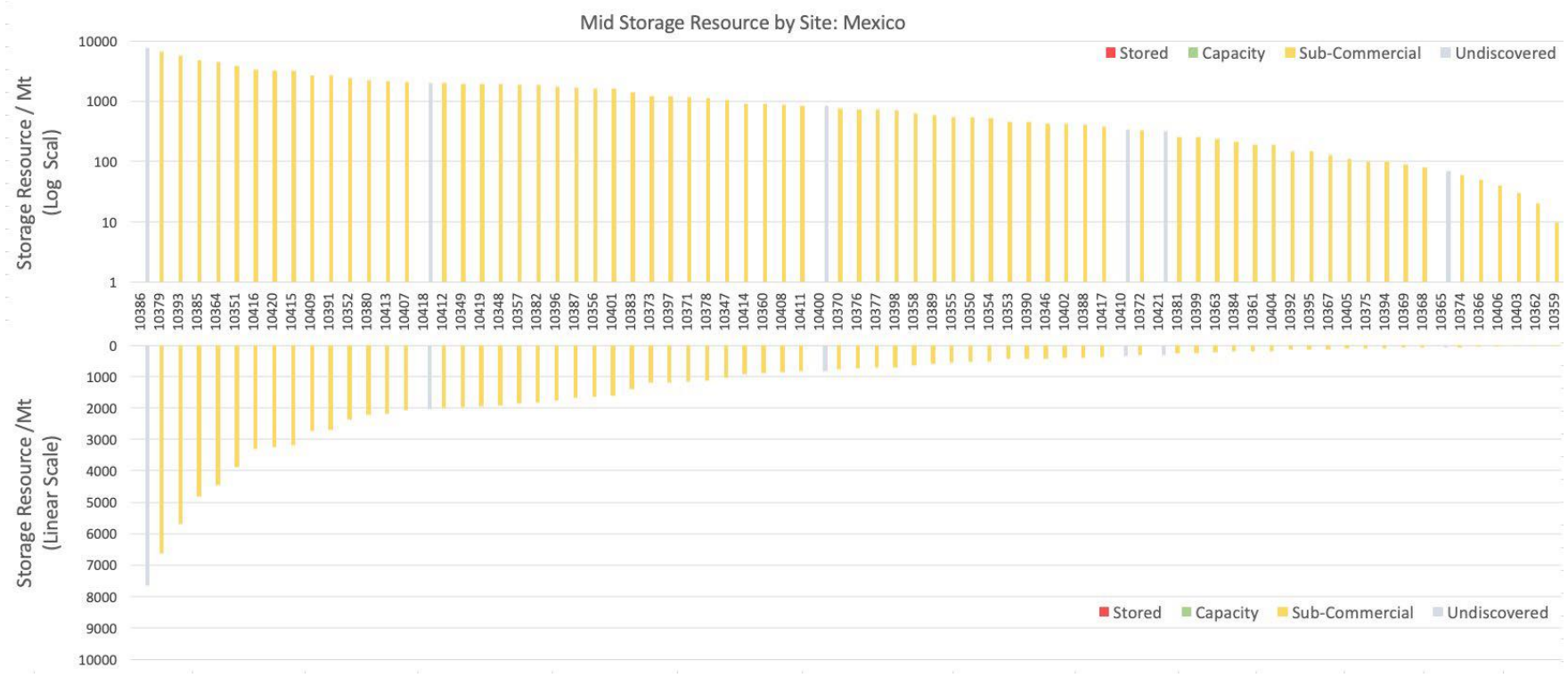


Figure 3-2: Storage resource summary for Mexico compiled in the CSRC.

Graph above is log scale and graph below is linear. No project specified sites were identified.

3.3 Evaluation History

Only two sources were available for the estimation of CO_2 storage resource within Mexico; where the North American CO_2 Storage Atlas (NASCA) [10] is the main source, with supplementary information provided by Moja (2016) [11]. Both sources reference the same storage resource evaluations for 76 sites across nine basins. These evaluations were conducted in two phases:

In the first phase, the basins were separated into the exclusion or inclusion zones, where excluded basins exhibited high seismicity, geothermal or volcanic activity and thus are not recommended for geological storage.

In the second phase, a theoretical storage resource was calculated for prospective sectors within basins in the inclusion zone. Maps displayed in the Appendix of the NASCA suggest that this evaluation was largely undertaken in areas around existing wells. The CSLF equation for saline aquifer storage was used to calculate the potential storage resource for geological formations at depths between 800 to 2,500m. The equation does not consider geological constraints to storage resource, injectivity, hazards, or solubility and mineral trapping, and importantly does not apply a storage efficiency factor. As such, the authors consider the calculated storage resource to be a theoretical maximum.

The evaluations were published in 2012 and no further work has been completed to assess Mexico's CO_2 storage potential, except for EOR feasibility projects.

3.4 Resource Review

3.4.1 Major Projects

No major CCS projects were identified in Mexico during Cycle 2.

Pilot capture plants were noted to be in development in the coming year by Heras (2018) [12], however no further details of either project could be sourced in the public domain. These capture pilots were to be located in Poza Rica and CO_2 EOR in Minatitlan, both the in Veracruz area.

3.4.2 Depleted Oil & Gas Fields

No CO_2 storage evaluations for Mexican depleted hydrocarbon fields were identified in the CSRC. Due to the wealth of fields in the country, it is likely that any future evaluations of storage resource in depleted fields would benefit the apparent potential within Mexico.

3.4.3 Saline Aquifers

The NASCA (2012) identified a total of 101Gt of storage resource, split across 9 basins which line the eastern coastline of Mexico [10]. Largely, this resource was calculated for an area surrounding a legacy well, and as such, could be classified as "Discovered". A smaller portion, 11.3Gt, was classified as "Undiscovered" due to its distance from well data points. The lack of

a developed CCS policy in Mexico, means the identified storage resource cannot be developed under the current regulatory constraints. Consequently, all storage resource potential in Mexico is classified as either "Undiscovered Inaccessible" or "Discovered Inaccessible". Should this position change, the storage resource can mature from the Inaccessible classification.

3.5 Regulatory Framework

Mexico's rating in the GCCSI Policy Indicator Report 2018 [13] increased significantly since the previous assessment in 2015. This is due to Mexico attracting funding from the World Bank to complete feasibility studies for demonstration projects, and for the establishment of the Mexican CCUS Centre, through which two pilot capture plants have been proposed. In October 2019, the Secretaría de Medio Ambiente y Recursos Naturales (SENERNAT) introduced a carbon market pilot program which includes stationary sources of CO_2 from the energy and industrial sectors, whose emissions exceed 100,000 tonnes per year. The pilot program is to last for 36 months, from 1st January 2020, and will transition into an Emissions Trading Scheme from 2022 [13].

3.6 Issues for the Assessment

Lack of recent and detailed reporting of CO_2 storage resource. The maturity of the CO_2 storage resource in Mexico is very low due to the lack of detailed reporting and developed CCS policy.

The reported resource also suffers from a lack of development since the initial evaluation published in 2012. An update to this work should be considered to build on the important work completed to date.

3.7 Future Updates

3.7.1 Future evaluations

A focus of future evaluations on CCS rather than CCUS for EOR would be welcome to allow inclusion in the Global CO_2 Storage Catalogue. Far more detailed reporting and evaluation of the CO_2 storage resource is also required to accurately represent Mexico's full potential.

A significant amount of subsurface data is likely to be available in Mexico, due to its active hydrocarbon industry. Further use of this data for CO_2 storage evaluations and more detailed reporting of these evaluations, would significantly benefit the reported resource and help to increase its maturity.

4 United States of America

4.1 Summary

The CSRC Cycle 1 assessment identified the CO_2 storage resource for the United States of America as shown in the table below. This was not updated in Cycle 2 but was in Cycle 3.

Classification	CO_2 storage resource (Gt) Project and no project	CO_2 storage resource (Gt) Project specified only
Stored	0.0052	0.0052
Capacity	0.004	0.004
Sub-Commercial	258	55
Undiscovered	7804	15
Aggregated*	8061.81	70.30

* The aggregated resource represents the summed storage resource across all maturity classes and as such should not be viewed as representative of the potential of the country.

Table 4-1: Storage resource classification summary for United States of America

- Storage resource potential is present in both saline aquifers and oil and gas fields.
- Potential storage resources have been identified in 36 US States with 12 projects and 14 regional studies included in the Cycle 1 Assessment. High level, state-wide estimates are also provided by the DOE Atlas V, but these have no detail in terms of individual resource location or estimate attached.
- As of December 2019, 4.36 Mt of CO_2 has been reported injected and stored or permitted for injection by 4 CCS projects operating in the USA: Illinois Basin Decatur project (1Mt), Illinois: ICCS (5 Mt), the Citronelle Project (0.1 Mt), and the Michigan Basin Niagaran Pinnacle Reef Trend project (0.14 Mt). A significant volume of CO_2 has also been injected into oilfields via EOR operations, but this figure is not included in the SRMS.
- While the US storage resource is distributed across the Lower 48, the regional saline aquifer studies are dominated by the northern states within the Williston, Michigan, Illinois, Powder River, and Denver basins. Future assessments should focus on updating with the vast potential in other parts of the country, including California, the southern states, the Gulf of Mexico region, and the Federal Offshore.
- The current regulatory system is positive to CCS with recent changes to the tax system (45Q) to incentivise both CO_2-EOR and geological storage. California leads the way with state-level credit-based systems. Permitting for existing CCS projects provides a way-forward for future projects.
- The DOE-funded CarbonSAFE initiative is currently funding thirteen Phase I 'Pre-Feasibility'

studies and six Phase II 'Feasibility' programs with the aim of identifying several saline aquifer sites with proven potential to store at least 50 Mt/site with an anticipated injection start-date of 2026.

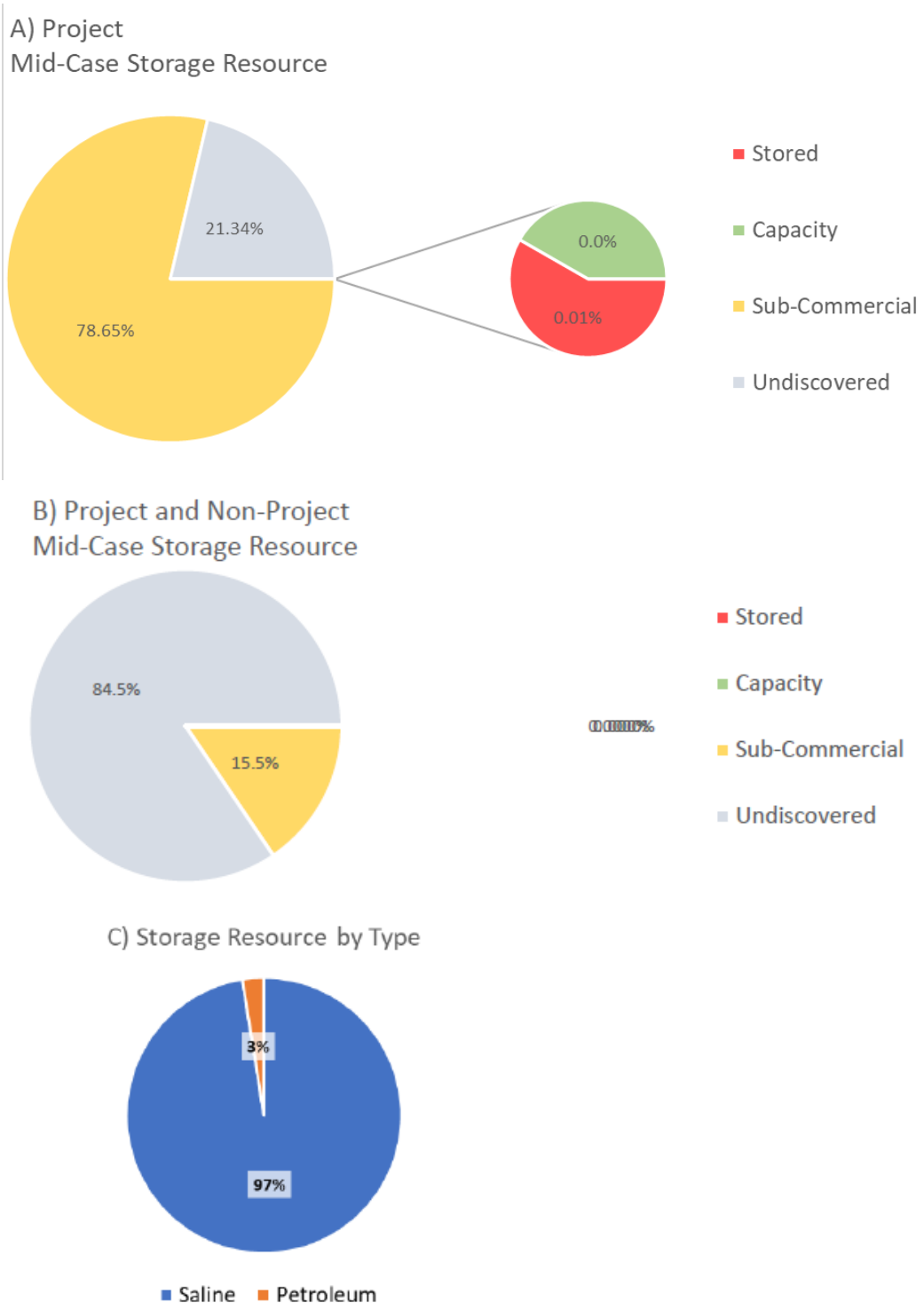


Figure 4-1: United States of America spread of Storage Sites

a) Spread of storage resource in U.S. sites (132) across SRMS classifications, where a project has been specified. b) Spread of storage resource in all Canadian sites across SRMS classifications; both project specified and not. c) Split of Canadian storage resource between saline aquifers and hydrocarbon fields, both project specified and not.

4.2 Resource Statement

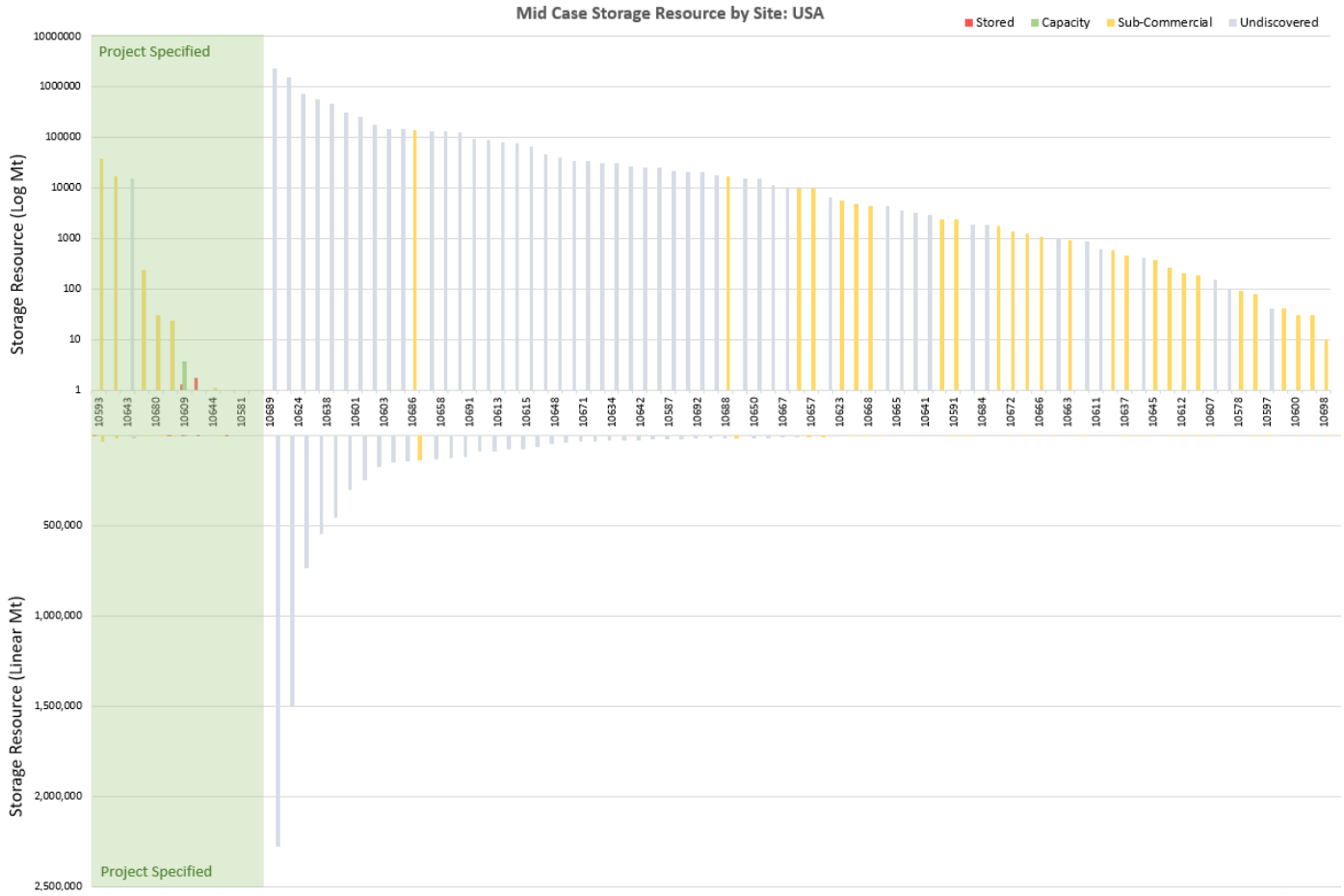


Figure 4-2: Storage resource summary for U.S. compiled in the CSRC.

Graph above is log scale and graph below is linear. Green box highlights sites where a project has been specified.

4.3 Evaluation History

The initial basis for the Cycle 1 Assessment was the 2015 US and North America Carbon Storage Atlas - fifth edition produced by the National Energy Technology Laboratory and commissioned by the US DOE Office of Fossil Energy. The storage information in Atlas V was developed to provide a high-level overview of the immense CO_2 storage potential of the North America region and was intended to provide developers with a starting point for further investigation. The Atlas considers a full range of sequestration options including oil and natural gas reservoirs (with or without EOR), saline aquifers, deep unmineable coal seams, unconventional organic rich shales, and basalt formations. Data and information in the Atlas are based on input from the DOE-funded Regional Sequestration Partnerships, research groups delivering evaluations of sequestration potential across the USA and parts of Canada. The Atlas V provides a state-by-state breakdown of potential CO_2 storage resources available in both saline formations, and oil and gas fields. These are referred to as 'State-wide Evaluations' for both saline aquifers and petroleum fields to highlight the fact that little is known about the origin and geographic location of the data presented. In addition, the Atlas delivers short case studies on the major evaluation and demonstration projects taking place across North America between 2005 and 2015 which points to the detail that is available but remains unpublished.

The State-wide saline aquifer evaluations have been further broken down into regional studies carried out by the Regional Partnerships. These are generally presented as estimates of storage resource potential at the sequence play level for a geological basin and, as such often cross state or as in the case of the Cambro-Ord Basal Sand, national boundaries. In such cases, it has been assumed that the regional studies by the partnerships represent the summed resource reported at the state level by the Atlas V and so the State-wide evaluation for those states is nulled.

In the Cycle 1 Assessment, the demonstration project sites identified from the Atlas V were reviewed and updated, where possible, to populate the SRMS database. The nature of the Atlas V has presented some challenges for the storage resource classification due to its extensive scope, but high-level overview approach; the data collated by the Cycle 1 Assessment is in no way intended as a substitute for site-specific characterisation, testing and assessment.

The calculation methods used to assess resource potential are essentially volumetric methodologies for the Statewide assessments, with local variations at the local/Project-scale provided where information is available.

For oil and gas fields, Potential CO_2 Storage Resources have been estimated by the replacement method where suitable records are available and the volumetric method where production and injection records are unavailable.

4.4 Resource Review

Despite the volume, quality, and progression of CO_2 storage in North America, the current

classification of potential storage resource is significantly limited due to the mismatch between the lack of detail available and the very large resource base, particularly for saline aquifers. The approach taken here is to adopt a minimum maturity level approach to classification and only elevate resources to more mature classes when there is both evidence and quantification available. This has led to an understatement of the maturity of the resource potential with 97% held within the Undiscovered: Prospective maturity class; the USA represents a strong candidate for re-classification.

The Sub-Commercial resource class contains both the oil and gas fields (203 Gt, classified as 'Inaccessible' at this stage due a lack of knowledge on field accessibility dates), and those storage projects (55 Gt), classified as 'Development Not Viable) for which detailed data are not published, or where their current activity status is on-hold, cancelled, or unknown.

4.4.1 Major Projects

The USA has amassed a huge amount of information through the Regional Carbon Sequestration Partnerships. These have informed the location and potential scale of storage through high level screening studies through to the selection of pilot projects. The US DOE is now developing the next generation of large-scale, integrated CCS projects: the CarbonSAFE Initiative.

At the time of assessment, the only projects reporting stored CO_2 in the subsurface (non-CO_2 EOR) are the Alabama Citronelle Project (0.114 Mt), the Illinois IBDP, injecting 1Mt over 3 years, and the IL: ICCS project, injecting up to 5Mt over 3 years.

4.4.2 Depleted Oil & Gas Fields

While there is a large inventory of CO_2 injection into commercial oil properties for enhanced oil recovery, there are very few studies which have evaluated the injection of CO_2 into depleted oil and gas fields for carbon storage without an uplift in hydrocarbon production. The DOE Atlas V does however report large resource estimates in oil and gas fields for some states, e.g., Texas: 17180 Mt, West Virginia: 9840 Mt, New Mexico: 9710 Mt, Louisiana: 5700 Mt, and California: 4850 Mt, but the source evaluations for these figures are unknown. The National Energy Technology Laboratory (NETL) has indicated that an additional demand of 10 to 45 Gt CO_2 for enhanced oil recovery operations may exist across the Lower 48 states, Alaska and Offshore Gulf of Mexico. This could significantly increase the available storage potential of depleted oil fields but a more detailed breakdown of where and which fields could be targets for CO_2 storage is needed, and a mechanism for including this resource into the SRMS.

4.4.3 Saline Aquifers

The storage resource in the USA is currently dominated by the state-wide (Basin Play) saline aquifer resource estimates provided by the DOE Atlas (7803 Gt), and regional studies (e.g., COSS (Basal Sand), and the Lower Cretaceous and Mississippian aquifers; 416 Gt) reported by the DOE Regional Partnerships. These regional estimates are assigned Undiscovered: Sequence

Play status due to the immense scale of the aquifers and the lack of published detail which would move them into the 'Discovered' resource category. The scale of this resource suggests that the USA 'Discovered' portfolio is heavily under-estimated.

The Cycle 1 Assessment focused the PCOR partnership studies which cover Montana, North and South Dakota, NW Nebraska, and NE Wyoming and focus on the Williston, Powder River and Denver basins. As discussed earlier (Section 6.3.4.2: Application of SRMS to North America), this region has required some careful treatment to avoid double counting. Those states wholly covered by the PCOR study area (MT, ND, SD) have had the State-wide saline aquifer evaluation nulled in the database to avoid double counting, however, there is a mismatch between the summed state-wide evaluations for these three states, and the summed regional sequence play resource estimates reported.

This is likely to be at least partly a result of re-calculation using a different storage efficiency factor by the DOE before incorporation into the Atlas, making direct comparison of reported data difficult.

The state-wide saline aquifer evaluations in other areas of the USA point to extremely large, gigatonne-scale, potential storage resources, for example, Texas: 1505.8 Gt, California: 1311.1 Gt, Louisiana: 734.6 Gt, Wyoming: 550.3 Gt, Mississippi: 459.2 Gt, and Alabama: 304.1 Gt. These regions require further evaluation to breakdown the resource for proper assessment against the SRMS. Future evaluations should also work towards validating, if appropriate, such large resource estimates.

4.5 Regulatory Framework

According to the GCCSI CCS Readiness Index 2018 (GCSSI, 2018), the USA ranks in the highest category, second only to Canada, indicating that, as a country the USA is well placed to enable CCS deployment, though long-term investment and commitment to CCS. Positive regulatory developments include a 2018 revision to the 45Q CCS tax incentive increasing the tax credit for dedicated geological storage to $22.66/ton (increasing linearly to $50/ton by 2026), and incorporation of a CCS Protocol into the California Low Carbon Fuel Standard (LCFS; a credit-based emissions reduction system). LCFS can also be stacked with 45Q. The final rules and a 2 year extension of 45Q was passed in December 2020. Several US states are looking to simplify CCS guidelines and provide regulatory clarity to help enable CCS deployment (Beck, 2019). The USA does, however, score maximum points on the GCCSI Inherent CCS Interest as a nation which relies heavily on fossil fuels and therefore is most likely to have a need for a robust CCS policy to achieve any future deep emissions reduction targets.

4.6 Issues for the Assessment

The Cycle 1 Assessment recognises that the resource statement significantly understates the Sub-Commercial storage resource within the USA saline aquifer systems due to the lack of detail on discovery status. The expectation is that there are large tracts of saline aquifer that

should be considered as discovered resource. Sub-Commercial storage resources are classified at this time as "Development Not Viable" due to the lack of information on this portfolio. The classification status of the commercial and active projects could also be improved through achieving more clarity regarding the progression and status of pilot projects with many projects only reporting very limited consents for injection at this time.

Several large, commercial-scale carbon capture facilities have either captured anthropogenic CO_2, or have commenced operations, however most are delivering to EOR operations. Large-scale capture and geological storage operations have not yet started-up in the USA. Future opportunities exist with the CarbonSAFE Initiative – see 'Future Updates' below.

4.7 Future Updates

4.7.1 Future assessments

The USA is expected to deliver several projects into the CCS pipeline in the next 5 years:

- IL: ICCS Project: this project follows (but is administratively separate to) the pilot IBDP project in Decatur, Illinois. CO_2 injection and monitoring continues through 2020. The final injection volume needs to be updated when it becomes available.

- CarbonSAFE Initiative (the Carbon Storage Assurance Facility Enterprise) is a DOE-funded program focused on the development of geological storage sites with the potential to store at least 50 Mt CO_2. The timeframe for deployment is 2025-2035. Currently there are 13 projects at the 'pre-feasibility' stage and 6 being funded to better establish the 'feasibility' of a project. The funding cycle for many of these ends in during 2020-2021 and so results should be available for update in the next two assessment cycles. It is anticipated that the projects which succeed at the 'Feasibility' stage will be the major projects with the best chance of progressing to the FEED study stage and onward to project commerciality.

- Gulf Coast Offshore opportunity: a key area which is under-represented in the current SRMS database is the offshore zone and the offshore Gulf Coast. The region is represented by two Pre-Feasibility CarbonSAFE projects, but any future country update should include published reviews of the offshore potential.

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