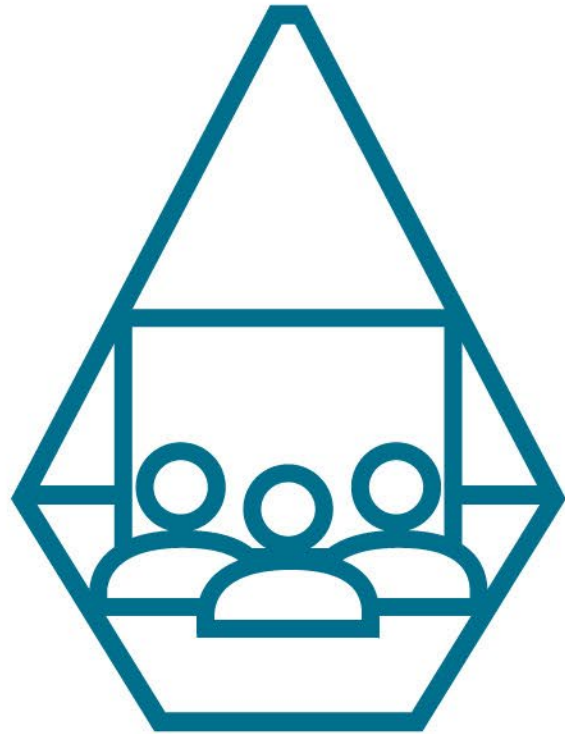




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# The Subsurface and CO<sub>2</sub>: Pore Space, CO<sub>2</sub>-EOR and Geologic Storage

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# Ownership of the Subsurface

- The subsurface may include three distinct estates:
  - The geologic rock structure beneath the land, including all non-mineral molecules;
  - The oil and gas, or other minerals in place, under, or within the land;
  - The reservoir space— or “reservoir estate”— made up of pore spaces within the rock structure that can be used for storage.

# The Reservoir Estate

- The reservoir estate is composed of the pore space.
- Statutory Definitions of Pore Space:
  - “subsurface space which can be used as storage space for CO<sub>2</sub> or other substances”
    - - WYO. STAT. ANN. § 34-1-152(d)
    - “a cavity or void, naturally or artificially created, in a subsurface sedimentary stratum”
      - - N.D. CENT. CODE ANN. § 47-31-02.

# Ownership of the Reservoir Estate

Neb. Rev. Stat. 57-1604

- (1) Title to any reservoir estate underlying the surface of lands and waters is vested in the owner of the overlying surface estate unless it has been severed and separately conveyed.
- In all states that have considered the issue, either courts or the legislature have confirmed that the reservoir estate is part of the surface property *unless it has been severed and separately conveyed*
- Some state statutes prohibit severance of pore space.

# Non-exclusive Use of the Reservoir Estate by the Mineral Owner

“Although the surface owner retains ownership and control of the subsurface materials, a mineral lessee owns a property interest—a determinable fee—in the oil and gas in place in the subsurface materials....The mineral estate is the dominant estate in the sense that the mineral owner has the right to use as much of the surface [including the subsurface] “as is reasonably necessary to produce and remove the minerals” -*Lightning Oil Co. v. Anadarko E&P Onshore*, 520 S.W.3d 39. (Tex. 2017).

# Use, Storage, and Disposal of CO<sub>2</sub>

CO<sub>2</sub> is injected into the subsurface for 3 primary purposes:

- (1) CO<sub>2</sub>-EOR
- (2) Waste disposal (Acid Gas Injection)
- (3) Carbon Sequestration

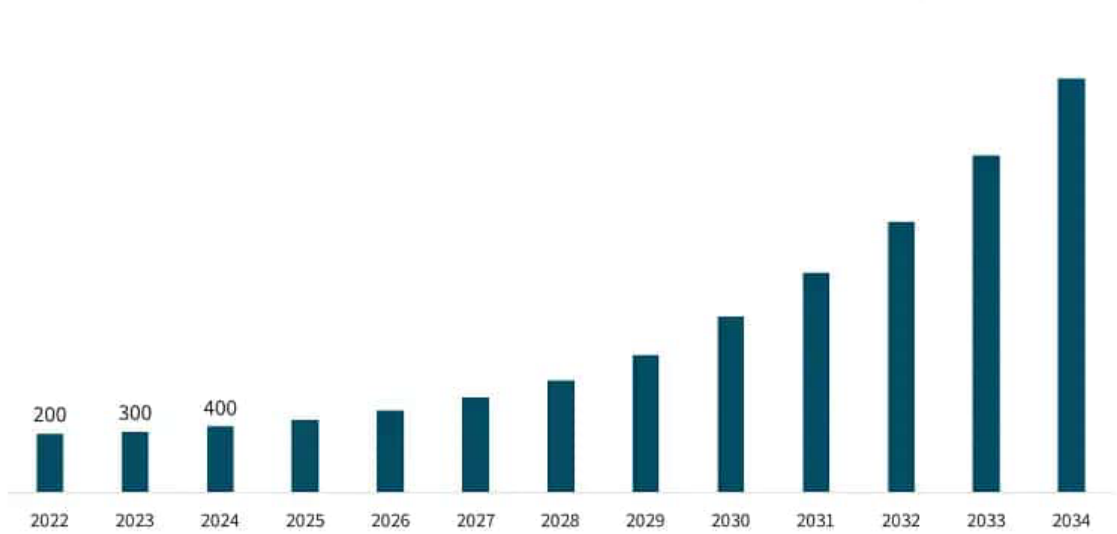
Any of these activities can be eligible to claim the 45Q tax credit, provided the CO<sub>2</sub> counts as a qualified carbon oxide.

# 45Q

- Requires *Secure Geological Storage* of “Qualified Carbon Oxide”
  - Captured at industrial source;
  - Would otherwise be released;
- Volume
  - Calculated based on lifecycle analysis of GHG emissions
  - Measured at source and verified at point of injection
- Credits for DAC (\$180/ton) and point source capture (\$85/ton) (if prevailing wage & apprenticeship requirements are met).

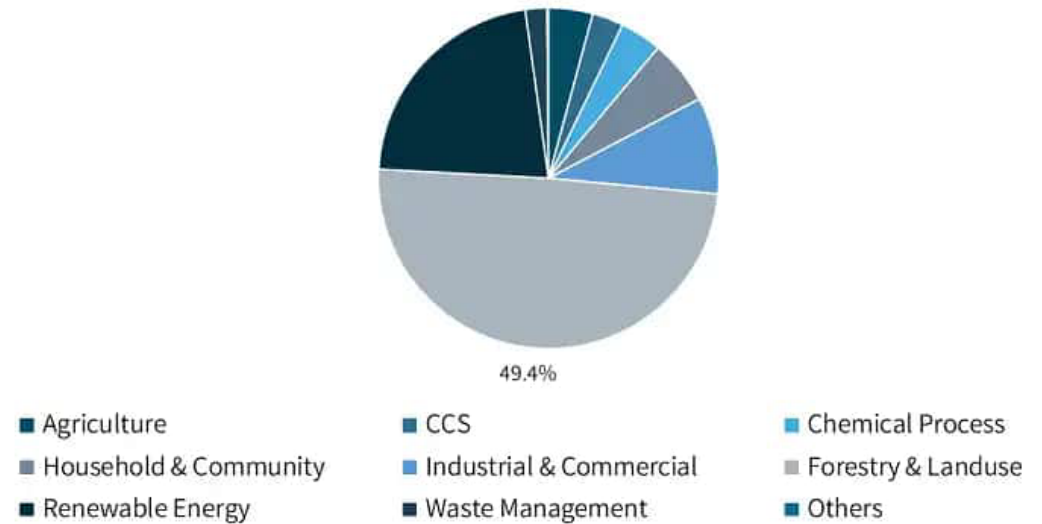
# Voluntary Carbon Markets

U.S. Voluntary Carbon Credit Market Size, 2022 - 2034 (USD Million)



Source: [www.gminsights.com](http://www.gminsights.com)

Voluntary Carbon Credit Market Revenue Share, By End Use, 2024

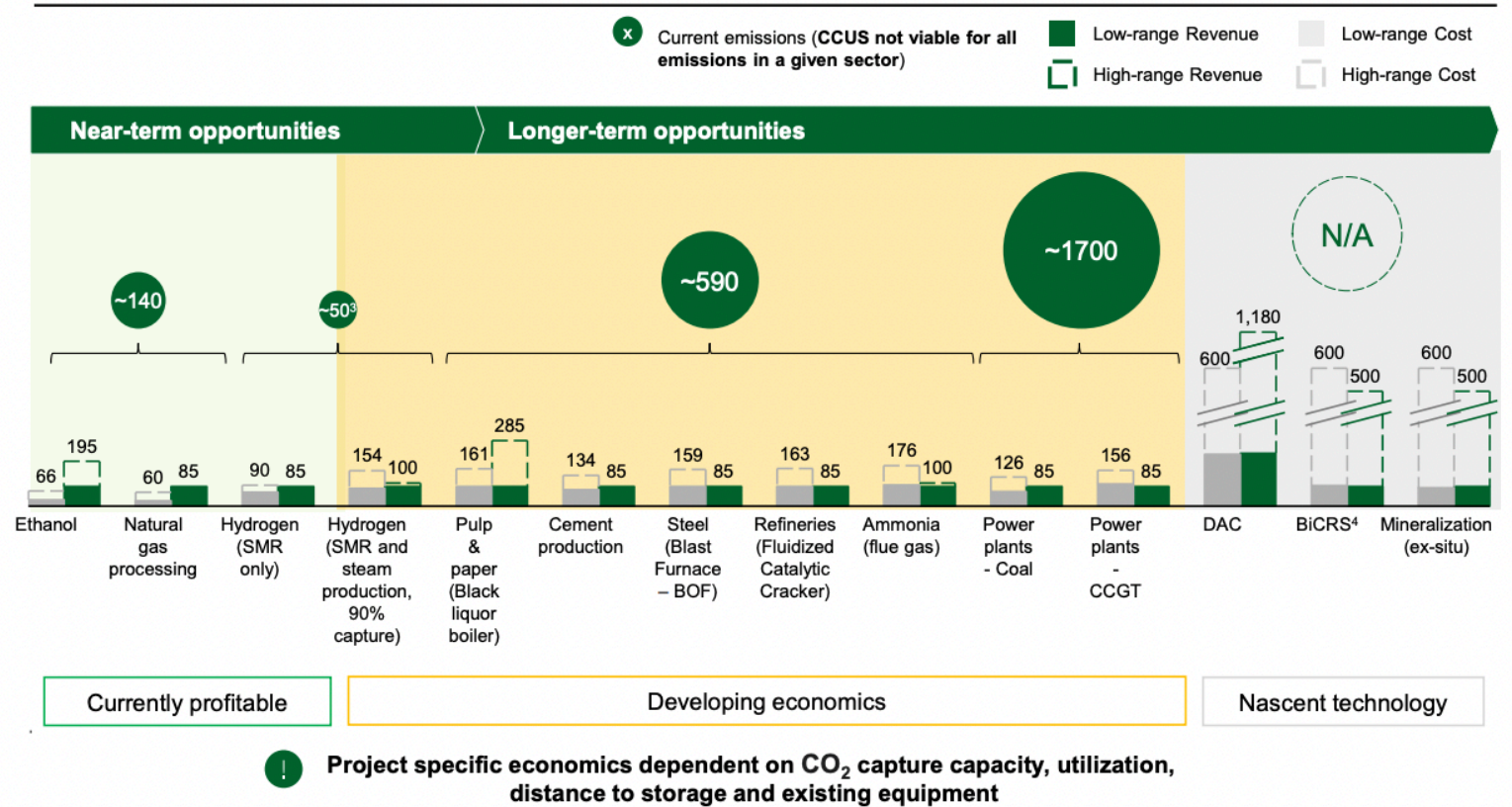


Source: [www.gminsights.com](http://www.gminsights.com)

# Capture Business Models

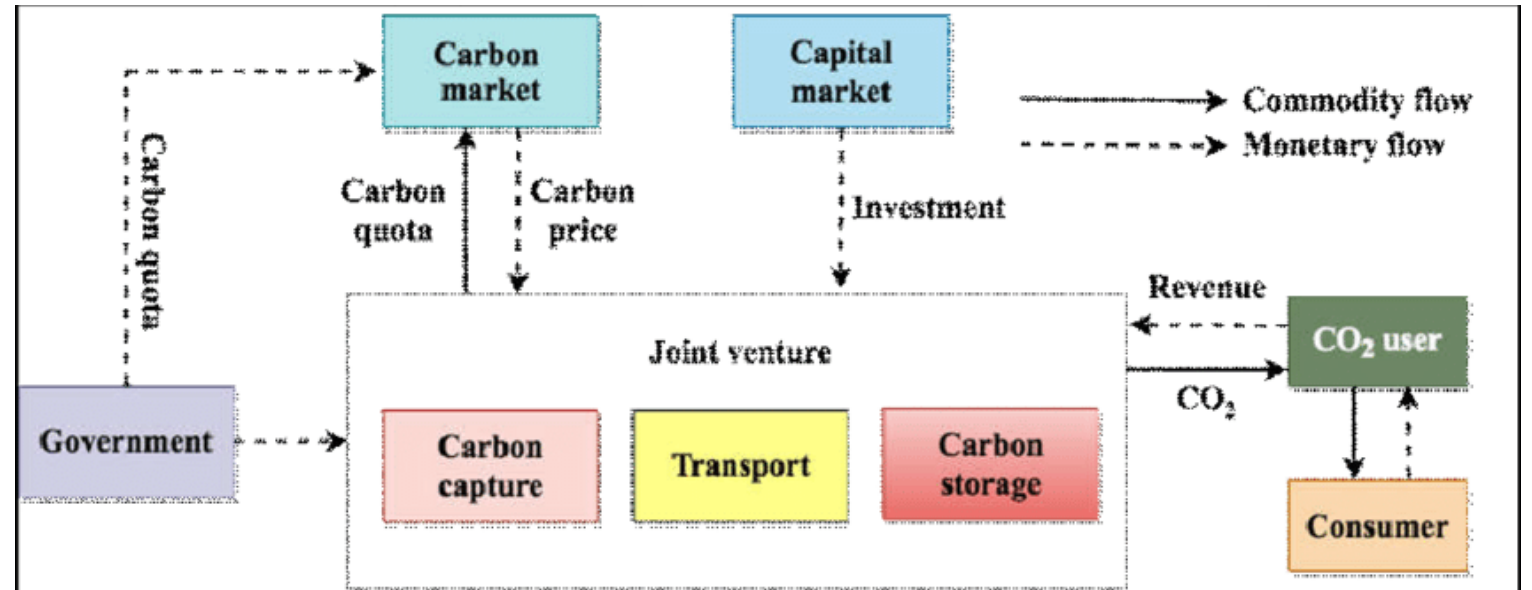
45Q credit paid to operator of capture equipment:  
 12 year period to claim credit  
 Only anthropogenic CO<sub>2</sub>  
 Voluntary carbon market  
 and offset markets  
 Monetization of low carbon products

Cost<sup>1</sup> and revenue<sup>2</sup> per industry or technology today, \$/tonne



# Transport and Storage Business Models

Development of storage complex  
May also operate pipeline  
Permitting  
CO<sub>2</sub> EOR, Waste Disposal,  
or Geologic Storage  
Single Source or Hub Model  
Negotiation with owner of  
capture equipment for  
“disposal fee”



Muslemani, et al, *Business Models for Carbon Capture, Utilization and Storage Technologies in the Steel Sector: A Qualitative Multi-Method Study*, Processes 8(5) (2020)

# The Safe Drinking Water Act

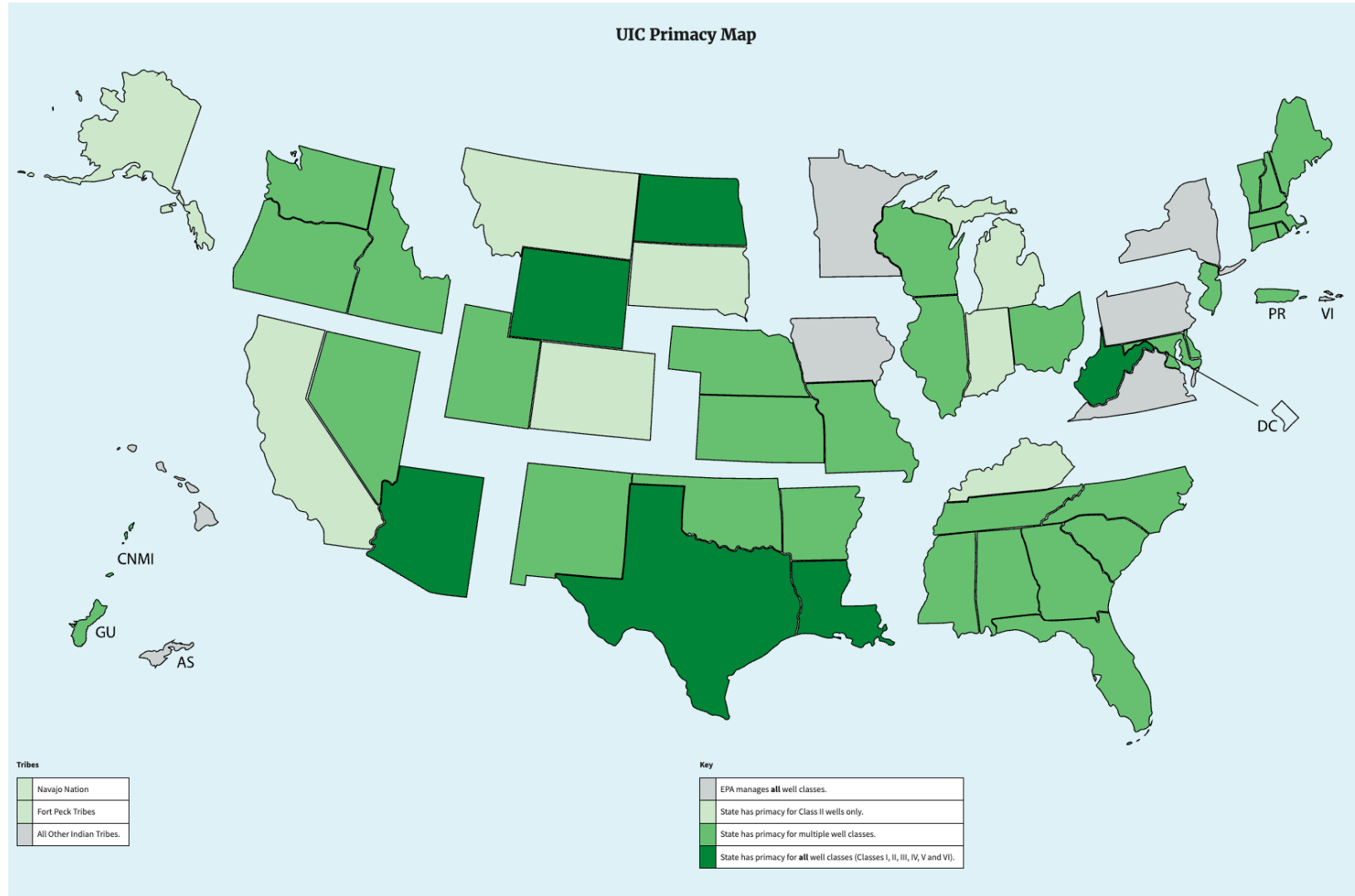
**Table I. UIC Well Classes and Estimated Wells**

Class	Estimated Number of Permitted Wells	Percentage of Total Wells	Type of Fluid Injected
Class I	903	0.12%	Injection of hazardous and non-hazardous wastes into deep, isolated rock formations
Class II	156,547	21.29%	Injection of fluids associated with oil and natural gas production (including injection of CO <sub>2</sub> for enhanced recovery and produced water disposal)
Class III	28,465	3.87%	Injection of fluids for solution mining (e.g., extracting uranium or salt)
Class IV	169	0.02%	Injection of hazardous or radioactive wastes through shallow wells into or above formations that contain a USDW (these wells are banned unless authorized under a federal or state groundwater remediation project)
Class V	549,322	74.70%	Any well used to inject non-hazardous fluids underground that does not fall under the other five classes, including storm water drainage wells, septic system leach fields, aquifer storage and recovery wells, and experimental wells; most Class V wells are used for injection of wastes into or above USDWs
Class VI	2	Less than .01%	Injection of CO <sub>2</sub> into geologic formations for long-term storage or geologic sequestration

Used for EOR and disposal of pre-combustion oil and gas waste CO<sub>2</sub>

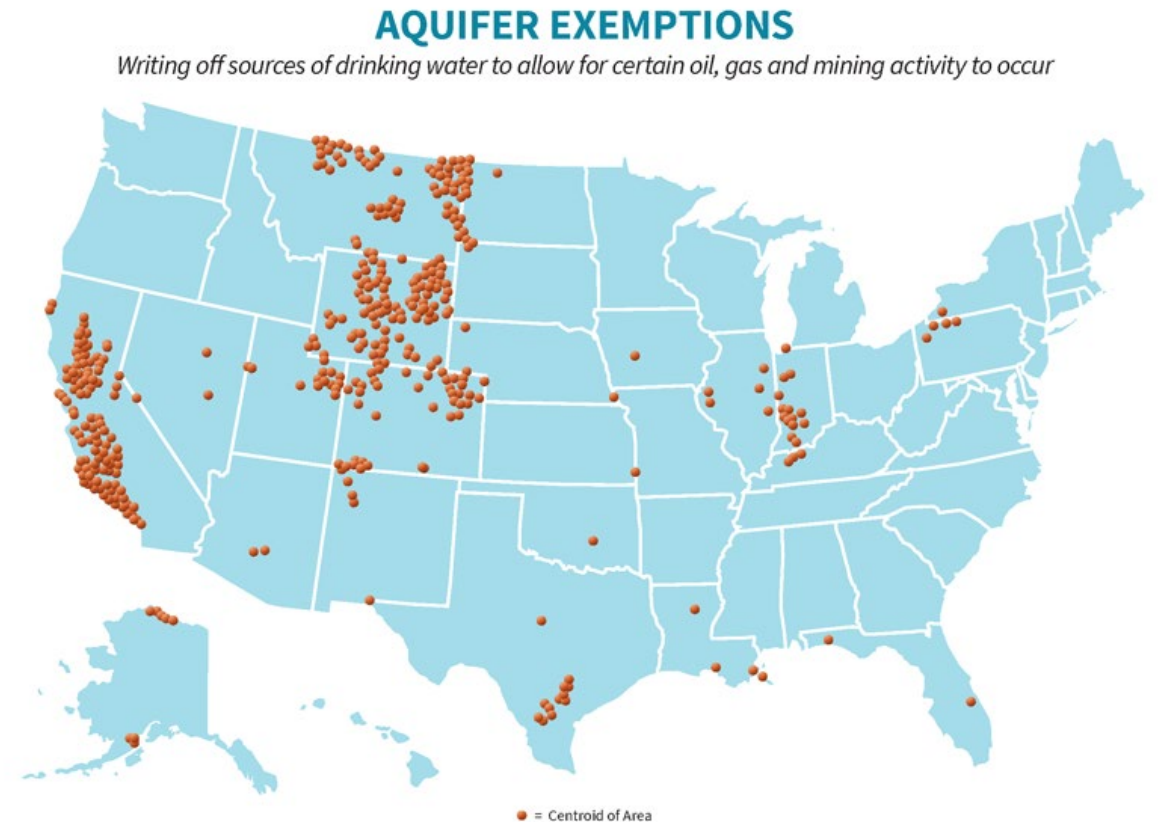
Used for direct air capture and point source capture CO<sub>2</sub>

# UIC Program Regulatory Authority



# Where Can I Inject? – It depends on your well class.

- Class I -V wells are eligible for an aquifer exemptions per 40 CFR 144.7 if the aquifer meets the criteria in 40 CFR 146.4.
- In contrast, 144.7 provides that “new aquifer exemptions shall not be issued for Class VI wells” thereby prohibiting any injection into an aquifer that meets the definition of an USDW.
  - Must have TDS > 10,000 mg/l



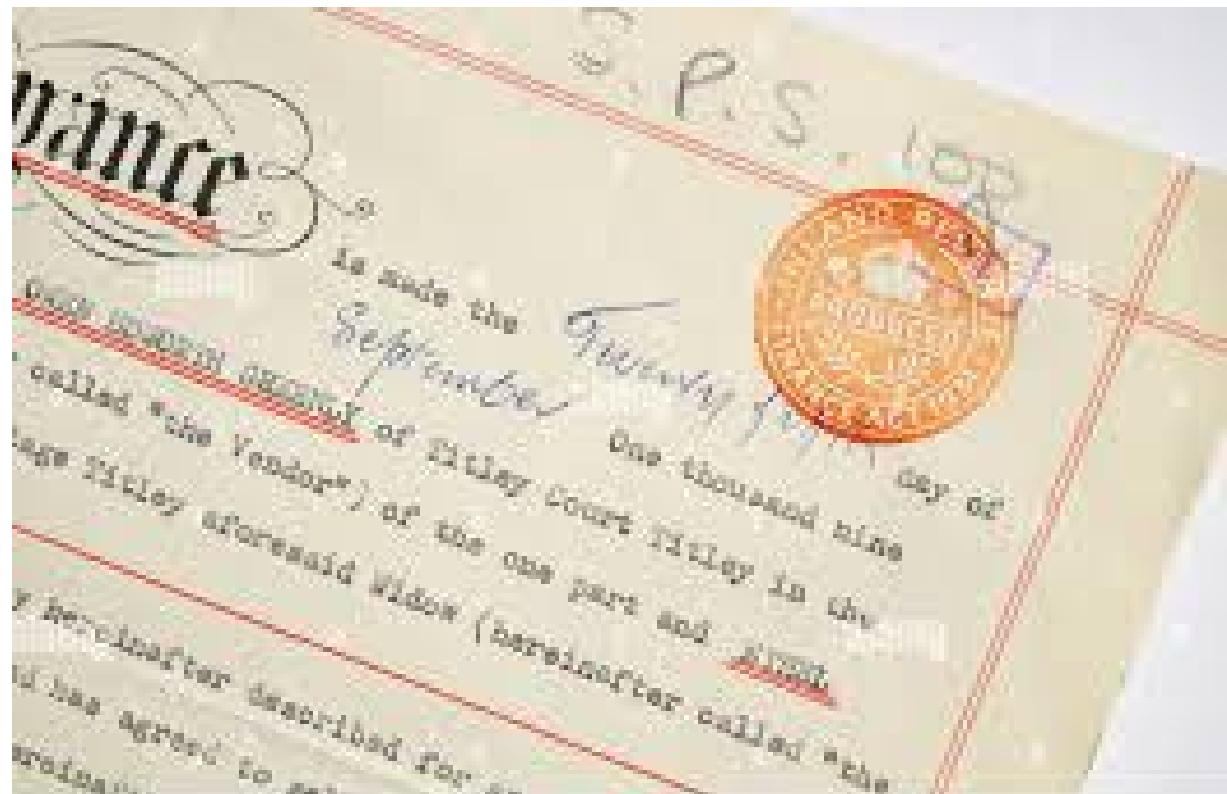
Sources: Esri, DeLorme, HERE, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, Geobase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, and the GIS User Community. Available EPA data as of May 2014.

# Other Regulations

- GHG Reporting Program:
  - Subpart RR applies to “The geologic sequestration of carbon dioxide (CO<sub>2</sub>) source category comprises any well or group of wells that inject a CO<sub>2</sub> stream for long-term containment in subsurface geologic formations” and “all wells permitted under Class VI”
  - EOR wells are under Subpart UU as are “other facilities that inject CO<sub>2</sub> underground”
- RCRA:
  - Includes drilling fluids and other wastes associated with oil, natural gas, or geothermal production
  - Conditionally excludes CO<sub>2</sub> injected and transported in compliance with Class VI and PHMSA Rules
- State Permitting (Air, CWA, Unitization, Oil and Gas Conservation, Step Rate Tests, Strat wells)

# Title for CCUS

- Title needed to identify storage rights interest owners and mortgage and lien holders
- Federal Class VI permit notice requirements require notice to state agencies and stakeholders
- State rules may be more extensive
  - Wyoming requires notice to all holders of subsurface interests including mining claims and royalty interests.



# Land Acquisition Fundamentals

The extent, manner, and reason for acquiring rights to inject will depend on whether the injections are for CO<sub>2</sub>-EOR, acid gas injection, or geologic disposal.

In all cases, having the appropriate suite of land rights, assures the developer that they will have adequate storage capacity for their injection activities and the right to prevent from interference or intrusion by other developers.

# Land Acquisition for EOR & AGI

## Rights Needed

- Right of geophysical exploration and right to inject substances for EOR or waste disposal is included as part of rights granted by majority of oil and gas leases.
- Developer will need additional rights from surface owner if it intends to continue injection after OGL expiration
- Customarily, pore space rights have not been acquired for disposal activities (AGI, produced water)
- Must acquire right to develop injection facility if injecting off lease substances.

## Challenges

- Oil and gas developer's rights are non-exclusive and limited to what is reasonably necessary for hydrocarbon production
- Rights are limited by the habendum clause of the lease
- Right to inject into AGI is limited to substances produced from the lease.

# Land Acquisition for Storage

## Rights Needed

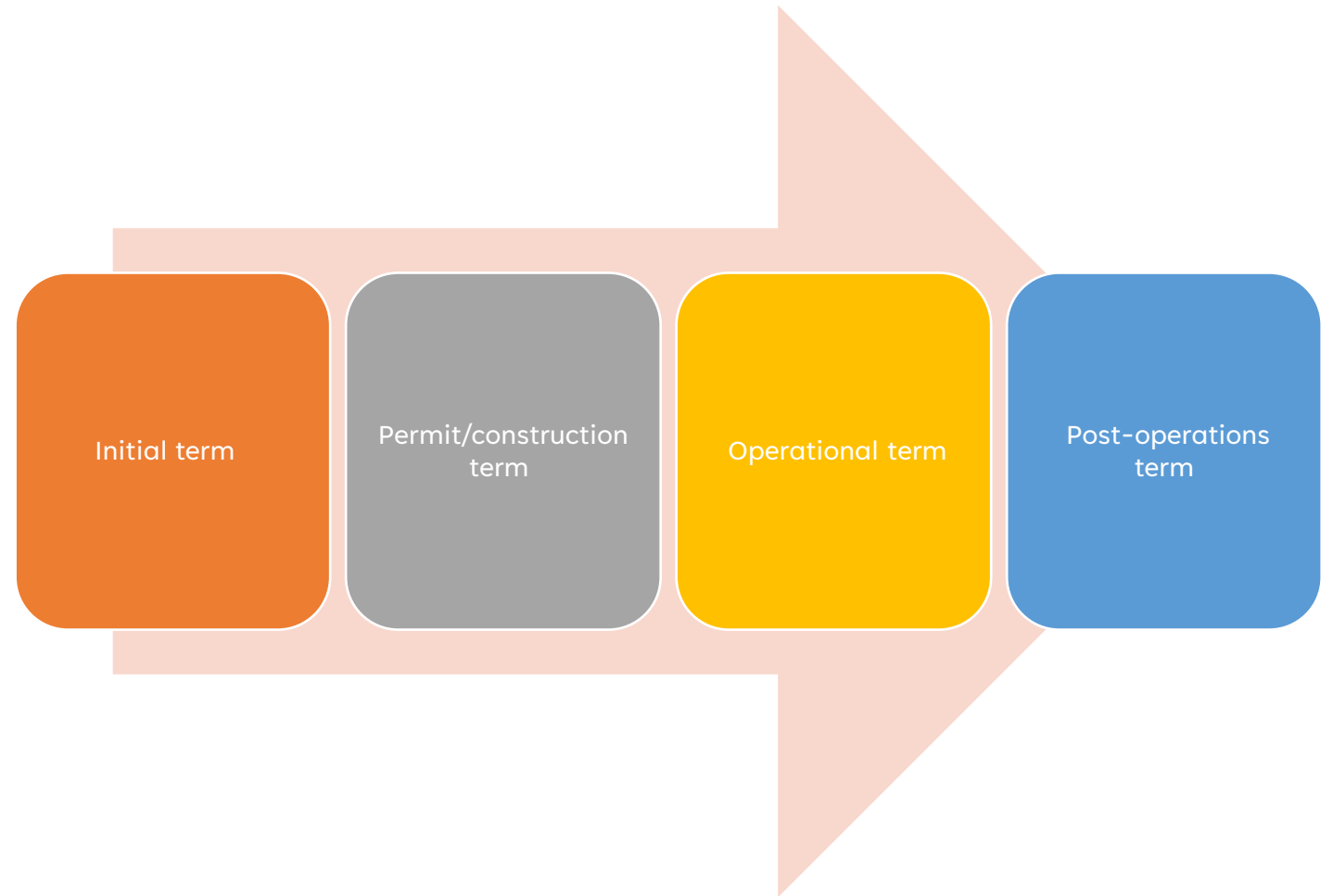
- Geologic characterization
- Injection and permanent storage
- Wellbore access for corrective action
- Access for MRV
- Restrictive covenants to prevent containment losses
- ROWs for pipelines
- DAC Land Leases
- Subrogation of liens and mortgages

## Challenges

- Split estates
  - Identifying rights holders and limitations on what can be conveyed
  - Rights may be non-exclusive as to one estate
- Fragmentation & coordination
- Conflicts with mineral development activities

# The “Pore Space” Acquisition Contract

- May be structured as purchase, lease, JV with landowner, or easement
- For storage projects, should include perpetual right of storage



# The “Pore Space” Acquisition Contract

- Many terms similar to OGL: Bonus, rental, development term, operational term, volumetric payment per ton
- Minimum injection provisions
- Most favored nations
- Minimum guaranteed annual payment
- Right to unitize
- Drill-through provisions
- Right to extract brines
- Corrective Action provisions

# Storage Contract Consideration:



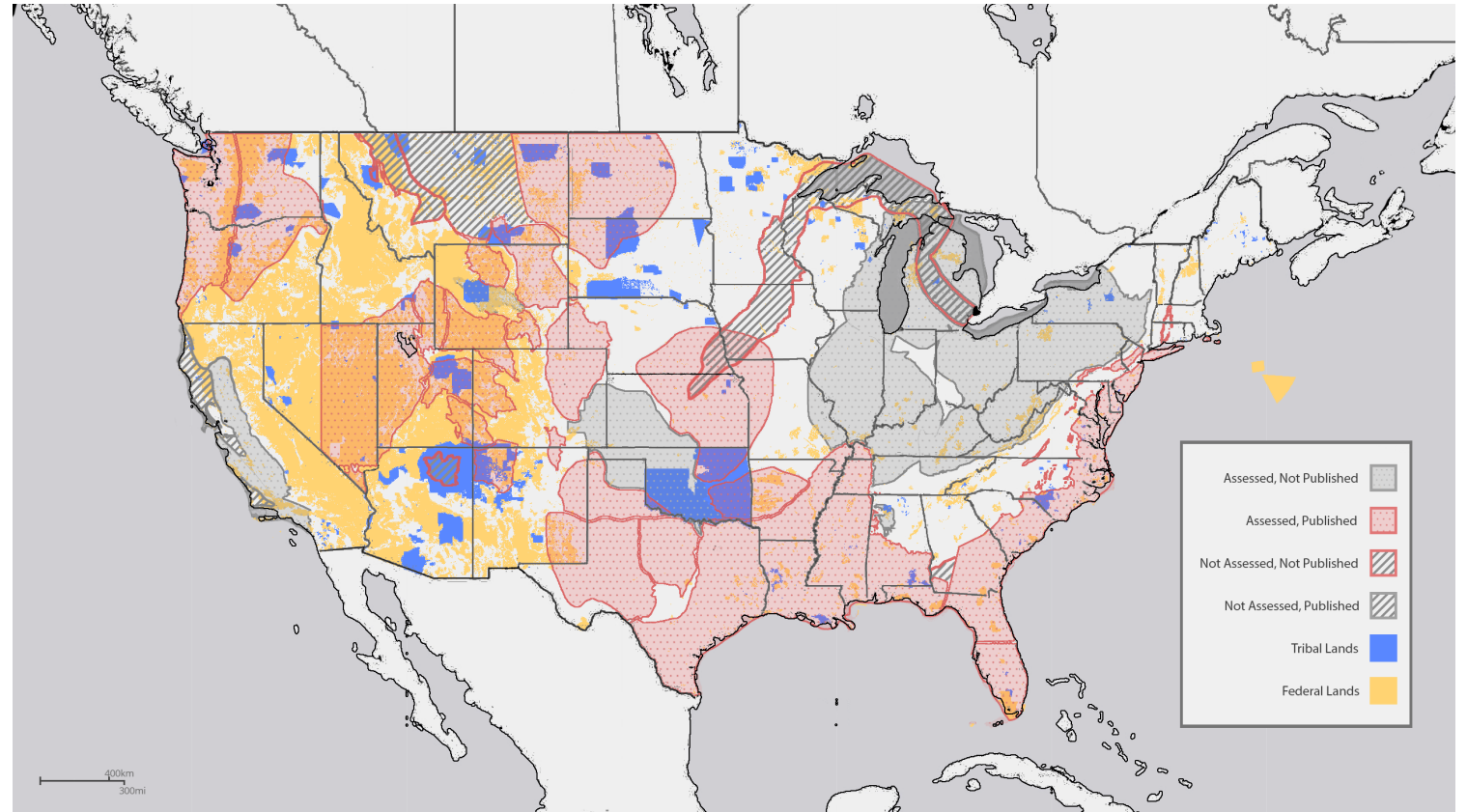
	Characterization & Application for Permit			Well Construction & Beginning of Injection				Injection					Restoration, Monitoring, & Certificate of Completion
	Bonus	Rental	Option to Extend	Bonus	Rental	Volumetric Fee	Option to Extend	Bonus	Rental	Volumetric Fee	Royalty	Annual Minimum	Annual Rental
<b>Louisiana</b>	\$34-\$425/acre	\$50-\$60/acre	2 years (Landowner Discretion)		\$50-\$60/acre	\$1.50-\$7.50/ton			\$50-\$60/acre	\$1.50-\$7.50/ton	10% of 45Q Credit Increases	0.5-1m tons	
<b>Texas</b>	\$4.5M (~\$100/acre)		1 year \$450,000 (~\$11/acre)	\$4.5M on commitment of CO2			1 year \$450,000 (~\$11/acre)	\$4.5M on first injection			3% (1 <sup>st</sup> 50 m tons), then 6%	~ 1m tons	
<b>Colorado</b>	\$12/acre	\$12/acre	1 year (Must pay annual rental in advance)		Up to \$24/acre	\$3.50/ton	Up to 4 1-year terms (Landowner discretion)		Up to \$24/acre	\$3.50/ton	10% of 45Q Credit Increases	20% of committed volume	50% of injection rent, applied to extent of surface disturbance
<b>Wyoming</b>	\$15-\$75/acre		1 year (10% of initial bonus)			\$1/ton w/CPI adjustment	1 year 25% of initial bonus			\$1/ton w/CPI adjustment			

For a public repository of storage agreements collected by researchers at the University of Wyoming, please visit:



# Federal, State, and Tribal Lands

- Current BLM guidance expired; Agency using ROW authority
- Forest Service – perpetual grants prohibited
- Tribal ROW authority
- State land special use leasing
- Compensation must be FMV.



Cole James, James Amato, & Kyle Summerfield, UW School of Energy Resources, 3D Visualization Center, 2024.

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