CHANGING PARADIGMS FOR A LOW-CARBON WORLD

K.K. DuVivier[*] & *Tara Righetti*[†]

Abstract

Energy companies are making billions of dollars in bids and investments to tie up development rights for wind energy and kick start commercial-scale carbon removal projects.[1] *Embracing these new technologies and creating pathways for their expedient development on federal lands is critical to addressing carbon emissions and climate change. Yet, leasing also results in fragmentation of interests in federal lands, which risks locking in waste of valuable climate solution resources in the absence of a fundamental paradigm shift in approaches.*

This essay addresses the evolution of a "rule of capture" paradigm in the context of oil and gas development and illustrates why a similar approach currently forming the foundation of federal land-use policies results in waste for geologic carbon storage and wind energy developments. Just as oil and gas evolved to use pooling and unitization regulation for a more collaborative system of developing reserves, geologic carbon storage and wind energy development would similarly benefit from cooperative governance structures that allow for coordination and planning on a resource scale.

Introduction

Two key strategies experts recommend for limiting global warming to 1.5°C of preindustrial levels are (1) carbon dioxide removal with geologic storage and (2) massive deployment of renewable electricity generation sources such as wind power.[2] The United States has abundant storage and wind resources essential to advancing these efforts, and recent executive and legislative efforts to rapidly increase carbon storage and wind deployment on public lands and in the outer continental shelf have

[*] Professor of Law & John A. Carver Jr. Chair in Natural Resources Law, University of Denver Sturm College of Law.

[†] Professor of Law, University of Wyoming College of Law & University of Wyoming School of Energy Resources.

[1] Valerie Volcovici, *U.S. Offshore Wind Auction Draws Record $4.37 Billion in Bids*, REUTERS (Feb. 28, 2022), https://www.reuters.com/business/energy/us-offshore-wind-auction-nears-4bln-third-day-bidding-2022-02-25/ (last visited May 24, 2022); GLOB. CCS INST., GLOBAL STATUS OF CCS 2021 (2021).

[2] Joeri Rogelj et al., *Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development*, *in* GLOBAL WARMING OF 1.5°C 95–96 (INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, 2018); E. LARSON ET AL., PRINCETON UNIV., NET-ZERO AMERICA: POTENTIAL PATHWAYS, INFRASTRUCTURE, AND IMPACTS FINAL REPORT SUMMARY 27 (2021) (finding that modeling in all pathways examined included at least 60 percent renewable energy and large-scale annual CO_2 sequestration in geologic formations).

placed the United States at a critical juncture. Aligning these efforts[3] with land and development policies that reflect the natural bounty of the resource is essential to avoid bygone paradigms that calcify wasteful policies.

This essay examines the hazard of applying rule-of-capture paradigms to subsurface carbon storage capacity and wind energy resources. Geologic storage capacity, like oil and gas deposits, is both non-renewable and subject to depletion. Wind, though itself renewable, nonetheless requires finite resources in land and may suffer from diminished generation capacity when adjacent owners engage in competitive development.[4] As such, both resources are vulnerable to waste. Yet, neither geologic storage nor wind resources are inherently rivalrous. They are made so through fragmentation of property rights in the resource and the application of capture-based paradigms. These two factors misalign the self-interest of individual rights holders with the collective interest in efficient and coordinated development of the resource. While this issue is not unique to public lands, the current rush to develop these public resources and the unified federal ownership provide a unique opportunity to address the mistakes of the past with respect to the fragmentation of rights in the resource and application of capture-based paradigms.

The vulnerability of wind and carbon storage resources to waste has been thoroughly explored in recent scholarship. A 2021 article, *Preventing Wind Waste*,[5] illustrated how using the competitive rule of capture norms employed for terrestrial wind to development of offshore wind energy will result in waste of the full potential of the resource. Another 2021 article, *Pore Space Property*,[6] articulated that absolute rule of capture currently applied to pore space will result in wasteful and inefficient use, coordination problems, and transaction costs that may eventually require statutory schemes to be resolved. Both pieces identify the particularized coordination challenges presented by rivalrous development among owners of common, yet fragmented resources. Those challenges, however, do not exist in large, contiguous areas of federal land. At least not yet. This essay is both more global in its identification of commonalities of waste across types of climate-critical resources and more specific in its focus on public lands. Drawing from the example of paradigm shifts in the field of oil and gas law, this essay argues that on federal land, there is an immediate opportunity to move beyond the rule of capture and to embrace new, less wasteful paradigms.

---

[3] *See, e.g.*, Exec. Order No. 14,008, 86 Fed. Reg. 7619 (Jan. 27, 2021); Infrastructure Investment and Jobs Act, Pub. L. No. 178-85, § 40307(a)(4), 135 Stat. 429, 1002 (2021) (amending 43 U.S.C. § 1337(p)(1)); Consolidated Appropriations Act, 2021, Pub. L. No. 116-260, div. Z, 134 Stat. 1182, 2418–615; *id.*, div. S, 134 Stat. at 2243–71.

[4] K.K. DuVivier & Brendan Mooney, *Moat Mentality: Onshore and Offshore Approaches to Wind Waking*, 1 NOTRE DAME J. EMERGING TECH. 1, 12 (2020).

[5] K.K. DuVivier, *Preventing Wind Waste*, 71 AM. U. L. REV. 1 (2021).

[6] Joseph Schremmer, *Pore Space Property*, 2021 UTAH L. REV. 1, 14, 47 (2021).

I. The Evolution of Oil & Gas Paradigms

It took the oil and gas industry almost a century of waste to evolve into a more cooperative system of development. Following the recognition of oil as a recoverable resource in Ohio in 1833,[7] courts struggled to apply existing jurisprudential philosophies about the nature of property to interests in oil and gas. Courts eventually articulated a "rule of capture"[8] that gave owners not only the right to extract oil from under their own lands, but because of the fugacious nature of oil and gas to migrate across properties, also the legal right to extract "all of the oil and gas [from adjacent properties] that will [also] flow out of the well on one's land."[9]

Despite its judicial efficiencies, the rule of capture resulted in extensive physical and economic waste of oil resources.[10] The absolute nature of the rule encouraged overproduction. Because the resource was subject to drainage by neighboring properties, an owner who delayed development might recover nothing. Efforts to preserve the resource on one property would be stymied by even more vehement production from others. Driven by the notion that "half a loaf is better than none," mineral owners drilled wherever they could make an individual profit by doing so, without regard to pressure maintenance, market, or availability of transportation. Oil, which could not be sold or transported, stood in pools at the surface and leached back into the ground.[11] Overproduction dissipated natural pressure-drives within reservoirs, stranding oil underground and "watering out" wells with brine.[12] Sometimes less than five percent of a field's oil was produced.[13] Waste in Spindletop, Texas, was so egregious that it has become eponymous for the commons-tragedy that can result from the "rapid and uncontrolled production" encouraged by the rule of

---

[7] EUGENE O. KUNTZ, 1 A TREATISE ON THE LAW OF OIL AND GAS 7–8 (1987) (citing AM. J. SCI. 21–26 (July 1833)) (describing evidence of oil well drilling in Washington County, Ohio); DANIEL YURGIN, THE PRIZE: THE EPIC QUEST FOR OIL, MONEY & POWER 30 (2008) (describing "Colonel" Edwin Drake's 1859 discovery of oil through drilling in Titusville, Pennsylvania); EDGAR WESLEY OWNE, TREK OF THE OIL FINDERS: A HISTORY OF EXPLORATION FOR PETROLEUM (1975).

[8] Westmoreland & Cambria Nat. Gas Co. v. De Witt, 18 A. 724, 725 (Pa. 1889).

[9] Brown v. Humble Oil & Refin. Co., 83 S.W.2d 935, 940 (Tex. 1935).

[10] *See* K.K. DuVivier, *Sins of the Father*, 1 TEX. A&M REAL PROP. L.J. 391, 402–07 (2014); David E. Pierce, *Minimizing the Environmental Impact of Oil and Gas Development by Maximizing Production Conservation*, 85 N.D. L. REV. 759, 759 (2009); Jacqueline Lang Weaver, *The Tragedy of the Commons from Spindletop to Enron*, 24 J. LAND RES. & ENV'T L. 187, 187–88 (2004). *See generally* JUDITH WALKER LINSLEY ET AL., GIANT UNDER THE HILL: A HISTORY OF THE SPINDLETOP OIL DISCOVERY AT BEAUMONT, TEXAS IN 1901 (2002).

[11] Champlin Refin. Co. v. Corp. Comm'n of Okla., 286 U.S. 210, 228 (1932) ("In Oklahoma prior to the passage of the Act, large quantities of oil produced in excess of transportation facilities or demand therefor were stored in surface tanks, and, by reason of seepage, rain, fire and evaporation, enormous waste occurred.").

[12] *Id.* ("Uncontrolled flow of flush or semiflush wells for any considerable period exhausts an excessive amount of pressure, wastefully uses the gas, and greatly lessens ultimate recovery."); Humble Oil & Refin. Co. v. West, 508 S.W.2d 812, 816 (Tex. 1974).

[13] FRED BOSSELMAN ET AL., ENERGY, ECONOMICS AND THE ENVIRONMENT: CASES AND MATERIALS 254 (3d ed. 2010).

capture.[14] At its peak, production was so profligate that prices plummeted: one could buy an entire barrel of oil for less than one would pay for a cup of water.[15] Ten years later, "Spindletop was a virtual ghost town."[16] Over-drilling also exacted its own costs: in addition to the economic losses from unrecovered and wasted oil, the rule of capture resulted in losses of up to $100 million a year for the drilling, equipping, and operating of unnecessary wells.[17]

As issues of scarcity and waste mounted, states moved to significantly constrain the rule of capture to optimize production. The formation of the Interstate Oil Compact Commission ("IOCC") in 1935, almost a century after the first oil was recovered in Ohio, signaled a paradigm shift.[18] Model regulations created by the IOCC included spacing rules to encourage optimal development of the resources[19] and mechanisms, such as pooling and unitization, to allow for combination of numerous property interests within a spacing unit or pool to coordinate development and provide for equitable allocation of costs and benefits.[20] Iterations of these conservation measures have been incorporated into statutes in nearly every state with significant oil and gas production activities[21] and in federal statutes and regulations.[22]

Whereas the absolute rule of capture was favored during initial periods of definition and scientific awareness, the shift to an "era of conservation"[23] signaled a

---

[14] *Id.*
[15] *Id.* ("A glut of oil dropped the price to as little as three cents a barrel, while a cup of water cost five cents.").
[16] *Id.*
[17] Robert E. Hardwicke, *Oil-Well Spacing Regulations and Protection of Property Rights in Texas*, 31 TEX. L. REV. 99, 111 & n.27 (1952) (calculating the economic waste from 1947 to 1952).
[18] *See* Owen L. Anderson, *The Evolution of Oil and Gas Conservation Law and the Rise of Unconventional Hydrocarbon Production*, 68 ARK. L. REV. 231, 240 (2015). The IOCC is now the Interstate Oil and Gas Compact Commission. *See id.* at 237, 257.
[19] *See id.* at 237 & n.33.
[20] Pooling is the combining of small tracts of land into an acreage that is sufficiently large to both secure a well permit and meet the spacing rules of a respective conservation commission, whereas unitization combines many spacing units into a fieldwide unit for the coordinated operation of several tracts on a reservoir, usually to conduct secondary recovery operations. JACQUELINE LANG WEAVER, UNITIZATION OF OIL AND GAS FIELDS IN TEXAS: A STUDY OF LEGISLATIVE, ADMINISTRATIVE, AND JUDICIAL POLICIES 7–8 (Res. for the Future Press 2011).
[21] Tara K. Righetti, *The Incidental Environmental Agency*, 2020 UTAH L. REV. 685, 697 (2020).
[22] Unitization has been available to lessees of federal land since at least 1931, *see* T. J. Files, *The Federal Exploratory Unit Agreement: Its Advantages and Disadvantages Insofar As the Fee Mineral Owner Is Concerned*, 14 WYO. L.J. 112, 114 (1960), and was incorporated into the 2004 version of the Model Oil and Gas Conservation Act, Owen L. Anderson & Ernest E. Smith, *Exploratory Unitization Under the 2004 Model Oil and Gas Conservation Act: Leveling the Playing Field*, 24 J. LAND RES. & ENV'T L. 277, 277 (2004).
[23] Laura H. Burney, *A Pragmatic Approach to Decision Making in the Next Era of Oil and Gas Jurisprudence*, 16 J. ENERGY NAT. RES. & ENV'T L. 1, 55 (1996) (citing Robert E. Sullivan, *A Survey of Oil and Gas Law in Montana as It Relates to the Oil and Gas Lease*, 16 MONT. L. REV. 1, 16 (1955)). Sullivan defined three eras: the Era of Definition and Comparative Ignorance, the Era of Scientific Awareness, and the Era of Conservation. *Id.* Burney mentions a fourth era—the

recognition of the reciprocal nature of oil and gas rights as existing within an interconnected resource that could only be fully enjoyed through coordinated development.[24] The push towards cooperative development has been further animated by the enhanced coordination challenges posed by unconventional development, enhanced resource recovery, and suburban and urban drilling.[25] Consistent with these changes, early drainage prevention rules, such as property line setbacks, have been largely displaced by cooperative development mechanisms allowing for pooling, allocation, and unitization.[26] These in turn have facilitated more efficient resource recovery and management of cumulative environmental impacts.[27]

Just as the evolution of oil and gas development provides a cautionary tale regarding waste in the capture-based allocation of resources, it also illustrates the promise of regulation which overcomes coordination problems and facilitates cooperative, resource-scale development. Embracing similar paradigm shifts early is essential to assuring optimal use of federally owned property to meet decarbonization goals.

II. From the Sky to the Center of the Earth: Waste of Geologic Storage and Wind Generation Capacity

When geologic storage and wind resources become fragmented, capture-based paradigms are both under and over inclusive. Underuse resulting from protectionism results in waste of the resource through non-development; overuse squanders it through inefficiency. Both limit the potential of public lands to address climate and result in public revenue losses.

Overdevelopment by competing interest holders within carbon storage reservoirs may result in physical waste of the subsurface storage capacity, economic waste through drilling of unnecessary wells, or increased environmental risks.[28] Carbon capture and storage requires immense subsurface reservoirs for permanent

---

Environmental Era—coined based on a work of James M. Colosky, *The Implied Covenant for Diligent and Prudent Operation in an Environmental Era*, 39 ROCKY MTN. MIN. L. INST. § 15 (1993). Burney, *supra*, at 56.

[24] Schremmer, *supra* note 6, at 46–47; David E. Pierce, *Carol Rose Comes to the Oil Patch: Modern Property Analysis Applied to Modern Reservoir Problems*, 19 PA. ST. ENV'T L. REV. 241, 246, 253–57 (2011).

[25] David E. Pierce, *Coordinated Reservoir Development—An Alternative to the Rule of Capture for Development of Oil and Gas*, 4 J. ENERGY L. & POL'Y 1, 62 (1983).

[26] For in-depth analysis of pooling and unitization, see generally Weaver, *supra* note 20; Nancy Saint-Paul, 4 SUMMERS OIL AND GAS § 54.2 (3d ed. 2013).

[27] *See* Righetti, *supra* note 21, at 751 (describing Colorado's regulatory frameworks for Comprehensive Drilling Plans and the Wattenberg Spacing Rule); Tara Righetti, Hannah Wiseman & James Coleman, *The New Oil and Gas Governance*, 130 YALE L.J. F. 51 (2020).

[28] Schremmer, *supra* note 6, at 58–59.

geologic sequestration of CO_2.[29] These potential storage resources exist often thousands of feet below the surface in the small porous voids within subsurface rock formations called "pore space."[30] As CO_2 is injected into the pore space, the gas migrates, displacing brine and creating pressure plumes around the areas of injection.[31] Over-pressuring caused by uncoordinated or excessive injections of CO_2 into the storage reservoir decreases holding capacity of the reservoir[32] and may increase geo-mechanical damage, risk of induced seismicity, and costs and coordination issues associated with pressure management techniques.[33] Thus, while CO_2 plumes can stabilize following conclusion of injection operations,[34] a capture paradigm that encourages continuous injection by multiple parties may present additional environmental risks or increase project costs. Moreover, injection by multiple parties within a storage complex may be inconsistent with environmental regulatory programs designed to control for leakage risk and groundwater contamination.[35]

In wind, overuse through placement of too many turbines or lack of coordinated placement of turbines can cause physical and economic waste as well as increased environmental risks. Wind turbines generate electricity when their large blades turn a generator. Studies, some dating back to the first large-scale wind farms in the 1980s,[36] have shown that the turbine blades create downwind turbulence or "wakes"

---

[29] The amount needed for any project will depend on the storage capacity which results from factors including formation thickness, pressure, and porosity. *See* M. Szulczewski et al., *Theoretical Analysis of How Pressure Buildup and CO_2 Migration Can Both Constrain Storage Capacity in Deep Saline Aquifers*, 23 INT'L J. GREENHOUSE GAS CONTROL 113, 118 (2014).

[30] Tara Righetti, *Correlative Rights and Limited Common Property in the Pore Space: A Response to the Challenge of Subsurface Trespass in Carbon Capture and Sequestration*, 47 ENV'T L. REP. 10,420 (May 2017). Based on U.S. Geological Survey estimates, federal lands overlay approximately 130 million acres of usable pore space. *See* MARC L. BUURSINK ET AL., U.S. GEOLOGICAL SURVEY, SCIENTIFIC INVESTIGATIONS REPORT NO. 2015–5021, NATIONAL ASSESSMENT OF GEOLOGIC CARBON DIOXIDE STORAGE RESOURCES—ALLOCATIONS OF ASSESSED AREAS TO FEDERAL LANDS 12 fig.2 (2015).

[31] Hossein Jahediesfanjani, Peter D. Warwick & Steven T. Anderson, *3D Pressure-Limited Approach to Model and Estimate CO_2 Injection and Storage Capacity: Saline Mount Simon Formation*, 7 GREENHOUSE GASES SCI. & TECH. 1080 (2017).

[32] Szulczewski, *supra* note 29.

[33] Thomas A. Buscheck et al., *Active CO_2 Reservoir Management for Carbon Storage: Analysis of Operational Strategies to Relieve Pressure Buildup and Improve Injectivity*, 6 INT'L J. GREENHOUSE GAS CONTROL 230, 231 (2012); Jens T. Birkholzer et al., *CO_2 Migration and Pressure Evolution in Deep Saline Aquifers*, 40 INT'L J. GREENHOUSE GAS CONTROL 203, 210–17 (2015).

[34] Rajesh Pawar et al., *Assessment of Relationship Between Post-Injection Plume Migration and Leakage Risks at Geologic CO_2 Storage Sites*, 101 INT'L J. GREENHOUSE GAS CONTROL 103, 138 (2020).

[35] Geologic storage activities are regulated under Class VI of the Underground Injection Control program, which contemplates management of plumes within the storage complex through extensive monitoring, verification, and reporting requirements, may require corrective action within the broader Area of Review, and permits site closure only after sustained demonstration of plume stability. *See* 40 C.F.R. §§ 144.11–144.19, 144.51 (2021).

[36] Neil D. Kelley, BOUNDARY LAYER TURBULENCE AND TURBINE INTERACTIONS WITH A HISTORICAL PERSPECTIVE 18–19 (2010); *see also* Neil D. Kelley et al., *Using Wavelet Analysis to Assess*

much like a boat making waves in the water as it moves.[37] Wind wakes result in two distinct forms of loss for a wind farm: equipment damage[38] and energy loss.[39] For example, with respect to equipment damage, wind developers sometimes place their turbines so close to a neighbor's that they cause premature fatigue and damage to the neighbor's turbines. In addition, with respect to energy loss, wind developers are incentivized to effectively "steal" wind energy from neighbors because, under the rule of capture, they can maximize energy recovery within the boundaries of their projects without any incentive to maximize recovery of the entire wind resource across different ownerships.[40] Overuse may further encourage economic waste though overinvestment in turbines. Like injection wells in over-pressured formations, downwind turbines that can no longer produce to the estimated capacity become wasted infrastructure—much of which the public has helped finance through tax or other incentives. Competitive development also encourages unnecessary duplication of infrastructure, such as substations and transmission lines. Finally, any additional unnecessary turbines increase potential disruption of animal habitat and other environmental risks.

Protective behavior encouraged by fragmentation and capture rules may similarly encourage waste through underutilization. Wind generation and carbon storage requires extensive resource modeling and investments in land and infrastructure. In order to prevent investment losses, a capture-based paradigm encourages protective behavior including uses of setbacks or moats to prevent interference or damage.[41] In the terrestrial wind industry,[42] private developers have resorted to creating moats or buffer zones around many of their projects as a protective measure for themselves.[43] Although strategies in carbon storage are less developed due to the newer nature of the industry, developers may adopt similar protective leasing strategies to prevent "pressure perturbations" and other conflicting uses within the pressure plumes created by injection activities to respond to similar

---

Turbulence-Rotor Interactions, 3 WIND ENERGY 121, 129–34 (2000) (expressing the importance of adequate wind flow to maintain reduced fatigue damage in turbines).

[37] *See, e.g.*, Julie K. Lundquist et al., *Costs and Consequences of Wind Turbine Wake Effects Arising from Uncoordinated Wind Energy Development*, 4 NATURE ENERGY 26, 26 (2019); Kimberly E. Diamond & Ellen J. Crivella, *Wind Turbine Wakes, Wake Effect Impacts, and Wind Leases: Using Solar Access Laws as the Model for Capitalizing on Wind Rights During the Evolution of Wind Policy Standards*, 22 DUKE ENV'T L. & POL'Y F. 195, 195 (2011); TROY A. RULE, SOLAR, WIND AND LAND: CONFLICTS IN RENEWABLE ENERGY DEVELOPMENT 50 (2014) (explaining how downward wake impacts can create a claim for nuisance); Troy A. Rule, *A Downwind View of the Cathedral: Using Rule Four to Allocate Wind Rights*, 46 SAN DIEGO L. REV. 207, 208–09 (2009) (explaining that downwind wake effects can stretch more than half a mile)

[38] DuVivier & Mooney, *supra* note 4, at 12–15.

[39] Lundquist et al., *supra* note 37, at 26–31.

[40] DuVivier, *supra* note 5, at 57.

[41] DuVivier & Mooney, *supra* note 4, at 25–28.

[42] To date, most onshore wind energy development has been on private lands. *See id.* at 7 & n. 37 (noting that, as of early 2019, only "3.284 GW of the U.S. total of more than 100 GW had been developed on [federal Bureau of Land Management] . . . land").

[43] *Id.* at 25–28.

issues including equipment risk and reduced economics.[44] While these may prevent damage in terms of over-pressurization or turbine damage, they also leave swaths of the resource undeveloped and thus diminish the total available utility of the resource.

There is a strong public interest in preventing waste of geologic storage and wind resources on public lands. Waste that reduces the given resource's capacity for electricity generation or storage undermines climate mitigation and diminishes revenue to the public from use of those lands. A 2018 Nature Energy article about the scope of wake impacts calculated that an upwind farm's wakes caused significant decreases in the amount of electricity generated by a downwind farm in Texas, resulting in a loss of revenue of up to $730,000 in lost sales and $2 million in lost production tax credits annually.[45] In addition, the value of the fossil-fuel generated power that the wind farm displaced over the study period represented an additional $4.1 million loss based on a social cost of carbon of $37 per ton.[46] Although economic models for use of pore space are less certain,[47] the value of the pore space exists in its capacity for storage.[48] It therefore reasons that unnecessary depletion of that capacity will both diminish total storage capacity and, with it, the potential revenue available from the section 45Q tax credit and other sources.[49]

III. Regulation for Cooperative Development

As storage and wind resources become fragmented by the grant of leasing and development rights, facilitating coordinated development among users of public lands will be essential to prevent waste and assure optimal use of climate-critical resources. Doing so requires a paradigm shift in the way rights to develop climate-critical resources are granted and managed on federal lands.

Where the government is the owner of large uninterrupted areas of contiguous property, it can coordinate development to assure optimal resource development.[50]

---

[44] *See* Jens T. Birkholzer et al., *Brine Flow up a Well Caused by Pressure Perturbation from Geologic Carbon Sequestration: Static and Dynamic Evaluations*, 5 INT'L J. GREENHOUSE GAS CONTROL 850 (2011).

[45] Lundquist et al., *supra* note 37, at 28; *see also* Diamond & Crivella, *supra* note 37, at 209–13; RULE, *supra* note 37, at 50; Rule, *supra* note 37, at 215–40.

[46] Lundquist et al., *supra* note 37, at 28.

[47] Publicly available examples of pore space leases on state lands favor a tipping fee model similar to that used in wastewater disposal, wherein the pore space owner would be paid a fee per metric ton of CO_2 injected. *See, e.g.*, Carbon-Dioxide Storage Agreement, La. R.S. 30:209(4)(e) (Sept. 22, 2021), https://perma.cc/KDT8-4H6V.

[48] *See* R. Lee Gresham & Owen L. Anderson, *Legal and Commercial Models for Pore-Space Access and Use for Geologic CO_2 Sequestration*, 72 U. PITT. L. REV. 701, 702 (2011).

[49] *Id.*

[50] Unitization laws allowing the combination of fragmented private, state, and federal interests for cooperative self-governance among owners may further encourage resource scale development, while also providing justice to owners by assuring each owners' rights of reasonable use and protection against waste. North Dakota, *see* N.D. CENT. CODE ANN. § 38-22-08 to -10 (2021), Wyoming, *see* WYO. STAT. ANN. § 35-11-313 to -316 (2021), and Kentucky, *see* KY. REV. STAT. ANN. § 353.806 (2021),

Uniformity of ownership naturally reduces the transaction costs and destructive self-interest that contributed to capture-based waste.[51] Implementation of leasing systems that fragment resources and encourage competitive behavior and capture among grantees, however, may reduce the benefits of uniform ownership[52] and risk repeating wasteful precedents. Accordingly, Congress should exercise its authority to dispose of federal property[53] to assure that managing agencies are empowered to grant development rights and adopt conservation mechanisms in a manner that prevents waste. It can do so by aligning the scope of development rights with optimal use of the resource. As agencies develop rules and guidance, they should encourage granting rights such that duration and scope align with the physical properties of the resource and with factors relative to the resource's optimal use.

Where resources have already been fragmented, laws and regulations should encourage cooperative development of federal resources among different rights holders to prevent waste.[54] For geologic storage, authorizing unitization would encourage cooperative plans of development to manage pressures and injections within the resource, and would align with requirements of environmental regulations for corrective action, monitoring and reporting, and site closure. Rather than incorporating setbacks into adjacent wind leases, as has been done in some offshore grants,[55] utilizing cooperative development in the form of resource-wide development plans, spacing rules, and providing shared returns for turbines along lease boundaries may be some of the best solutions for preventing wind waste. These mechanisms would also encourage development of shared and adaptable infrastructure such as meshed transmission systems that can incorporate future growth and prevent interruptions.[56]

The time to make these changes is now, before capture-based systems become entrenched by existing grants, investments, and infrastructure. In many areas,

---

already have such laws. Joseph Schremmer, *A Unifying Doctrine of Subsurface Property Rights*, 46 HARV. ENVTL. L. REV. (forthcoming 2022).

[51] Tara Righetti & Joseph Schremmer, *Waste and the Governance of Private and Public Property,* 93 COLO. L. REV. 611, 660 (2022).

[52] Karen Bradshaw & Dean Lueck, *Contracting for Control of Landscape-Level Resources*, 100 IOWA L. REV. 2507, 2544 (2015).

[53] U.S. CONST. art. IV; Anthony Moffa, *Constitutional Authority, Common Resources, and the Climate*, 2022 UTAH L. REV. 169, 211–12 (2022).

[54] Most grants of interests in federal land include provisions subjecting the grants to future laws and regulations regarding the disposition of federal land, thus allowing for an overlay of cooperative structures.

[55] *See, e.g.*, BUREAU OF OCEAN MGMT., U.S. DEP'T OF THE INTERIOR, COMMERCIAL LEASE OF SUBMERGED LANDS FOR RENEWABLE ENERGY DEVELOPMENT ON THE CONTINENTAL SHELF, at C-17 add. C (Apr. 1, 2019), https://perma.cc/L8HA-2AE5 ("In its COP [construction and operations plan] project design, the Lessee must incorporate a 750 m setback from any shared lease boundary within which the Lessee may not construct any surface structures, unless the Lessee and the adjacent lessee agree to a smaller setback, the Lessee submits such agreement to BOEM [the Bureau of Ocean Energy Management], and BOEM approves it.").

[56] Heather Richards, *Is Mesh the Answer to Offshore Wind's Grid Troubles?*, E&E NEWS (Mar. 24, 2022), https://perma.cc/Z7AX-LKG8.

development rights have not yet been granted or programs are either nascent or under development. The Department of the Interior has yet to promulgate regulations or new guidance regarding its process for granting storage rights in federal land.[57] Although the framework for wind energy is more developed, as of the time of this writing, only two offshore wind projects in federal waters have been approved, and only one of these has broken ground.[58] There is still time for federal agencies to pivot towards cooperative development and conservation models while the patterns and expectations for development on federal lands have not calcified. By adopting cooperative structures now, before existing grants and investments in infrastructure create path dependency, there is an opportunity to realize greater efficiencies in development.

Preventing fragmentation and adopting cooperative development mechanisms can advance multiple policy aims including preventing waste, encouraging investment, optimizing development, and protecting environmental values. Coordination mechanisms can further encourage efficiencies in development and design, thus limiting the industrial footprint of climate infrastructure.

Conclusion

Federal investments in research and development,[59] loan guarantees,[60] and tax programs[61] have spurred innovation such that, today, geologic carbon storage and

---

[57] The Infrastructure, Investment, and Jobs Act, passed in 2021, amended section 8(p)(1) of the Outer Continental Shelf Lands Act to authorize issuance of leases, easements, or rights of way that "provide for, support, or are directly related to the injection of a carbon dioxide stream into sub-seabed geologic formations for the purpose of long-term carbon sequestration" and directs DOI to promulgate regulations within a year. *See* Infrastructure Investment and Jobs Act, Pub. L. No. 178-85, § 40307(a)(4), 135 Stat. 429, 1002 (2021) (codified as amended at 43 U.S.C. § 1337(p)(1)); Tara Righetti et al., *The Carbon Storage Future of Public Lands*, 38 PACE ENV'T L. REV. 181, 186–88 (2021).

[58] On May 11, 2021, the Bureau of Ocean and Energy Management ("BOEM") granted final approval for Vineyard Wind I, the first U.S. commercial offshore wind project. After years of delays, this project, which will generate 800 megawatts of electricity annually, broke ground about six months later. Press Release, U.S. Dep't of the Interior, Secretary Haaland, Massachusetts Leaders Celebrate Groundbreaking of Nation's First Commercial Offshore Wind Project in Federal Waters (Nov. 18, 2021), https://perma.cc/5BZ8-NZUL. Less than a week after the Vineyard Wind I groundbreaking, BOEM granted final approval for the United States' second commercial wind project, South Fork Wind, offshore of Rhode Island. Press Release, U.S. Dep't of the Interior, Interior Department Approves Second Major Offshore Wind Project in U.S. Federal Waters (Nov. 24, 2021), https://perma.cc/K46J-36CJ.

[59] ASHLEY LAWSON, CONG. RSCH. SERV., IF11861, FUNDING FOR CARBON CAPTURE AND CARBON REMOVAL AT DOE (2021).

[60] *DOE Loan Guarantees & IRS Guidance on 45Q Tax Credit Could Benefit Carbon Capture Projects*, U.S. DEP'T OF ENERGY (Feb. 21, 2020), https://perma.cc/MGS9-BULZ.

[61] 26 U.S.C. § 45Q; 42 U.S.C. § 13317; Deepika Nagabhushan & John Thompson, *Carbon Capture & Storage in the United States Power Sector: The Impact of 45Q Federal Tax Credits*, CLEAN AIR TASK FORCE (Feb. 2019), https://perma.cc/CN2P-DUUG; *see, e.g.*, Denbury, Inc., Annual Report (Form 10-K) 38 (Dec. 31, 2021) ("We believe the incentives offered under Section 45Q of the Internal Revenue

offshore wind development are technically and economically feasible. New federal laws and regulations authorizing development create the possibility of new a land rush for climate resources on federal lands across the United States. Preventing waste of climate-critical federal resources benefits the public by accelerating development of carbon-reducing or carbon-free technologies that help mitigate climate change and drive economic activity, and—because federal lands are a collective asset—assuring maximal economic returns to the public. Faced with a precipitous and urgent mandate to decarbonize, the world cannot afford 100 years of waste and underinvestment before heralding a paradigm shift that embraces conservation and cooperative development of resources necessary to the energy transition.

Code ('Section 45Q') or otherwise will drive demand for CCUS and will allow us to collect a fee for the transportation and storage of captured industrial-sourced CO2, including CO2 utilized in our EOR operations. As the enhanced Section 45Q regulations are relatively new, it will likely take several years to construct new capture facilities and for dedicated storage sites to be developed.").