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Geologic Storage Cost Analysis Tool (GeoCAT)

Presented by Harry Vidas, ICF

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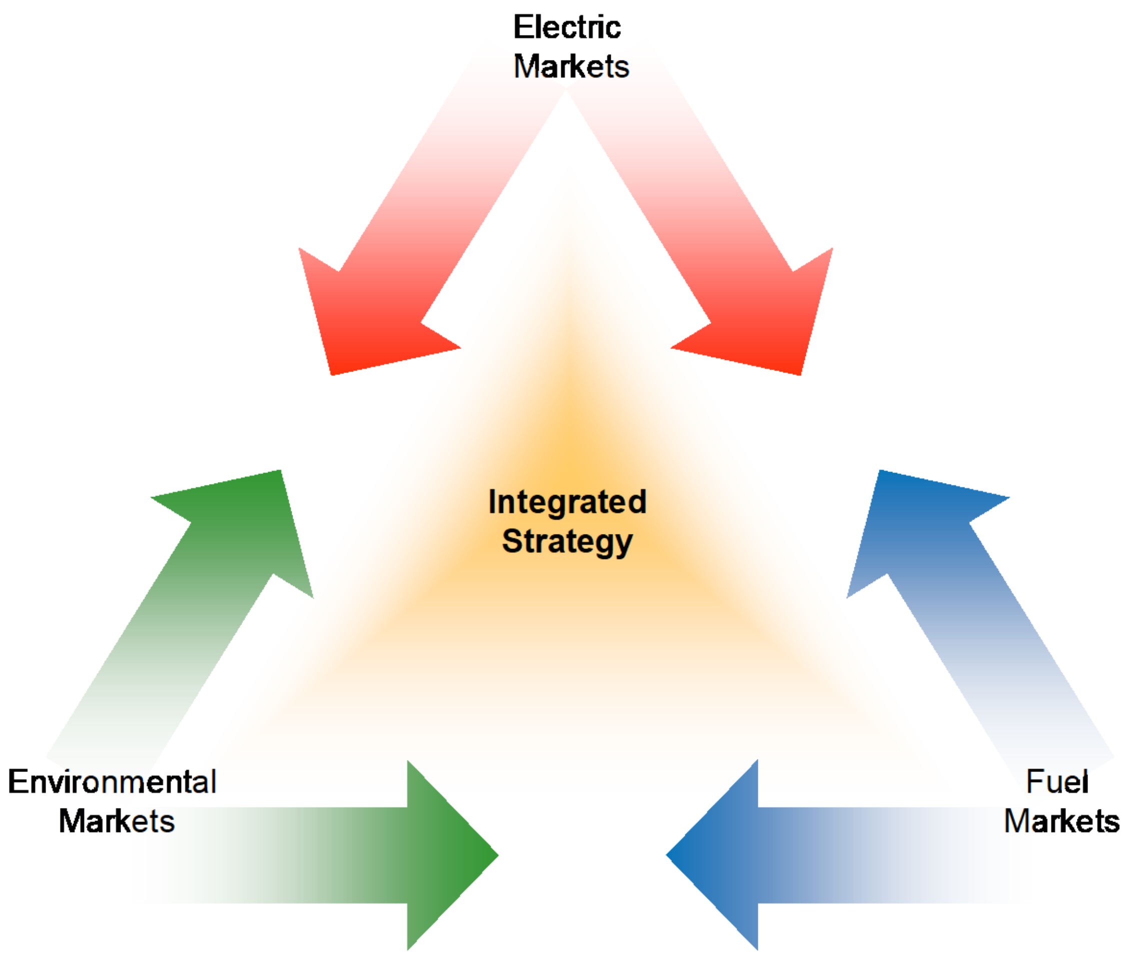
History of GeoCAT

- Initial modeling of geologic storage cost by EEA/ICF was done for DOE in support of BNL and the MARKAL model in early- to mid-2000's.
- That work was carried forward for EPA in 2008-2010 in support of the Class VI rulemaking effort. That included analyses of several Class VI regulatory options.
- Data from the Class VI rulemaking work and other sources was used to create the GeoCAT model in 2009. The goal was to incorporate geologic storage of CO_2 into ICF's Integrated Planning Model (IPM)that is used by EPA and others.
- The GeoCAT model has undergone several updates including ongoing work.

What is the Integrated Planning Model (IPM)?

- IPM is a long-term capacity expansion and production costing model for analyzing the North American electric power sector
  - Multi-regional, deterministic, dynamic linear programming model.
- Finds the least-cost solution to meeting electricity demand subject to environmental, transmission, fuel, reserve margin, and other system operating constraints.
- Provides detailed projections on electric system operation, electric generation mix, new capacity, retirements, fuel choices and prices, pollution control technologies, allowance markets, emissions, and costs.
- Data is available at several aggregation levels (e.g., state, regional, and national) for multiple future years over the modeling time horizon.



Overview of CCS in IPM

- The emitted CO_2 in electricity production regions can be transported through pipelines and sequestered in CO_2 storage regions.
- IPM uses CO_2 storage cost curves from GeoCAT and a CO_2 transportation cost matrix as inputs.
  - The storage cost curves represent the cost of storing CO_2 in each storage region summed for various types of storage reservoirs (e.g. saline aquifers, EOR, abandoned oil and gas fields, etc.)
  - Transportation cost matrix captures the cost of transporting CO_2 from the CO_2 production regions to the CO_2 storage regions.
- IPM solves for the optimal strategy for capturing, transporting and storing CO_2 in any given year over the forecast horizon.

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Storage Cost Curves

- The CO_2 storage cost curves capture are developed in GeoCAT (Geosequestration Cost Analysis Tool) model.
- The GeoCAT model combines detailed characteristics of sequestration capacity by state and geologic setting for the U.S. with costing algorithms for individual components of geologic sequestration of CO_2.
- The outputs of the model are regional sequestration cost curves that indicate how much potential storage capacity is available at different full-cycle (site selection through site closure and long-term care) cost points.
- The storage volumes are translated for IPM into maximum annual storage capacities (using a ratio of 1 annual ton per 50 tons of geologic capacity)
- A portion of the storage capacity is subtracted from IPM inputs to account for potential use of that capacity for industrial CO_2 emissions.

Geologic Storage Capacities

- GeoCAT employs the volumes documented in the DOE NATCARB V Atlas (carried out by NETL)
- State level onshore and offshore capacity volumes are reported for storage in oil and gas reservoirs, unmineable coal seams, and saline formations
- The great majority of storage volume is in saline reservoirs, which are present in many states, and in most states with oil and gas production (offshore storage is also included)
- ICF carries out a separate analysis to break out CO_2 EOR storage potential from the total potential in oil and gas reservoirs reported in NATCARB. EOR storage tends to the lowest-cost tranche of storage since the CO_2 has value in enhanced oil recovery.

Geologic Storage Capacities (continued)

- Table shows the NATCARB V storage volumes for the U.S. Lower-48 as allocated to GeoCAT categories.
- Total Lower-48 mid-point capacity is 8,216 gigatonnes.
- There are no volumes in the current EPA model for potential storage in gas shale, depleted gas reservoirs, or basalt formations because these are not reported in NATCARB.

Gtonnes					Offshore Allocation in GeoCAT					
		Onshore	Offshore	Total	Louisiana	Texas	GOM Total	Pacific	Atlantic	Total
CO_2 Enhanced Oil Recovery	Low	11.2	1.1	12.3						
	Mid	**15.0**	**1.5**	**16.4**	**1.5**	**0.0**	**1.5**	**0.0**	**0.0**	**1.5**
	High	22.5	2.2	24.7						
Depleted Oil	Low	128.0	11.8	139.8						
	Mid	**170.7**	**15.7**	**186.4**	**12.7**	**3.0**	**15.7**	**0.1**	**0.0**	**15.7**
	High	256.0	23.6	279.6						
Unmineable Coal	Low	47.8	2.0	49.8						
	Mid	**63.7**	**2.6**	**66.4**	**0.0**	**0.0**	**0.0**	**2.6**	**0.0**	**2.6**
	High	95.6	4.0	99.5						
Saline	Low	4,252	1,708	5,960						
	Mid	**5,669**	**2,277**	**7,947**	**1,240**	**798**	**2,038**	**37**	**202**	**2,277**
	High	12,477	3,416	15,893						
Totals	Low	4,439	1,723	6,162						
	Mid	**5,919**	**2,297**	**8,216**	**1,254**	**801**	**2,055**	**40**	**202**	**2,297**
	High	12,851	3,446	16,297						
Oil and Gas Totals	Low	139.2	12.9	152.1						
(EOR plus Depleted Oil Flds.)	**Mid**	**185.6**	**17.2**	**202.8**	**14.16**	**2.97**	**17.13**	**0.05**	**0.00**	**17.18**
	High	278.5	25.8	304.2						

Storage Costs

- The GeoCAT storage cost algorithms include three elements: a unit cost specification module, a project scenario costing module, and a geologic and regional cost curve module.
- The unit cost module includes data and assumptions for 120 “unit cost” elements falling within the following cost categories:
  - Geologic site characterization
  - Monitoring
  - Injection well construction
  - Area of review and corrective action
  - Well operation
  - Mechanical integrity testing
  - Financial responsibility
  - Site closure
  - Post-closure monitoring
  - General and administrative
- Depending on the nature of each cost element, it is specified as cost per site, per square mile, as a function of well depth, per labor hour, or other specification.

Storage Costs (continued)

- The costs derived in the unit cost specification module are used in the GeoCAT project scenario costing module to develop commercial scale costs for up to eight sequestration categories (last four typically not included in EPA version):
  - Non-basalt saline reservoirs,
  - Depleted gas fields,
  - Depleted and abandoned oil fields,
  - Enhanced oil recovery (EOR) conversion,
  - Enhanced coalbed methane recovery (ECBM),
  - Gas shales,
  - Basalt reservoirs, and
  - Unmineable coal seams.
- Each pro forma project has specifications for volume of CO2 injected, depth, number of injection and monitoring wells, and other factors. Based on the timing of expenses and financial assumptions, these costs are translated in the model into levelized dollars per metric ton of CO2 injected using standard discounted cash flow techniques.
- Storage potential and cost curves are aggregated at the state level before going into IPM

CO_2 Transport Costs

- The costs of pipeline transportation are based on standard engineering calculations for what diameter of pipeline is needed to transport a given volume of CO_2.
- Costs may also be influenced by certain assumptions about how CO_2 from individual power plants gets aggregated. That is, a “telescoping” of pipeline sizes as the transport distances increase
- The capital cost of the CO_2 pipelines is represented in terms of dollars per inch-mile of pipeline. These capital cost plus O&M costs are translated into levelized $/metric ton costs (akin to cost-of-service tariff calculation for regulated gas pipelines) and $/metric ton-mile costs
- The region-to-region transportation cost matrix is created by multiplying the travel distances (calculated with geospatial geometry using latitude-longitude center points of the regions) by the relevant dollar-per-ton-mile transportation costs.