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ARTICLES

COMMENTS

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UNFIXABLE: FIXED VS. FLOATING ROYALTIES AT THE TEXAS SUPREME COURT

Demetri J. Economou[*]

I. INTRODUCTION

On a January morning in 1924, George Hill Mulkey rose to the crackle of frost in the trees. It would be too cold to go to the farm—a little place, only a few acres, but still somewhere to go in his old age. There was always work to be done on the farm.

George Mulkey was seventy-seven and, by all measure, his life had been a success. He'd been a soldier, banker, inventor, rancher, and public servant. "Uncle George" to most of Fort Worth, he accumulated vast wealth and influence. But he did not love those things. Not like he loved the farm.

George had business in town anyway. He would ride the streetcar downtown to the office of his friend and lawyer, W. E. Williams. There he'd sign over the deed to the Mulkey Ranch in exchange for $58,850; a century later that deed would land in front of the Texas Supreme Court in a case called *Van Dyke*.[1]

Perhaps it would be warm enough to go to the farm that afternoon.

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1. Van Dyke v. Navigator Grp., 668 S.W.3d 353, 357 (Tex. 2023).

The people who execute deeds are ultimately just that: people. Some are uneducated. Some are poor. And some, like George Mulkey, are neither.[2] Yet the current application of the "legacy of the one-eighth royalty" and the "estate misconception theory," as applied to the Mulkey Deed in *Van Dyke*, takes nothing of individual differences into account.[3] According to the current formulation, a wealthy man is just as capable of being misconceived as to the nature of his estate as a poor man.[4] A person advised by lawyers is treated the same as one who could not even read the instrument he was signing.

If certain words appear in a deed, we now presume—take as "patent evidence"—that the person was misconceived as to the nature of his estate.[5] Geniuses and imbeciles are treated alike. This is pure folly.

The Mulkey Deed had those magic words, consisting of a double-fraction ending in "one-eighth" (a reservation in the Mulkeys of "one-half of one-eighth of all minerals").[6] Under the estate misconception theory, this "of one-eighth" is patent evidence that George Mulkey was misconceived as to the nature of his mineral interest and believed "one-eighth of all minerals" to actually mean "all minerals."[7]

When he reserved "one-half of one-eighth" in 1924, he intended to reserve one-half of all their minerals.

George Hill Mulkey died in 1926, on his farm, of a heart attack.[8]

This paper does not attempt to evaluate the personal circumstances of every party to a famous double-fraction conveyance and, indeed, that would be both impossible and unnecessary. Cases prior to *Van Dyke* (and, arguably, *Hysaw*) did not suggest this analysis as required and would have undoubtedly found it outside the four corners rule and its exceptions.

Van Dyke, however, purports to undertake a "full contextual analysis" of the deed at issue and then, to apply a broad presumption to all people executing instruments with double-fractions of one-eighth.[9] By evaluating how people in 1924 thought and what they were perceived to know, the court attempted to enter the minds of the parties to the Mulkey Deed. This is beyond deriving intent, in the author's view. This is clairvoyance.

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2. *See George Hill Mulkey Biography*, GENEALOGY MAGAZINE, https://www.genealogymagazine.com/george-hill-mulkey-biography (last visited Jan. 30, 2024).
3. *See Van Dyke*, 668 S.W.3d at 359.
4. *See id.*
5. *Id.* at 363.
6. *Id.* at 357–58.
7. *Id.* at 359.
8. *See Uncle George: Soiled Doves Riff-Raff, and Roller Skates*, HOMETOWN BY HANDLEBAR (Jan. 20, 2023), https://hometownbyhandlebar.com/?paged=44 (detailing the fascinating life of George Hill Mulkey, from his time as a fifteen-year old Confederate soldier to his death on the farm).
9. *See Van Dyke*, 668 S.W.3d at 364.

And so, we return to the premise demonstrated by George Mulkey's individual characteristics: George Mulkey was a unique person.[10] What George Mulkey knew or did not know was unique to him. How George Mulkey and his successors treated their interest was unique to their circumstances. We cannot and should not presume that it was the same as the rest of the world. Yet that is the presumption that the Texas Supreme Court asks us to make after *Van Dyke*.[11]

This paper attempts to unpack the pained history of the estate misconception theory and the presumed grant doctrine. We will consider whether these doctrines are pervasive, or even important, doctrines in modern title examination and whether the Texas Supreme Court has perhaps exaggerated their function. Finally, we will consider the uncertainties in Texas law concerning royalty interests following *Van Dyke*.

II. THE ESTATE MISCONCEPTION THEORY

"Estate misconception" was coined as a term in 1993 by Laura H. Burney, then an associate professor at St. Mary's School of Law in San Antonio.[12] The Texas Supreme Court's formulation of the estate misconception theory, as originally announced in *Hysaw*, draws directly from Professor Burney's writing:

> This theory refers to a once-common misunderstanding (perpetuated by antiquated judicial authority) that a landowner retained only 1/8 of the minerals in place after executing a mineral lease instead of a fee simple determinable with the possibility of reverter in the entirety. "For example, a lessor who has leased the entire mineral estate, but desires to sell-one half [sic] of the minerals, would assume that he owned 1/8 of the minerals due to the existing lease . . . [and] would use the fraction 1/16, or a double fraction, 1/2 of 1/8, to convey 1/2 of what he perceived he owned."[13]

Professor Burney's definition is in turn drawn from the Williams & Meyers treatise, whose authors "suspect the use of the double fraction is a mistake," but nonetheless then applied straight multiplication of double fractions such as "1/16 of 1/8" as equaling 1/128.[14]

Hysaw refined the concept of "suspect[ed] mistake" into the "specter of estate misconception."[15] Both the Texas Supreme Court and Williams &

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10. *See Uncle George: Soiled Doves, Riff-Raff, and Roller Skates*, *supra* note 8.
11. *See Van Dyke*, 668 S.W.3d at 364.
12. *See* Laura H. Burney, *The Regrettable Rebirth of the Two-Grant Doctrine in Texas Deed Construction*, 34 S. TEX. L. REV. 73, 89 (1993).
13. Hysaw v. Dawkins, 483 S.W.3d 1, 10 (Tex. 2016) (quoting Laura H. Burney, *The Regrettable Rebirth of the Two–Grant Doctrine in Texas Deed Construction*, 34 S. TEX. L. REV. 73, 89 (1993)).
14. 2 HOWARD R. WILLIAMS & CHARLES J. MEYERS, OIL & GAS LAW § 327.3 (2000).
15. *See Hysaw*, 483 S.W.3d at 15.

Meyers therefore were skeptical about a bright-line rule governing double-fractions: "Though we acknowledge the call for more certain and predictable guidance, we reject bright-line rules of interpretation that are arbitrary and, thus, inimical to an intent-focused inquiry."[16] After all, a court's role is to give effect to the intent of the parties "as expressed in the [instrument's] four corners" through harmonization of the entire instrument and all its clauses.[17]

The Texas Supreme Court in *Hysaw* therefore refused to apply "a mechanical approach requiring rote multiplication of double fractions whenever they exist" (as advocated by Williams & Meyers).[18] But the court eschewed *all* mechanical, bright-line rules, not just those calling for straight multiplication and a fixed interest calculation; it reinforced the four corners doctrine and deriving the intent of the parties (which is necessarily a case-by-case inquiry), and it refused to apply estate misconception as dispositive or even as a presumption.[19] As to estate misconception, particularly, Justice Guzman wrote that "[t]he estate-misconception theory and the historical use of 1/8 as the standard royalty may inform the meaning of fractions stated in multiples of 1/8, but these considerations are not alone dispositive."[20]

In other words, the Texas Supreme Court in *Hysaw* gave a traditional ruling on deed interpretation: instruments are to be evaluated on a case-by-case basis under the four corners rule in order to derive the intent of the parties.[21] The court reached a floating royalty interest the same way as previous appellate decisions in *Luckel v. White* and *Butler v. Horton*, by evaluating differing fractions in the same instrument, some which signaled a fixed interest and others floating royalty interest, in light of an existing lease for a one-eighth royalty.[22]

In *Luckel*, the Texas Supreme Court was confronted with the following clauses:

- Three instances of "an undivided 1/32 royalty interest"; and
- Two instances of "1/4 of any and all royalties";
- One instance of "1/2 of 1/16 royalty"; and

16. *Id.* at 4 (citing Concord Oil Co. v. Pennzoil Expl. & Prod. Co., 966 S.W.2d 451, 460–61 (Tex. 1998); Luckel v. White, 819 S.W.2d 459, 464 (Tex. 1991)).

17. *Id.*

18. *Id.*

19. *See id.*

20. *Id.* at 13 (citing ANTONIN SCALIA & BRYAN A. GARNER, READING LAW: THE INTERPRETATION OF LEGAL TEXTS 78 (2012) ("Words must be given the meaning they had when the text was adopted.")).

21. *See id.* at 16.

22. *See id.*

- Surrounding circumstances: active lease with 1/8 lease royalty.[23]

Let us first note that there was no contention of ambiguity.[24] Therefore, the court was left to interpretation based on the four corners of the instrument and any surrounding circumstances of execution (but not parol evidence).[25]

The first-listed references are clearly in conflict: one thirty-second versus one-fourth.[26] To harmonize these conflicting parts of the instrument, the court looked only to the instrument itself, stating "it is not the actual intent of the parties that governs, but the actual intent of the parties *as expressed in the instrument as a whole*, 'without reference to matters of mere form, relative position of descriptions, technicalities, or arbitrary rules.'"[27]

"One-fourth of any and all royalties" is unambiguous and requires nothing further to inform the clear intent—*as expressed in the instrument*—to reserve a one-fourth royalty interest.[28] It cannot be assaulted by the existence of the next conflicting term: "one thirty-second royalty interest."[29] Conversely, in order to find the instrument reserved a "one thirty-second royalty interest," the court would have had to marry the concepts of "one-fourth and one-eighth," inserting a double-fraction where none existed.[30] The assertion of "one thirty-second royalty interest" cannot withstand the existence of "one-fourth of any and all royalties."[31] The court found in favor of the floating one-fourth royalty interest.[32]

Note here that *Luckel* does not present double fractions in the sense that we understand them in *Van Dyke* or *Hysaw*. The last reference contains something of a double-fraction, but it is misleading.[33] In this case, the grantor was conveying "one-half of the 1/16th royalty she owned, which conveyed royalty was *one-fourth of the total royalty* provided for in the [1/8] lease."[34] Therefore, the last reference supports the conveyance of one-fourth royalty interest, and is not a double-fraction like in *Hysaw* or *Van Dyke*.[35]

Butler v. Horton presented a similar dilemma but this time with a double-fraction.[36] In the year prior to *Hysaw*'s release, the Eastland Court of Appeals interpreted a reservation containing:

23. Luckel v. White, 819 S.W.2d 459, 461 (Tex. 1991) (reorganized for readability).
24. *Id.*
25. *Id.* at 461–62.
26. *See id.* at 461.
27. *Id.* at 462 (quoting Sun Oil Co. v. Burns, 84 S.W.2d 442, 444 (1935)) (emphasis in original).
28. *See id.*
29. *Id.* at 461.
30. *See id.* at 462.
31. *Id.*
32. *Id.*
33. *See id.* at 461.
34. *Id.*
35. *See id.*
36. *See* Butler v. Horton, 447 S.W.3d 514, 516 (Tex. App.—Eastland 2014, no pet.).

- One instance of "1/2 of the usual 1/8 royalty";
- One reference to "1/2 of the royalty *as provided above*"; and
- One reference of "1/2 of any bonus payments or delay rentals *as provided above*."[37]

Similar to *Luckel*, the Eastland Court found "1/2 of the royalty" and "1/2 of any bonus payments or delay rentals" to unambiguously express the intent to reserve a one-half royalty interest ("fraction of" or floating royalty).[38] Additionally, the conditioning of each phrase with "as provided above" gave the Eastland Court clarity that it should interpret that phrase above—one-half of one-eighth—as equivalent to the phrases below, both being one-half of royalty.[39]

The Eastland Court also states as follows: "As noted in *Williams & Meyers Oil and Gas Law* in a list of illustrations of provisions that result in fractions of royalty, a reference to one-half of the usual 1/8 royalty has been held to effectuate a reservation of a fraction of royalty."[40] This should not suggest to the reader that the Eastland Court was adopting, or that Williams & Meyers advocated, that *all* instances of "[fraction] of the usual 1/8 royalty" should be interpreted as a fraction of or floating royalty.[41]

We reach *Hysaw* and, while Justice Guzman evaluates the estate misconception theory, the disposition of the case is ultimately in line with *Luckel*, *Butler*, and similar cases.[42] In *Hysaw*, the Supreme Court analyzed Ethel Hysaw's will which contained the following provisions:

- Three instances of "1/3 of an undivided 1/8 of all oil, gas or other minerals in or under or that may be produced from said lands, the same being a non-participating royalty interest";
- Three instances of "1/3 of an 1/8 royalty"; and
- Three instances of "in the event of royalty sold during my lifetime, then [to devisee] 1/3 of the remainder of unsold royalty."[43]

The Court's decision is summed up in the following paragraph, which states that the final one-third royalty clause controls:

37. *See id.* at 516–17 (reorganized for readability).
38. *Id.* at 519.
39. *Id.*
40. *Id.* (citing 2 HOWARD R. WILLIAMS & CHARLES J. MEYERS, OIL AND GAS LAW § 327.2 (2013)).
41. *Id.*
42. *See* Hysaw v. Dawkins, 483 S.W.3d 1, 16 (Tex. 2016).
43. *Id.* at 5 (reorganized for readability).

> The third royalty clause demonstrates that Ethel intended the royalty devise to be equal and that re-equalization would be required if an inter vivos event diminished the available royalty. If Ethel had truly intended the fee-owning child to benefit exclusively from any excess royalty, as Inez's successors argue, equalization following a royalty-diminishing transaction would produce a paradoxical result. The only plausible construction supported by a holistic reading of the will is that Ethel used "one-eighth royalty" as shorthand for the entire royalty interest a lessor could retain under a mineral lease . . . . We therefore hold that Ethel's will devised to each child 1/3 of any and all royalty interest on all the devised land tracts.[44]

In sum, *Hysaw* is faithful to precedent in its interpretation of Ethel Hysaw's will.[45] Justice Guzman maintained the four corners rule, harmonized all parts of the instrument, and eliminated those royalty clauses that could not withstand the plain application of the other.[46] Like *Luckel* and *Butler*, this resulted in the interpretation of a floating royalty interest.[47] *Hysaw* does not establish the estate misconception theory as a means of reaching that royalty interpretation.[48]

After all, the court's words "double fractions in a mineral conveyance may or may not evince intent to fix the interest" are not compatible with "the appearance of 1/8 in the double fraction 'should be considered patent evidence that the parties were functioning under the estate misconception.'"[49]

A. From Hysaw *to* Van Dyke

The intervening seven years between *Hysaw* and *Van Dyke* were not without event. Soon after *Hysaw* (and with the Texas Supreme Court's opinion having been considered by the appellate court) the San Antonio Court of Appeals decided *Laborde Props. v. U.S. Shale Energy*, which would be reversed by the Texas Supreme Court in 2018.[50] Beginning with the appellate opinion, the San Antonio court considered the following provision:

> There is reserved and excepted from this conveyance unto the grantors herein, their heirs and assigns, an undivided one-half (1/2) interest in and to the Oil Royalty, Gas Royalty and Royalty in other Minerals in and under or that may be produced or mined from the above described premises, the same

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44. *Id.* at 15–16.
45. *See id.* at 16.
46. *Id.*
47. *Id.* at 15–16; *see* Luckel v. White, 819 S.W.2d 459, 464 (Tex. 1991); *see also* Butler v. Horton, 447 S.W.3d 514, 516–17 (Tex. App.—Eastland 2014, no pet.).
48. *See Hysaw*, 483 S.W.3d at 16.
49. *Id.* at 14; *but see* Laura H. Burney, *Interpreting Mineral and Royalty Deeds: The Legacy of the One-Eighth Royalty and Other Stories*, 33 ST. MARY'S L.J. 1, 24 (2001).
50. *See* Laborde Props., L.P. v. U.S. Shale Energy II, LLC, 551 S.W.3d 740, 755 (Tex. App.—San Antonio 2016), *rev'd*, 551 S.W.3d 148 (Tex. 2018)

> being equal to one-sixteenth (1/16) of the production. This reservation is what is generally termed a nonparticipating Royalty Reservation . . . .[51]

This is similar to a provision interpreted in the noteworthy case, *Graham v. Prochaska*:

> One-half (1/2) of the one-eighth (1/8) royalty to be provided in any and all leases for oil, gas and other mineral now upon or hereafter given on said land, or any part thereof . . . the same being equal to one-sixteenth (1/16th) of all oil, gas, and other minerals of any nature, free and clear of all costs of production, except taxes.[52]

Graham was interpreted as a floating royalty based on what the San Antonio court recited as: "(1) language in the deed objectively demonstrating the parties' assumption of '*the*' one-eighth (1/8) royalty in the current and all future leases; and (2) language in prior deeds establishing the creation of a floating interest."[53] According to the *Laborde* court, this rendered *Graham* distinguishable; *Laborde* only had a single clause to interpret.[54]

Because "this [single clause was] the only portion in the deed that [spoke] to the amount and nature of the reserved royalty interest," the San Antonio court only found itself to harmonize the two parts of this single provision.[55]

The San Antonio court substituted for "Oil Royalty" the fraction of one-eighth, and substituted "the same being" for an equal sign, rendering the full mathematical equation: 1/2 x 1/8 = 1/16.[56]

According to the San Antonio court, "[e]ven application of the misconception theory would not change the result" because "[i]f the grantors and grantee in this case assumed a one-eighth lease royalty, the reference to a 1/16 of production . . . shows an intent to reserve an unchanging 1/2 of the assumed 1/8 royalty, or 1/16 of production: 1/2 times 1/8, *i.e.*, a fixed interest."[57]

The Texas Supreme Court reversed the San Antonio Court of Appeals in 2018.[58] In an opinion authored by Justice Lehrmann, the court agreed that only the single provision quoted above was subject to harmonization.[59]

But "[b]y using the phrase 'one-half (1/2) interest in and to the *Oil Royalty*,' the parties expressed their intent to tie the reservation to the royalty

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51. *Id.* at 743.
52. Graham v. Prochaska, 429 S.W.3d 650, 653 (Tex. App.—San Antonio 2013, pet. denied).
53. *Id.* at 665; *see also Laborde*, 551 S.W.3d at 751 (citing Graham, 429 S.W.3d at 662–64).
54. *See Laborde*, 551 S.W.3d at 752.
55. *Id.* at 751.
56. *Id*.
57. *Id.* at 753.
58. U.S. Shale Energy II, LLC v. Laborde Props., L.P., 551 S.W.3d 148, 155–56 (Tex. 2018).
59. *Id.* at 153–54.

rate that was in effect at any given time."[60] There was no lease in effect at the time of conveyance so, it would have been inappropriate to substitute one-eighth—in other words, the flaw in the San Antonio court's ruling was the assumption of an "assumed royalty rate," rather than interpreting "Oil Royalty" as "current royalty rate."[61]

The Texas Supreme Court offered all of one sentence of treatment on the estate misconception theory.[62] Estate misconception did not inform the Supreme Court's decision in *U.S. Shale.*[63]

While several intermediate appellate and federal decisions came down in the years after *U.S. Shale*, the Supreme Court would not reach the estate misconception theory again until *Van Dyke* in 2023.[64] We pick up the chronology of *Van Dyke* in the Eastland Court of Appeals.[65]

B. Van Dyke *in the Eastland Court of Appeals: Treatment of the Estate Misconception Theory*

The case arrived at the Eastland Court of Appeals after the disposition of dueling motions for summary judgment in Martin County, interpreting the following provision in the Mulkey Deed: "[i]t is understood and agreed that one-half of one-eighth of all minerals and mineral rights in said land are reserved in grantors, Geo. H. Mulkey and Frances E. Mulkey, and are not conveyed herein."[66]

The Mulkey Assignees (successors in interest to the grantors, George and Frances Mulkey), argued under the estate misconception theory and presumed grant doctrine that the Mulkey Deed reserved one-half of all minerals.[67] The White Assignees (successors in interest to the grantees) argued the reservation was a one-sixteenth interest, based on a calculation of one-half multiplied by one-eighth, and argued that estate misconception and presumed grant were inapplicable.[68]

The trial court in Martin County, Judge Timothy D. Yeats, found for the White Assignees and the one-sixteenth position.[69] The trial court's order does

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60. *Id.* at 153.
61. *Id.* at 155.
62. *Id.* at 152 (quoting Hysaw v. Dawkins, 483 S.W.3d 1, 10 (Tex. 2016)) ("Though not inexorably so, the reality is that use of 1/8 (or a multiple of 1/8) in some instruments undoubtedly embodies the parties' expectation that a future lease will provide the typical 1/8th landowners' royalty with no intent to convey a fixed fraction of gross production.").
63. *See id.*
64. Van Dyke v. Navigator Grp., 668 S.W.3d 353, 363 (Tex. 2023).
65. *See* Van Dyke v. Navigator Grp., 647 S.W.3d 901, 913 (Tex. App.—Eastland 2020), rev'd, 668 S.W.3d 353, 363 (Tex. 2023).
66. *Id.* at 904.
67. *Id.* at 905.
68. *See id.* at 904.
69. Daniels v. Endeavor Energy Res., LP, No. 6668, 2018 WL 4200911, at *2 (118th Dist. Ct., Martin County, Jan. 12, 2018).

not contain a reasoned opinion as to why the estate misconception theory and presumed grant doctrine did not apply, but the court found as follows: (1) the Mulkey Deed was unambiguous, and (2) it "reserved 1/16th of the mineral[s] . . . and conveyed 5/16th of the mineral[s]."[70]

Senior Chief Justice Jim Wright delivered the opinion of the Eastland Court of Appeals, affirming the trial court's interpretation.[71]

We will examine presumed grant in the sections below. The Eastland Court of Appeals' analysis of the estate misconception theory was based on the "bundle of sticks," specifically:

> [T]he estate misconception theory, as relied upon by the Mulkey Assignees, is built upon the principle that mineral owners in the era in which this deed was executed assumed that, after they had executed an oil and gas lease, they retained only a one-eighth interest in the minerals. The Mulkeys could not have been operating under the estate misconception theory because, at the time of the deed, they owned all the attributes of the mineral estate; *there was no lease of the minerals and there had been no conveyance of any part of the bundle of sticks that make up mineral and mineral rights ownership—the Mulkeys owned it all*.[72]

Unpacking the court of appeals' analysis: there was no lease, so there could be no estate misconception.[73] This is consistent with the scholarly publications relied on by the Texas Supreme Court in *Hysaw*, namely those of Professor Burney: "[t]he question posed by these "double" recitations becomes particularly crucial when a *later* lease provides for a *different* royalty."[74] "The 'estate misconception' stems from a misunderstanding about the estates *created in an oil and gas lease*. Because the typical lease provides for a 1/8 landowner's royalty, many lessors assume that *after leasing* they only owned 1/8 of the minerals."[75]

Having dispatched estate misconception and, soon after, presumed grant, the court of appeals needed to only interpret the plain, unambiguous deed provision: one-half of one-eighth means one-sixteenth.[76]

C. Van Dyke *in the Supreme Court*

The Mulkey Assignees filed a petition for review with the Supreme Court and they were supported by two *amici curiae*: Professor Christopher

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70. *Id.* at *2.
71. *See* Van Dyke v. Navigator Grp., 647 S.W.3d 901, 913 (Tex. 2023).
72. *Id.* at 908 (emphasis added).
73. *See id.*
74. Laura H. Burney, *Interpreting Mineral and Royalty Deeds: The Legacy of the One-Eighth Royalty and Other Stories*, 33 ST. MARY'S L.J. 1, 3 (2001) (emphasis added).
75. *Id.* at 15 (emphasis added).
76. *See Van Dyke*, 647 S.W.3d at 908.

Kulander of South Texas College of Law Houston, advocating the estate misconception theory and presumed grant doctrine, and the Texas Land and Mineral Owners Association (TLMA) advocating presumed grant.[77] The Texas Supreme Court granted the petition for review and conducted oral argument on October 6, 2022.[78]

Justice Evan Young delivered the opinion of the unanimous Texas Supreme Court on February 17, 2023.[79]

The portions of the opinion on estate misconception theory mirror—without reference, as it turns out—Professor Kulander's amicus brief.[80] Professor Kulander, in turn, cites Professor Burney's 1993 and 2011 articles.[81]

1. "Patent Evidence . . . of Estate Misconception."

At the beginning of this Article, we embraced the truth that all individuals are unique. There has never been a person imprinted with the exact same upbringing, knowledge, education, life experiences, business acumen, or access to legal services as another person. Through this prism, George Mulkey was as different from Ethel Hysaw as he was from you or me.

But after *Van Dyke*, the Supreme Court no longer recognizes individual differences when applying the estate misconception theory.[82] Justice Young adopted, wholesale, Professor Burney's statement from her 1993 article that "the very use of 1/8 in a double fraction 'should be considered *patent evidence* that the parties were functioning under the estate misconception.'"[83] This statement arrived without citation in 1993, circulated in the legal papers for 20 years, and was suddenly adopted wholesale in *Van Dyke*.[84]

Perhaps the Supreme Court will clarify that this is simply *dicta*—that when the Court explained the estate misconception theory, it meant only to

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77. Br. of Christopher Kulander as Amicus Curiae Supporting Petitioners, Van Dyke v. Navigator Grp., 668 S.W.3d 353 (2023) (No. 21-0146) [hereinafter Kulander Amicus]; Br. of Texas Land and Mineral Owners Ass'n as Amicus Curiae Supporting Petitioners, Van Dyke v. Navigator Grp., 668 S.W.3d 353 (2023) (No. 21-0146) [hereinafter TLMOA Amicus].

78. *See* Transcript of Oral Argument, Van Dyke v. Navigator Grp., 668 S.W.3d 353 (2023) (No. 21-0146).

79. *See* Van Dyke v. Navigator Grp., 668 S.W.3d 353, 356 (Tex. 2023).

80. *See id.* at 363; *see also* Kulander Amicus, *supra* note 77, at 15–20.

81. *See* Kulander Amicus, *supra* note 77, at 15–18.

82. *See Van Dyke*, 668 S.W.3d at 363.

83. *Id.* (quoting Laura H. Burney, *The Regrettable Rebirth of the Two-Grant Doctrine in Texas Deed Construction*, 34 S. TEX. L. REV. 73, 90 (1993)) (emphasis added); *see also* Kulander Amicus, *supra* note 77, at 18.

84. *Compare* Hysaw v. Dawkins, 483 S.W.3d 1, 11 (2016) ("[Professor Burney argues] that the appearance of 1/8 in a double fraction is patent evidence the parties were operating under the estate misconception."), *with* Van Dyke, 668 S.W.3d at 363 ("the very use of 1/8 in a double fraction 'should be considered patent evidence that the parties were functioning under the estate misconception.'").

signify that certain legal commentators have stated as such, but the reader should not interpret it as the holding of the Court.

Treating the statement as *dicta* is certainly not within the plain reading of *Van Dyke*, and at least one court of appeals has already interpreted it as the Texas Supreme Court's holding: "The court explained that the very use of 1/8 in a double fraction in a deed of this era 'should be considered patent evidence that the parties were functioning under the estate misconception.'"[85] As *Van Dyke* looms as the only commanding Texas Supreme Court precedent, this interpretation (or misinterpretation) will likely multiply in the courts of appeals. The Texas Supreme Court should clarify whether use of one-eighth in a double-fraction is "patent evidence" of estate misconception in the next available case.

To be sure, *Van Dyke* is a marked change from the uncertainty over estate misconception expressed by Justice Guzman in *Hysaw*.[86]

First, in introducing the estate misconception theory, Justice Guzman recites that while "the reality is that the use of 1/8 (or a multiple of 1/8) in some instruments undoubtedly embodies the parties' expectation that a future lease will provide the typical 1/8th landowners' royalty[,]" this is "not inexorably so."[87]

Second, "variety of outcome should be expected" and the court should eschew "mechanical or bright-line rules as a substitute for an intent-focused inquiry rooted in the instrument's words."[88] Both of these proclamations are inconsistent with the rule, pronounced in *Van Dyke*, that every instance of a double-fraction of one-eighth in a mineral deed is patent evidence of estate misconception.[89]

Third, Justice Guzman referenced the "specter of estate misconception": "the use of double fractions in lieu of single fixed fractions, with one fraction connoting equality among the three children (1/3) and the other raising the specter of estate misconception or use of the then-standard 1/8 royalty as a synonym for the landowner's royalty."[90]

Estate misconception was not considered a constant state of the universe in *Hysaw*.[91] Even when the "specter of estate misconception" was raised, it did not displace the "analytical approach that emphasizes the four-corners rule and harmonization principles[.]"[92] In other words, estate misconception may or may not exist in a given case—"double fractions in a mineral

85. Johnson v. Clifton, No. 08-22-00132-CV, 2023 WL 4443016, at *9 (Tex. App.—El Paso July 10, 2023, pet. filed) (quoting *Van Dyke*, 668 S.W.3d at 363).
86. *See Hysaw*, 483 S.W.3d at 10–11.
87. *Id.* at 10.
88. *Id*. at 13.
89. Van Dyke v. Navigator Grp., 668 S.W.3d 353, 363 (Tex. 2023).
90. *Hysaw*, 483 S.W.3d at 15.
91. *See id.*
92. *Id*. at 12.

conveyance may or may not evince intent to fix the interest"—and only a case-by-case analysis of estate misconception is appropriate.[93]

2. A Prescription for Softening Van Dyke

Justice Guzman stated that the court's double-fraction opinions have done "little to pour oil on turbulent waters," complicating rather than calming Texas jurisprudence.[94] Justice Young sought to calm the waters, adopting a "rule [that is] flexible even as it advances stability and predictability from case to case."[95]

Through the adoption of the "patent evidence" rule advocated by Professors Burney and Kulander, *Van Dyke* instead pours gasoline on a fire.[96] Case-by-case analysis yields to a rigid application of "magic words"; holistic interpretation yields to a "full contextual analysis" clearly escaping the four corners of the instrument.[97]

It was not Justice Young's intent, in this author's view, to introduce a completely new legal framework to address double-fractions of one-eighth in all mineral conveyances. He conditioned his first words carefully: "in the law, 'one half of one-eighth' *sometimes* equals one-half[.]"[98] In the case of the Mulkey Deed, it did, for reasons even outside of estate misconception.[99]

Van Dyke also purports to extend, not abrogate, *Hysaw*, *Luckel*, and *Concord Oil*.[100] In those cases, the court "rejected mechanical rules of construction, such as giving priority to certain clauses over others, or requiring the use of so-called 'magic words.'"[101]

The court resolves all deed interpretation cases on a case-by-case basis.[102] This author is not against the court installing guardrails and signposts for the interpretation of deeds, but leveling a presumption against each and every signatory regardless of education, skill, and unique individual circumstances goes too far. Justice Guzman referenced the "specter of estate misconception" in *Hysaw*.[103] There is no doubt that certain people in the 1920s and 30s were misconceived as to the nature and extent of their mineral estate, and the specter of estate misconception will undoubtedly present itself

93. *Id*. at 14.
94. *Id.* at 11.
95. Van Dyke v. Navigator Grp., 668 S.W.3d 353, 365 (Tex. 2023).
96. *See* Kulander Amicus, *supra* note 77, at 18.
97. *See Van Dyke*, 668 S.W.3d at 364 (citing Hysaw v. Dawkins, 483 S.W.3d 1, 10–12 (2016)).
98. *Id.* at 357.
99. *Id.*
100. Hysaw v. Dawkins, 483 S.W.3d 1 (Tex. 2016); Luckel v. White, 819 S.W.2d 459 (Tex. 1991); Concord Oil Co. v. Pennzoil Expl. & Prod. Co., 966 S.W.2d 451 (Tex. 1998).
101. Wenske v. Ealy, 521 S.W.3d 791, 794 (Tex. 2017) (citing Concord Oil Co. v. Pennzoil Expl. & Prod. Co., 966 S.W.2d 451, 465 (Tex. 1998)).
102. *See Van Dyke*, 668 S.W.3d at 361.
103. *Hysaw*, 483 S.W.3d at 15.

in those cases.[104] It does not follow that we must presume that *all* individuals were misconceived when certain common language is present in a deed.

The Texas Supreme Court should hew closer to *Hysaw* (as it purported to do in *Van Dyke*) and apply estate misconception only when there is good reason to believe that particular signatory was misconceived.[105] That is, unless the court is convinced that all individuals who executed double-fraction of one-eighth conveyances were similarly misconceived—then it need do nothing at all.[106]

III. The Presumed Grant Doctrine

The second doctrine embraced by the Texas Supreme Court in reversing *Van Dyke* is the presumed grant doctrine.[107] Unlike estate misconception, the presumed grant doctrine has over a century of use in the courts.[108]

The presumed-grant doctrine, "also referred to as title by circumstantial evidence, has been described as a common law form of adverse possession."[109] The doctrine requires its proponent to establish three elements: (1) a long-asserted and open claim, adverse to that of the apparent owner; (2) nonclaim by the apparent owner; and (3) acquiescence by the apparent owner in the adverse claim.[110]

The court of appeals imposed an additional fourth element: a gap in the title.[111] Satisfying the doctrine is properly difficult, but neither our precedent nor the doctrine's underlying purposes support mandating this additional test.[112]

As described in the above-cited case, *Fair*, "the purpose [of the presumed grant doctrine] is to settle titles where the land was understood to belong to one who does not have a complete record title, but has claimed the land a long time."[113]

Despite the name, the doctrine is not exclusively employed to "presume a grant," although a review of the doctrine's historical use shows that this is

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104. Taken to its logical extreme, an oil and gas lawyer reserving a double-fraction of one-eighth of his own mineral interest, advised by more lawyers and accountants, would be presumed misconceived as to the nature and extent of his estate due to the language in the deed.

105. *See Hysaw*, 483 S.W.3d at 11–12.

106. Justice Young warned against implementing "Procrustean solutions": either always multiplying or never multiplying the double-fraction. *Van Dyke*, 668 S.W.3d at 365. Believing that all persons were misconceived or no persons were misconceived is similarly ridiculous; the answer is somewhere in between. The estate misconception presumption, if any presumption should exist, must account for individualism and variability and cannot be leveled at once against all humanity.

107. Van Dyke v. Navigator Grp., 668 S.W.3d 353, 366 (Tex. 2023).

108. *Id.;* Magee v. Paul, 221 S.W. 254, 256–57 (Tex. 1920).

109. Fair v. Arp Club Lake, Inc., 437 S.W.3d 619, 626 (Tex. App.—Tyler 2014, no pet.).

110. *Magee*, 221 S.W. at 257.

111. Van Dyke v. Navigator Grp., 647 S.W.3d 901, 913 (Tex. App.—Eastland 2020), rev'd, 668 S.W.3d 353, 363 (Tex. 2023).

112. *Van Dyke*, 668 S.W.3d at 366.

113. Fair v. Arp Club Lake, Inc., 437 S.W.3d 619, 626 (Tex. App.—Tyler 2014, no pet.).

the most common application.[114] Indeed, the precursor to *Fair*, *Conley v. Comstock Oil*, refers to the doctrine as the "doctrine of presumed lost deed" and "doctrine of presumed lost deed or grant."[115] In *Brewer v. Cochran*, the forerunner of *Magee*, the instruments were "both lost or destroyed, as also are the records thereof, if ever recorded."[116] And in *Howland v. Hough*, the Texas Supreme Court referred to the doctrine as one for the "presumption of a lost grant or conveyance" and used to "[fill] the ancient 1845–1878 gap in [the plaintiff's] title."[117] Even in *Van Dyke*, the Mulkey parties raised together the affirmative defenses of "presumed grant [and] lost deed."[118]

The Texas Supreme Court fairly interpreted the presumed grant doctrine in *Van Dyke* as not requiring a gap in the chain of title.[119] There can be no doubt that, going back to the very roots of the doctrine, the courts did not require a gap in title to be filled—the doctrine simply presents itself most applicably in circumstances where there is a gap in title.[120]

A. Treatment of the Presumed Grant Doctrine as to Royalty Interests

The progenitors of *Van Dyke*—namely *Hysaw*—demonstrate that double-fractions are equally present and problematic in royalty conveyances as in mineral conveyances.[121] A casual reading of *Van Dyke*, as an extension of *Hysaw*, would interpret *Van Dyke*'s formulation of the presumed grant doctrine to apply equally to double-fraction royalty interests.[122]

However, this is not settled. The presumed grant doctrine is a "common law form of adverse *possession*."[123] "[N]onpossessory interests, including royalty interests, are not subject to adverse possession."[124]

To be sure, the recognized elements of the presumed grant doctrine speak no more to tangible possession than they do to gaps in title: "(1) a long-asserted and open claim, adverse to that of the apparent owner; (2) nonclaim by the apparent owner; and (3) acquiescence by the apparent

114. *See id.*

115. Conley v. Comstock Oil & Gas, LP, 356 S.W.3d 755, 764–65 (Tex. App.—Beaumont 2011, no pet.).

116. Brewer v. Cochran, 45 Tex. Civ. App. 179, 180, 99 S.W. 1033, 1034 (1907, writ ref'd); *see also* Humphreys v. Green, 234 S.W. 562, 565 (Tex. App.—Beaumont 1921, no writ).

117. Howland v. Hough, 570 S.W.2d 876, 878–80 (Tex. 1978).

118. Van Dyke v. Navigator Grp., 668 S.W.3d 353, 359 (Tex. 2023).

119. *See id.* at 366.

120. *Id.*; Magee v. Paul, 221 S.W. 254, 257 (Tex. 1920) (the Supreme Court in *Magee* stated: "The rule is essential to the ascertainment of the very truth of ancient transactions. . . Its application becomes more and more important with the passing years, as it becomes more and more difficult to get living witnesses to that which long ago transpired." The Supreme Court did not require the evidence of the transaction be both ancient and lost.)

121. *See* Hysaw v. Dawkins, 483 S.W.3d 1, 4 (Tex. 2016).

122. *Van Dyke*, 668 S.W.3d at 367–68.

123. *Id.* at 366 (emphasis added) (quoting Fair v. Arp Club Lake, Inc., 437 S.W.3d 619, 626 (Tex. App.—Tyler 2014, no pet.)).

124. Moore v. Moore, 568 S.W.3d 725, 733 (Tex. App.—Eastland 2019, no pet.).

owner in the adverse claim."[125] "Claims" are routinely made on and against royalty interests, and they are "owned" interests.[126]

Lands are divided into parcels; when an abutting owner openly encroaches on his neighbor's property, adverse possession may be triggered. Royalties are divided into decimal interests and proceeds are paid according to division orders, which function to fence in the various decimal interests in the royalty base. When these figurative fences move and result in a "long-asserted and open claim" by one owner, and nonclaim and acquiescence by the other, there is no reason presumed grant should not apply as it would for a possessory real property interest.

The Texas Supreme Court in *Howland v. Hough*, cited above, stated that "actual possession . . . is not essential."[127] In that case, the tract at issue was "wild land . . . of which there has never been actual possession by anybody."[128] *Brewer v. Cochran*, which informed the court's decision in *Magee*, reached the same conclusion decades earlier than *Howland* with similarly "wild" land because "[i]n this state it has been held that actual possession under an alleged deed is not an essential element of proof of the execution of such deed by circumstances, or to create an inference of presumption of fact from such circumstances, of the execution of such deed."[129]

The presumed grant doctrine, while described like adverse possession, has nothing to do with possession and, consequently, does not apply exclusively to possessory property interests.[130] The only requirements are that there be an open claim to an interest by one person, juxtaposed with a nonclaim and acquiescence by the other.[131] The presumed grant doctrine therefore applies to royalty interests when all elements are met.

B. Assertion of the Presumed Grant Doctrine by Any Party

Van Dyke also leaves open the question of which parties may assert the presumed grant doctrine: the plaintiff or the defendant? The party looking to increase its interest or to protect what it has? In truth, it should not matter. Whether we are talking about mineral or royalty interests, the entire base always adds up to 1.0000000. Therefore, any dispute over an allegedly "open claim" to a mineral or royalty interest, such that would trigger the presumed grant doctrine, will constitute both an increase and decrease in competing interests. In other words, it's all relative.

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125. *Van Dyke,* 668 S.W.3d at 366.
126. *See* Hysaw v. Dawkins, 483 S.W.3d 1, 4 (Tex. 2016).
127. Howland v. Hough, 570 S.W.2d 876, 879 (Tex. 1978).
128. *Id.*
129. Brewer v. Cochran, 99 S.W. 1033, 1035 (1907, writ ref'd).
130. *See* Van Dyke v. Navigator Grp., 668 S.W.3d 353, 366 (Tex. 2023).
131. *See id.*

Either the plaintiff or defendant may be the party asserting that open claim. The party asserting the open claim may not be looking to increase its interest, but only to show that the open claim for the currently recognized interest—the interest it seeks to protect in the suit—is the grant to be presumed.

It is also theoretically possible to have both sides in the dispute asserting presumed grant against one another, each supporting their allegedly "open" claim and adducing competing evidence of nonclaim and acquiescence by the other party.

In its mission to streamline presumed grant jurisprudence, it would be helpful for the court to clarify that the doctrine is available for use by any party asserting an allegedly open claim.

IV. The Next Generation of Cases

In the months following *Van Dyke*, it was assumed by many practitioners that *Thomson v. Hoffman*, a royalty case before the Texas Supreme Court involving the estate misconception theory but not the presumed grant doctrine, would "bat cleanup" for the court and settle any uncertainties remaining after *Van Dyke*.[132] *Thomson*, however, was simply remanded to the San Antonio Court of Appeals for further briefing and treatment consistent with the "new legal formulation" in *Van Dyke*.[133]

Thomson is therefore no longer the heir-apparent to *Van Dyke*. Instead, it has been jumped by other cases decided after *Van Dyke* and now before the Texas Supreme Court at various stages.

Permico v. Barron and *Johnson v. Clifton* arise from opinions issued the same day by the El Paso Court of Appeals.[134]As of the press date, both cases have fully-briefed petitions for review but the Court has not yet requested briefs on the merits.[135] *Barron* offers the Texas Supreme Court the opportunity to revisit and clarify its holdings on the estate misconception theory, while *Clifton* deals with both estate misconception and presumed grant.[136] Yet more cases loom in the courts of appeal nearing decision.

V. Conclusion

The Texas Supreme Court's decision in *Van Dyke* represents, as the Court later conceded in *Thomson*, a "new legal formulation" as to the estate

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132. *See* Thomson v. Hoffman, 674 S.W.3d 927, 928 (Tex. 2023).

133. *Id.* at 928–29.

134. Permico Royalties, LLC v. Barron Properties Ltd., No. 08-22-00168-CV, 2023 WL 4442007 (Tex. App.—El Paso July 10, 2023, pet. filed); Johnson v. Clifton, No. 08-22-00132-CV, 2023 WL 4443016 (Tex. App.—El Paso July 10, 2023, pet. filed).

135. *See Barron*, 2023 WL 4442007.

136. *Id.* at *4; *Clifton*, 2023 WL 4443016, at *9, 11.

misconception theory.[137] It is not merely an extension of *Hysaw* and its forerunners. In its attempt to fix a problem with double-fractions, the court provided Texas with a one-size-fits-all solution that every double-fraction of one-eighth in a mineral conveyance presumably means a fraction of all minerals.[138] This may well be the solution ultimately crafted for double-fractions of one-eighth in royalty conveyances.

One size rarely fits all in the law, and it does not fit here. The presumption leveled in *Van Dyke* is a presumption about state of mind, intelligence, and knowledge—because each person is different, such a presumption upon all of humanity is unworkable. Instead, leaning on Justice Guzman's words in *Hysaw*, the court should apply such a presumption only when the "specter of estate misconception" is present—when the circumstances reasonably indicate that the particular person was misconceived as to the nature and extent of their estate.[139]

137. *See* Thomson v. Hoffman, 674 S.W.3d 927, 928–29 (Tex. 2023).
138. Van Dyke v. Navigator Grp., 668 S.W.3d 353, 359 (Tex. 2023).
139. Hysaw v. Dawkins, 483 S.W.3d 1, 15 (Tex. 2016).

LI TO ME: WHO OWNS LITHIUM IN BRINE?

Reagan M. Marble, Peter E. Hosey, and Brandon Durrett[*]

I. INTRODUCTION

For centuries, technological advances have propelled the energy industry forward creating reservoirs of opportunity. One of those technological advances, by way of example, was the confluence of horizontal drilling and hydraulic fracturing. The marriage of those technological marvels not only led to the recovery of millions of barrels of oil and gas, but opened wide the choke of prosperity in the form of jobs, wealth, and a modern-day industrial revolution. Given these large, often sudden, leaps forward, it would not be inaccurate to describe the energy industry as a series of up-dips and down-dips in between the domes of major technological advancement. And with those major technological advancements, typically come legal questions (and billable hours) galore.

Recently, one of those commercialized technologies—called "direct lithium extraction"—may lead to the recovery of otherwise unrecoverable, diluted lithium found in hyper-saline water which may then be used to create

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batteries that store electricity.[1] This paper aims to be the first of its kind on a series of very difficult legal topics: the present ownership and subsequent leasing of lithium brine for extraction in Texas. We begin with a history of brine production: namely, in Arkansas (bromine), Nevada (lithium), and the famous "Golden Triangle" (lithium), where the borders of Argentina, Chile, and Bolivia collide.[2]Then, the reader receives a brief overview of the technological advancements that make this topic timely, relevant, and potentially economic.[3] Next, we dive into the complicated world of brine and lithium ownership and eventually clumsily stumble our way through the legal process of how, and from whom, to lease brine for lithium extraction in the present unsure ownership landscape.[4] Finally, this paper concludes with the authors' proposed legislative solution to the ownership conundrum.[5]

II. THE HISTORY OF BRINE PRODUCTION

Brine mining, in its simplest form, is the extraction of useful materials (minerals, elements, compounds) that are naturally dissolved in water of high salinity.[6] This paper will not address—nor is it anticipated to be a meaningful part of the industry's development—in-situ leaching or solution mining, a method of injecting water or chemicals to dissolve materials in a solid state. When the authors refer to "brine" throughout this article, we are generally referring to hyper-saline water of greater than thirty parts per thousand found deep under the Earth's surface. Technically, however, saline water (salt lakes, etc.) is thirty to fifty parts per thousand while brine is considered fifty parts per thousand or greater.[7] Brine is produced through a brine production well made up of all the typical well "accoutrement" that an oil and gas lawyer may be familiar with, including casing, production tubing, and a pump and motor.[8] Outside of the need to replace tubing and other parts of the well due to the highly corrosive nature of brine, the well is typical. The history of industrialized brine production, however, is anything but.[9] And now that

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1. *Direct Lithium Extraction: A Potential Game Changing Technology*, GOLDMAN SACHS, (Apr. 27, 2023, 9:31 PM), https://www.goldmansachs.com/intelligence/pages/gs-research/direct-lithium-extraction/report.pdf (hereinafter *Direct Lithium Extraction*).

2. *See infra* Part II (exploring the production of brine in different areas).

3. *See infra* Part III (discussing the technology that has led to current brine production).

4. *See infra* Part IV (explaining brine and lithium ownership and how to lease brine).

5. *See infra* Part V (describing proposed brine ownership legislation).

6. Argyris Panagopoulos & Katherine-Joanne Haralambous, *Environmental Impact of Desalination and Brine Treatment—Challenges and Mitigation Measures*, MARINE POLLUTION BULL., Dec. 2020 at 1, 6.

7. David A. Anati, *The Salinity of Hypersaline Brines: Concepts and Misconceptions*, 8 INT'L. J. SALT LAKE RSCH. 55, 55–70 (1999).

8. *See General Information Regarding Brine in Arkansas*, OFFICE OF THE STATE GEOLOGIST, http://www.geology.arkansas.gov/energy/brine-in-arkansas.html (last visited Feb. 11, 2024).

9. This paper will not address the other ways lithium is commercially produced including lithium clay or pegmatite (hard-rock) lithium.

commercial quantities of lithium have been discovered in the United States, and demand for the "lightest metal known to man" is expected to increase ten-fold by 2028, the industry seems prime for takeoff now more than ever.[10]

A. Arkansas

The only state within the United States with a substantial history of commercial brine production is Arkansas, the "Natural State." Utilizing the Smackover Limestone Formation—a geologic strata that many Southwestern Arkansas oilmen jokingly refer to as "an ocean with a little bit of oil"—Arkansas began producing brine for the purpose of extracting dissolved elements as early as 1955.[11] Chemists discovered concentrations of bromine—an element known for its use as a fire retardant, water purifier, or pain reliever (*i.e.*, Aleve)—exceeding any known concentrations in the Western Hemisphere.[12] Upon the discovery of bromine in commercial quantities, Ethyl Corporation (now Albemarle Corporation) and Michigan Chemical Corporation (now Lanxess) built "brine-to-bromine" infrastructure to produce and extract bromine from the hyper-saline water.[13] This is where the blueprints for direct extraction of constituent elements and minerals were drawn up.

After drilling wells with large bores and equipping those wells with downhole pumps that run on electricity, the brine is lifted to the surface at rates up to 20,000 barrels per day.[14] The brine is then piped to nearby plants where bromine is extracted from the brine's bromide salts through a process that includes infusing the brine with chlorine and steam.[15] After extraction, the leftover brine (known as "tail brine") gets reinjected into the ground.[16] Interestingly, these injection wells can be used in a quasi-secondary recovery fashion, helping maintain reservoir pressure and forcibly migrating usable brine towards the production wellbore.[17] Eventually, the "water flooding" leads to the production of tail brine instead of bromine-rich brine, and the wells are shut in.[18]

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10. Stephanie Ebbs, et al., *Nevada Sees Lithium 'White Gold Rush' as Demand Set to Skyrocket*, ABC WORLD NEWS (Apr. 23, 2021, 5:09 AM), https://abcnews.go.com/US/nevada-sees-lithium-white-gold-rush-demand-set/story?id=77166661 (hereinafter "ABC NEWS").

11. Thomas Daily, *Arkansas' Brine Production Business: How You Make Something From Less Than Nothing*, INTERSTATE OIL & GAS COMPACT COMM'N, https://iogcc.ok.gov/sites/g/files/gmc836/f/documents/2021/brine_paper.pdf (last visited Feb. 11, 2024).

12. *Id.*

13. *Id.* at 3.

14. *Id.*

15. *Id.*

16. *Id.*

17. *Id.*

18. *Id.* at 3–4.

B. Nevada and the "Golden Triangle"

Despite tremendous potential,[19] Nevada only has one commercial facility that produces brine for the extraction of a constituent element: the Silver Peak facility owned by Albemarle.[20] South America, however, has many commercial brine production facilities in an area known as the "Golden Triangle"; the confluence of the Argentine, Chilean, and Bolivian borders.[21]

Unlike the direct bromine extraction process identified above, the extraction of lithium from brine in Nevada and South America relies on the evaporative process.[22] The evaporative process has been heavily criticized for its intensive surface impact and its protracted duration.[23] The process is not novel. Brine is produced through a typical brine production well, but instead of extracting lithium through a processing plant, it utilizes large surface ponds (the size of multiple football fields) that hold 100-800 cubic meters of water.[24] After a twelve- to eighteen-month evaporative process and multiple chemical applications, lithium carbonate is ready for transport.[25] Despite the time-intensive process, the Golden Triangle, beneath a dry salt lake in Salar de Olaroz, Argentina, has the largest concentration of lithium found in the world at 690 mg/L.[26] This high concentration of lithium is why more than half of the world's supply is produced in the Golden Triangle.[27]

III. THE TECHNOLOGY AND ECONOMICS BEHIND EXTRACTION

You might be thinking: "if the highest concentrations of lithium in the world are in South America, why would the United States think it can compete for market share?" That answer is simple: technology.

Direct Lithium Extraction (DLE) is a process birthed to eliminate the environmental impact and time constraints for which evaporative technology

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19. *See* J. R. Davis & J. D. Vine, *Stratigraphic and Tectonic Setting of the Lithium Brine Field, Clayton Valley, Nevada*, RMAG-UGA 1979 BASIN & RANGE SYMP. p. 421–30 (1979) (Concentrations in Nevada are as high has 300 mg/L, making it a "world class" resource.).

20. *See Albemarle Announces Expansion of Nevada Site to Increase Domestic Production of Lithium*, ALBEMARLE (Jan. 7, 2021), https://www.albemarle.com/news/albemarle-announces-expansion-of-nevada-site-to-increase-domestic-production-of-lithium.

21. Samar Ahmad, *The Lithium Triangle: Where Chile, Argentina, and Bolivia Meet,* HARV. INT'L REV. (Jan. 15, 2020), https://hir.harvard.edu/lithium-triangle/.

22. Adam Voiland, *Racing to Mine Lithium*, NASA: EARTH OBSERVATORY (Dec. 8, 2022), https://earthobservatory.nasa.gov/images/150730/racing-to-mine-ithium#:~:text=Like%20many%20lithium%20mines%20around,double%20its%20production%20by%202025.

23. Maria L. Vera et al., *Environmental Impact of Direct Lithium Extraction from Brines*, 4 NATURE REVS. EARTH & ENV'T 149, 149 (2023).

24. *Id.* at 150.

25. *Direct Lithium Extraction*, *supra* note 1 at 18.

26. *See Salar de Olaroz—Olaroz Lithium Facility*, OROCOBRE, https://www.orocobre.com/operations/salar-de-olaroz/ (last visited Feb. 11, 2024).

27. *Id.*

is criticized.[28] Generally, DLE processes lithium quicker than traditional evaporation by extracting lithium from "brine using filters, membranes, ceramic beads, or other equipment."[29] The surface footprint currently occupied by evaporation ponds substantially decreases, as this processing equipment is found in small warehouses or buildings at or near the well site.[30]

A. The Technology

DLE technology is in its infancy and includes adsorption, ion exchange, and solvent extraction.[31] For the lay person (including your authors), adsorption is the easiest process to understand. Adsorption is the process by which the Lithium Chloride (LiCl) molecule found in brine is physically adsorbed (the adhesion of a molecule onto the surface of another)[32] onto a sorbent and is removed with a strip solution.[33] The next two processes are heavy on chemistry, light on layman understanding.[34] Ion exchange is where the lithium ion in brine is "chemically absorbed into [a] solid ion exchange material and swapped for another positive ion."[35] And finally, solvent extraction is where concentrated brine is mixed with an organic liquid, stripped free, and concentrated more.[36]

As the most developed DLE technology, we will take a deeper dive into adsorption.[37] Adsorption resins are synthetic round-shaped beads designed to meet a specific pore size, surface area, and porosity in order to purify, extract, separate, concentrate, and decolorize lithium.[38] Lithium chloride molecules from the brine infiltrate the atomic layers of an adsorbent.[39] After lithium chloride attaches to the adsorbent, it is washed with a diluted lithium chloride stream to remove unwanted ions and lithium chloride, resulting in recovery of more than 90% of the lithium present.[40]

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28. *Direct Lithium Extraction, supra* note 1, at 18.
29. *Id.* at 20.
30. *Id.*
31. *Id.*
32. Compare with "absorption," the soaking of a molecule into another substance. *Absorption*, BLACK'S LAW DICTIONARY (10th ed. 2014).
33. *Direct Lithium Extraction, supra* note 1, at 20.
34. *See id.*
35. *Id.* at 21.
36. *Id.* at 23.
37. *Id.* at 22.
38. *Id.*
39. *Id.*
40. *Id.*

B. The Economics

What does it cost? The commercial viability of such a nascent technology is surprising, if not unbelievable.[41]

Goldman Sachs has prepared one of the most comprehensive white papers on DLE technology and economics.[42] The first exhibit in the public work is an economic comparison of lithium brine extraction methods, comparing evaporation and DLE.[43] It demonstrates stark economic differences between evaporation and DLE.[44] For example, the most obvious is the production time; evaporation takes months to years, while DLE takes hours to days.[45] The recovery rate is 30% more in DLE than in evaporation (60% v. 90%).[46] While capex is nearly identical, the most shocking statistic is that operating expenses for DLE—a brand new technology that will only become more efficient—are $500 per ton cheaper than evaporation ($3,300/t v. $2,800/t).[47] Still not sold by the investment bank's analysis? Then take a look at a case-specific study.

Standard Lithium Company, a brine production company with a position in Southwest Arkansas, released detailed information about its "SWA Project" after it completed a Preliminary Feasibility Study in the third quarter of 2023.[48] The SWA Project, located in the heart of the Smackover, fifteen miles west of Magnolia, Arkansas, includes 36,000 acres of unitized brine production.[49] It is estimated that the average lithium operating expense is $4,073 per tonne, with an estimated capacity of 30,000 tonnes annually.[50] For comparison, Albemarle—one of the United States' largest lithium producers and a Standard Lithium direct competitor—produces 85,000 tonnes annually of lithium worldwide, but only 5,000 of that through their evaporative process at the Silver Peak Facility in Nevada.[51] Standard Lithium aims to increase that annual production by 600%.[52] What is even more exciting than this case study? Standard Lithium's numbers are based on an average lithium concentration of 437 milligrams per liter.[53] One of their

41. OIL & GAS COMM'N, *Lithium from Brine*, ARK. DEP'T OF ENERGY & ENV'T, https://www.aogc.state.ar.us/lithium/default.aspx (last visited Feb. 11, 2024).

42. *Direct Lithium Extraction*, *supra* note 1, at 23–25.

43. *Id. at 23*.

44. *Id.*

45. *Id.*

46. *Id.*

47. *Id.*

48. *See The Smackover Formation*, STANDARD LITHIUM, https://www.standardlithium.com/projects/arkansas-smackover (last visited Feb. 11, 2024).

49. Frank Gray, et al., *Southwest Arkansas*, STANDARD LITHIUM 1, 1 (Aug. 8, 2023), https://d1io3yog0oux5.cloudfront.net/_4be41d2fd2a14374236f4111f0871932/standardlithium/files/pages/standardlithium/db/369/description/South_West_Arkansas_Project_-_Pre-Feasibility_Study_2023.09.18.pdf.

50. *Id.* at 10.

51. *Id.* at 11.

52. *Id.* at 19.

53. *Id.*

recent tests in Cass County showed an average lithium concentration of 634 milligrams per liter just west of McLeod, Texas.[54] Imagine what Standard Lithium and other companies could do in Cass County once the infrastructure is developed.

IV. OWNERSHIP OF BRINE, ITS CONSTITUENT ELEMENTS, AND MINERALS

The most difficult question for an energy law practitioner is often who owns the minerals (that are not oil or gas) after they are severed from the surface by a grant or reservation of "other minerals."[55] For example, Oklahoma applies the doctrine of *ejusdem generis* to the phrase "oil, gas, and other minerals" to conclude that such a reservation only includes oil and gas because the specific controls over the general.[56] Pennsylvania applies the "*Dunham* Rule" which, in short, holds that a specific reservation of oil and gas is required to retain title because the word "mineral" is construed in the sense that "the mass of mankind would understand the term."[57] Tennessee also considered the *Dunham* Rule but reached the exact opposite result, holding that "oil and gas" would be effectively included in a generic reservation of "minerals."[58] For what it is worth, the majority rule is that of Tennessee.[59]

The more difficult question for energy law practitioners becomes: to whom do the constituent elements found in brine belong—the surface estate or mineral estate? Fortunately, for potential lithium production states like Arkansas, the answer is clear-ish with a regulatory backstop. Unfortunately for Texans, however, that answer is as clear as drilling mud right now.

A. Arkansas

In Arkansas, subject to the analysis of reservations or grants of other minerals utilizing the *Strohacker* doctrine,[60] brine and its naturally dissolved components, used as a source of raw material, belong to the present owner of the mineral estate.[61]

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54. *See Standard Lithium Drills and Samples Highest Confirmed Grade Lithium Brine in North America*, STANDARD LITHIUM (Mar. 28, 2023, 6:00 AM), https://www.standardlithium.com/investors/news-events/press-releases/detail/137/standard-lithium-drills-and-samples-highest-confirmed-grade.

55. *See* State v. Butler, 753 P.2d 1334, 1336–39 (Okla. 1987) (discussing the issue of who owns the minerals after severance).

56. *Id.*

57. *See* Dunham v. Kirkpatrick, 101 Pa. 36, 40 (1882).

58. *See* Murray v. Allard, 43 S.W. 355, 359–60 (Tenn. 1897).

59. *See* Eugene O. Kuntz, *The Law Relating to Oil and Gas in Wyoming*, 3 WYO. L.J. 107, 111 (1949).

60. *See generally* Mo. Pac. R.R. Co. v. Strohacker, 152 S.W.2d 557, 558–63 (1941) (discussing the doctrine that settled oil and gas ownership disputes).

61. ARK. CODE. ANN. § 15-76-315 (2015).

Under the 1941 hallmark case of *Missouri Pacific Railroad Co. v. Strohacker*,[62] whether a substance is included in a grant or reservation of "minerals" depends on the answer to the following question: at the time of the grant or reservation—in the place where the lands are located—were those substances generally regarded as minerals in the legal and commercial context.[63] In *Strohacker*, a railroad's predecessor had reserved "all coal and mineral deposits" in a deed conveying land in Miller County, Arkansas.[64] Strohacker owned the surface and filed a lawsuit asking the court to declare him the owner of the oil and gas under the land.[65] Arguing that "all coal and mineral deposits" did not include oil and gas, Strohacker won at the trial court.[66] On appeal, the railroad argued, and the court agreed, that the intent of the party making the reservation at the time it was executed and the surrounding circumstances were the "best and surest" method for determining whether "oil and gas" were intended to be included in a reservation of "all. . .mineral deposits."[67] Unfortunately for the railroad, the court concluded that because the surrounding circumstances indicated that the reservation was made at a time before oil and gas production and exploration occurred in Miller County, the legal and commercial usage of the term "all . . . mineral deposits" could not have included oil and gas.[68]

Despite several challenges to the *Strohacker* doctrine, the Arkansas Supreme Court has upheld its reasoning, only slightly altering the application.[69] Specifically, the scope of the rule has shifted from the subjective intent of the grantor, to the subjective intent of both the grantor and grantee, to the full-blown objective intent.[70] For example, Missouri Pacific was once again in front of Arkansas's high court when it considered whether bauxite was included in a reservation of "all . . . mineral deposits" in an 1892 deed.[71] Citing *Strohacker*, the court considered the intentions of

62. *Strohacker*, 152 S.W.2d at 565.
63. *Id.* at 563.
64. *Id.* at 558.
65. *Id.*
66. *Id.*
67. *Id*. at 562.
68. *Id.* at 563.
69. *See, e.g.*, Stegall v. Bugh, 310 S.W.2d 251, 252–53 (Ark. 1958) (holding that the scope of the reservation is to be measured by the "legal or commercial" usage of the word "mineral" at the time of conveyance, not the intent of the grantor); Brizzolara v. Powell, 218 S.W.2d 728, 873–74 (1949) (holding that the test for the word "mineral" requires the court to look to both parties' intent at the time of conveyance); Mo. Pac. R. Co. v. Furqueron, 196 S.W.2d 588, 589 (Ark. 1946) (broadening the scope of *Strohacker*, to include both the intent of the grantor and the grantee to determine the meaning of "other minerals" in a reservation).
70. *See, e.g.*, *Stegall*, 310 S.W.2d at 252–53 (holding that the scope of the reservation is to be measured by the "legal or commercial" usage of the word "mineral"); *Brizzolara*, 218 S.W.2d at 873–74 (holding that the court is required to look at both parties' intent at the time of conveyance); *Furqueron*, 196 S.W.2d at 589 (finding that both the intent of the grantor and the grantee should be considered to determine the meaning of "other minerals" in a reservation).
71. Carson v. Mo Pac. R.R. Co., 209 S.W.2d 97, 97–98 (Ark. 1948).

all parties to the instrument and concluded that bauxite was not generally known at the time of the conveyance, and thus, not reserved.[72] Almost half a century later, the Arkansas Supreme Court was again asked whether a reservation of "the mineral interest in said lands" included oil and gas.[73] Stegall argued and offered testimony that at the time of the conveyance (approximately 1900), land near the grantor produced traces of oil and gas and he approached a lawyer specifically to prepare a deed to reserve the mineral rights for oil and gas when the land was conveyed.[74] The court rejected that contention, and instead looked to the "general legal and commercial usage" of the word "mineral," which included evidence that no oil and gas production in Union County occurred until *after* the execution of the subject deed.[75] In the context of Arkansas' commercial brine production, January 1, 1955 became the "Strohacker Date."[76] As a result, practitioners in Arkansas credit "those severed mineral owners whose interests derive from generic mineral grants or reservations after January 1, 1955 with brine ownership." [77] The result of *Strohacker* is that title in Arkansas can have three separate estates: brine, oil and gas, and the surface.[78]

As a result of the commercial viability of brine production and case law failing to apply the rule of capture to the brine industry,[79] the 1979 Arkansas General Assembly enacted the Arkansas Brine Conservation Act (Act).[80] The Act, as amended, addresses several important matters, including: (1) the right to pool or unitize brine production units; (2) the right to pay an annual rental "in lieu of royalty"; (3) who may apply to form a unit; (4) the size of a brine production unit; (5) the right of an owner to petition to be included in a unit; (6) the timeline for an owner to elect to participate in a unit or transfer his interest in the brine; (7) the definition of mineral to include brine; and (8) the operator's authority to produce and account on a fair and equitable basis to each unit owner for "all additional substances" that are found to be profitably extracted which were not profitably extracted prior to January 1, 1979.[81] Of

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72. *Id.* at 98.

73. Stegall v. Bugh, 310 S.W.2d 251, 252 (1958).

74. *Id.*

75. *Id.* at 253.

76. Thomas A. Daily, *Arkansas' Brine Production Business How You Make Something From Less Than Nothing*, INTERSTATE OIL & GAS COMPACT COMM'N 1, 5, https://iogcc.ok.gov/sites/g/files/gmc836/f/documents/2021/brine_paper.pdf (last visited Feb. 11, 2024).

77. *Id.* at 5.

78. *Id.*

79. Young v. Ethyl Corp., 521 F.2d 771, 774 (1975) (holding that if a tract is unleased, fee-owned, and within a producer's recycling area, then displacing minerals beneath the tract is an actionable trespass).

80. ARK. CODE ANN. § 15-76-301 (1979) (hereinafter the "Act").

81. *Id.*

course, only bromine was extracted profitably from brine prior to January 1, 1979.[82]

So, what does *Strohacker* and the Act mean for lithium production in Arkansas? While these authors have no prediction, notable Arkansas practitioners, like Thomas Dailey, opine that when lithium is "profitably extracted" from brine, the Arkansas Oil and Gas Commission will likely be tasked with setting a rate and method for its royalty.[83] This determination will implicate a number of complicated issues including whether the "net back" method is a proper way to determine royalty owed.[84] For now, however, Arkansas lithium companies will continue to lease, force pool, and extract lithium from the owners of the brine estate, which include fee simple owners and owners of the mineral estate, as a result of a reservation or grant of minerals after January 1, 1955.

B. Texas

There is substantial confusion surrounding the question of what is included in a reservation or grant of "other minerals" in Texas.[85] The confusion created by Texas courts is the result of balancing two interests, which are generally at loggerheads, the right of the surface owner to preserve its surface integrity and the right of the mineral owner to produce his substances for a profit.[86] Below, we start by taking a look at Texas's attempt to clarify the ownership of saltwater and brine.[87] Then, we will become granular, looking at the meaning of "other minerals" in severances before 1983 and after 1983.[88]

1. Robinson v. Robbins Petroleum *and Its Forbearers*

There is no better case—and, by happenstance, a very important case in our present ownership predicament—than *Robinson v. Robbins Petroleum* to

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82. Thomas A. Daily, *Arkansas' Brine Production Business: How You Make Something Out of Nothing*, INTERSTATE OIL & GAS COMPACT COMM'N 1, 8 (May 12, 2021), https://iogcc.ok.gov/sites/g/files/gmc836/f/documents/2021/brine_paper.pdf.

83. *Id.* at 12–17 (discussing that the "additional substance" provision has only been utilized to force an operator to pay additional royalty once in 2007 for calcium chloride, sodium chloride, and magnesium chloride).

84. *Id.* at 15 ("Remember, the mineral to be valued is brine, not lithium, and remember that we base oil royalty upon oil, not gasoline.").

85. Peter Hosey, *Title to Uranium and Other Minerals (Still Crazy After All These Years)*, JACKSON WALKER L.L.P. 63, 64 (Dec. 2008), https://www.jw.com/wp-content/uploads/2016/05/1101.pdf.

86. *Id.*

87. *See infra* Section III.B.1. (addressing Texas case law regarding ownership of saltwater and brine).

88. *See infra* Section III.B.1. (discussing case law determining the meaning of "other minerals").

highlight the tension between a surface owner and mineral owner during development.[89]

In *Robinson*, an operator had taken oil and gas leases across multiple tracts known as the "Wagoner Lease" totaling approximately 221 acres.[90] Of that 221 acres, eighty acres were owned by R.O. Robinson.[91] The oil company was producing saltwater from Mr. Robinson's tract and using it to waterflood three nearby units.[92] The question arose as to whether the operator had trespassed by utilizing saltwater from one tract to produce the minerals of the other.[93] The court held that it was a trespass as an unreasonable use of the surface estate because it was used for another mineral lease.[94] Incidental to the primary ruling, the court succinctly presents the preliminary question of who owns the water, its reasoning, and an answer:

> The first question presented is whether salt water is part of Robinson's surface estate . . . . We are not attracted to a rule that would classify water according to a mineral contained in solution . . . . It is the water in which these parties are concerned and not the dissolved salt. If a mineral in solution or suspension were of such value or character as to justify production of the water for extraction . . . . The substance extracted might well be the property of the mineral owner . . . . [T]he water itself is an incident of surface ownership . . . . [S]aline content has no consequence upon ownership.[95]

That means that brine is owned by the surface estate in Texas, right? Not exactly. In seeming conflict with the holding in *Robinson*, citing the Supreme Court and San Antonio Court of Appeals, one Texas court held that saltwater is a mineral within the meaning of "other minerals."[96] In *Ambassador Oil Corp.*, an individual who owned both the surface and mineral estate underlying part of a pooled unit sued the operator seeking a declaration over his rights to saltwater and damages for third-party sales.[97] In both the subject lease and the unitization agreement, the phrase "other minerals" was used in the grant.[98] Basing its reasoning on the fact that salt is

89. *See generally* Robinson v. Robbins Petroleum, 501 S.W.2d 866 (Tex. 1973) (discussing issues between surface and mineral owners).

90. *Id.* at 866.

91. *Id.*

92. *Id.*

93. *Id.* at 867.

94. *Id.* at 868.

95. *Id.* at 866–67.

96. Ambassador Oil Corp. v. Robertson, 384 S.W.2d 752, 763 (Tex. App.—Austin 1964, no writ) (citing State v. Parker, 61 Tex. 265, 267 (1884); Cain v. Neumann, 316 S.W.2d 915, 917 (Tex. App.—San Antonio 1988, no writ)).

97. *Id.* at 754.

98. *Id.* at 763.

a mineral, the appellate court held that the phrase "other minerals" includes saltwater.[99]

Interestingly, in reaching its decision, the *Ambassador Oil Corp.* court cited the Texas Supreme Court case of *State v. Parker*.[100] In *Parker*, the issue was whether a Texas constitutional release of all "mineral substances" on certain surface patents included a salt lake.[101] Holding in favor of the mineral owner, and also basing its decision on the fact that salt is a mineral, the *Parker* Court held that the phrase "mineral substances" included the salt lake.[102]

Without expressly overruling *Ambassador Oil Corporation* and *Parker*, *Robinson* seemingly reaches conflicting conclusions on whether brine (saltwater or produced water) is included in a grant of "other minerals."[103] Because *Robinson* is a later Supreme Court opinion, however, it should control the question of whether the phrase "other minerals" includes saltwater.[104] But, even if *Robinson* controls, it leaves open the inquiry: if saltwater belongs to the surface estate, is a mineral dissolved in said saltwater included in the phrase "other minerals" when the mineral in solution is "of such value" that it "justif[ies] production of the water for extraction"?[105]

2. The "Tests" for Other Minerals

Since *Robinson* and its forbearers, Texas has taken two somewhat fact-intensive and formulaic approaches to determining whether a mineral falls within the grant of "other minerals" in the chain of title.[106] Fortunately, practitioners know that Texas courts have expressly rejected the following ways to determine the meaning of a "mineral": the rule of *ejusdem generis*;[107] a technical, scientific definition;[108] and an inquiry into whether the parties had knowledge of the substance's value or existence at the time of execution.[109]

Unfortunately, the tests Texas courts apply do not provide much more clarity than the tests that they rejected.[110] In Texas, for grants or reservations of "other minerals" before June 8, 1983, courts applied the "Surface

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99. *Id.*
100. *Id.* (citing State v. Parker, 61 Tex. 265, 266 (1884)).
101. *Parker*, 61 Tex. at 267–68.
102. *Id.* at 268.
103. *Robinson*, 501 S.W.2d at 867.
104. *See id.* at 866–67.
105. *See id.*
106. *See id.*
107. *See, e.g.*, Southland Royalty Co. v. Pan Am. Petroleum Corp., 378 S.W.2d 50, 54 (Tex. 1964) (holding that *ejusdem generis* has never been accepted for minerals).
108. Heinatz v. Allen, 217 S.W.2d 994, 997 (Tex. 1949).
109. Acker v. Guinn, 464 S.W.2d 348, 352 (Tex. 1971) (adopting a general intent approach to determining ownership, resulting in actual knowledge of a substance's existence irrelevant).
110. *See* Reed v. Wylie, 597 S.W.2d 743, 748 (Tex. 1980); *see also* Moser v. U.S. Steel Corp., 676 S.W.2d 99, 103 (Tex. 1984) (deciding the date of which a particular test should be applied).

Destruction Test," but for those after June 8, 1983, courts apply the "Ordinary and Natural Meaning Test."[111]

Beginning in 1919, courts in Texas disagreed on whether the extraction method for a mineral should be considered in determining whether that mineral is owned by the surface or mineral estate.[112] In *Luse v. Boatman*, an appellate court held that a reservation of "coal and mineral" included oil and gas as part of the severance because "it makes no difference whether the means used for extracting the mineral is . . . pick and shovel . . . or by drill or bit."[113] However, three decades later, the Texas Supreme Court pivoted, concluding that the term "mineral rights" should be interpreted "according to its ordinary and natural meaning."[114] In so doing, the court identified four factors to consider: (1) the nature of the substance; (2) its relation to the soil; (3) its use and value; and (4) the effect of removal on the land. As Texas's jurisprudence evolved, the fourth factor—the effect of removal on the land—became the exclusive factor for determining whether a substance belonged to the mineral estate or surface estate.[115]

a. The Surface Destruction Test (Pre-1983)

The year 1971 can be deemed the year that the "surface destruction test" was deployed in full force by the Texas Supreme Court in *Acker v. Guinn*.[116] In *Acker*, the owners of a half interest "in and to all of the oil, gas and other minerals in and under, and that may be produced" sued for a declaration that they owned the iron ore which extended from outcroppings to fifty feet below their tract.[117] Evidence showed that the only way to mine the iron ore was by open pit mining methods.[118] The court reasoned that because "the surface owner could make practically no beneficial use of his land where the mining operations are in progress," including "farming, ranching, and timber production," iron ore belonged to the surface estate.[119] It was here that the court succinctly set forth the surface destruction test: "Unless the contrary intention is affirmatively and fairly expressed, therefore, a grant or reservation of 'minerals' or 'mineral rights' should not be construed to

111. *See* Reed v. Wylie, 597 S.W.2d 743, 748 (Tex. 1980); *see also* Moser v. U.S. Steel Corp., 676 S.W.2d 99, 103 (Tex. 1984) (applying the "ordinary and natural meaning test").

112. *See* Luse v. Boatman, 217 S.W. 1096, 1099 (Tex. Civ. App.—Fort Worth 1919, writ ref'd).

113. *Id.* at 1011.

114. Heinatz v. Allen, 217 S.W.2d 994, 997 (Tex. 1949).

115. Hosey, *supra* note 85 at 68, (citing Acker v. Guinn, 464 S.W.2d 348, 352 (Tex. 1971); Reed v. Wylie, 597 S.W.2d 743, 747 (Tex. 1980)).

116. *Acker*, 464 S.W.2d at 349.

117. *Id.* at 351–52.

118. *Id.* at 350.

119. *Id.* at 351.

include a substance that must be removed by methods that will, in effect, consume or deplete the surface estate."[120]

As one commentator noted, the surface destruction test was largely based on the premise that a rational surface owner would not convey a substance of which production would deprive him of beneficial use of his land.[121] Unfortunately for practitioners, despite expanding the surface destruction test to include as part of the surface estate, substances within 200 feet of the surface as a matter of law, the court changed its mind about that premise just a few years later.[122]

b. The Ordinary and Natural Meaning Test (Post-1983)

In 1983, the Texas Supreme Court dropped a judicial bombshell when it formally recognized that its *Acker, Reed I,* and *Reed II* jurisprudence had created fact-intensive uncertainty through application of the surface destruction test and wholeheartedly abandoned it as the standard for determining what is included in a reservation or grant of minerals.[123] In *Moser v. U.S. Steel Corp.*, owners of the surface asked the court to quiet title to uranium deposits on a tract of land.[124] The document severing the estates reserved to the mineral owner, "all of the oil, gas, and other minerals of every kind and character, in, on, under and that may be produced[.]"[125] The trial court applied the surface destruction test and the mineral owner prevailed because in-situ leach mining was the only method available in 1949 (the time of execution) that would not destroy the surface.[126] Concluding, however, that the surface destruction test "has resulted in title uncertainty," the Texas Supreme Court ruled that "title to uranium is held by the mineral estate as a matter of law" and announced a return to the ordinary and natural meaning test for mineral severances after June 8, 1983.[127] The court succinctly proposed the ordinary and natural meaning rule as follows: "[A] severance of minerals in an oil, gas and other minerals clause includes all substances within the ordinary and natural meaning of that word, whether their presence or value is known at the time of severance."[128]

120. *Id.* at 352.
121. *Hosey*, *supra* note 85.
122. Moser v. U.S. Steel Corp., 676 S.W.2d 99, 101 (Tex. 1984).
123. *Id.* at 103.
124. *Id.* at 100.
125. *Id.*
126. *Id.* at 101.
127. *Id.* at 101–02.
128. *Id.* at 102.

3. The Tests Applied to Lithium

Although there is no direct Texas case law on the question, it is probable that lithium is a mineral when analyzed either through the lens of the ordinary and natural meaning test (post-1983) or the surface destruction test (pre-1983).

As for the ordinary and natural meaning test, on its face, there appears to be little to no controverting evidence that someone would not consider lithium within the ordinary and natural meaning of the word "mineral." For instance, lithium is found beneath the surface of the Earth. It is not a building material (sand, limestone, gravel, caliche); it is silvery white in color, found in the periodic table of elements, and is a metal. Tellingly, under the ordinary and natural meaning test, Texas courts have recognized other silvery white metals found underground and on the periodic table of elements as minerals; namely, uranium in *Moser*.[129]

Notably, Section 75 of the Texas Property Code, which deals with escheat of unclaimed mineral proceeds, defines "mineral" in reliance on the ordinary and natural meaning test.[130] The statute does not specifically mention lithium in the litany of substances enumerated as minerals, but does give some context and includes "any other substance that is ordinarily and naturally considered a mineral[.]"[131] It further states that such substances are defined as "minerals" regardless at what depth they are found.[132] This appears to be an attempt to override the surface destruction test. However, Section 75 has limited application since it only addresses escheat matters, but it was enacted after *Moser* took effect and appears to be the Texas legislature's only attempt to define "minerals."[133] It is a contextual argument at best.

As for the surface destruction test, like the court of appeals in *Moser*—which applied the surface destruction test and held that uranium did not result in substantial destruction of the surface when mined by in-situ leaching—there is no reason to distinguish lithium from uranium.[134] Lithium extraction in Texas will most likely occur by means of producing brine water through a wellbore and then processing out the lithium at the surface through DLE.[135] The impact on ranching, farming, or timber harvesting will be *de minimis* if not non-existent—the focus of those pre-*Moser* courts and a mining methods

129. *Id.* at 101–102.

130. TEX. PROP. CODE ANN. § 75.001(a)(1).

131. *Id.*

132. *Id.*

133. *Id.*

134. *Moser*, 676 S.W.2d at 101.

135. *DLE vs Hardrock Extraction vs Evaporation*, CLEANTECH LITHIUM, https://ctlithium.com/lithium/dle-vs-hardrock-vs-evaporation/ (last visited Feb. 11, 2024) (describing how the Texas climate—as arid and dry as some parts may be—does not lend itself to evaporative pits in Cass County, Texas).

"substantial impact."[136] Since there is likely not a substantial destruction of the surface, lithium should be considered a mineral.

However, since water is an attribute of the surface estate as a matter of law, an issue that was decided post-*Moser*, an argument can be made that mining lithium from brine should be considered substantial destruction of the surface because much of the brine is consumed before reinjecting into the sub-surface strata. This is similar to the correlative rights argument made in *Robinson*, (i.e., producing brine for use on another tract was an unreasonable use of the surface) which also held that brine was not included in the grant of other minerals.[137] However, *Robinson* may be distinguished when extraction of the brine is done specifically to recover lithium and not water. For the operator in *Robinson*, salt extraction was not the objective, the objective was injecting the salt-laden groundwater for oil and gas extraction, and the court noted that specifically.[138]

Whether lithium is within the ordinary and natural meaning of "mineral," or the extraction of the substance would consume the surface, would be, in most cases, a question of fact. Thus, a legislative solution may be appropriate.

IV. A PROPOSED LEGISLATIVE SOLUTION

To resolve the title questions surrounding lithium extraction from brine, Texas should consider a legislative solution. Similar real property rights questions regarding geothermal development (i.e., does the surface or mineral estate own geothermal heat) were frequently addressed by the legislature. This may serve as a model for lithium.[139] Any bill regarding the lithium issue should address both the ownership of the lithium itself, the role and rights of the surface owner in production of brine, and the effect of "other minerals" such as the following:

> Except as otherwise expressly provided by a conveyance, contract, deed, reservation, exception, limitation, lease, or other binding obligation, lithium at any depth is owned as real property by the owner of the mineral estate of the land. The owner of the mineral estate of the land shall have the right, and may lease to or otherwise authorize third parties, to drill for, produce, and consume subsurface brine for the purpose of extracting the constituent lithium therefrom without obtaining consent from or providing compensation to the owner of the surface estate in the land. Severances of 'other minerals' from the fee by grant or reservation shall be deemed to include lithium regardless of the date of severance.

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136. Acker v. Guinn, 464 S.W.2d 348, 353 (Tex. 1971).
137. Robinson v. Robbins Petroleum, 501 S.W.2d 865, 866 (Tex. 1973).
138. *Id.*
139. TEX. NAT. RES. CODE ANN. § 141.004.

V. CONCLUSION

While mineral extraction from brine has existed for many years, Texas law on the matter is still in its infancy. Texas case law provides clues about the ownership of lithium as extracted from brine and the rights of the surface owner, but investment in the industry would benefit from settling those matters under the law. Rather than waiting on the development of case law, which could take a long time and may not produce clear answers, Texas should consider a legislative solution addressing these issues. But in the meantime, ask us our opinion on who owns the lithium in brine in Texas . . . we can "li" to you.

HYDROGEN, A TEXAS-SIZED ENDEAVOR

Laura Bowen[*]

There, on January 10, 1901, a new age of human progress was born when the first great oil gusher roared in. There and then, America was blessed with the supply of energy and the incentive to move up from a secondary position in world affairs to that of undisputed leadership. Before Spindletop oil was used for lamps and lubrication. The famous Lucas gusher

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changed that. It started the liquid fuel age, which brought forth the automobile, the airplane, the network of highways, improved railroad and marine transportation, the era of mass production and untold comforts and conveniences.
– Michel T. Halbouty and James A. Clark[1]

I. INTRODUCTION

Like the wildcatters, an attorney can find one's life changed from one day to the next. Such it was in 2021, when I traveled to West Texas for my very first meeting about a green hydrogen lease. In my representation of farmers and ranchers, I have seen every flavor of wind, solar, battery, carbon capture, bitcoin mining, and countless other "newfangled" land agreements, but green hydrogen seemed of greater consequence. I spent the night before the meeting contemplating hydrogen-powered cars and boats, reading lofty carbon-neutral goals, and generally attempting to understand why any company would try and lease the Chihuahuan Desert for such a water-intensive venture as green hydrogen. The next day, much of the meeting was spent asking questions, which prompted more questions than answers, and I was fairly certain that we had scared the company off with our skepticism of their plans. Looking back, I underestimated the tenacity of Texans—where there is money to be made, there is a way.

Considering the scope of climate change conversations, carbon-free fuel and hydrogen production have moved from the theoretical to the established, with hundreds of new hydrogen facilities planned around the globe.[2] Almost overnight, my meetings, client calls, lunches, and dinners became occupied with speculation on future hydrogen markets and legal limitations of technologies—which I was learning at breakneck speed. As more hydrogen agreements crossed my desk, I became compelled to write on the subject of hydrogen agreements, as so much of it happens behind closed doors and a confidentiality wall.[3]

I beg the grace of the reader, as I am an attorney and not a scientist. I have included, in the footnotes, helpful resources I use to better understand the purpose, scope, and pitfalls of hydrogen agreements. This paper should serve the reader as a basic overview of hydrogen production and a dive into the practical legal issues with hydrogen agreements. If interested, the reader should review the scientific literature, as the technology hypothesized is a truly exciting glimpse into our future. My legal considerations focus on the

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1. JAMES A. CLARK & MICHEL T. HABOUTY, SPINDLETOP xv (Random House, Inc., 1st ed. 1952).
2. *See Global Hydrogen Review 2021*, INTEL ENERGY AGENCY, (Sept. 20, 2023 5:00 PM), https://www.iea.org/reports/global-hydrogen-review-2021/executive-summary.
3. *See* RODERICK E. WETSEL & BECKY H. DIFFEN, WIND & SOLAR LAW §§ 2.19, 3.19 (Matthew Bender ed. 2023).

practical—as we encounter hydrogen agreements, what should we be concerned about?

Even as I wrote this article, the possibility of ammonia production as a secondary refinement of hydrogen and a solution to the hydrogen storage problem was presented to one of my clients, and in turn presented to me. For both my client and for this article, I had to swiftly educate myself on the ammonia production process and how it would possibly affect my surface owner client. Certainly, as new technologies emerge and present new opportunities for the energy market, so too must our legal analysis of such advancements evolve and adapt so that we can best serve our clients and keep pace with the industry. I have no doubt that hydrogen production has only begun to change the energy landscape and will become a bigger conversation in the years to come.

II. HYDROGEN, FUEL OF THE FUTURE

A. Hydrogen and Hydrogen Classifications

Hydrogen as a fuel and hydrogen production has been around for many decades, but new global and federal agendas have reinvigorated efforts to produce hydrogen as a carbon-free fuel source.[4] Hydrogen enjoys the number one spot on the periodic table, being discovered in 1766 and named water (hydro) creator (gen), after scientists discovered that burning the gas created water.[5] Hydrogen is everywhere, in water, soil, and fossil fuels, but hydrogen rarely occurs naturally in pure form.[6]

Because pure hydrogen has not been discovered in qualities useable for fuel, additional energy and refining are necessary to separate the hydrogen out of source materials (feedstock).[7] Depending on the process of extraction and the source of the hydrogen, hydrogen production is categorized by color.[8] The following paragraphs list the current classifications of hydrogen in descending order of prevalence.[9]

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4. *See generally* Julien Armijo et al., *Global Hydrogen Review*, INT'L ENERGY AGENCY 5–6 (2022), https://iea.blob.core.windows.net/assets/c5bc75b1-9e4d-460d-9056-6e8e626a11c4/GlobalHydrogenReview2022.pdf (discussing hydrogen projects across the globe).

5. Natalie Marchant, *Grey, Blue, Green – Why are there so many Colours of Hydrogen?*, WORLD ECON. F. (July 27, 2021), https://www.weforum.org/agenda/2021/07/clean-energy-green-hydrogen/.

6. *See* S. Shiva Kumar & Hankwon Lim, *An Overview of Water Electrolysis Technologies for Green Hydrogen Production*, ENERGY REPORTS (Sept. 20, 2023, 5:00 PM), https://www.sciencedirect.commcom/science/article/pii/S2352484722020625.

7. *See generally Types of Hydrogen Fuel*, UNIV. OF CALGARY (Sept. 20, 2023, 5:00 PM), https://energyeducation.ca/encyclopedia/Types_of_hydrogen_fuel (discussing different processes to produce hydrogen and their colors).

8. *Id.*

9. *Id.*; Marchant, *supra* note 5; *The colours of hydrogen*, EWE, https://www.ewe.com/en/shaping-the-future/hydrogen/the-colours-of-hydrogen (last visited Sept. 27, 2023); *Hydrogen Production: Natural Gas Reforming*, OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY, https://www.energy.gov/eere

1. Grey Hydrogen

Grey hydrogen is currently the most prolifically produced hydrogen type globally.[10] Grey hydrogen is the broad definition of hydrogen produced from fossil fuels, typically methane from natural gas production or coal.[11] Currently, the term "grey hydrogen" is most commonly associated with methane hydrogen production as coal hydrogen production has been given its own moniker—black hydrogen.[12] Methane is pressurized with high-temperature steam, splitting the methane into hydrogen and carbon monoxide ($CH_4 + 2H_2O = CO_2 + 4H_2$), in a process called steam–methane reform.[13] Carbon monoxide produced is then further treated to create carbon dioxide which can be vented into the air.[14] Grey hydrogen and blue hydrogen, discussed below, have a $10 billion to $12 billion annual domestic market, currently representing 95% of the United States' hydrogen production.[15] Natural gas remains one of the cheapest and most plentiful resources in the United States, and significant research has gone into decarbonizing the grey hydrogen process through the blue and turquoise hydrogen processes, discussed below.[16]

2. Blue Hydrogen

Blue hydrogen is produced through the same process as grey hydrogen, but the carbon dioxide created during the steam reform is sequestered underground.[17] With blue hydrogen, sequestering the carbon produced in the steam reforming process would eliminate up to 60% of emissions, thus blue hydrogen is considered a cleaner alternative to grey hydrogen.[18] Carbon sequestration adds additional expense to the steam reforming process, and is

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/fuelcells/hydrogen-production-natural-gas-reforming#:~:text=In%20steam%2Dmethane%20reforming %2C%20methane,for%20the%20reaction%20to%20proceed (last visited Sept. 27, 2023); *5.1 Gasification Introduction*, NAT'L ENERGY TECH. LAB., https://netl.doe.gov/research/Coal/energy-systems /gasification/gasifipedia/intro-to-gasification (last visited Sept. 27, 2023).

10. *Pathways to Commercial Liftoff: Clean Hydrogen*, U.S. DEP'T OF ENERGY (Mar. 5, 2023), https://liftoff.energy.gov/wp-content/uploads/2023/05/20230320-Liftoff-Clean-H2-vPUB-0329-update. pdf.

11. *Hydrogen Production: Natural Gas Reforming*, *supra* note 9.

12. *The Hydrogen Colour Spectrum*, NAT'L GRID, https://www.energy.gov/eere/fuelcells/hydrogen-production-natural-gas-reforming#:~:text=In%20steam%2Dmethane%20reforming%2C%20methane, for%20the%20reaction%20to%20proceed (last updated Feb. 23, 2023).

13. *Hydrogen Production: Natural Gas Reforming*, *supra* note 9.

14. *Id.*

15. *Pathways to Commercial Liftoff: Clean Hydrogen*, *supra* note 10, at 11, 23 (Projections were published in 2023, based on a 2021 market report).

16. *See* Adam Kay, *It's Time to Pay Attention to Turquoise Hydrogen*, AM. GAS ASS'N (June 23, 2023) https://www.aga.org/its-time-to-pay-attention-to-turquoise-hydrogen/.

17. *Types of Hydrogen Fuel*, *supra* note 7.

18. *Pathways to Commercial Liftoff: Clean Hydrogen*, *supra* note 10, at 11.

limited by necessary geography for storing carbon long term.[19] In the near term, blue hydrogen producers may take advantage of the 45Q tax credits to offset carbon capture costs, as discussed below.[20]

3. Turquoise Hydrogen

Turquoise Hydrogen is produced with a process called methane pyrolysis, where reactors or blast furnaces are used to split methane feedstock.[21] The turquoise hydrogen process is in the experimental phase, but shows promise as carbon produced from methane pyrolysis is in a solid state (carbon black), which is usable in other industries or easily stored **($CH_4 = C + 2H_2$)**.[22]

4. Black Hydrogen

Black hydrogen is type of grey hydrogen, produced through applying the steam reform process to bituminous coal.[23] Byproducts of black hydrogen include carbon monoxide, further reformed to carbon dioxide, and various other mineral residues.[24] China is one of the biggest producers of black hydrogen, with 62% of the total 25 million tons of hydrogen produced in China coming from coal gasification.[25]

5. Brown Hydrogen

Brown hydrogen is a type of grey hydrogen, and is produced through the same method as black hydrogen, with the exception that brown hydrogen is produced by applying the steam reform process to lignite.[26] Black and

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19. *See* Adam Baylin-Stern & Niels Berghout, *Is Carbon Capture too Expensive?*, INTEL ENERGY AGENCY (Feb. 17, 2021), https://www.iea.org/commentaries/is-carbon-capture-too-expensive.

20. *Pathways to Commercial Liftoff: Clean Hydrogen*, *supra* note 10, at 11.

21. *Types of Hydrogen Fuel*, *supra* note 7.

22. Jose M. Marin Arcos & Diogo M. F. Santos, *The Hydrogen Color Spectrum: Techno-Economic Analysis of the Available Technologies for Hydrogen Production*, MULTIDISCIPLINARY DIG. PUBL'G INST. (Feb. 3, 2023), https://www.mdpi.com/2673-5628/3/1/2#:~:text=According%20to%20the%20literature%2C%20pink,thermochemical%20water%20splitting%20%5B10%5D; *see also* Schalk Cloete, *Clean Turquoise Hydrogen: A Pathway to Commercial Readiness*, ENERGYPOST.EU (July 22, 2022), https://energypost.eu/clean-turquoise-hydrogen-a-pathway-to-commercial-readiness/.

23. *Types of Hydrogen Fuel*, *supra* note 7.

24. Arcos, *supra* note 22.

25. Hack Heyward, *How Quickly will China Clean Up Its World-Leading, Yet Extremely Dirty Hydrogen Industry?*, RECHARGE GLOB. NEWS AND INT'L FOR THE ENERGY TRANSITION (Sept. 23, 2021), https://www.rechargenews.com/energy-transition/cop26-how-quickly-will-china-clean-up-its-world-leading-yet-extremely-dirty-hydrogen-industry-/2-1-1072159 (This estimate is dated to 2021. Accurate numbers for 2023 were difficult to secure).

26. *The Hydrogen Colour Spectrum*, *supra* note 12.

brown hydrogen production account for approximately 4% of the United States' hydrogen production.[27]

6. Green Hydrogen

Green hydrogen is produced by running electricity from renewable sources through water (H_2O) to separate the hydrogen atoms from the oxygen atom, in a process called electrolysis.[28] Provided that all electricity used in electrolysis is from renewable sources, the only byproduct of the green hydrogen process is oxygen.[29] Renewable electricity sources are primarily wind and solar, but also include hydropower.[30]

The process of electrifying water to extract the hydrogen is straightforward—children around the world have conducted simple experiments to create hydrogen bubbles with a 12-volt battery and wire in water.[31] To produce and capture hydrogen on a commercial scale, electrolyzed water passes through stages of membranes which separate the hydrogen from the oxygen ions produced, thus allowing produced gas to be captured.[32]

Considering that electricity produced on the grid is mixed, there has been some debate as to what hydrogen can be classified as "green."[33] The European Commission has released guidelines on renewable hydrogen and the United States will finalize proposed guidelines later in 2024.[34] Green

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27. *Hydrogen Strategy Enabling a Low-Carbon Economy*, U.S. DEP'T OF ENERGY (July 2020), https://www.energy.gov/sites/prod/files/2020/07/f76/USDOE_FE_Hydrogen_Strategy_July2020.pdf.

28. Chiara Signoria & Marco Barlettani, *Environmental, Health, Safety, and Social Management of Green Hydrogen in Latin America and the Caribbean: a Scoping Study,* IDB (May 2023), https://publications.iadb.org/en/environmental-health-safety-and-social-management-green-hydrogen-latin-america-and-caribbean.

29. *Id.*

30. *Types of Hydrogen*, *supra* note 7.

31. *Exploding bubbles of hydrogen and oxygen*, ROYAL SOC'Y OF CHEMISTRY, https://edu.rsc.org/experiments/exploding-bubbles-of-hydrogen-and-oxygen/752.article (last visited Oct. 19, 2023); *see also Hydrogen Fuel from Water*, ARGONNE NAT'L LAB., (May 30, 2023), https://www.anl.gov/sites/www/files/2020-09/Hydrogen%20Fuel%20from%20Water_v2.pdf.

32. Signoria, *supra* note 28.

33. *Energy explained, Electricity in the United States*, U.S. ENERGY INFO. ADMIN., https://www.eia.gov/energyexplained/electricity/electricity-in-the-us.php (last updated June 30, 2023); Dan Feldman et al, *Europe's Definition of Green Hydrogen (RFNBO) Adopted into EU Law*, JD SUPRA (June 22, 2023), https://www.jdsupra.com/legalnews/europe-s-definition-of-green-hydrogen-6926790/.

34. Directorate-General for Energy, *Renewable hydrogen production: new rules formally adopted*, EUROPEAN COMM'N (June 20, 2023), https://energy.ec.europa.eu/news/renewable-hydrogen-production-new-rules-formally-adopted-2023-06-20_en; *see* David Iaconangelo, *E.U.'s "green" hydrogen rules may shape American Industry*, ENV'T & ENERGY NEWS BY POLITICO (July 7, 2023, 6:38 AM), https://www.eenews.net/articles/e-u-s-green-hydrogen-rules-may-shape-american-industry/; *see Section 45V Credit for Production of Clean Hydrogen; Section 48(a)(15) Election To Treat Clean Hydrogen Production Facilities as Energy Property*, FED. REG. (Dec.. 26, 2023), https://www.federalregister.gov/documents/2023/12/26/2023-28359/section-45v-credit-for-production-of-clean-hydrogen-section-48a15-election-to-treat-clean-hydrogen.

hydrogen production accounts for only 1% of United States hydrogen production.[35]

Green hydrogen is a part of global plans to de-carbonize the energy sector, and has thus been a focus for expansive research and investment.[36] As discussed in depth in Section III below, there are a number of hurdles to a viable green hydrogen market.[37]

7. Red Hydrogen

Red hydrogen is reformed with the same process as black and brown hydrogen, but steam reform is applied to biomass.[38] Red hydrogen typically generates lower levels of associated carbon dioxide.[39] Provided the carbon dioxide created is sequestered, red hydrogen can be a low carbon process.[40]

8. Pink Hydrogen

Pink hydrogen is produced through a green hydrogen process where water is electrolyzed using electricity from nuclear power facilities.[41] Three pink hydrogen facilities are being integrated into existing nuclear facilities at Nine Mile Point Nuclear Power Station in New York, at Davis-Bessee Nuclear Power Station in Ohio, and at Prairie Island Nuclear Generating Plant in Minnesota.[42]

9. Purple Hydrogen

Purple hydrogen, sometimes confused with pink hydrogen, is the thermochemical splitting of water, often using high heat from nuclear energy and various chemical compounds to cause a chain reaction splitting the

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35. *Hydrogen Strategy Enabling A Low-Carbon Economy*, U.S. DEPT. OF ENERGY (July 5, 2020), https://www.energy.gov/sites/prod/files/2020/07/f76/USDOE_FE_Hydrogen_Strategy_July2020.pdf.

36. Arcos, *supra* note 22.

37. *See* discussion *infra* Section III.

38. *Types of Hydrogen*, *supra* note 7.

39. *Id.*

40. *Id.*; *Hydrogen Production: Biomass-Derived Liquid Reforming*, OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY, https://www.energy.gov/eere/fuelcells/hydrogen-production-biomass-derived-liquid-reforming (last visited Sept. 27, 2023).

41. *Types of Hydrogen*, *supra* note 7 (purple and pink hydrogen are often interchanged, depending the resource of information).

42. *3 Nuclear Power Plants Gearing Up for Clean Hydrogen Production*, OFFICE OF NUCLEAR ENERGY (Nov. 9, 2022), https://www.energy.gov/ne/articles/3-nuclear-power-plants-gearing-clean-hydrogen-production.

hydrogen atoms away from oxygen atoms.[43] When the chemical compounds are used in a closed loop, purple hydrogen's only biproduct is oxygen.[44]

10. Yellow Hydrogen

Yellow hydrogen is a form of green hydrogen where electricity used in the electrolyzers process is entirely from solar power.[45]

11. White/Gold Hydrogen

White hydrogen is the classification given to naturally occurring gaseous hydrogen.[46] Studies are being conducted into the amount of white hydrogen volumes occurring globally in geological formations, such as, volcanoes, geysers, and hydrothermal systems.[47] Gold hydrogen is the specific name given to naturally occurring hydrogen in depleted oil wells; hydrogen is a byproduct of fermenting microbes.[48] If natural hydrogen deposits can be discovered it would greatly reduce the cost associated with hydrogen, because, like oil and natural gas, hydrogen could be extracted rather than manufactured.[49]

B. Hydrogen as a Fuel

Hydrogen, produced by any of the processes above, is in a gaseous state.[50] Hydrogen gas is non-toxic, but handling requires hydrogen-specific infrastructure, since the atom is smaller and more difficult to contain than gasoline or natural gas.[51] Further, as made infamous by the *Hindenburg*, hydrogen has a lower ignition factor than other flammable gases, thus creates

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43. *Hydrogen Production: Thermochemical Water Splitting*, OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY https://www.energy.gov/eere/fuelcells/hydrogen-production-thermochemical-water-splitting#:~:text=How%20Does%20It%20Work%3F,and%20produces%20hydrogen%20and%20oxygen.

44. *Id.*

45. *Types of Hydrogen Fuel*, *supra* note 7.

46. Arcos, *supra* note 22.

47. *Id.*

48. Andrea Willige, *The colors of hydrogen: Expanding ways of decarbonization*, SPECTRA (July 28, 2022), https://spectra.mhi.com/the-colors-of-hydrogen-expanding-ways-of-decarbonization.

49. Ryze Hydrogen, *There's Hydrogen in Them There Hills: The Trailblazers Mining for 'Gold Hydrogen'*, HYDROGEN CENT. (Mar. 4, 2023), https://hydrogen-central.com/theres-hydrogen-hills-trailblazers-mining-gold-hydrogen-ryze-hydrogen/.

50. *Types of Hydrogen*, *supra* note 7.

51. Signoria, *supra* note 28.

a greater fire danger for hydrogen in concentrated amounts.[52] Being colorless and odorless in its gaseous form makes hydrogen dangerous to store.[53]

Hydrogen has a lower volumetric energy density than other fuels.[54] To accommodate for this lower energy density, hydrogen may be pressurized into liquid form at -423 degrees Fahrenheit (-253 degrees Celsius), or further refined into other energy carriers such as ammonia, as discussed in more detail below.[55] The hydrogen liquid to gas ratio is approximately 1:850, or 1 gallon of liquid hydrogen equals 850 gallons of stored gaseous hydrogen.[56]

Hydrogen in liquid form requires both cold and pressure to remain in liquid form requiring hydrogen specific storage or, alternatively, further modification to existing storage infrastructure in order to house liquid hydrogen.[57] Thus, for long term storage solutions, hydrogen facilities are looking to store hydrogen gas in subterranean salt domes similar to those used to store natural gas.[58]

Electrolysis facilities for the production of green hydrogen, typically consist of several modular electrolyzers either housed in a building or in system-contained units the approximate size of rail cars.[59] These facilities input water and pipe out gaseous hydrogen, with some electricity used to power the ancillary mechanisms around the electrolyzer.[60] Depending on the type of facility and the targeted outputs, facility size can range from a few thousand square feet to several dozen acres.[61]

In contrast, steam methane reform (SMR) facilities, for the production of grey and blue hydrogen, are visually similar to systems present in oil and gas refineries.[62] SMR facilities can be integrated into existing natural gas

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52. Signoria, *supra* note 28; *see also* Donovan Webster, *What Really Felled the Hindenburg*?, SMITHSONIAN (May 4, 2017), https://www.smithsonianmag.com/smithsonian-institution/80th-anniversary-hindenburg-disaster-mysteries-remain-180963107/.

53. Signoria, *supra* note 28.

54. *Hydrogen Storage*, HYDROGEN & FUEL CELL TECH. OFFICE, https://www.energy.gov/eere/fuelcells/hydrogen-storage#:~:text=On%20a%20mass%20basis%2C%20hydrogen,44%20MJ%2Fkg%20for%20gasoline (last visited Sept. 26, 2023).

55. Signoria, *supra* note 28.

56. *Hydrogen Compared with Other Fuels*, HYDROGEN TOOLS, https://h2tools.org/bestpractices/hydrogen-compared-other-fuels (last visited Sept. 26, 2023).

57. Signoria, *supra* note 28.

58. *Hydrogen City: The World's first to market green hydrogen production and storage hub*, GREEN HYDROGEN INT'L, https://www.ghi-corp.com/projects/hydrogen-city (last visited Sept. 27, 2023).

59. *Water electrolysers / hydrogen generators*, NEL, https://nelhydrogen.com/water-electrolysers-hydrogen-generators/ (last visited Sept. 26, 2023); Alan Adler, *Cummins adding hydrogen electrolyser manufacturing in US*, FREIGHT WAVES (Oct. 10, 2022), https://www.freightwaves.com/news/cummins-adding-hydrogen-electrolyzer-manufacturing-in-us; *Green Hydrogen Production*, SIEMENS ENERGY, https://www.siemens-energy.com/global/en/offerings/renewable-energy/hydrogen-solutions.html?Gclid=Cj0KCQjw0IGnBhDUARIsAMwFDLmsWuuic670FXdd40hUlhqkB8XNzoRR4iMvwpwVYy0avrmgfJQMes0aAoyHEALw_wcB (last visited Sept. 26, 2023).

60. *Id.*

61. *Id.*

62. *What is Steam Methane Reform (SMR)?*, HYDROGEN NEWSLETTER, https://www.hydrogennews

pipelines and refineries, especially where existing carbon sequestration infrastructure exists.[63] The targeted output of the facilities will determine the facility footprint.[64]

Globally, yearly demand for hydrogen is ninety-five million tons and rising.[65] The majority of demand is from existing markets, as noted in 2023 where only 0.1% of hydrogen demand was from new applications.[66] Historically, the bulk of produced hydrogen is consumed by refineries as a purifying agent or an additive.[67] The remainder of produced hydrogen is used for ammonia, methanol, and in the steel industries.[68] China has the largest demand for hydrogen, followed by, in descending order, the United States, the Middle East, India and Europe.[69]

For several transport applications, research is being conducted into hydrogen fuel cells, operating similar to a battery.[70] Pure hydrogen, negatively charged, is mixed back with positively charged oxygen from the environment to produce an electrochemical reaction.[71] The only byproducts of the hydrogen fuel cell reaction are electricity, heat, and water; thus, if green hydrogen is used for fuel, the entire process is carbon-free.[72] At the end of 2022, the United States had approximately 350 megawatts of hydrogen fuel cell electrical generation capacity.[73] In California, hydrogen fuel cells have been used to power zero-emission vehicles, though, the current costs have prohibited significant growth.[74] In 2023, a company successfully

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letter.com/what-is-steam-methane-reforming-smr/ (last visited Sept. 13, 2023) (depicting photos of a steam reforming facility and a list of facility manufactures).

63. *Hydrogen Production: Natural Gas Reforming*, OFFICE OF ENERGY & RENEWABLE ENERGY, https://www.energy.gov/eere/fuelcells/hydrogen-production-natural-gas-reforming (last visited Sept. 13, 2023).

64. *Oklahoma Hydrogen Transport and Infrastructure Task Force, Introduction to the Hydrogen Economy*, OFFICE OF THE SEC'Y OF ENERGY & ENV'T (Aug. 2021), https://ee.ok.gov/wp-content/uploads/2021/08/Presentation-Hydrogen-101.pdf.

65. Praveen Bains et al., *Global Hydrogen Review*, INT'L ENERGY AGENCY 1, 13 (Dec. 2023), https://iea.blob.core.windows.net/assets/ecdfc3bb-d212-4a4c-9ff7-6ce5b1e19cef/GlobalHydrogenReview2023.pdf.

66. *Id.*

67. *Id.* at 22.

68. *Id.* at 20.

69. *Id.* at 20.

70. OFFICE DEP'T OF ENERGY, *Fuel Cells*, https://www.energy.gov/eere/fuelcells/fuel-cells (last visited Sept. 14, 2023).

71. *See id.*; *Hydrogen explained use of hydrogen*, U.S. ENERGY INFO. ADMIN., https://www.eia.gov/energyexplained/hydrogen/use-of-hydrogen.php (last updated June 23, 2023).

72. *Fuel Cell Basics*, FUEL CELL & HYDROGEN ENERGY ASS'N., https://www.fchea.org/fuelcells (last visited Sept. 13, 2023).

73. *Hydrogen explained use of hydrogen*, U.S. ENERGY INFO. ADMIN., https://www.eia.gov/energyexplained/hydrogen/use-of-hydrogen.php (last updated June 23, 2023).

74. *See* Cal. Air Res. Bd., *Hydrogen Fuel Cell Electric Cars*, DRIVECLEAN, https://driveclean.ca.gov/hydrogen-fuel-cell (last visited Sept. 26, 2023); *see also Hydrogen explained use of hydrogen*, *supra* note 73.

completed a test flight on a multi-engine aircraft with one of its turbine engines powered by liquefied hydrogen fuel cells.[75]

III. HYDROGEN: THE MISSING LINKS

The United States, as part of the 2021 Infrastructure Investment and Jobs Act (also known as the Bipartisan Infrastructure Law (BIL)) and the 2022 Inflation Reduction Act (IRA), signaled federal support for additional hydrogen production, especially green hydrogen.[76] In June of 2023, the United States Department of Energy (DOE) released general goals for hydrogen production, to be completed by 2030, 2040, and 2050.[77]

In the near term, hydrogen production will be subsidized by Production Tax Credits (PTC) and DOE's funding of Regional Clean Hydrogen Hubs.[78] Over the next decade, the DOE predicts that the economies of scale will shift the production cost of hydrogen to the point that private hydrogen infrastructure will overtake the market and become a viable, carbon-free replacement for many fossil fuel markets.[79] Practically speaking, there are a number of production costs which will have to drop in order for private production to remain profitable after the expiration of the PTC in 2032.[80] These costs include equipment costs, storage costs, distribution costs, and most importantly—electricity costs.[81] At the time of this articles publishing, green hydrogen costs between $3–$6 per kilogram to produce.[82] DOE has set an ambitious goal, known as the "Hydrogen Shot," to target reduce hydrogen production costs to $1 per kilogram by 2031, an 80% reduction in current

75. Rob Verge, *This Plane powered by hydrogen has made an electrifying first flight*, POPULAR SCI. (Mar. 7, 2023, 3:00 PM), https://www.popsci.com/technology/hydrogen-fuel-cell-aircraft-explained/.

76. *See generally U.S. National Clean Hydrogen Strategy & Roadmap*, DEP'T OF ENERGY 1, 3, https://www.hydrogen.energy.gov/pdfs/us-national-clean-hydrogen-strategy-roadmap.pdf (last visited Sept. 26, 2023).

77. *Id*. at 6.; *see generally United States of Hydrogen*, HYDROGEN FORWARD, https://www.hydrogenfwd.org/wp-content/uploads/2021/11/Hydrogen-Fwd-Projects_v2.pdf (last visited Sept. 26, 2023) (for an overview of hydrogen projects in the United States).

78. *Pathways to Commercial Liftoff: Clean Hydrogen*, *supra* note 12, at 2 (as part of BIL, the United States designed seven billion dollars to create six to ten regional hydrogen production facilities); *see also Regional Clean Hydrogen Hubs*, OFFICE OF CLEAN ENERGY DEMONSTRATIONS, https://www.energy.gov/oced/regional-clean-hydrogen-hubs (last visited Sept. 13, 2023) (Regional Clean Hydrogen Hubs are also called H2Hubs).

79. *Id.*

80. *Id.* (The production tax credits will phase out in the later of (i) 2032 or (ii) the reduction of U.S. power sector greenhouse gas emissions by 25% of 2022 levels. Proposed guidelines for qualifying clean hydrogen incentives were published on December 22, 2023); *see Treasury Sets Out Proposed Rules for Transformative Clean Hydrogen Incentives*, THE WHITE HOUSE (Dec. 22, 2023), https://www.whitehouse.gov/cleanenergy/clean-energy-updates/2023/12/22/treasury-sets-out-proposed-rules-for-transformative-clean-hydrogen-incentives/#:~:text=The%20%C2%A7%2045V%20tax%20credit,catalyze%20nearly%20%2450%20billion%20in.

81. *Id.*

82. *Id.* (The IRA hydrogen green tax credit is up to $3/kg, significantly changing potential green hydrogen financials. Currently, more guidance on what hydrogen will qualify for this credit is pending).

costs.[83] There are a number of practical limitations to this ambitious goal, discussed below.[84] The DOE's plan includes grey and blue hydrogen production, with proposed methods to scale production and eliminate portions of the carbon produced.[85]

Despite the established and promising science behind green hydrogen, many green hydrogen facilities are in the early stages, with only one hundred kilotons of available global production of green hydrogen.[86] As of the publication of this article, China leads the globe in green hydrogen production, the biggest facility being the Kuqa facility in Xinjiang with 260 megawatts of electrolyzer capacity.[87]

A. New Versus Existing Infrastructure

Extensive infrastructure must be installed or repurposed to support new hydrogen production.[88] Proponents of hydrogen are evaluating the potential for existing infrastructure, including pipelines, to be used to transport hydrogen from production facilities for use in the industry.[89] In particular, studies are being conducted into blending hydrogen into existing natural gas pipelines as a way to reduce carbon emissions from the natural gas sector.[90] Early studies have highlighted the research gaps and potential risks inherent with mixing an element with a lower energy density into an aging system.[91] Hydrogen is the smallest element and pressured hydrogen requires specialized piping in order to avoid significant product loss.[92] Research indicates these issues extend to hydrogen blends which are likely to increase fatigue on pipelines, where existing cracks and other faults could fail to adequately contain the hydrogen atoms.[93]

New pipelines require considerable capital expenditures—one estimate for a dedicated hydrogen pipeline priced a new line between $2 million and

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83. *Hydrogen Shot*, OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY, https://www.energy.gov/eere/fuelcells/hydrogen-shot (last visited Sept. 20, 2023).

84. *See infra* Sections III.A–B.

85. *See generally Pathways to Commercial Liftoff: Clean Hydrogen*, *supra* note 10, at 2.

86. Praveen Bains et al., *Global Hydrogen Review*, INT'L ENERGY AGENCY 1, 65 (Dec. 2023), https://iea.blob.core.windows.net/assets/ecdfc3bb-d212-4a4c-9ff7-6ce5b1e19cef/GlobalHydrogenReview2023.pdf.

87. Leigh Collins & Xu Yihe, *World's largest green hydrogen project—China's260MW Kuqa Facility—to be commissioned at the end of May*, HYDROGENINSIGHT (May 26, 2023), https://www.hydrogeninsight.com/production/world-s-largest-green-hydrogen-project-chinas-260mw-kuqa-facility-to-be-commissioned-at-the-end-of-may/2-1-1457242.

88. *Hydrogen Blending into Natural Gas Pipeline Infrastructure: Review of the State of Technology*, NAT'L RENEWABLE ENERGY LAB'Y (Oct. 2022), https://www.nrel.gov/docs/fy23osti/81704.pdf.

89. *Id.*

90. *Id.* at 10.

91. *Id.* at 14.

92. *Id.* at 22.

93. *Id.* at 22.

$10 million per inch-mile.[94] Any scaled hydrogen production will include additional pipeline infrastructure on a magnitude of more than two million miles.[95]

One key element of the natural gas network is subterranean storage facilities.[96] Hydrogen gas storage and blue hydrogen production may compete with the same natural storage spaces used for natural gas storage and carbon sequestration. [97] Thanks to recent expansions of the 45Q tax credits, carbon sequestration and carbon capture agreement are blanketing favorable locations.[98]

Currently, the United States has a little over 400 natural gas underground storage facilities, with 80% of storage in depleted oil and gas fields.[99] Aside from the ownership problem discussed in Section IV, there are several major physical limitations which arise with the subterranean storage of hydrogen.[100] First, if the end use of hydrogen requires 100% hydrogen, hydrogen stored underground likely needs additional purification (read cost) in order to market.[101] Second, certain microorganisms present in subterranean structures react with hydrogen to produce methane and other gases (adding to the hydrogen purity issues) and create biofilms that degrade the ability to store hydrogen in porous rock.[102] Lastly, locations are limited to naturally existing storage spaces.[103] Overall, it is estimated that approximately only 2,000 of suitable natural caverns exist in the United States, and hydrogen storage may compete over these locations with other natural gas storage.[104] Blending hydrogen into the natural gas system may have consequences on the underground storage integrity for both pipelines and pumps to move hydrogen into the storage space and affect the integrity of the subsurface structure.[105] Even where storage is available, there are concerns regarding the ownership of storage spaces, as discussed further in Section IV.[106] In

94. *Pathways to Commercial Liftoff: Clean Hydrogen*, *supra* note 10, at 15.

95. *Green Hydrogen 101: Unlocking the Potential of The Renewable Energy Source*, PLUG POWER (Mar. 8, 2023), https://www.plugpower.com/green-hydrogen-101-unlocking-the-potential/.

96. *Underground Nat'l Gas Storage*, AM. PETROLEUM INST., https://www.energyinfrastructure.org /energy-101/natural-gas-storage (last visited Sept. 19, 2023).

97. *Infra* note 102, at 17.

98. Austin Lee et al., *The Way Forward: A Legal and Commercial Primer on Carbon Capture, Utilization, and Sequestration*, 16.1 TEX. J. OIL GAS & ENERGY L. 45–61 (2021) (discussing amendments to section 45Q of the Internal Revenue Code that create opportunities for carbon capture and storage).

99. *Underground Natural Gas and Working Storage Capacity*, U.S. ENERGY INFO. ADMIN. (Aug. 31, 2022), https://www.eia.gov/naturalgas/storagecapacity/.

100. *See* discussion *infra* Section IV.B.

101. *Hydrogen Blending into Natural Gas Pipeline Infrastructure: Review of State Technology*, NAT'L RENEWABLE ENERGY LAB (Oct. 2022), https://www.nrel.gov/docs/fy23osti/81704.pdf.

102. *Supra* note 97, at 25.

103. Armijo, *supra* note 4, at 125.

104. *Pathways to Commercial Liftoff: Clean Hydrogen*, *supra* note 8, at 17.

105. *See* discussion *infra* Section IV.B.

106. *See* discussion *infra* Section IV.B.

Texas, there are several established hydrogen salt cavern storage spaces, including the Clemens Dome, Moss Bluff, and Spindletop.[107]

Hydrogen may be transported via truck if not delivered downstream by a pipeline, which has significant limitations.[108] Ambient-temperature hydrogen may be pressurized and transported in containers, although low-energy density means higher unit cost.[109] Hydrogen gas trucking can offer lower barriers to entry for transportation of hydrogen, but will likely only have limited applications.[110]

Hydrogen can be chilled and pressurized into a liquid for trucking to combat energy density issues, but cost increases due to requirements to maintain temperatures.[111] All liquid storage must have dedicated power sources to maintain storage parameters.[112] After Texas's winter storm Uri, conversations on energy infrastructure focus on source reliability in times of crisis.[113] Ongoing necessary power for maintaining pressurized hydrogen storage must be identified and prioritized as critical infrastructure.[114]

B. Ammonia Production

As a potential solution to these storage limitations, experts are studying how to convert hydrogen into stable compounds.[115] One promising compound is ammonia (NH3), which if created using a green hydrogen, does not produce any carbon during the fuel process and does not require significant additional water.[116] Ammonia is a distinct smelling gas at room temperature and highly corrosive due to its alkaline properties.[117] Ammonia is far easier to transport either in gaseous or liquid states, but has the drawback of being highly toxic.[118]

To create ammonia, nitrogen from the atmosphere is added to hydrogen at a high temperature and pressurized using the Haber-Bosch process, named after the Nobel Prize winning chemists who first discovered the chemical method.[119] Currently, the Haber-Bosch process is used to create

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107. Armijo, *supra* note 4, at 125.
108. *Pathways to Commercial Liftoff: Clean Hydrogen*, *supra* note 10, at 15.
109. *Id.*
110. *Id.* at 16.
111. *Id.* at 15.
112. AIRPRODUCTS, *Safetygram #9 Liquid Hydrogen* 1, 3 (2007), https://www.energy.gov/eere/fuelcells/articles/safetygram-9-liquid-hydrogen.
113. Heather House, Laurie Stone, & Jubing Ge, *Are We Ready for Another Uri?*, ROCKY MOUNTAIN INST. (Feb. 15, 2022), https://rmi.org/are-we-ready-for-another-uri/.
114. *See id.*
115. Signoria, *supra* note 28, at 2.
116. *Id.* at 3.
117. Dogan Erdemir & Ibrahim Dincer, *A perspective on the use of ammonia as a clean fuel: Challenges and solutions*, 45 INT'L J. OF ENERGY RSCH. 4827 (Mar. 2021).
118. Signoria, *supra* note 28, at 3.
119. Signoria, *supra* note 28, at 27.

nitrogen-based fertilizers using black and brown hydrogen, but by using green hydrogen, the ammonia could be carbon-free as well.[120] As an added incentive, hydrogen can be converted into ammonia on-site with a electrolyzer, eliminating the need for additional transportation costs between hydrogen and ammonia facilities.[121]

Ammonia emerges as the potential solution for shipping hydrogen because production costs are cheaper to ship hydrogen as ammonia, and split the hydrogen out at the end market rather than ship the liquified or gaseous hydrogen.[122] Further, the existing ammonia market for fertilizer could switch to green ammonia.[123]

C. Investment

In order to meet the Hydrogen Shot goals by 2030, it is estimated that between $85 billion to $215 billion needs to be invested; with at least half the capital to fund transportation and end use infrastructure, and an additional third to construction green electricity facilities.[124] By the end of 2050, investment numbers are projected to be between $800 billion and $1.1 trillion.[125] It is predicted that by 2050, the hydrogen market will bloom to a $10 trillion global business.[126]

Green energy research and development has seen increased investment as the global concern about climate change has increased.[127] For green hydrogen, production facilities require both a electrolyzer and a renewable facility, requiring significant amounts of capital.[128] It is estimated that 1 million tons of green hydrogen can be produced using ten gigawatts of electricity from as much as twenty gigawatts of renewable production, which roughly translates to $30 billion in investment, otherwise known as the 1-10-20-30 Rule.[129] The majority of capital is dedicated to installation of

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120. *Id.*

121. *What is an Electrolyzer and what is it used for?*, ACCELERA, https://www.accelerazero.com/news/what-is-an-electrolyzer-and-what-is-it-used-for (last visited Oct. 19, 2023).

122. Praveen Bains et al., *Energy Technology Perspectives 2023*, INT'L ENERGY AGENCY (2023), https://iea.blob.core.windows.net/assets/d1ec36e9-fb41-466b-b265-45b0e7a4af36/EnergyTechnologyPerspectives2023.pdf.

123. Hannah Boyles, *Climate-Tech to Watch: Green Ammonia*, INFO. TECH. & INNOVATION FOUND. (Apr. 2023), https://www2.itif.org/2023-climate-tech-green-ammonia.pdf.

124. *Pathways to Commercial Liftoff: Clean Hydrogen*, *supra* note 10, at 42.

125. *Id.*

126. Alberto Gandolfi et al., *Green Hydrogen the next transformational driver of the Utilities*, GOLDMAN SACHS (Sept. 22, 2020, 9:41 PM), https://www.goldmansachs.com/intelligence/pages/gs-research/green-hydrogen/report.pdf.

127. Dolf Gielen et al., *Unleashing the power of hydrogen for the clean energy transition*, WORLD BANK BLOGS (Apr. 21, 2023), https://blogs.worldbank.org/energy/unleashing-power-hydrogen-clean-energy-transition#:~:text=Green%20hydrogen%20production%20is%20capital,20%2D30%20rule%E2%80%9D).

128. *Id.*

129. *Id.*

renewable power.[130] Replacing all grey hydrogen used today with green hydrogen would require doubling the current solar and wind power generation capacity currently operating.[131]

Green Hydrogen International (GHI) has commenced plans to create Hydrogen City on the Texas coast, including a green hydrogen production, storage, and transportation hub.[132] These ambitious plans include 3 billion kilograms of green hydrogen production connected with sixty gigawatts of off-grid green electricity.[133] To put that number into perspective, as of the fall of 2023, the Texas grid had 154,571 megawatts or 154.5 gigawatts of total installed capacity.[134] The Texas coast site is uniquely suited for hydrogen because of its close proximity to salt caverns that are hypothesized to store up to 120 gigawatt hours of hydrogen.[135] The first phase is slated for 2026, so an uptick in off-grid capacity installation is expected in the coming years.[136]

GHI's ambitious project is being closely watched as the final end user or users of the hydrogen has yet to be determined.[137] GHI is in conversations to export green ammonia for shipping fuel, fertilizer, green hydrogen for aviation, and rocket fuel, and alternative fuel for natural gas power plants, with no clear first customer indicated.[138] The Texas renewable energy industry is closely monitoring the progress of Hydrogen City, as both new and existing projects may be called to contribute to the necessary electrical needs of GHI.[139]

On the Texas Coast, Mitsubishi announced plans to store hydrogen in subterrain salt domes as a solution for long-term storage issues.[140] In addition, Mitsubishi has signed with the Corpus Christi Port Authority to install a utility-scale ammonia facility.[141]

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130. Dolf Gielen, Priyank Lathwal & Silvia Carolina Lopez Rocha, *Financing Renewable Hydrogen globally: ramp up to 2023 only needs $150bn/year*, ENERGYPOST.EU (May 26, 2023), https://energypost.eu/financing-renewable-hydrogen-globally-ramp-up-to-2030-only-needs-150bn-year/.

131. *Id.*

132. GREEN HYDROGEN INT'L CORP., *Green Hydrogen International Announces Hydrogen City, Texas.–The World's largest green hydrogen Production and Storage hub*, PR NEWSWIRE (Mar. 3, 2020, 8:44 AM), https://www.prnewswire.com/news-releases/green-hydrogen-international-announces-hydrogen-city-texas--the-worlds-largest-green-hydrogen-production-and-storage-hub-301494988.html#:~:test=Hydrogen%20City%2C%20Texas%20will%20be,Dome%20located%20in%20Duval%20County.

133. *Id.*

134. COMPTROLLER.TEXAS.GOV, *Texas Energy Tour: ERCOT*, https://comptroller.texas.gov/economy/economic-data/energy/2023/ercot.php (last visited May 21, 2024).

135. Armijo, *supra* note 4, at 129.

136. *See id*. at 32.

137. *See supra* note 59; *Hydrogen City: The World's first to market green hydrogen production and storage hub*, GHI, https://www.ghi-corp.com/projects/hydrogen-city (last visited Oct. 19, 2023).

138. *Id.*

139. *See id.*

140. *Mitsubishi Power and Texas Brine Join Forces on Large-scale Hydrogen Storage Solution to Support Decarbonization Efforts in the Eastern United States*, MITSUBISHI POWER (May 12, 2021), https://power.mhi.com/regions/amer/news/20210512.html.

141. *Id.*

Air Products, in partnership with AES, has secured land rights in Wilbarger County, Texas, to build a green hydrogen facility capable of producing 200,000 metric tons of hydrogen per day.[142] To produce electricity, the project will include 900 megawatts of wind and 500 megawatts of solar.[143]

OCI N.V., an Amsterdam hydrogen company, is slated to build a blue hydrogen plant in Beaumont, Texas, worth $1.7 billion.[144] In the near future, hydrogen will be used for ammonia fertilizer and long-term supply hydrogen for transport fuels.[145]

D. End Users: Planes, Trains and Toaster Ovens

Ultimately, investment into the hydrogen space necessitates some final customer for hydrogen.[146] There are a number of energy users looking to replace current energy usage with hydrogen fuel blends or pure hydrogen—which includes replacing electronically generated processes—as a heating element, for household cooking use, steel refining, and other industrial uses typically associated with natural gas.[147] Further, research is being conducted regarding hydrogen mixed with existing fuels, as well as, 100% hydrogen-powered vehicles, ships, trains, and aircrafts.[148] As a transportation fuel, global hydrogen increased by 60% between 2020 and 2022, though hydrogen only accounted for 0.003% of global transport energy.[149] As hydrogen fuel cell technology and the price per kilogram of hydrogen drops, hydrogen could become a viable alternative fuel source with the PTC as soon as 2030.[150] This projection depends on the required development of hydrogen fuel cell technology, and the willingness of companies to offer new or retrofitted vehicles equipped with hydrogen fuel cells.[151]

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142. *Governor Abbott Celebrates Construction of Nation's Largest Green Hydrogen Facility in Texas*, OFFICE OF THE TEX. GOVERNOR (Dec. 8, 2022), https://gov.texas.gov/news/post/governor-abbott-celebrates-construction-of-nations-largest-green-hydrogen-facility-in-texas.

143. Dylan Baddour, *A Texas project hopes to turn water into fuel for cars, planes, ships and trains—using wind*, THE TEX. TRIB., (Jan. 9, 2023, 2:00 PM), https://www.texastribune.org/2023/01/09/texas-clean-energy-green-hydrogen-inflation-reduction-act/.

144. Brandon Mulder, *Linde to Build Blue Hydrogen Facility on Texas Coast for Ammonia Production*, S&P GLOB. (Feb. 6, 2023, 2:46 PM), https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/natural-gas/020623-linde-to-build-blue-hydrogen-facility-on-texas-coast-for-ammonia-production.

145. *Id.*

146. *See generally id.* (discussing marketing to downstream customers).

147. *See* Armijo, *supra* note 4, at 17–64.

148. *Id.*

149. *Id.* at 40.

150. *See Pathways to Commercial Liftoff: Clean Hydrogen*, *supra* note 10, at 40–41.

151. *Id.*

As discussed above, some measure of hydrogen will be dedicated to ammonia production for the fertilizer industry.[152] Currently, ammonia is the first and only viable scaled market for hydrogen.[153]

E. Green Hydrogen: Further Hurdles

Unlike grey and blue hydrogen, green hydrogen production is a relatively new process.[154] As energy companies attempt to scale green hydrogen, conversations about process feedstock have ramped up, especially conversations concerning water and electricity—two scarce resources that, in many cases, are already pledged to other industries.[155]

1. Water

The hypothesized conversion of water to hydrogen is nine liters (or approximately 2.4 gallons) of water to one kilogram of hydrogen.[156] Current system inefficiencies make the hydrogen production process consume between ten to twenty-four kilograms of water in order to make one kilogram of hydrogen.[157] Likely, research and development will increase green hydrogen production efficiency, but the environmental impacts of additional water use must still be considered.[158]

Estimations of the water necessary for green hydrogen production vary greatly depending on the source and analyzed production process.[159] It is projected that to meet global targeted hydrogen production with exclusively green hydrogen, facilities will need between 13.2 to 20.5 billion cubic meters of fresh water per year—approximately 0.33% to 0.51% of the world's yearly freshwater use.[160] While this is a seemingly large number, other industries

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152. *Id.* at 19.

153. *See id*. at 57.

154. *See* Zach Stein, *Green Hydrogen*, CARBON COLLECTIVE, https://www.carboncollective.co/sustainable-investing/green-hydrogen (last updated May 21, 2024).

155. *See* Rebecca R. Beswick et al., *Does the Green Hydrogen Economy Have a Water Problem?*, AM. CHEM. SOC'Y ACS ENERGY LETTERS 3011, 3167–68 (Sept. 10, 2021), https://pubs.acs.org/doi/epdf/10.1021/acsenergylett.1c01375.

156. Chiara Signoria & Marco Barlettani, *Environmental, Health, Safety, and Social Management of Green Hydrogen in Latin America and the Caribbean: A Scoping Study*, INTER-AM. DEV. BANK 1, 2 (Apr. 2023), https://publications.iadb.org/publications/english/viewer/Environmental-Health-Safety-and-Social-Management-of-Green-Hydrogen-in-Latin-America-and-the-Caribbean.pdf.

157. *Id*.

158. *See* Emily Grubert, *Water Consumption from Electrolytic Hydrogen in a Carbon-Neutral US Energy System*, SCI. DIRECT (Feb. 26, 2023), https://www.sciencedirect.com/science/article/pii/S2666791623000106.

158. *See* Kaitlyn Ramirez et al., *Hydrogen Reality Check: Distilling Green Hydrogen's Water Consumption*, ROCKY MOUNTAIN INST. (Aug. 2, 2023), https://rmi.org/hydrogen-reality-check-distilling-green-hydrogens-water-consumption/#:~:text=Globally%2C%20estimates%20for%20future%20hydrogen,percent%20of%20current%20global%20freshwater.

159. *Id.*

160. *Id.*

are far more water-intensive, including irrigated agriculture, which uses 2,700 billion cubic meters of freshwater annually.[161] Proponents of green hydrogen argue by producing fuel from water, water used in the fossil fuel production process will become obsolete.[162] This belief, however, presupposes that hydrogen will be a viable one-to-one alternative for transport, electrical production, and other uses of natural gas, coal, and oil, rather than additional fuel sources to support the growing global population.[163]

Hydrogen City, Texas, has been subject to recent study and concern despite confident calculations that green hydrogen will not make a significant impact on global water use, green hydrogen facilities are still under scrutiny as many are sited in areas already experiencing severe water shortages.[164] Depending upon the accessibility of local water and ownership battles, water for hydrogen feedstock may greatly limit scalable green hydrogen production.[165]

Water shortage has already derailed a six gigawatt green hydrogen project in Southern Australia.[166] The project was slated to include desalination units to make up for the lack of water supply, but the additional cost was a fatal blow to the project's viability.[167]

2. Saltwater

As an alternative to using fresh water, studies have been conducted regarding whether saltwater can be used by electrolyzers.[168] Saltwater is corrosive and electrolysis produces chlorine as a byproduct.[169] To pass saltwater through the electrolysis equipment, prior desalination is necessary to divide the water into liquids for hydrogen production and a concentrated brine.[170] The concentrated brine creates potential waste concerns as the brine is twice as concentrated as seawater and includes additives from the initial

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161. Beswick et al., *supra* note 155, at 3168.

162. *Id.*

163. *Id.* at 3167.

164. Valerie Volcovici, *Biden's Green hydrogen plans hits climate obstacle: Water Shortage,* REUTERS (July 3, 2023, 1:47 PM), https://www.reuters.com/sustainability/climate-energy/bidens-green-hydrogen-plan-hits-climate-obstacle-water-shortage-2023-07-03/.

165. Grubert, *supra* note 156 at 8.

166. Bella Peacock, *Green hydrogen megaproject in SA discontinued*, PV MAG. (May 31, 2022), https://www.pv-magazine-australia.com/2022/05/31/green-hydrogen-megaproject-in-sa-discontinued/.

167. *Water supply scuppers South Australia 6GW hydrogen plan*, ARGUS MEDIA GRP. (May 21, 2022), https://www.argusmedia.com/en/news/2336691-water-supply-scuppers-south-australia-6gw-hydrogen-plan.

168. *See generally* Beswick et al., *supra* note 155 at 3168.

169. Signoria, *supra* note 28, at 2; *see also Chlorine Manufacture*, THE CHLORINE INS., https://www.chlorineinstitute.org/stewardship/chlorine/chlorine-manufacture/#:~:text=Most%20chlorine%20is%20manufactured%20electrolytically,chloride%20ions%20to%20elemental%20chlorine (last visited Sept. 22, 2023).

170. BESWICK et al., *supra* note 156, at 3168; Signoria, *supra* note 28, at 26.

water cleaning and hydrogen process.[171] Though not significant, the need for further treatment of brine adds to the cost of producing hydrogen from seawater; the additional energy costs are suggested to be between $0.01 and $0.02 per kilogram.[172] To reduce costs, systems have been hypothesized to put hydrogen electrolyzers on platforms adjacent to offshore wind turbines.[173]

3. Reliable, Cheap Power

Green hydrogen production suffers from the same issues as any large electric user—current renewable resources are dependent on variable resources—the wind and sun.[174] Further, wind and solar facilities remain costly to install.[175] To produce hydrogen with the lowest possible carbon emission, and to qualify for federal funding, green hydrogen producers are looking to install their own renewable sources, including wind, solar, and hydropower facilities.[176] Installation of these dedicated facilities presents challenges with both capex costs and typical legal concerns surrounding siting, as discussed below in Section IV.[177] Storage is considered to be a key component to combat the variable nature of renewable energy generation.[178]

Hydrogen electrolyzers may utilize electricity from the grid at large, but the process is resource, intensive and comes with a large carbon footprint, especially in regions with a high percentage of fossil fuel electrical production.[179]

Additional consideration must be given to siting renewable resources as the best wind and solar resources may not be located near the best water resources.[180] For example in Texas, the best wind and solar co-located resources are in West Texas, but the best water resources, hydrogen storage and downstream buyers, are on the Texas coast because of the proximity to

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171. Signoria, *supra* note 28, at 94.

172. *Id.* at 26.

173. Darius Snieckus, *Dolphyn floating wind-powered 'hydrogen from seawater' Pilot leaps ahead with key deal*, DN MEDIA GRP. (Oct. 11, 2022, 2:28 PM), https://www.rechargenews.com/wind/dolphyn-floating-wind-powered-hydrogen-from-seawater-pilot-leaps-ahead-with-key-deal/2-1-1332252.

174. *See Solving Challenges in Energy Storage*, U.S. DEP'T OF ENERGY (July 2019), https://www.energy.gov/sites/default/files/2019/07/f64/2018-OTT-Energy-Storage-Spotlight.pdf; Wayne Hicks, *Declining Renewable Costs Drive Focus on energy Storage,* NAT'L RENEWABLE ENERGY LAB'Y (Jan. 2, 2020), https://www.nrel.gov/news/features/2020/declining-renewable-costs-drive-focus-on-energy-storage.html.

175. *Average U.S. construction costs drop for solar noise for wind and natural gas generators*, U.S. ENERGY INFO. ADMIN. (Nov. 3, 2022), https://www.eia.gov/todayinenergy/detail.php?id=54519#:~:text=The%20average%20construction%20cost%20for%20the%20largest%20wind%20farms%E2%80%94those,in%202020%2C%20down%205.2%25.

176. *Pathways to Commercial Liftoff: Clean Hydrogen*, *supra* note 10, at 12.

177. *See infra* Section IV.

178. Bains et al., *supra* note 122, at 303.

179. *Pathways to Commercial Liftoff: Clean Hydrogen*, *supra* note 10, at 12.

180. WETSEL, *supra* note 4 at § 1.04

shipping corridors and skilled labor. This then requires that hydrogen is either produced and moved to the coast, or hydrogen producing resources—electricity for green hydrogen and methane for blue and grey hydrogen—are moved to the coast to be refined.[181] Additional consideration has also been given to discern if electrolyzers should be sited next to the power sources for green hydrogen, or whether the electricity should be sent, via power line to the electrolyzers along the coast, nearer to the end consumer.[182] Overall, production of hydrogen at the electricity source is a cheaper and more flexible option than sending electricity via transmission lines to electrolyzers.[183]

IV. The Legal Limitations

Efforts are being made around the globe to reduce carbon emissions while still providing cheap, reliable power on which the world relies.[184] The United States is not the current leader in hydrogen production, despite ample resources, due in part by the requirement that land and resources for the production of hydrogen are subject to private ownership and may not simply be co-opted.[185] The domestic and foreign production limitations discussed above are only a part of the equation—United States hydrogen developers must also consider the legal limitations they will face with siting facilities and consuming water.[186] This paper is generally limited to Texas law, but the footnotes cite to helpful resources for answering these same inquiries for other jurisdictions.

A. Easements and Leases

Electrolyzers and steam reform facilities have a relatively small footprint.[187] In contrast, green hydrogen facilities may encompass thousands of acres of wind turbine and solar facilities in addition to the electrolyzers.[188] Considering the slated investment into the green hydrogen field, transactional practitioners are beginning early-stage development for new green hydrogen

181. Joshua D. Rhodes et al., *Renewable Electrolysis in Texas: Pipelines versus Power Lines*, H2@UT (Aug. 2021), https://sites.utexas.edu/h2/files/2021/08/H2-White-Paper_Hydrogen-Pipelines-versus-Power-Lines.pdf.

182. *Id.* at 1.

183. *Id*. at 4.

184. *See generally Net Zero by 2050: A Roadmap for the Global Energy Sector*, INT'L ENERGY AGENCY (Oct. 2021), https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf.
(discussing countries' attempts at reducing carbon emissions while still requiring cheap energy).

185. *See supra* texts companying notes 78–83.

186. *See, e.g.*, Simone Goligorsky et al., *Hydrogen in Tomorrow's World: Destination or Aspiration*, REED SMITH, (June 27, 2022), https://www.reedsmith.com/en/perspectives/energy-transition/2022/06/hydrogen-regulations-by-jurisdiction-and-changing-transmission-systems?section=top-of-article.

187. *See supra* text accompanying notes 62–64.

188. Baddour, *supra* note 143.

facilities.[189] Early agreements typically consist of small leases for steam methane or electrolyzer facilities or sweeping surface leases for all necessary green hydrogen infrastructure.[190] Green hydrogen facilities may increase burdens on a landowner's property, so practitioners must now review wind and solar leases with hydrogen in mind.[191]

Traditional wind and solar leases were designed for delivery of electricity to a grid to power the United States' growing need electricity needs. Understanding that green hydrogen production may be the end goal of new wind and solar leases, practitioners should inquire whether new wind or solar facilities will go to into electrical production on the grid or 'off-grid' servicing hydrogen or alternative fuel facilities.[192] This discussion may affect how leases should be drafted to protect landowners from unwanted nuisance caused by the hydrogen facility, or how to prevent unpaid water usage by the larger project.[193]

Overall, a basic green hydrogen lease follows the same model as the last decade of wind and solar leases, with a few important deviations: granting language, water requirements, and development term length.[194]

Wind and solar leases typically include several provisions of granting language, laid out in detail to cover the installation and operation of a complicated, electricity-producing-and-gathering facility.[195] Generally included are the rights to unencumbered ingress and egress, survey, study property, install metering equipment, construct subterrain supports, install roads, underground and overhead lines, telecommunications equipment, substations, battery storage, operations facility, and take any other action necessary, useful, or desirable to the lessee, and mostly importantly, the right to install the solar panels or wind turbines.[196] When considering broad granting language, it is possible to read in a grant for a hydrogen facility, especially where the granting language includes the ability to pump and use groundwater.[197] In practice, red pen is often used liberally on granting clauses, narrowing the agreement scope to only necessary facilities for the wind or solar project.[198]

While it may be possible for established wind and solar developers to retroactively install hydrogen facilities, it would be ill-advised.[199] Any

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189. Laura Marie Bowen, *8th Annual Oil and Gas Disputes CLE: Solar and Wind Update* (Jan. 20–21, 2022).

190. *Id.*

191. *Id.*

192. *Pathways to Commercial Liftoff: Clean Hydrogen*, *supra* note 10, at 12.

193. *Id.*

194. *See generally* Roderick E. Wetsel & Laura M. Bowen, *The Sun Ariseth: A Guide to Drafting Solar Leases*, 16 TEX. J. OIL GAS & ENERGY L. 77 (2021) (discussing the components of a solar lease).

195. WETSEL, *supra* note 2, at §§ 2.01, 3.01.

196. *Id.* at §§ 2.02, 3.02.

197. *Id.* at §§ 2.08, 3.07.

198. *See id.* at §§ 2.01, 3.01.

199. *See id.*

banking institution or financial backing for the hydrogen facility will likely require assurance that underlying land use agreements are not subject to any potential litigation—extrapolating an additional grant of hydrogen production rights from a wind or solar lease would likely be the type of issue financial institutions look to avoid.[200] Further, considering that the land requirements for a electrolyzer are relatively minimal, the best practices are either to secure site control adjacent to an existing wind or solar facility, or present an amendment contemplating the new land use.[201] In tandem, the lessee can negotiate for any additional water rights necessary from the surface owner.[202] These insular facilities carry intrinsic value for the developer, allowing for minimal lost power and few additional transportation costs.[203]

For a stand-alone hydrogen facility, granting language may be broad enough to cover both a electrolyzer facility and additional facilities for converting hydrogen into ammonia or other alternative storage methods.[204]

The second major deviation from a traditional renewable energy lease is the necessary addition of water rights to the lease form.[205] A good wind or solar lease addresses groundwater usage and includes the right to drill, pump, and consume groundwater; which usage is fairly limited.[206] Renewable facilities need water for processes like concrete batching, watering down roads, and potentially, water to wash turbine blades or solar panels—all intermittent water uses.[207]

In contrast, a commercial scale green hydrogen facility requires a large, steady supply of water.[208] A green hydrogen lease typically includes some additional language to govern how water will be drilled and produced from the property.[209] Landowners may negotiate a set price per barrel for water within the surface lease form, or, depending on the source, enter into a separate water use lease—requiring the hydrogen developer to purchase

200. SungJe Byun & Joe Kneip, *Renewable energy projects present unique lender risks, need for oversight*, FED. RSRV. BANK OF DALL. (Apr. 12, 2022) https://www.dallasfed.org/research/economics/2022/0412.

201. *See supra* text accompanying notes 59–61.

202. *Water Law: An Overview*, THE NAT'L AGRIC. L. CTR., https://nationalaglawcenter.org/overview/water-law/ (last visited Sept. 27, 2023).

203. *See supra* text accompanying notes 59-61.

204. *See supra* Section III.B.

205. F. Parks Brown, *Solar Lease Negotiations from the Landowner's Perspective*, 49 TEX. J. BUS. L. 1, 10 (Fall, 2020).

206. *See id*. at 10.

207. Jack Wallace, *Recover Lost Energy Output with Blade Cleaning*, WIND SYS. (Jan. 15, 2016), https://www.windsystemsmag.com/recover-lost-energy-output-with-blade-cleaning/.

208. Melissa B. Mahle, *The Future of Energy: Commercial scale Hydrogen*, BRADLEY (July 13, 2023), https://www.bradley.com/insights/publications/2023/07/the-future-of-energy-commercial-scale-hydrogen.

209. *See* Wetsel, *supra* note 192.

water from the surface owner and outline deficiencies in water.[210] For example, if the surface estate produces less than the fixed number of barrels of water per day, hydrogen developer may then purchase water from other sources.[211] Prices for water have historically increased and will likely continue to rise as water demand increases in the energy sector.[212]

The last major deviation from the traditional wind and solar lease is the length of the option or development period.[213] Prior to constructing a solar or wind facility, the developer will pay for a period of three to five years where the developer can access the property for feasibility studies.[214] These studies include soil samples, coring, endangered species studies, surveying, and other necessary development tasks prior to commencing construction on a facility.[215] Regarding payment, hydrogen leases attached to solar facilities may offer higher development rates than a mixed use or wind exclusive green hydrogen facility; nevertheless, green hydrogen lease rates largely track with standard renewable development rates applicable for the region.[216]

Over the last few years, development periods for wind and solar leases have lengthened due to various issues with supply chains and grid oversight.[217] Hydrogen leases, in particular, have longer development terms to give time for the hydrogen market to catch up before paying operations term rents, sometimes extended to ten years.[218] After the development term, the construction and operations terms are more in line with a traditional wind and solar lease—between one to two years for construction of the project and thirty to fifty years for project operations.[219]

The remainder of green hydrogen leases follow the model which practitioners are familiar with for wind and solar leases.[220] Facility footprints will be the same—electricity collected and pooled into a substation connected to the electrolyzer facility.[221]

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210. *See* James M. Berger, *Key Issues for Hydrogen Developers*, NORTON ROSE FULBRIGHT (June 23, 2023), https://www.projectfinance.law/publications/2023/june/key-issues-for-hydrogen-developers/.

211. *See supra* Section III.E.

212. *The Future of Hydrogen*, INT'L ENERGY AGENCY (June 2019), https://iea.org/reports/the-future-of-hydrogen.

213. *See* Shannon L. Ferrell, *Understanding Solar Energy Agreements*, NAT'L AGRIC. L. CTR. , https://nationalaglawcenter.org/wp-content/uploads/assets/articles/ferrell-solar.pdf (last visited Sept. 26, 2023).

214. *Id.*

215. *See id.*

216. *See* Eero Vartiainen et al., *True Cost of Solar Hydrogen*, WHILEY ONLINE LIBR. (Sept. 7, 2021), https://onlinelibrary.wiley.com/doi/10.1002/solr.202100487.

217. *See* WETSEL, *supra* note 2, at §§ 2.04, 3.03.

218. *Id*. at §§ 2.05, 3.04.

219. *Id.*

220. *Id*.

221. *See supra* note 178.

B. Storage Space Ownership

As discussed above, part of a viable hydrogen market is the ability to store reserves, or the case of blue hydrogen-sequester carbon dioxide.[222] As practitioners used concepts from established oil and gas leases to inform early wind and solar leases, the issues with subterrain storage for hydrogen are already being addressed in natural gas storage and carbon sequestration agreements.[223] When presented with ownership of these long-term storage spaces, one important question arises: in a severed estate, who owns the right to grant subterranean storage?

The first considerations are ownership of the subterrain storage space, how one will access the storage space, and what to do if those two parties are not the same.[224] In an ideal world, a hydrogen production facility would sit on property which it owns, *ad coelum*, requiring no additional permissions to source feedstock, produce, and store hydrogen.[225] Fee simple absolute ownership, however, is increasingly rare and considering that developers are limited to siting where the necessary resources are located, developers must find and enter into a contractual relationship with the owners or lessees of the resources they need.[226] If there is a split surface and mineral estate, overlying a hydrogen storage space, who has the right to lease?[227]

Texas, a leader in both oil and gas production and litigation, has encountered and addressed the bounds of subterranean ownership in a severed estate.[228] Perhaps, a conflicting notion to the lay person, the surface owner has ownership of the subterranean storage space and the right to inject gases into the same.[229] The Texas Supreme Court noted in *Humble Oil* that the surface owner "owns all non-mineral 'molecules' of the land, i.e., the mass that undergirds the surface".[230] In the recent case, *Lighting v. Anadarko*, the Court affirmed that the surface owner owns the "mass" below the surface, regardless of depth, and that the mineral owner does not possess rights to the "space where the minerals are located."[231]

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222. *See supra* Section III.A.
223. *See Seasonal Assessment of Resource Adequacy for the ERCOT Region (SARA) Summer 2023*, *supra* note 134.
224. Humble Oil & Refining Co. v. West, 508 S.W.2d 812, 815 (Tex. 1974).
225. *See Cujus est solum, ejuse est usque ad ccelum et ad infernos Definition & Legal Meaning*, THE L. DICTIONARY, https://thelawdictionary.org/cujus-est-solum-ejus-est-usque-ad-ccelum-et-ad-inferos/ (last visited Oct. 5, 2023) (*ad coelum* in English means: to whomsoever the soil belongs, he owns also to the sky and to the depths).
226. *See supra* Section III.A.
227. Moser v. U.S. Steel Corp., 676 S.W.2d 99, 101 (Tex. 1984).
228. *See Exploration & Surface Ownership*, R.R. COMM'N OF TEXAS https://www.rrc.texas.gov/about-us/faqs/oil-gas-faq/oil-gas-exploration-and-surface-ownership/ (last visited Oct. 15, 2023).
229. *See* Lee et al., *supra* note 98, at 43; *see also*, *supra* Section III.A.
230. Dunn-McCampbell Royalty Int., Inc., v. Nat'l Park Serv., 630 F.3d 431, 442 (5th Cir. 2011); *see* Lightning Oil Co. v. Anadarko E&P Onshore, LLC, 520 S.W.3d 39, 46 (Tex. 2017).
231. *Lightning*, 520 S.W.3d at 49−50.

In *Lightning*, the surface owner, Briscoe Ranch, granted rights for an adjacent mineral lessee, Anadarko, to drill from the Briscoe Ranch horizontally to develop Anadarko's minerals on an adjacent tract.[232] The mineral lessee underlying the Briscoe Ranch, Lightning Oil, sued Anadarko for trespass among other things, claiming that by Anadarko drilling through Lightning's leasehold, Anadarko's drilling activities were displacing and producing Lightning's minerals.[233] The Court ultimately held that Briscoe Ranch owned the subterranean material surrounding Lightning's minerals and that by drilling through Lightning's leasehold, the mineral loss was not sufficient injury to claim trespass.[234] The Court drew the distinction that while the surface owner owns the matrix underlying their property, the surface owner does not have the "exclusive control and use" of portions of the subsurface that contain minerals.[235]

By changing the facts from *Lightning* slightly, the Court may have come to a different conclusion.[236] Part of the Court's determination that Lighting had not suffered harm to their mineral estate hinged on the fact that mineral loss caused by Anadarko's drilling passing through was diminutive.[237] Because the disturbance to Lightning's mineral estate was only the space occupied by the well bore, and considering that Texas has an interest in maximizing oil and gas production, the Court concluded that Anadarko's use of the subsurface did not create sufficient injury to Lightning to warrant a trespass claim.[238]

The question of subterranean ownership was again considered in the recent *Myers-Woodward, LLC v. Underground Services Markham* case, where the mineral owner claimed rights to subterranean salt caverns.[239] Ultimately, the court followed *Humble Oil* and *Lightning*, finding that the salt caverns were part of the surface estate, and further clarified that the surface owner is the proper party to grant rights for subterranean hydrocarbon storage.[240] In claiming ownership of the salt caverns, the mineral estate cited *Mapco v. Carter*, which held that salt caverns created during mineral extraction remained a part of the mineral estate.[241] The *Myers* court declined

232. *See id.* at 43.
233. *Id*. at 50–51.
234. *Id.*
235. *See id*. at 46–48; *Dunn-McCampell*, 630 F.3d at 442 (quoting Springer Ranch, Ltd. v. Jones, 421 S.W.3d 273, 283 (Tex. App.—San Antonio 2013, no pet.)).
236. *See* Lightning Oil Co. v. Anadarko E&P Onshore, LLC, 520 S.W.3d 39, 50 (Tex. 2017).
237. *Id*.
238. *Id*. at 50–51.
239. *See* Myers-Woodward, LLC v. Underground Servs. Markham, LLC, No. 13-20-00172-cv 2022 WL 2163857, at *1 (Tex. App.—Corpus Christi 2022, pet. denied).
240. *Id*. at *11.
241. *Id*. (citing Mapco Inc. v. Carter, 808 S.W.2d 262, 278 (Tex. App.—Beaumont 1991, writ granted), rev'd in part, 817 S.W.2d 686 (Tex. 1991)).

to follow *Mapco*, but the decision highlights the potential for conflicting ownership conclusions within Texas Courts.[242]

A practitioner should carefully examine both severance and reservation language for reservations which are atypical to the traditional surface and mineral severance.[243] Just as sophistication in mineral ownership has expanded, so too has the specificity in reservation language.[244] Potential parties to a hydrogen storage or carbon sequestration in blue hydrogen project would include the surface owner, the mineral owner, and the mineral lessee as a potentially injured party, the necessity of each hinging on the language in the reservation.[245] In light of the *Lighting* holding hinging upon the minimal disruption of the minerals, where mineral production will be significantly more expensive or partial or completely impaired by the use of subsurface for hydrogen storage, the mineral owner or mineral lessee should be a necessary party to any accommodation.[246]

Practical guidance may be drawn from mineral accommodation by solar facilities.[247] While it was feared that mineral owners and mineral lessees would flood the courts with suits, there has only been one case of note regarding mineral and surface accommodation, *Lyle v. Midway*.[248] Due in part to the onerous financing requirements for a solar lease, solar developers are required to de-risk their projects, including securing accommodation agreements or surface waivers with the mineral owners or mineral lessees as a preventative measure against lawsuits.[249] Best practice for carbon or hydrogen storage would follow the same path, by entering into an accommodation or rights waiver, the carbon or hydrogen storage project would be better protected against a lawsuit.[250]

C. Green Hydrogen: Water Use and Water Ownership

Scalable green hydrogen production will require cheap, reliable access to water.[251] Who owns the water and the quantities available for fuel production could be the most litigated aspects of green hydrogen production as producers will join the ranks of parties vying for their percentage of a dwindling natural resource.[252] The complex web of common law, regulations,

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242. *Id.*
243. *See* Lee et al., *supra* note 98, at 60.
244. *Id.*
245. *Id.*
246. Lightning Oil Co. v. Anadarko E&P Onshore, LLC, 520 S.W.3d 39, 50 (Tex. 2017).
247. Rod E. Wetsel & Laura M. Bowen, *Make Peace, Not War: Negotiating and Drafting Accommodation Agreements in the Oil and Gas Industry with Wind and Solar Companies*, UT L. CLE, https://utcle.org/ecourses/oc8691/get-asset-file/asset_id/51341 (last visited Sept. 27, 2023).
248. *See* Lyle v. Midway Solar, LLC, 618 S.W.3d 857 (Tex. App.—El Paso 2020, pet. denied).
249. *See* WESTEL, *supra* note 2, at §§ 3.06, 3.17.
250. *Lightning*, 520 S.W.3d at 50.
251. Signoria, *supra* note 28.
252. *See, e.g.*, *Who Owns The Water?*, WATER SYS. COUNCIL, https://winapps.umt.edu/winapps/

and administrative requirements is briefly discussed below, but as with all water use, the ultimate ownership is nuanced.[253]

Water ownership is split between surface water and ground water, with each having different ownership considerations.[254] Texas surface water is owned by the state of Texas and regulated by the Texas Commission on Environmental Quality (TCEQ), under the doctrine of "first in time, first in right."[255] In the event of surface water shortages, those with the longest historic use will have priority over other newer uses.[256] Existing water rights transferred though a change in water use will trigger additional oversite and permitting with the TCEQ.[257]

Texas groundwater is owned by the surface owner and governed by the "rule of capture."[258] Underground water reservoirs do not correspond with surface ownership, and water will move freely underneath many properties; therefore, whichever surface owner pumps out (captures) the water will become the owner of the water.[259] There are some limitations to this right—Texas specifically prohibits drilling and producing water for a wasteful purpose to maliciously harm a neighbor, or to produce in such a way that water drainage causes land subsidence.[260] Texas has created a series of Groundwater Conservation Districts (GCDs) and other reservoir specific restrictions to further curb unchecked pumping of groundwater.[261] GCDs can create rules to regulate spacing and water production in order to preserve and allow for recharge of groundwater sources.[262]

To further complicate matters, it is well settled that water rights can be severed from the surface estate.[263] It is possible for an owner to sever their own water rights, creating a "groundwater estate" dominant to the surface estate; this includes the implied right to use as much of the surface estate as

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media2/wilderness/toolboxes/documents/water-rights/Who%20Owns%20the%20Water.pdf (last updated Aug. 2016); Alexander Trattner et al., *Sustainable Hydrogen Society – Vision, Findings and Development of a Hydrogen Economy Using the Example of Austria*, 47 INT'L J. OF HYDROGEN ENERGY 2059 (Jan 12, 2022), https://www.sciencedirect.com/science/article/pii/S0360319921042233.

253. *See, e.g.*, *Surface Water Rights and Availability*, TEX. COMM'N ON ENV'T QUALITY, https://www.tceq.texas.gov/permitting/water_rights (last visited Sept. 27, 2023); *Who Owns The Water?*, WATER SYS. COUNCIL, https://winapps.umt.edu/winapps/media2/wilderness/toolboxes/documents/water-rights/Who%20Owns%20the%20Water.pdf (last updated Aug. 2016).

254. *Am I Regulated? Water Rights in Texas*, TEX. COMM'N ON ENV'T QUALITY, https://www.tceq.texas.gov/permitting/water_rights/wr-permitting/wr_amiregulated.html (last visited Sept. 27, 2023).

255. *Id.*

256. *Id.*; *Water Rights and Water Use Data*, TEX. COMM'N ON ENV'T QUALITY, https://www.tceq.texas.gov/permitting/water_rights/wr-permitting/wrwud (last visited Sept. 27, 2023).

257. *A Texan's Guide to Water and Water Rights Marketing*, TEX. WATER DEV. BD., https://www.twdb.texas.gov/publications/reports/infosheets/doc/WaterRightsMarketingBrochure.pdf (last visited Sept. 27, 2023).

258. TEX. WATER CODE ANN. § 36.002.

259. *See* Hous. & T.C. R.R. Co. v. East, 81 S.W. 279, 280 (Tex. 1904).

260. TEX. WATER CODE ANN. § 36.002(b).

261. *Id.* at §§ 35.001, 35.004, 36.251, & 36.002(e)(1)-(3).

262. *Id.* at § 36.101.

263. Coyote Lake Ranch, LLC v. City of Lubbock, 498 S.W.3d 53, 55 (Tex. 2016).

reasonably necessary to develop the groundwater rights.[264] The bounds of this right to groundwater have not been litigated as heavily as the severed rights of the mineral estate, though the Court signaled that disputes would be resolved using the same principles as found in general oil and gas practice.[265]

After securing site control for a hydrogen facility, additional inquiries will be required regarding water quantity and water ownership.[266] As of the publication of this paper, the TCEQ has been silent on surface water for green hydrogen production. If unable to secure water rights through application with the TCEQ, green hydrogen producers will have to contract with existing surface water producers to purchase necessary water.[267]

If relying on groundwater, green hydrogen producers may have rights through the surface contract, and careful title research will indicate whether there is a severance of the groundwater estate.[268] Further, if the groundwater is controlled by a GCD, additional permitting may be required.[269]

Finally, consideration should be given to water uses in the oil field where the oil producer has the right to use as much of the water as reasonably necessary for the development and production of minerals.[270] In *Sun Oil Co.* v *Whitaker*, the Court held that water flood operations to produce deleting mineral reserves was a necessary use by the mineral estate and the surface owner—a farmer using water for irrigation—could not enjoin Sun Oil from producing 100,000 gallons of water daily.[271] Existing water use by oil and gas operations may directly conflict with water use for hydrogen production, requiring careful research into parties with active interest in water rights underlying the surface.[272]

The Hydrogen City project proposes 2.5 million tons of hydrogen to be produced each year.[273] As discussed above, it takes approximately ten to twenty-four kilograms of water to make one kilogram of hydrogen gas.[274]

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264. *Id.* at 65.

265. *See* Getty Oil Co. v. Jones, 470 S.W. 2d 618, 622 (Tex. 1971); Merriman v. XTO Energy, Inc., 407 S.W.3d 244, 250 (Tex. 2013).

266. Ramirez et al., *supra* note 158.

267. *A Texan's Guide to Water and Water Rights Marketing*, *supra* note 258, at 11.

268. *See supra* Section IV.A.

269. *Groundwater Data*, TEX. WATER DEV. BD., https://www.twdb.texas.gov/groundwater/data/index.asp (last visited Sept. 27, 2023).

270. *See* Sun Oil Co. v. Whitaker, 483 S.W.2d 808, 810–11 (Tex. 1972).

271. *Id.* at 812.

272. Dylan Baddour, *Fracking waste gets second look to ease looming West Texas water shortage*, HOUS. CHRON. (Dec. 19, 2022), https://www.houstonchronicle.com/business/energy/article/permian-fracking-water-recycle-17664786.php.

273. Leigh Collins, *World's largest green hydrogen project unveiled in Texas, with plan to produce clean rocket fuel for Elon Musk*, RECHARGE NEWS, https://www.rechargenews.com/energy-transition/world-s-largest-green-hydrogen-project-unveiled-in-texas-with-plan-to-produce-clean-rocket-fuel-for-elon-musk/2-1-1178689 (last updated Mar. 3, 2022, 6:34 PM).

274. *See supra* Section IV.C.

After a historically dry summer, Texans are left to wonder where all this water will come from.[275]

V. CONCLUSION

Both the legal and practical hurdles to hydrogen production addressed in this article may seem insurmountable, but surely the hurdles of formerly "new" energy sources we use today did too.[276] The first cross country pipeline, fracked well, wind farm, and LNG tanker surely received a fair ration of skepticism. Perhaps, I will have the opportunity to write on hydrogen again in twenty years and examine how many ways industry overcame these limitations.

275. *Texas*, U.S. DROUGHT MONITOR, https://droughtmonitor.unl.edu/currentmap/statedroughtmonitor.aspx?TX (last updated Oct. 3, 2023, 8:00 AM); Matt Weiser, *Oil Boom in Southern New Mexico Ignites Groudwater Feud with Texas*, THE NEW HUMANITARIAN (July 16, 2018), https://deeply.thenewhumanitarian.org/water/articles/2018/07/16/oil-boom-in-southern-new-mexico-ignites-groundwater-feud-with-texas.

276. *See supra* Part III.E., IV.

THE ELEPHANT IN THE LANDFILL: HOW ARE WE GOING TO MANAGE RENEWABLE ENERGY WASTE?

Anevay N. Sanchez

ABSTRACT

The elephant in the landfill is a colloquialism for avoiding the discussion of renewable energy waste management (wind turbines, solar panels, and lithium-ion batteries). Companies, agencies, and environmentalists have steadfastly ignored the elephant in the landfill, but it will soon become so immense that continuing to ignore it will be impossible. We are starting to see the signs of the impending waste crisis: turbine blades are stacked or buried in fields, and solar panels and lithium-ion batteries are disposed of in landfills where the contaminants are not contained properly.

In a short decade, or possibly sooner, we will experience large-scale decommissioning events that will overwhelm the disposal and recycling industries. With nowhere to go and no plan to execute, both economic and environmental catastrophes will follow. It is currently lucrative and politically attractive to be in the renewable energy industry; however, if a plan for waste management is not made, financial hardship is inevitable, and the green appearance of such political initiatives will fail.

It is not too late to begin preventive measures, but the industry, agencies, and environmental organizations need to rally hastily and begin cooperative efforts to solve these problems. If they fail to do so, millions of tons of waste will be left unmanaged, and soon after, billions of tons of waste. At that point, what would remediation cost? Who will be responsible? The process of developing this plan will be slow, and the first step is to acknowledge the elephant in the landfill. As the old proverb goes, "How do you eat an elephant? One bite at a time."

I. INTRODUCTION

Renewable energy disposal is a topic tip-toed around by politicians, renewable energy companies, and environmentalists. Clean energy innovation has led to improvements in environmental quality and will continue to lead to these improvements.[1] However, as the industry continues to mature, it will face the looming challenge of disposal.[2] One cannot help but question whether the ramifications of disposal will negate the low carbon power provided. Will the trade-off be worth it? The key to ensuring success in this environmental crusade is to address the elephant in the room, determine how to dispose of renewable energy waste, and enforce regulations aimed at that goal. Currently, there is limited law and guidance on the matter. This Comment seeks to encourage a conversation about feasible solutions, with a primary focus on the state of Texas. As one of the leading states in renewable energy innovation, Texas should be leading the charge in finding solutions for the industry's waste. Texas will be greatly impacted due to its significant renewable energy infrastructure, and, therefore, the main focus of this Comment.[3]

A brief overview of the root problems leading to the waste crisis is necessary. Solar panels, turbines, and lithium-ion batteries will eventually

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1. OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY, *Environmental Impacts of Clean Energy*, ENERGY.GOV, https://www.energy.gov/eere/environmental-impacts-clean-energy (last visited Sept. 6, 2023).

2. *Id.*

3. Dan Gearino, *Inside Clean Energy: Texas Is the Country's Clean Energy Leader, Almost in Spite of Itself*, INSIDE CLIMATE NEWS (Feb. 17, 2022), https://insideclimatenews.org/news/17022022/inside-clean-energy-texas-clean-energy-leader/.

need to be disposed of.[4] This may occur upon the end of their useful life or lease expiration; however, replacement may be required earlier due to damage or replacement with improved technology.[5] An overwhelming influx of waste has yet to come because the industries are relatively new and most lease terms have not expired.[6] By the early 2030s, a short decade away, it is anticipated that a large amount of waste from decommissioning can be expected on an annual basis.[7] To put this problem in perspective, consider the following statistics. The average lease term for a wind farm is thirty to fifty years, and currently, most wind turbines have a useful life of twenty years.[8] In the United States, as of 2021, there were 82,831 wind turbines in operation, not including previously decommissioned turbines or discarded blades.[9] In Texas, as of June 2022, 20,183 wind turbines were in operation.[10] Solar leases have an average lease term of thirty to forty years, and solar panels have a useful life of twenty years.[11] As of 2020, approximately 24,318,750 solar panels were in operation in the United States.[12] In Texas, 3,769,750 solar panels were operating as of 2022.[13] Consider the many new solar projects in progress. Of those solar farms currently operating, 70% were built within the last five years.[14] New to the scene, lithium-ion batteries used for energy storage have a useful life that ends when they drop to 80% efficiency.[15] As of October 2022, the U.S. had 7.8 gigawatts of battery

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4. *EPA Releases Briefing Paper on Renewable Energy Waste Management*, U.S. ENV'T PROT. AGENCY, https://www.epa.gov/newsreleases/epa-releases-briefing-paper-renewable-energy-waste-management (last updated Sept. 22, 2023).

5. Melody Bomgardner & Alex Scott, *Recycling Renewables*, CHEM. & ENG'G NEWS (Apr. 9, 2018), https://cen.acs.org/energy/renewables/Recycling-renewables/96/i15#.

6. *Id.*

7. *End-of-Life Management: Solar Photovoltaic Panels*, INT'L RENEWABLE ENERGY AGENCY (June 2016), https://www.irena.org/publications/2016/Jun/End-of-life-management-Solar-Photovoltaic-Panels.

8. RODERICK E. WETSEL & BECKY H. DIFFEN, WIND AND SOLAR LAW § 2.04 (Matthew Bender & Co. eds., 2023).

9. *2021 Annual Market Report*, AM. CLEAN POWER, https://cleanpower.org/resources/clean-power-annual-market-report-2021/ (last visited Sept. 6, 2023).

10. *The Biggest Wind Farms in Texas 2023*, ELEC. RATE, https://www.electricrate.com/green-energy/wind-energy-farms/ (last updated Mar. 23, 2023) (Calculating the number of wind turbines from megawatt produced averages).

11. RODERICK E. WETSEL & BECKY H. DIFFEN, WIND AND SOLAR LAW § 3.03 (Matthew Bender & Co. eds., 2023).

12. *Largest Solar Power Plants in USA*, LIST SOLAR, https://list.solar/plants/largest-plants/solar-plants-usa/ (last updated June 1, 2021) (Calculating the number of panels from megawatts produced averages).

13. *Texas Solar*, SOLAR ENERGY INDUS. ASS'N, https://www.seia.org/state-solar-policy/texas-solar (last visited Sept. 6, 2023).

14. OFF. OF ENERGY EFFICIENCY & RENEWABLE ENERGY, *End-of-Life Management for Solar Photovoltaics*, ENERGY.GOV, https://www.energy.gov/eere/solar/end-life-management-solar-photovoltaics (last visited Sept. 6, 2023).

15. Lauren Neuhaus, The Electrifying Problem of Used Lithium-Ion Batteries: Recommendations for Recycling and Disposal, 42 ENVIRONS ENV'T L. & POL'Y J. 67, 68–93 (2018).

storage.[16] By the year 2025, it is anticipated that battery storage capacity will be at thirty gigawatts, 75% of which will be in Texas.[17] Let these numbers sink in. The state of Texas and the nation are facing an immense waste management challenge.[18]

Various incidental damages could lead to an increase in waste such as hailstorms that damage solar panels, fires erupting at battery storage plants, and lightning striking wind turbines.[19] As technology improves and becomes more cost-effective, operators have begun to replace many solar panels and turbines before their useful life has ended.[20] Over the last thirty years, turbine blades have become increasingly longer, adding to the amount of waste.[21] Additionally, with the grid failures experienced during winter storm Uri in 2021, there is a push to exchange the existing turbine blades with those that have internal heaters.[22] These are all examples of incidental events adding to the volume of renewable energy waste.[23]

There will be an ever-increasing amount of renewable energy development and, therefore, an ever-increasing amount of renewable energy waste.[24] To demonstrate the state's efforts to encourage exploration and development of renewable energy, Texas codified its renewable energy goals in the Texas Administrative Code (TAC).[25] Furthermore, the Inflation Reduction Act of 2022 provides tax incentives for the growth of renewable energy installations and battery storage installations.[26] Social pressures will

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16. U.S. ENERGY INFO. ADMIN., *U.S. Battery Storage to Increase Significantly By 2025*, CLEAN TECHNICA (Dec. 8, 2022), https://cleantechnica.com/2022/12/08/u-s-battery-storage-capacity-to-increase-significantly-by-2025/.

17. *Id.*

18. *Id.*

19. Michael Cheng, *What You Need to Know About Solar Panel Hail Damage*, SOLAR REVIEWS, https://www.solarreviews.com/blog/solar-panel-hail-damage-what-you-need-to-know, (last updated Feb. 3, 2023); Heidi Vella, *When Lightning Strikes: Managing Impacts on Wind Turbines,* POWER TECH. (May 25, 2021), https://www.power-technology.com/features/when-lightning-strikes-managing-impacts-on-wind-turbines/; Neil Farrell, *Questions Over Battery Plants After Moss Landing Incident,* ESTERO BAY NEWS (Oct. 21, 2021), https://esterobaynews.com/news/questions-over-battery-plants-after-moss-landing-incident/.

20. Sabra Ayres, *What Should Texas Do with Its Old Wind Turbine Blades?,* SPECTRUM NEWS 1 (May 8, 2021, 12:12 PM), https://spectrumlocalnews.com/tx/south-texas-el-paso/news/2021/05/07/what-should-texas-do-with-its-old-wind-turbine-blades-.

21. *Id.*

22. Scott Carpenter, *Why Wind Turbines in Cold Climates Don't Freeze: De-Icing and Carbon Fiber*, FORBES (Feb. 16, 2021, 11:05 PM), https://www.forbes.com/sites/scottcarpenter/2021/02/16/why-wind-turbines-in-cold-climates-dont-freeze-de-icing-and-carbon-fiber/?sh=334b723e1f59.

23. *See id.*

24. Rich Segal, *Texas Leads the Country in Combined Wind, Solar Renewable Energy,* KXAN, https://www.kxan.com/weather-traffic-qas/texas-leads-the-country-in-combined-wind-solar-renewable-energy/ (last updated Mar. 18, 2023, 12:39 PM).

25. 16 TEX. ADMIN. CODE § 25.173.

26. Adam Gerza, *Standalone Energy Storage – Investment Tax Credit (ITC) in the Inflation Reduction Act of 2022: What You Need to Know*, ENERGY TOOLBASE (Aug. 2, 2022), https://www.energy toolbase.com/newsroom/blog/standalone-energy-storage-investment-tax-credit-itc-in-the-inflation-reduc tion-act-of-2022.

also ensure steady growth of the industry.[27] On a national level, waste projections for the year 2050 are as follows: 10 million tons of solar panels and 6.8 million tons of wind turbines.[28] It is expected that by 2030 there will be 2 million tons of lithium-ion battery waste per year.[29] To place those estimations into context, the United States currently produces 200 million tons of solid waste annually.[30] Evidence of impending waste issues has begun to emerge where turbine blades have been replaced, and the carcasses lie stacked up in fields without a final resting place.[31] Continuing to evade the elephant that is renewable energy waste will lead to steep environmental ramifications that contradict the purpose of renewable energy.

II. OVERVIEW OF THE RENEWABLE WASTE ISSUE

Analyzing the details of wind turbines, solar panels, and lithium-ion batteries will expose the roots of the renewable waste issue, as well as assist in developing solutions.

A. Wind and Solar Waste

Improper waste management, or no waste management, of wind turbine and solar panel waste will have harmful environmental and health impacts because of the components that comprise them. As of now, there is no standard waste management plan in place and the results of poor planning and lack of regulation are beginning to surface. To address this issue, multiple disposal and recycling options should be explored.

1. The Detrimental Health and Environmental Impacts

Most solar panels are made up of lead, cadmium, and antimony.[32] If these components leak from damage caused by stacking on land or leak out

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27. *About the Power Up Texas Alliance,* POWER UP TEX., https://poweruptexas.org/#about (last visited Sept. 6, 2023).

28. *End-of-Life Management: Solar Photovoltaic Panels*, INT'L RENEWABLE ENERGY AGENCY (June 2016), https://www.irena.org/publications/2016/Jun/End-of-life-management-Solar-Photovoltaic-Panels.

29. Mitch Jacoby, *It's Time to Get Serious About Recycling Lithium-ion Batteries*, CHEM. & ENG'G NEWS (July 14, 2019), https://cen.acs.org/articles/97/i28/time-serious-recycling-lithium.html.

30. OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY, *End-of-Life Management for Solar Photovoltaics*, ENERGY.GOV, https://www.energy.gov/eere/solar/end-life-management-solar-photovoltaics (last visited Sept. 6, 2023).

31. Sabra Ayres, *What Should Texas Do with Its Old Wind Turbine Blades?*, SPECTRUM NEWS 1 (May 8, 2021, 12:12 PM), https://spectrumlocalnews.com/tx/south-texas-el-paso/news/2021/05/07/what-should-texas-do-with-its-old-wind-turbine-blades-.

32. Michael Shellenberger, *If Solar Panels Are so Clean, Why Do They Produce so Much Toxic Waste?*, FORBES (May 23, 2018, 12:28 PM), https://www.forbes.com/sites/michaelshellenberger/2018/05

of the lining from an unfit landfill, the contaminants would spread and mobilize through the soil and water table.[33] The contaminants then accumulate in plants and animals, affecting the food supply, or even accumulate in humans.[34] Negative health impacts from lead exposure include anemia, kidney damage, brain damage, or even memory loss.[35] Less serious health effects are abdominal pain, tiredness, nausea, weakness, and loss of appetite, all of which diminish quality of life.[36] Lead can also breach the placental barrier, which could expose unborn children to lead, potentially damaging the child's developing nervous system.[37] Cadmium is carcinogenic, and low levels of exposure may also lead to kidney disease and fragile bones.[38] Oral exposure to antimony, which could occur through accumulation in the food or water supply, primarily results in gastrointestinal issues.[39] Antimony is also possibly carcinogenic.[40] Although we are already exposed to these contaminants in our daily lives, if renewable energy waste is not properly managed, nearby locations would experience high concentrations of these contaminants and pose serious health concerns.[41] The environmental impacts of lead, cadmium, and antimony include a decrease in plant and animal reproduction, as well as an increase in plant and animal mortality, from pollution in the soil and water.[42] Researchers have found that rainfall is washing cadmium off of solar panels, especially damaged ones.[43] The Department of Energy has suggested that the Environmental Protection Agency (EPA) begin to phase out the use of cadmium and replace it with

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/23/if-solar-panels-are-so-clean-why-do-they-produce-so-much-toxic-waste/.

33. *Id.*

34. Genevieve Coyle, *The Not-So-Green Renewable Energy: Preventing Waste Disposal of Solar Photovoltaic (PV) Panels*, 4 GOLDEN GATE UNIV. ENV'T. L.J. 329, 337 (2011) (discussing the hazards of potential leaks).

35. *Id.*

36. *Id.*

37. CTR. FOR DISEASE CONTROL & PREVENTION, *Pregnant Women*, https://www.cdc.gov/nceh/lead/prevention/pregnant.htm. (last updated July 21, 2022).

38. CTR. FOR DISEASE CONTROL & PREVENTION, *Cadmium*, https://www.cdc.gov/niosh/topics/cadmium/#NIOSH%20Chemical%20Resources (last updated June 24, 2019).

39. NAT'L CTR. FOR BIOTECHNOLOGY INFO., *Antimony* TOXICITY, NAT'L INSTS. OF HEALTH (Dec. 20, 2010), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3037053/.

40. *Id.*

41. *Renewable Energy Waste Streams*, ENV'T PROT. AGENCY (Jan. 6, 2021), https://www.epa.gov/sites/default/files/2021-01/documents/renewable_energy_waste_briefing_paper_january_2021.pdf.

42. *Cadmium*, CTRS. FOR DISEASE CONTROL & PREVENTION, https://www.cdc.gov/niosh/topics/cadmium/#NIOSH%20Chemical%20Resources (last updated Apr. 7, 2017).

43. Michael Shellenberger, *If Solar Panels Are so Clean, Why Do They Produce so Much Toxic Waste?*, FORBES (May 23, 2018, 12:28 PM), https://www.forbes.com/sites/michaelshellenberger/2018/05/23/if-solar-panels-are-so-clean-why-do-they-produce-so-much-toxic-waste/.

substitute components because of its high toxicity.[44] For these reasons, a waste management plan is critical to human and environmental health. [45]

Wind turbines are made up of steel, fiberglass, plastic, copper, and aluminum.[46] The health impacts of aluminum are not fully known; however, it may cause Alzheimer's or kidney disease, though there are currently no concrete studies confirming these health impacts.[47] There are also not any known long-term health impacts from fiberglass or steel.[48] Copper is an essential mineral humans need in their daily lives; however, in high concentrations, copper can cause gastrointestinal problems, or kidney and liver disease.[49] Plastics contain endocrine-disrupting chemicals that can cause cancer, diabetes, and reproductive disorders.[50] The major impact that wind turbine disposal has on the environment is that the above-listed components do not decompose, or they take hundreds of years to decompose.[51] Furthermore, volatile materials may leach from these metals into the soil and mobilize through the water.[52]

2. Lack of Waste Management

The combination of components within solar panels results in impurities in the glass, making it difficult or impossible to recycle the panels.[53] Currently, solar panels are either being disposed of in landfills that are not designed to contain their contaminants effectively, or they are being stacked

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44. Man Varma & Herbert Katz, *Environmental Impact of Cadmium*, 40:6 J. ENVIRON. HEALTH 308, 131 (1978), https://www.jstor.org/stable/pdf/44537329.pdf?refreqid=excelsior%3Ab3fa2391c028e4a411bbd0f51eba4f8a&ab_segments=&origin=&initiator=&acceptTC=1.

45. *Renewable Energy Waste Streams*, UNITED STATES ENV'T PROT. AGENCY (Jan. 6, 2021), https://www.epa.gov/sites/default/files/2021-01/documents/renewable_energy_waste_briefing_paper_january_2021.pdf.

46. *What Materials Are Used to Make Wind Turbines?*, UNITED STATES GEOLOGICAL SURVEY, https://www.usgs.gov/faqs/what-materials-are-used-make-wind-turbines (last visited Sept. 6, 2023).

47. AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY, *Public Health Statement for Aluminum*, CTR. FOR DISEASE CONTROL AND PREVENTION, https://wwwn.cdc.gov/TSP/PHS/PHS.aspx?phsid=1076&toxid=34 (last updated Mar. 12, 2015).

48. *Fiberglass*, WASH. STATE DEP'T OF HEALTH, https://doh.wa.gov/community-and-environment/air-quality/indoor-air/fiberglass (last visited Sept. 6, 2023).

49. AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY, *ToxFAQs for Copper*, CTR. FOR DISEASE CONTROL & PREVENTION, https://wwwn.cdc.gov/Tsp/ToxFAQs/ToxFAQsDetails.aspx?faqid=205&toxid=37 (last updated Apr. 27, 2022).

50. Pippa Naill, *Plastics Pose a Threat to Human Health*, ENV'T J. (Dec. 16, 2020), https://environmentjournal.online/articles/plastics-pose-a-threat-to-human-health/.

51. Chris Martin, *Wind Turbine Blades Can't Be Recycled, so They're Piling Up in Landfills*, BLOOMBERG, https://www.bloomberg.com/news/features/2020-02-05/wind-turbine-blades-can-t-be-recycled-so-they-re-piling-up-in-landfills#xj4y7vzkg (last updated Feb. 7, 2020, 10:54 AM).

52. Megan, *Is Fiberglass Biodegradable? (Eco & Health Facts You Should Know)*, CITIZEN SUSTAINABLE (July 1, 2020), https://citizensustainable.com/fiberglass/.

53. Michael Shellenberger, *If Solar Panels Are so Clean, Why Do They Produce so Much Toxic Waste?*, FORBES (May 23, 2018, 12:28 PM), https://www.forbes.com/sites/michaelshellenberger/2018/05/23/if-solar-panels-are-so-clean-why-do-they-produce-so-much-toxic-waste/?sh=1fba71a5121c.

on leased land.[54] Presently, only 10% of solar panels are recycled.[55] Various types of solar panels are on the market. As a result, most do not meet the Resource Conservation and Recovery Act (RCRA) classification of solid hazardous waste, evading regulations meant to curtail their environmental impact.[56] The reason many panels are not designated as solid hazardous waste is because they do not have a high enough concentration of hazardous material; however, when there is a massive discharge of panels disposed of in the same area, the level of hazardous material will be far exceeded.[57] In spite of their classification, those few panels that do classify as hazardous solid waste are still being disposed of in landfills.[58] Similarly, wind turbines are being disposed of in landfills, stacked on leased land, or even buried.[59] A distinction is that wind turbines have more recycling opportunities than solar panels because their components and materials are more easily separated.[60] Generally, about 85% of a turbine is recyclable.[61]

3. Recycling and Disposal Options

Three primary methods exist to recycle solar panels: refurbishment, mechanical recycling, and thermal recycling.[62] Refurbishment requires minimal processing and lessens the demand for new panels; however, there are some disadvantages.[63] One major drawback of this method is that the panel loses efficiency, so it is not ideal for commercial settings.[64] Instead, these refurbished panels are typically better suited for smaller-scale power generation such as family dwellings, company headquarters, or public buildings.[65] In mechanical recycling, the panels are physically broken down into their components, and what is unable to be separated, is ground into a mixture called a glass cullet and used for construction purposes.[66] With

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54. *Id.*

55. Casey Crownhart, *Solar Panels Are a Pain to Recycle*, MIT TECH. REV. (Aug. 19, 2022), https://www.technologyreview.com/2021/08/19/1032215/solar-panels-recycling/.

56. U.S. ENV'T. PROT. AGENCY, *End-of-Life Solar Panels: Regulations and Management*, https://www.epa.gov/hw/end-life-solar-panels-regulations-and-management (last updated Aug. 28, 2022).

57. *Id.*

58. *Id.*

59. Tom Leonard, *Graveyard of the Green Giants*, WIND WATCH (Feb. 28, 2022), https://www.wind-watch.org/news/2022/02/28/graveyard-of-the-green-giants/.

60. Katerin Ramirez-Tejeda & David Turcotte, *Unsustainable Wind Turbine Blade Disposal Practices in the U.S.: A Case for Policy Intervention & Technological Innovation*, 26 NEW SOLUTIONS J. OF ENV'T & OCCUPATIONAL HEALTH POL'Y 4, 4–8 (2016).

61. Dillon Clayton, *Are Wind Turbines Recyclable? Parts Explained*, ENERGY FOLLOWER, https://energyfollower.com/are-wind-turbines-recyclable/ (last updated July 21, 2021).

62. Jacob Marsh, *Solar Panel Recycling: What You Need to Know*, ENERGY SAGE (Mar. 1, 2023), https://news.energysage.com/recycling-solar-panels/.

63. *Id.*

64. *Id.*

65. *Id.*

66. *Id.*

thermal recycling, chemical reactions are performed on a molecular level that thoroughly separates the components that make a panel.[67] The best waste management practice would be an integrative method that encompasses all three approaches.

While endless opportunities exist for recycling wind turbines, their size and durability makes recycling difficult.[68] To make waste management of turbine blades less difficult, the blades are cut into smaller pieces.[69] One way to recycle blades is to use the shredded material as an additive in cement.[70] Recovered fiberglass is also recycled into textiles and other fiber-reinforced materials.[71] Additionally, people are becoming creative with turbine blades and repurposing them for things like children's playgrounds.[72]

B. Lithium-Ion Battery Waste

Inadequate waste management of lithium-ion batteries will have detrimental impacts on the environment and human health. Currently, there is no conventional practice or regulation for the management of lithium-ion battery waste. To solve the problem, various disposal and recycling options should be considered.

1. The Detrimental Health and Environmental Impacts

Lithium-ion battery storage plants are used as energy reserves to compensate for the unpredictable impact the renewables industry is having on electric grid reliability.[73] These batteries are typically made of lithium, cobalt, nickel, aluminum, and manganese, which are toxic.[74] If these substances leak from a landfill, they will likely contaminate the water table and soil.[75] If absorbed into plants and animals, these battery components can also enter the food chain and affect the human reproductive system, genetics, and gastrointestinal health.[76] When lithium-ion batteries ignite, as they are prone to do, they release toxic emissions into the air.[77] Additionally, these

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67. *Id.*

68. Mitch Jacoby, *How Can Companies Recycle Wind Turbine Blades?*, CHEM. & ENG'G NEWS (Aug. 8, 2022), https://cen.acs.org/articles/100/i27/companies-recycle-wind-turbine-blades.html.

69. *Id.*

70. *Id.*

71. *Id.*

72. *Id.*

73. Brittany Westlake, *Recycling and Disposal of Battery-Based Grid Energy Storage Systems: A Preliminary Investigation*, ELECTRIC POWER RSCH. INST. 1, 1-1 (Dec. 11, 2017), https://www.epri.com/research/products/000000003002006911.

74. *Id.*

75. *Frequent Questions on Lithium-ion Batteries*, U.S. ENV'T PROT. AGENCY, https://www.epa.gov/recycle/frequent-questions-lithium-ion-batteries (last updated July 6, 2023).

76. *Id.*

77. *Id.*

components have the potential to cause ozone depletion.[78] The Morris lithium-ion battery fire in Illinois is one example of the environmental concerns regarding lithium-ion batteries.[79] Lithium-ion batteries contain a flammable electrolyte, that overheats and ruptures when pressurized, causing a fire.[80] This is how the Morris battery fire started.[81] The EPA has taken control of remediating the site by gathering hazardous materials, packaging them, and shipping them off for disposal.[82] The EPA uses the Cirba Solution (Retrieve) disposal facility, located in Michigan.[83] This highlights the transportation issue of renewable waste having to be handled out of state, raising costs and making transport difficult.[84] Additionally, the EPA is conducting air monitoring and sampling the waste and burned material from the site.[85] The EPA's involvement may indicate that Illinois was either not individually equipped to handle the remediation of the site or unwilling to properly remediate.[86] It also indicates a lack of accountability placed on the company responsible for the incident.[87]

2. Poor Waste Management

Currently, no federal regulations exist regarding the disposal of lithium-ion batteries.[88] Small-scale lithium-ion batteries such as those in electric cars, phones, laptops, and other daily items, are rarely disposed of properly.[89] Regarding lithium-ion car batteries, some private companies have made recycling plants, and some manufacturers are developing recycling methods specific to their batteries.[90] Many batteries are temporarily being stored until there is ample recycling capacity and the components are more economically valuable.[91] Companies are resistant to standardizing their battery

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78. Lauren Neuhaus, *The Electrifying Problem of Used Lithium-Ion Batteries: Recommendations for Recycling and Disposal*, 42 ENVIRONS ENV'T L. & POL'Y J. 67, 72 (2018).

79. Rachel Bassler, *EPA Resumes Cleanup of Hazardous Substances at Morris Lithium Battery Fire Site in Morris, Illinois*, U.S. ENV'T PROT. AGENCY, https://www.epa.gov/newsreleases/epa-resumes-cleanup-hazardous-substances-morris-lithium-battery-fire-site-morris (last updated Mar. 27, 2023).

80. *Id.*

81. *Id.*

82. *Id.*

83. *Id.*

84. Email from Rachel Bassler, U.S. EPA Pub. Info. Officer, to author (Nov. 8, 2022, 01:49 CST) (on file with author).

85. Rachel Bassler, *EPA Resumes Cleanup of Hazardous Substances at Morris Lithium Battery Fire Site in Morris, Illinois*, U.S. ENV'T PROT. AGENCY (Apr. 8, 2022), https://www.epa.gov/newsreleases/epa-resumes-cleanup-hazardous-substances-morris-lithium-battery-fire-site-morris.

86. *Id.*

87. *Id.*

88. Lauren Neuhaus, *The Electrifying Problem of Used Lithium-Ion Batteries: Recommendations for Recycling and Disposal*, 42 ENVIRONS ENV'T L. & POL'Y J. 67, 89–90 (2018).

89. *Id.* at 77.

90. *Id.* at 86.

91. *Id.* at 90.

formulations because they are seeking to remain innovatively competitive.[92] It is evident that companies that own battery storage plants that have caught fire, or have experienced other damages, do not exercise transparency as to how they handle or dispose of waste.[93] This reluctance to disclose proprietary information makes it difficult to determine the best waste management practices and hinders progress.

3. Recycling and Disposal Options

Multiple challenges exist in developing an effective disposal or recycling plan in regards to lithium-ion batteries.[94] Aside from battery storage being an emerging technology, the models that are currently in the market vary significantly.[95] Batteries vary in chemical makeup, shape, and size, resulting in a lack of uniformity which makes regulation and waste infrastructure difficult to establish.[96] Additionally, recycling processes recover a minimal quantity of valuable materials; consequently, the cost of recycling outweighs the benefits.[97] Various disposal options are being explored with a focus on cost efficiency, which depends on the components of the battery.[98] Smelting is a process that uses high temperatures to burn off the organic material in a battery and recovers only the valuable materials for refining.[99] The remaining materials can be used as additives to concrete.[100] Another method is direct recovery processing which separates the active metals and materials through low-temperature chemical and physical processes.[101] This method tends to use less energy than smelting.[102] The recovered materials may then be used in creating another lithium-ion battery for storage.[103]

4. Lead-Acid Battery Management as an Encouraging Example

The lead-acid battery recycling program is a commendable example of a successful waste management plan and joint implementation by both government and industry.[104] Lead-acid batteries are those found under the

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92. *Id.*
93. *Id.*
94. Neuhaus, *supra* note 88 at 90.
95. *Id.*
96. *Id.*
97. *Id.* at 68.
98. *Id.* at 74.
99. *Id.* at 71.
100. *Id.*
101. *Id.* at 75.
102. *Id.*
103. *Id.*
104. *Id.* at 78.

hood of the standard combustion vehicle.[105] Today, 98% of all lead-acid batteries are recycled; however, this percentage of disposal is aspirational.[106] To achieve these results, the EPA listed lead-acid batteries as "solid hazardous waste" and prohibited the exportation of the batteries unless the generator complied with specific requirements for RCRA regulation exemptions.[107] The Code of Federal Regulation (CFR) exempted reclaimed lead-acid batteries from RCRA regulation.[108]

In 1996, the Mercury-Containing and Rechargeable Battery Management Act was passed requiring all states to conform to universal waste regulation standards, resulting in the development of a national waste collection and recycling program.[109] These regulations provide treatment options and prevent environmentally hazardous disposal of the batteries.[110] It is now easier and more cost-effective to comply with the regulations than to deal with the "red tape" and consequences of non-compliance.[111] The regulations have also made recycling a profitable activity.[112]

Some notable differences between lithium-ion batteries and lead-acid batteries may make the same level of success difficult.[113] Lithium-ion batteries are experiencing rapid innovation and are composed of a wider variety of materials.[114] Each battery component is valued differently and does not result in the same economic return as a lead-acid battery.[115] The lithium that is extracted from recycled batteries costs five times more than what mined lithium is worth.[116] Other extracted materials, like nickel and cobalt, are becoming less utilized.[117] Despite these challenges, the lead-acid battery recycling program serves as a strong template to build upon.[118]

III. THE GOVERNANCE AND ENFORCEMENT OF WASTE MANAGEMENT

Currently, there is a lack of oversight from both federal and state governments for renewable waste management. Additionally, there is no statutory authority on how to manage such waste in environmental and administrative codes.

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105. *Id.*
106. *Id.* at 76.
107. *Id.* at 79.
108. *Id.*
109. *Id.*
110. *Id.* at 80.
111. *Id.*
112. *Id.*
113. *Id.*
114. *Id.*
115. *Id.*
116. *Id.* at 79.
117. *Id.* at 76.
118. *Id.* at 80.

A. A Lack of Oversight from the Environmental Protection Agency and The Resource Conservation Recovery Act

The Resource Conservation Recovery Act regulates waste and its transportation, generation, treatment, storage, and disposal.[119] Those who generate waste regulated under the RCRA have the responsibility of ensuring that their waste ends up in a qualified facility.[120] Generators who fail to comply could face civil or criminal penalties.[121] Solid waste is considered hazardous if its characteristics may cause a significant increase in injury or mortality, or pose a hazard to human health or the environment.[122] Enforcing the code is the responsibility of state and local governments.[123] There is a current lack of state involvement in enforcing the RCRA regarding renewable waste. Some local governments have attempted to regulate disposal but have been unsuccessful.[124]

The EPA classifies lithium-ion batteries as universal waste, which is a sub-category of hazardous waste.[125] Universal waste is typically designated as such because of how common it is.[126] Studies conducted on lithium-ion batteries demonstrate toxicity, corrosivity, ignitability, and reactivity, which qualifies lithium-ion as a hazardous solid waste under the RCRA.[127] Under the RCRA, some solar panels are designated as solid waste and others as hazardous solid waste.[128] Solid waste is regulated under Subtitle D of the act, and hazardous waste is regulated under Subtitle C.[129] Generators are responsible for determining if waste meets the threshold of being considered hazardous solid waste.[130] The concern with this system is that generators may not be self-accountable or know how to properly determine if the battery rises

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119. *Id.* at 73.

120. *Id.*

121. Genevieve Coyle, *The Not-So-Green Renewable Energy: Preventing Waste Disposal of Solar Photovoltaic (PV) Panels*, 4 GOLDEN GATE U. ENV'T L.J. 329, 343 (2011).

122. Lauren Neuhaus, *The Electrifying Problem of Used Lithium-Ion Batteries: Recommendations for Recycling and Disposal*, 42 ENVIRONS ENV'T L. & POL'Y J. 67, 74 (2018).

123. *Id.* at 74.

124. *End-of-Life Solar Panels: Regulations and Management*, U.S. ENV'T PROT. AGENCY, https://www.epa.gov/hw/end-life-solar-panels-regulations-and-management (last updated Aug. 17, 2023).

125. *Lithium-Ion Battery Recycling Frequently Asked Questions*, U.S. ENV'T PROT. AGENCY, https://www.epa.gov/hw/lithium-ion-battery-recycling-frequently-asked-questions#chemistries (last updated July 6, 2023).

126. *Universal Waste*, U.S. ENV'T PROT. AGENCY, https://www.epa.gov/hw/universal-waste (updated last Jan. 3, 2023).

127. Thomas Brugato, *EPA Clarifies Hazardous Waste Requirements Applicable to Lithium Ion Batteries*, COVINGTON (May 30, 2023) https://www.insideenergyandenvironment.com/2023/05/epa-clarifies-hazardous-waste-requirements-applicable-to-lithium-ion-batteries/.

128. *End-of-Life Solar Panels: Regulations and Management*, *supra* note 124.

129. *Resource Conservation and Recovery Act (RCRA) Overview*, U.S. ENV'T PROT. AGENCY, https://www.epa.gov/rcra/resource-conservation-and-recovery-act-rcra-overview (last updated June 19, 2023).

130. Lauren Neuhaus, *The Electrifying Problem of Used Lithium-Ion Batteries: Recommendations for Recycling and Disposal*, 42 ENVIRONS ENV'T L. & POL'Y J. 67, 74 (2018).

to the level of solid hazardous waste.[131] Solar panels classified as solid hazardous waste that is used by family dwellings, residential facilities, and hotels are exempt from being treated and disposed of as hazardous waste.[132] This exemption could potentially add to the mismanagement of hazardous waste. These users should be held to the same standards as companies that own commercial solar farms. Although the panels may not be disposed of in as high of quantities as commercial generators, they are still improperly handled by being dumped in a landfill typically equipped to handle household trash.[133] Wind turbines and blades are classified as non-hazardous solid waste.[134] Non-hazardous waste is minimally regulated under RCRA, and the states are allowed to impose their own regulations.[135] The RCRA ban on open dumping of non-hazardous waste is currently being violated by the many companies that stack turbine blades in open fields.[136]

It can be inferred that the EPA has purposefully avoided taking aggressive action on renewable energy waste. The agency engages in avoidance to protect its "clean energy" agenda. If the agency does not take enforcement action soon, it will only hinder the renewable energy industry. The EPA is reflecting the mantra of tomorrow's problems are for tomorrow when its mission is to make efforts to prevent further harm to human health and the environment.[137] The fact that renewable energy sources have their pitfalls does not doom the clean(er) energy movement; the issue of waste should be addressed to ensure industry success.

B. A Lack of Involvement from the Texas Commission on Environmental Quality and The Texas Administrative Code

In Texas, the disposal of wind turbines, solar panels, and lithium-ion batteries is regulated within the Texas Administrative Code under industrial hazardous waste Chapter 335 and municipal solid waste Chapter 330.[138] However, there are no specific references to renewable waste.[139] Not many

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131. Karen Yeung, *Very few Businesses Can Be Trusted*, NEW YORK TIMES (Nov. 10, 2015, 3:20 AM), https://www.nytimes.com/roomfordebate/2015/11/10/is-vw-proof-that-businesses-cant-regulate-themselves/very-few-businesses-can-be-trusted#:~:text=Businesses%20cannot%20be%20relied%20on%20to%20regulate%20themselves,cannot%20ensure%20that%20firms%20will%20behave%20with%20integrity.

132. 40 C.F.R. § 261.4(b)(i).

133. *End-of-Life Solar Panels: Regulations and Management*, *supra* note 124.

134. *Fact Sheet: Wind Turbine Blades*, ASS'N OF STATE & TERRITORIAL SOLID WASTE MGMT. OFFICIALS (Nov. 2022), https://astswmo.org/files/Resources/Hazardous_Waste/2022-11-Wind-Turbine-Blades-Fact-Sheet.pdf .

135. *Id.*

136. *Resource Conservation and Recovery Act (RCRA) Overview*, *supra* note 129.

137. *Our Mission and What We Do***,** U.S. ENV'T PROT. AGENCY, https://www.epa.gov/aboutepa/our-mission-and-what-we-do (last updated, May 23, 2023).

138. 30 TEX. ADMIN. CODE § 335 (2022); 30 TEX. ADMIN. CODE § 330 (2010).

139. *Id.*

reported cases exist regarding the state of Texas taking enforcement action for the improper disposal of renewable energy waste. Primarily because there are no specific regulations for renewable waste and there is a lack of awareness among the state's environmental investigators of the renewable waste issue.[140] One of the reported instances occurred when the Texas Commission on Environmental Quality (TCEQ) brought an enforcement action against an electronic recycling facility involved in the disposal of municipal solid waste and industrial solid waste.[141] During a site investigation, an environmental investigator observed unauthorized waste in the facility, which included solar panels.[142] The company received violations for failing to conduct hazardous waste determinations and classifications and was sent to enforcement.[143] The TCEQ required the company to pay a fine and take corrective action.[144] The corrective action ordered by the TCEQ included removing the waste and disposing of it in an authorized facility; evidence of this action was also required.[145] Evidence includes receipts, photographs, or other documents certifying the violator has properly disposed of the waste.[146] This instance of state action is reassuring that the state will be moving forward in the right direction; however, it is one recorded instance, and there is a massive unknown quantity of renewable waste being improperly disposed of.[147] Here, it is likely that the improper disposal of the solar panel would have gone undiscovered if the investigator had not observed other wrongfully disposed of waste at the facility.[148]

IV. PROPOSED SOLUTION

Multiple solutions should be considered and implemented due to the monumental size of this waste crisis. These solutions should be environmentally sound and cost-effective, which will require creative thinking. Government assistance will be necessary to jump-start the process. An enforcement procedure will need to be established for such programs to be successful.

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140. *Id.*
141. *In re* Enforcement Action Concerning ECS Big Town, LLC, No. 2018-1486-MLM-E 2018 WL 5306815, at *1 (Tex. Comm'n Env't Quality 2019).
142. *Id.* at 2.
143. *Id.*
144. *Id.*
145. *Id.*
146. *Id.*
147. Amy O'Donoghue, *The Dark Side of 'Green Energy,' and Its Threat to the Nation's Environment*, DESERET NEWS (Jan. 30, 2021, 11:00 PM), https://www.deseret.com/utah/2021/1/30/22249311/why-green-energy-isnt-so-green-and-poses-harm-to-the-environment-hazardous-waste-utah-china-solar.
148. In re Enforcement Action Concerning ECS Big Town, LLC, No. 2018-1486-MLM-E 2018 WL 5306815, at *1 (Tex. Comm'n Env't Quality 2019).

A. A Need for Creative Solutions and Regulations

Because there is a lack of standardization, particularly in the solar panel and lithium-ion battery market[149], and because regulation to push uniformity would stifle innovation[150], a database that tracks the types of solar panel and battery contaminants based on manufacturer would help determine the best management options. Based on the chemical components of renewable energy waste, new landfills may need to be constructed and new landfill lining requirements should be implemented based on the content of the waste.[151] These landfills should accept only that specific type of product; for example, solar panel landfills should accept only solar panels, not turbine blades or household trash. The method by which the waste is placed in the landfill should be engineered in a way that would avoid damaging or further damaging the waste, which would prevent leakage of pollutants. If a single type of renewable waste was stored carefully, an opportunity to recycle that material would be preserved for when it becomes more cost-effective and the technology is widely available.[152] The ultimate goal should be to mandate recycling renewable energy waste; however, it is going to take time for the infrastructure to be built, the technology to advance, and the cost to become effective.[153] States should require operators of renewable energy plants to have an end-of-life plan before construction.[154] While both wind and solar operators are now required by statute to post removal bonds, no waste management requirements are currently in place.[155] This lack of renewable waste regulation could pose a serious problem in meeting removal bond requirements. The above solutions are actions that can be taken in the meantime in correlation with government regulation and industry cooperation.

B. A Need for Incentives, Grants, and State Involvement

One approach to encourage the development of renewable waste facilities would be to give tax credits. After all, this is how the renewable

149. *Neuhaus*, *supra* note 122 at 89–90.
150. *Id.* at 68.
151. *Id.* at 71.
152. Melody M. Bomgardner, *Recycling Renewables*, CHEM. & ENG'G NEWS (Apr. 9, 2018), https://cen.acs.org/energy/renewables/Recycling-renewables/96/i15#.
153. *Neuhaus*, *supra* note 122 at 72.
154. *See End-of-Life Solar Panels: Regulations and Management*, U.S. ENV'T PROT. AGENCY, https://www.epa.gov/hw/end-life-solar-panels-regulations-and-management (last updated Aug. 17, 2023).
155. Act of Sept. 1, 2019, 86th Leg., R.S., ch. 1293, § 1, 2019 Tex. Gen. Laws 3815 (codified at TEX. UTIL. CODE § 301.0003(a)); Act of Sept. 1, 2021, 87th Leg., R.S., ch. 582, § 2, 2021 Tex. Gen. Laws 2 (codified at TEX. UTIL. CODE § 302.0004(a)).

energy industry took root in Texas.[156] The process would be done in a similar manner as the production tax credit and the investment tax credit for wind farms.[157] These credits would last for only a certain window of time to spur growth and development before a massive decommissioning event arrives.[158] The major drawback to this approach is the burden shift to the taxpayer which should be avoided; instead, Texas should place the burden on industry participants. The Texas Rainy Day Fund is an example of how the energy industry provides for the good of the state. The Rainy Day Fund was created to ensure economic stability when a downturn in the oil and gas industry affected the economy of the entire state.[159] It is now being utilized to make up for the shortcomings and emergencies of the state.[160] Companies that decide to develop and operate renewable energy facilities in the state should have to pay taxes into a fund designated for the development of recycling facilities or disposal sites for renewable waste. The fund could be called the "Solutions for Renewable Energy Waste Fund". The funding may be used for scientific research, building recycling facilities, or building proper landfills. Another solution may be to create a fund similar to the "Oil and Gas Regulation and Clean Up Fund", which is administered under the Railroad Commission for the plugging of orphan wells.[161] The fund in this case would be administered through the TCEQ, and the funding would be established by bonds and fees paid by renewable energy operators, as well as by a percentage of the fines collected from related violations given by the agency.

Many states receive extensive funding to establish or improve recycling facilities[162], and Texas needs these grants. Since Texas is a leader in the renewable energy industry and has a higher volume of impending renewable energy waste, it makes sense to build these facilities within Texas.[163] These facilities should also be located where there are high concentrations of wind farms, solar farms, and battery plants.[164] This proximity makes it more cost-effective for the operator. For example, if a solar panel recycling facility were

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156. *See* RODERICK E. WETSEL & BECKY H. DIFFEN, WIND AND SOLAR LAW § 1.02, (Matthew Bender eds., 2023)

157. *See id.* at § 6.03.

158. Johanna Newman, *New Study: Solar and Wind Saved Texas Consumers Billions*, ENV'T AM. RSCH. & POLICY CENTER (Nov. 7, 2022), https://www.environmentamerica.org/center/updates/new-study-solar-and-wind-saved-texas-consumers-billions/.

159. Tim Hardin, *Explainer: What Is the Texas Rainy Day Fund?*, TEXANS FOR FISCAL RESPONSIBILITY (Feb. 1, 2022), https://www.texastaxpayers.com/what-is-the-texas-rainy-day-fund/.

160. *See id.*

161. *Oil & Gas Regulation and Cleanup Fund*, TEX. R.R. COMM'N, https://rrc.texas.gov/oil-and-gas/environmental-cleanup-programs/oil-gas-regulation-and-cleanup-fund/ (last visited Sept. 6, 2023).

162. *Solid Waste Infrastructure for Recycling Grant Program*, U.S. ENV'T PROT. AGENCY, https://www.epa.gov/infrastructure/solid-waste-infrastructure-recycling-grant-program (last updated Sept. 13, 2023).

163. *See* Dan Gearino, *Inside Clean Energy: Texas Is the Country's Clean Energy Leader, Almost in Spite of Itself*, INSIDE CLIMATE NEWS (Feb. 17, 2022), https://insideclimatenews.org/news/17022022/inside-clean-energy-texas-clean-energy-leader/.

164. *Neuhaus, supra* note 122 at 82.

built near McCamey, Texas, where there is a high volume of renewable energy production, operators would be more inclined to recycle because the cost would be less than shipping it out of state. States should also consider accepting only waste from within the state to avoid congestion and becoming backlogged. Recycling companies that have attempted to build facilities in heavily renewable concentrated areas have failed without federal or state financial support.[165] For example, Global Fiber Glass Solutions began the process of developing a wind turbine blade recycling facility in Sweetwater, Texas, home of one of the largest wind farms in the state;[166] however, the feat became too expensive, and the project failed.[167] As a result of this failed endeavor, Global Fiber Glass Solution owns two turbine blade graveyards in Sweetwater, which contain the initial blades that the company intended to recycle.[168] The sites have been declared a public nuisance.[169] If not all, an integrative method encompassing a couple of these ideas is likely the best approach to establishing renewable waste management in Texas.

C. A Need for Enforcement

The task of regulating renewable waste disposal should not be left to local government. Local governments lack the resources and authority to effectively enforce proper disposal.[170] State governments should enforce their administrative code through their environmental enforcement agency.[171] For example, in Texas, the TCEQ enforces municipal solid waste and industrial hazardous waste disposal by conducting compliance investigations, giving violations for non-compliance, and sending repeat offenders to enforcement.[172] A solution for renewable waste disposal would be for state regional office investigators to oversee the disposal process.[173] Investigators would make on-site visits confirming proper removal and documentation of disposals such as receipts from an agency-accredited recycling or waste

165. Russell Gold, *Thousands of Old Wind Turbine Blades Pile Up in West Texas*, TEX. MONTHLY (Aug. 24, 2023), https://www.texasmonthly.com/news-politics/sweetwater-wind-turbine-blades-dump/.

166. *Id.*

167. *See* Jared Paben, *Company Expands Wind Turbine Recycling Operation*, PLASTICS RECYCLING UPDATE, https://resource-recycling.com/plastics/2019/03/27/company-expands-wind-turbine-recycling-operation/ (last updated Jan. 28, 2020).

168. Saba Ayres, *What Should Texas Do with Its Old Wind Turbine Blades?*, SPECTRUM NEWS 1 (May 8, 2021, 12:12 PM), https://spectrumlocalnews.com/tx/south-texas-el-paso/news/2021/05/07/what-should-texas-do-with-its-old-wind-turbine-blades-.

169. Tyler Greene, *Old Windfarm Blades Causing Problems in Noland County*, KTXS 12 ABC (Aug. 24, 2022, 5:37 PM), https://ktxs.com/news/local/old-windfarm-blades-causing-problems-in-nolan-county.

170. Lauren Neuhaus, *The Electrifying Problem of Used Lithium-Ion Batteries: Recommendations for Recycling and Disposal*, 42 ENVIRONS ENV'T L. & POL'Y J. 67, 82 (2018).

171. *Id.*

172. *The Enforcement Process: From Violations to Actions*, TEX. COMM'N ON ENV'T QUALITY, https://www.tceq.texas.gov/compliance/enforcement/process.html (last visited Sept. 6, 2023).

173. *See id.*

facility.[174] If the developer does not comply, it would be given a violation, or depending on the degree of the violation, immediate enforcement action would be taken resulting in a fine.[175] The developer would also be required to take corrective action and remediate.[176] When a new wind farm, solar farm, or battery storage plant is constructed, the developer would be required to provide a time frame of useful life and relevant lease terms to the agency.[177] The developer would also need to provide notification to the agency if decommissioning occurs before the reported time for whatever reason and in any quantity. This protocol would allow the agency to set scheduled compliance investigations at the time disposal is anticipated to take place. The agency may also consider periodically inspecting the sites. Unscheduled investigations within a period of five years would help ensure company accountability and that waste is not being improperly stored on the premises. Both operators and those who accept the waste and improperly manage it would be responsible for separate violations and fines. Under this model of enforcement, the state's environmental enforcement agency would be taking on a new industry and may need to expand by creating a new department for renewable oversight.

State legislation that supports extended producer responsibility should also be considered as an option.[178] Manufacturers are not likely to volunteer to provide such services.[179] However, potential legislation could make producers responsible for their panels, turbines, or batteries when they are decommissioned; this process is known as a take-back program.[180] Producers would be responsible for the disposal and recycling of the waste.[181] They could develop their facility or use third-party companies.[182] Because manufacturers made the product, they are likely the most knowledgeable about its recycling requirements.[183] This distribution of responsibility takes the economic burden off the state and, therefore, the taxpayer. In contrast, a consumer-fee model would place the burden on the user, which would likely deter industry growth, and the goal should be to avoid further burdening the taxpayer.[184] These two approaches could be used to prevent more drastic measures of the state to control the impending waste issue. [185]

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174. *Id.*

175. *Id.*

176. *Id.*

177. *See, e.g.*, RODERICK E. WETSEL & BECKY H. DIFFEN, WIND AND SOLAR LAW § 3.03.4, (Matthew Bender eds., 2023) (discussing how most solar leases contain useful life provisions).

178. Genevieve Coyle, *The Not-So-Green Renewable Energy: Preventing Waste Disposal of Solar Photovoltaic (PV) Panels*, 4 GOLDEN GATE U. ENV'T L.J. 329, 353 (2011).

179. *Id.* at 355.

180. *Id.* at 353.

181. *Id.*

182. *Id.* at 354.

183. *Id.* at 353.

184. *Id.* at 354.

185. *See id.*

V. CONCLUSION

It can be inferred that the State of Texas refuses to implement renewable waste regulations so it may remain an attractive location for developers. The lack of regulation surrounding the renewable energy industry in Texas has helped foster growth.[186] While there is hesitation to enact regulation in fear of hindering the industry, regulation of renewable waste disposal in the long term will prove to be cost-effective.[187] Paying for recycling and disposal of such waste after it has insurmountably accumulated will take a far greater toll on the industry and the state's financial resources than if the problem is addressed now.[188] The state needs to take the first step in leading the charge by implementing new laws and regulations. Industry support and cooperation is the key to success. If those with influence to push this matter find themselves reading the end of this Comment, please heed this as a call to action; the time to address the elephant in the landfill is now.

186. *See* RODERICK E. WETSEL & BECKY H. DIFFEN, WIND AND SOLAR LAW § 1.02, 6, (Matthew Bender eds., 2023).

187. *EPA Releases Briefing Paper on Renewable Energy Waste Management*, U.S. ENV'T PROT. AGENCY, https://www.epa.gov/newsreleases/epa-releases-briefing-paper-renewable-energy-waste-management (last updated Sept. 22, 2023).

188. *Id.*

PUTTING THE CART BEFORE THE HORSE: THE RUSH TO BUILD ELECTRIC VEHICLES AND THEIR BATTERIES

Taylor Terry

ABSTRACT

Many think electric vehicles can solve the problems they believe internal combustion vehicles cause. However, electric cars come with issues and

concerns that the government and individuals have failed to address, such as end-of-life battery disposal, lack of information about the batteries, new infrastructure, and additional pressure on existing infrastructure. Electric vehicle battery recycling is not the perfect solution to battery disposal because the industry is still attempting to discover the best way to recycle the batteries. Additionally, recyclers have received little information from battery manufacturers to help improve the recovery of materials. Another concern is that these vehicles require charging infrastructure to allow consumers to travel across the country freely, and these cars impose a more considerable strain on the already struggling infrastructure. These are significant problems that electric vehicles will impose on society.

This Comment addresses possible solutions to these problems while considering business, environmental, and safety concerns. Because information is vital to understanding how to handle electric vehicle batteries for safety and recycling, manufacturers must share information about these batteries so individuals who interact with the battery to recycle it can do so safely and effectively. Additionally, this information will help recyclers discover more efficient ways to recover materials from the batteries. Lastly, investing in the construction of electric cars will be useless if this country's infrastructure cannot support them. Slowing down electric vehicles does not prevent them from entering the market but lessens their impact once they do.

I. INTRODUCTION

The United States government believes that switching from internal combustion engines (ICE) to electric cars is one solution to help reach its climate agenda.[1] Unfortunately, its focus has been on producing electric vehicles (EVs) and their batteries, not planning for the batteries' end life or the infrastructure required to support them.[2] The federal government has pushed for the shift to electric vehicles through the Environmental Protection Agency's (EPA) emission regulations,[3] and state governments like California have implemented regulations requiring all new vehicles sold after 2035 to be electric.[4] The federal government and states have failed to consider how

1. *Electric Vehicles Are an Important Climate Solution—Spread the Word*, UNION OF CONCERNED SCIENTISTS, https://secure.ucsusa.org/a/2021-02-ax-spread-word-evs-are-important-climate-solution#:~:text=Despite%20what%20you%20may%20have,to%20more%20renewable%20energy%20sources (last visited Apr. 24, 2024).

2. Liz Crampton, *Mayors to Biden: We're not prepared for your electric vehicle boom*, POLITICO (Oct. 18, 2023, 4:30 AM), https://www.politico.com/interactives/2023/50-mayors-us-cities/ev-infrastructure/.

3. *Regulations for Greenhouse Gas Emissions from Passenger Cars and Trucks*, ENV'T PROT. AGENCY https://www.epa.gov/regulations-emissions-vehicles-and-engines/regulations-greenhouse-gas-emissions-passenger-cars-and (last updated Mar. 20, 2024).

4. *Cars and Light - Trucks are Going Zero – Frequently Asked Questions*, CAL. AIR RES. BD., https://ww2.arb.ca.gov/resources/documents/cars-and-light-trucks-are-going-zero-frequently-asked-questions#:~:text=ADVANCED%20CLEAN%20CARS%20II%20REQUIREMENTS&text=Yes.%20C

these timelines will impact our current infrastructure, and they have failed to consider, moving forward, how much infrastructure is needed to support the cars and their disposals.[5] The most effective way to address these issues is by sharing information about the batteries, extending the timeline for state and federal regulations, and increasing investment in infrastructure. This Comment discusses the significant issues that will arise in forcing the switch to electric vehicles without adequately preparing for their disposal and their impact on infrastructure. Part II provides background on battery creation, recycling methods, and the status of the infrastructure needed to support the vehicles. Part III analyzes how governments should support the transition to these vehicles to avoid creating more problems in the future.

II. Overview of Electric Vehicles and Their Batteries

Electric vehicle batteries contain various valuable materials that can be recycled at the end of their life and used to create new batteries.[6] However, the recycling industry is still working to discover the most cost-effective and viable process to retrieve the materials.[7] Technological advancements in battery composition pose challenges for recyclers because recycling is easier when there is uniformity in the product.[8] The ever-changing battery composition and lack of information about batteries pose challenges for recycling the batteries.[9] Another concern with the switch to electric vehicles is the current condition of the United States' infrastructure, which has been neglected over the years and struggles to support current demands.[10] The lack of investment or attention to updating and maintaining infrastructure poses problems in the long run with the increased number of electric vehicles.[11] These issues must be addressed before society is forced to switch to electric cars because if not, the EVs will cause more problems than they would solve.

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alifornia%20is%20only%20requiring,and%20fuel%20cell%20electric%20vehicles (last visited Apr. 24, 2024).

5. Crampton, *supra* note 2.

6. Nicolle Portilla, *Lithium Car Battery Recycling & the Rise of Electric Vehicles*, RTS (Dec. 7, 2021), https://www.rts.com/blog/lithium-car-battery-recycling-the-rise-of-electric-vehicles/.

7. *Electric Vehicle Battery Recycling*, FUTURE TRACKER (May 31, 2022), https://www.futuretracker.com/post/electric-vehicle-battery-recycling#:~:text=Because%20of%20the%20complexity%20of,ideal%20solution%20called%20direct%20recycling.

8. Ian Morse, *A Dead Battery Dilemma*, SCIENCE (May 20, 2021, 12:44 PM), https://www.science.org/content/article/millions-electric-cars-are-coming-what-happens-all-dead-batteries.

9. *Id.*

10. *Modernizing U.S. Infrastructure: The Bipartisan Infrastructure Law*, THE WHITE HOUSE (Nov. 15, 2021), https://www.whitehouse.gov/cea/written-materials/2021/11/15/the-time-is-now-to-modernize-u-s-infrastructure/#:~:text=How%20neglected%20is%20America's%20infrastructure,the%20overall%20quality%20of%20infrastructure.

11. Nives Dolsak & Aseem Prakash, *The Lack of EV Charging Stations Could Limit EV Growth*, *FORBES* (May 5, 2021, 1:28 AM), https://www.forbes.com/sites/prakashdolsak/2021/05/05/the-lack-of-ev-charging-stations-could-limit-ev-growth/?sh=d354f6c6a131.

A. Electric Vehicle Battery Materials

Electric vehicle battery compositions vary depending on the battery's use, changing technology, and the costs of acquiring the materials.[12] Cobalt, nickel, lithium, manganese, graphite, and aluminum are typical metals used in electric vehicle batteries.[13] Cobalt is one of the essential metals in electric vehicle batteries.[14] Cobalt is mainly mined in the Democratic Republic of Congo, which holds around half of the world's cobalt reserves.[15] Approximately 85% of the cobalt mined from this area goes into batteries for cars and electronics.[16] However, mining in the Democratic Republic of Congo has sparked concerns for the health of the workers in the region.[17] Human rights groups have exposed the poor working conditions in the Congo, where there were deaths, child labor, and poor working conditions.[18] Because of the attention brought to these working conditions, companies have begun searching for other ways to obtain cobalt or limit its use in their batteries.[19] However, cobalt is valuable because of its high energy density and stability, providing longer driving ranges and battery life.[20] Additionally, it helps reduce the chance of the battery overheating and catching fire.[21] The industry is looking to find an alternative, but until then, cobalt will continue to be part of the composition of EV batteries.[22]

Another metal used in electric vehicle batteries is nickel, which is mined in around twenty-five countries.[23] China operates the most mines, with twenty in operation and around twenty smelting and refinery operations.[24] The United States has only one mine and no refinery or smelting operations.[25]

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12. *See* Govind Bhutada, *The Key Minerals in an EV Battery*, ELEMENTS BY VISUAL CAPITALIST (May 2, 2022), https://elements.visualcapitalist.com/the-key-minerals-in-an-ev-battery/#:~:text=The%20higher%20nickel%20content%20in,NMC%20batteries%2C%20improving%20their%20safety.

13. Brandon S. Tracy, *Critical Minerals in Electric Vehicle Batteries*, CONG. RSCH. SERV. (Aug. 29, 2022), https://crsreports.congress.gov/product/pdf/R/R47227.

14. Hannah Ritchie, *Is cobalt the 'blood diamond of electric cars'? What can be done about it?*, SUSTAINABILITY BY NOS. (July 28, 2023), https://www.sustainabilitybynumbers.com/p/cobalt.

15. *Id.*

16. *Id.*

17. *Id.*

18. *Id.*

19. *Id.*

20. Chin Trento, *Cobalt in EV Batteries: Advantages, Challenges, and Alternatives*, STANFORD ADVANCED MATERIALS, https://www.samaterials.com/cobalt-in-ev-batteries-advantages-challenges-alternatives.html (last updated Dec. 27, 2023).

21. Pratima Desai, *Explainer: Costs of nickel and cobalt used in electric vehicle batteries*, REUTERS (Feb. 3, 2022, 9:05 AM), https://www.reuters.com/business/autos-transportation/costs-nickel-cobalt-used-electric-vehicle-batteries-2022-02-03/#:~:text=Cobalt%20ensures%20cathodes%20do%20not,for%20eight%20to%2010%20years.

22. Trento, *supra* note 20.

23. *About nickel*, NICKEL INST., https://nickelinstitute.org/en/about-nickel-and-its-applications/ (last visited Apr. 24, 2024).

24. *Id.*

25. *Id.*

Nickel is typically extracted by strip mining because of the metal's shallow depth in the earth, but it requires underground mining operations if it is deeper.[26] Nickel might be the replacement for cobalt the industry is looking for, but nickel does not have the energy density of cobalt.[27]

Another material used in batteries is lithium.[28] Lithium is reactive and utilized in all rechargeable batteries, such as batteries for laptops and cell phones.[29] Australia is home to the world's ten largest lithium mines,[30] producing around half of the global production in 2022.[31] Another area where lithium is mined is in the "lithium triangle," located between Bolivia, Chile, and Argentina in South America.[32] The region earned its name because it holds around 58% of the world's lithium reserves.[33] Recovery of commercial lithium occurs using two techniques: brine extraction and hard rock mining.[34] Brine recovery involves pumping salt-rich water to the surface into evaporation ponds, and over months, the water evaporates, leaving salts and brine with lithium concentrations.[35] Once the concentration reaches a certain level, the brine undergoes a purification process, receives a chemical treatment to remove desirable products, is filtrated to remove solids, and is treated again to precipitate lithium carbonate.[36] Finally, the lithium is washed and dried into the final product.[37] Hard rock lithium mining involves mining ores containing lithium that then undergo a process to extract the lithium.[38] The ore is then crushed, roasted, cooled, and then roasted with acid to produce lithium sulfate.[39] Lithium is a valuable material used in the

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26. *Nickel*, GEOSCIENCE AUSTL., https://www.ga.gov.au/education/minerals-energy/australian-mineral-facts/nickel#:~:text=The%20size%2C%20grade%2C%20morphology%20and,deposits%20and%20their%20clayey%20nature (last updated Apr. 19, 2024).

27. Trento, *supra* note 20.

28. *Batteries for Electric Vehicles*, U.S. DEP'T OF ENERGY, https://afdc.energy.gov/vehicles/electric_batteries.html#:~:text=Most%20of%20today's%20all%2Delectric,that%20of%20consumer%20electronics%20batteries (last visited Apr. 24, 2024).

29. *Lithium facts*, GOV'T OF CAN. (Feb. 29, 2024), https://natural-resources.canada.ca/our-natural-resources/minerals-mining/mining-data-statistics-and-analysis/minerals-metals-facts/lithium-facts/24009.

30. *Top ten biggest lithium mines in the world*, MINING TECH. (Aug. 30, 2019), https://www.mining-technology.com/features/top-ten-biggest-lithium-mines/?cf-view&cf-closed.

31. *Lithium facts*, *supra* note 29.

32. *Id.*

33. Ryan C. Berg & T. Andrew Sady-Kennedy, *South America's Lithium Triangle: Opportunities for the Biden Administration*, CSIS (Aug. 17, 2021), https://www.csis.org/analysis/south-americas-lithium-triangle-opportunities-biden-administration.

34. *Lithium Extraction*, CARMEUSE SYS., https://www.sttsystems.com/industries/lithium-extraction/#:~:text=Most%20commercial%20lithium%20extraction%20is,crushing%2C%20roasting%20and%20acid%20leaching (last visited Apr. 24, 2024).

35. *Id.*

36. *Id.*

37. *Id.*

38. *Id.*

39. *Id.*

production of batteries but is challenging to recover in the recycling process.[40]

Manganese is also used in electric vehicle batteries.[41] South Africa holds around 80% of the world's manganese resources, but it is also mined in Australia, China, India, Ukraine, Brazil, and Gabon.[42] Manganese is extracted through open-pit mining,[43] which involves digging into the earth, creating different levels that look like an inverted pyramid to reach the valuable ores.[44] Other concentrations of manganese are smelted in a furnace until manganese is recovered.[45] In the future, manganese usage in batteries might increase because it provides a better driving range at a lower cost.[46]

Next, graphite is a highly used material in lithium-ion batteries because of its conductivity, lost cost, and high energy density.[47] Seventy percent of graphite reserves are in Turkey, China, and Brazil, estimated at over 330 million tonnes.[48] In 2021, China was the largest graphite producer, producing around 820 thousand tonnes.[49] Graphite is extracted using open-pit mining and underground mining techniques.[50] The demand for graphite will increase in the coming years because of its use in electric vehicle batteries.[51]

Lastly, aluminum is used in electric vehicle batteries but could become more prominent because it could store more energy than lithium.[52] Aluminum is extracted from the ground by open-pit mining bauxites, which contain

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40. Alt. Fuels Data Ctr., *Batteries for Electric Vehicles*, U.S. DEP'T OF ENERGY, https://afdc.energy.gov/vehicles/electric_batteries.html#:~:text=Lithium%2DIon%20Batteries,-Lithium%2Dion%20batteries&text=They%20also%20have%20a%20high,a%20challenge%20for%20the%20industry (last visited Apr. 24, 2024).

41. *Lithium Extraction*, *supra* note 34.

42. *Manganese Mining and Processing: Everything You Need to Know*, GEN. KINEMATICS (May 7, 2014), https://www.generalkinematics.com/blog/manganese-mining-processing-everything-need-know/.

43. *Id.*

44. *Open-Pit Mining: Method, Environmental Impact & Examples*, STUDY.COM, https://study.com/academy/lesson/open-pit-mining-method-impact-issues.html (last updated Oct. 8, 2022).

45. James H. Downing, *manganese processing*, BRITANNICA, https://www.britannica.com/technology/manganese-processing (last updated Aug. 23, 2013).

46. *Benchmark: battery demand for manganese set to increase 8-fold this decade*, GREEN CAR CONG. (Sept. 5, 2023), https://www.greencarcongress.com/2023/09/20230905-benchmark.html#:~:text=Manganese%20is%20a%20crucial%20element,to%20use%20even%20more%20manganese.

47. *Graphite for Battery Materials*, ELCAN INDUS., https://elcanindustries.com/graphite-for-battery-materials/#:~:text=Graphite%20is%20the%20most%20commonly,most%20part%20is%20readily%20available (last visited Apr. 24, 2024).

48. *Graphite facts*, GOV'T OF CAN., https://natural-resources.canada.ca/our-natural-resources/minerals-mining/minerals-metals-facts/graphite-facts/24027 (last updated Feb. 28, 2023).

49. *Id.*

50. David Stewart, *How is Graphite Extracted?*, SCIENCING, https://sciencing.com/graphite-extracted-10041885.html (last updated Apr. 25, 2017).

51. *Graphite facts*, *supra* note 48.

52. *Aluminum materials show promising performance for safer, cheaper, more powerful batteries*, U.S. NAT'L SCI. FOUND. (Aug. 31, 2023), https://new.nsf.gov/news/aluminum-materials-show-promising-performance#:~:text=The%20aluminum%20anode%20could%20store,potentially%20outperform%20lithium%2Dion%20batteries.

aluminum.[53] Bauxites must be processed to produce aluminum oxide; the most common method is known as the Bayer process.[54] The bauxite is placed in sodium hydroxide where aluminum dissolves and is heated, then the temperature is lowered, and the aluminum crystallizes and is recovered.[55]

These materials vary in use in the ever-changing electric vehicle battery compositions and impact how recycling occurs.[56] Calls for recycling have increased in the United States due to concerns about the accessibility of these materials because most are mined and processed in other countries.[57]

B. Electric Vehicle Battery Compositions

Electric vehicle batteries have various compositions to account for the different needs of drivers.[58] For example, a composition with an increased driving range is essential for users who want to drive longer distances without charging.[59] Additionally, battery longevity allows batteries to be charged more times and alleviates the need to replace batteries sooner.[60] The first type of battery is the lithium iron phosphate (LFP) battery, which contains the materials in its name, excluding nickel, cobalt, and magnesium.[61] The LFP battery composition is popular because it is cheaper to manufacture than its counterparts.[62] Additionally, it provides the most extended charging life, allowing for 2,000 plus charging cycles before it needs replacement.[63] However, this composition contains the least energy density, translating to a shorter driving range.[64]

Another composition is the Nickel-Manganese-Cobalt (NMC) battery, which is around 33% of each named material.[65] This composition is the most common because it has a higher energy density, which creates longer driving ranges.[66] NMC batteries charge faster than LFP batteries but have an

53. *How Aluminum is Produced*, ALL ABOUT ALUMINUM, https://www.aluminiumleader.com/production/how_aluminium_is_produced/ (last visited Apr. 24, 2024).

54. *Id.*

55. *Id.*

56. *See* Bhutada, *supra* note 12.

57. Matt McFarland, *How a battery shortage could threaten US national security*, CNN (Feb. 23, 2022, 8:48 AM), https://www.cnn.com/2022/02/22/cars/electric-vehicle-battery-supply-chain/index.html.

58. Henry Man, *What are LFP, NMC, NCA Batteries in Electric Cars?*, ZE CAR (July 15, 2023), https://zecar.com/resources/what-are-lfp-nmc-nca-batteries-in-electric-cars.

59. *Id.*

60. *Id.*

61. *Introducing Lithium Iron Phosphate Batteries*, FRANKLINWH (June 13, 2023), https://www.franklinwh.com/blog/lithium-iron-phosphate-batteries.

62. *Id.*

63. *Id.*

64. *Id.*

65. J.J. Hocken, *Lithium Nickel Maganese Cobalt Oxide (NMC)*, Mitsubishi Elec. (Apr. 17, 2023), https://www.mitsubishicritical.com/resources/blog/the-runaway-review/lithium-nickel-manganese-cobalt/.

66. *Id.*

increased fire risk.[67] Another concern with NMC batteries is their cobalt content, which came under fire because of the working conditions in the Congo.[68]

Lastly, the Nickel-Cobalt-Aluminum (NCA) battery's typical composition is around 84% nickel, 12% cobalt, and 4% aluminum.[69] These batteries were created by Tesla and Panasonic and provide a longer life span because of the aluminum content.[70] NCA batteries are manufactured and used exclusively by Tesla.[71] The NCA batteries are more expensive than LFP batteries because they contain cobalt.[72]

These battery compositions are constantly being tweaked and changed to account for the lack of materials and increase the batteries' value moving forward.[73]

C. Methods of Recycling Electric Vehicle Batteries

The recycling industry is a business that requires profitability for the venture to continue.[74] Battery recycling is a well-known process because electronic and lead batteries are currently recycled, but electric vehicle battery recycling is much newer.[75] The industry is still discovering the supply and demand for battery materials and how to increase valuable material extractions moving forward.[76] Currently, the industry recycles batteries in two main ways, with a new method on the rise.

1. Hydrometallurgical and Pyrometallurgical Recycling

The two main methods of battery recycling begin once the batteries are collected and then discharged and disassembled by hand.[77] In both processes,

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67. FRANKLINWH, *supra* note 61.

68. Ritchie, *supra* note 14.

69. *Nickle in Batteries*, NICKLE INST., https://nickelinstitute.org/en/about-nickel-and-its-applications/nickel-in-batteries/#:~:text=Two%20of%20the%20most%20commonly,batteries%20now%20rely%20on%20nickel (last visited Apr. 24, 2024).

70. *Panasonic Reduces Tesla's Cobalt Consumption by 60% in 6 Years*, BENCHMARK (May 3, 2018), https://www.benchmarkminerals.com/blog-archive/panasonic-reduces-teslas-cobalt-consumption-by-60-in-6-years/.

71. *Id.*

72. Henry Man, *What are LFP, NMC, NCA Batteries in Electric Cars?*, ZECAR (July 15, 2023), https://zecar.com/resources/what-are-lfp-nmc-nca-batteries-in-electric-cars.

73. *See* Tim Stevens, *How EV Batteries Will Get Better Even Without a Major Breakthrough*, MOTORTRENDS (Sept. 6, 2023), https://www.motortrend.com/features/ev-battery-improvements-technology/.

74. *Battery recycling takes the driver's seat*, MCKINSEY & CO. (Mar. 13, 2023), https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/battery-recycling-takes-the-drivers-seat.

75. *Id.*

76. *Lithium-ion Car Battery Recycling Advisory Group Final Report*, CAL. ENV'T PROT. AGENCY 42–43 (Mar. 16, 2022), https://calepa.ca.gov/wp-content/uploads/sites/6/2022/05/2022_AB-2832_Lithium-Ion-Car-Battery-Recycling-Advisory-Goup-Final-Report.pdf.

77. *The difference between hydrometallurgy and pyrometallurgy*, TES (May 2, 2023), https://www

the batteries are shredded and thermally treated to remove plastic, then crushed, screened, and sorted to recover the materials.[78] The screening and sorting processes help by using the physical properties of the materials, like magnetism, shape, and conductivity, to produce a black mass of valuable, recoverable materials.[79] For hydrometallurgical recycling, the first step is known as leaching, a process "where substances are dissolved and removed from a solid by a solution."[80] In this process, a metal ore is brought into contact with sulfuric acid to extract the materials.[81] Next, the leached liquor must undergo a precipitation process, selectively removing the targeted metal compound.[82] Lastly, there is metal recovery by cementation and oxidation, where the metal compound is heated and combined with oxygen to recover the metals.[83] Hydrometallurgy processing recovers materials that are not as easily obtained using other methods, such as burning.[84] It does pose health and environmental concerns because of the chemicals used, but research is pushing for more efficient methods.[85]

For pyrometallurgical recycling, the first step is roasting, where the ores are heated into oxides.[86] Next, the material is smelted in furnaces to extract the metal from the ore.[87] Lastly, the metals undergo a refining process by additional smelting to separate them according to their chemical properties.[88] Pyrometallurgical recycling yields high nickel and cobalt recovery, but lithium, aluminum, and manganese are unable to be recovered.[89] The concern with pyrometallurgy is that it is energy-intensive because it requires heating between 1200-1600 degrees Celsius.[90] Often, these processes are combined to increase the recovery of the most materials possible.[91]

.tes-amm.com/news/the-difference-between-hydrometallurgy-and-pyrometallurgy#:~:text=With%20pyrometallurgy%2C%20a%20vast%20amount,and%20nickel%2C%20can%20be%20recycled.

78. *Id.*

79. *Id.*

80. Aiden Ford & Danielle Reid, *Leaching: Definition, Concept & Process*, STUDY.COM, https://study.com/learn/lesson/leaching-concept-process.html#:~:text=Leaching%20is%20a%20natural%20process,contact%2C%20separation%2C%20and%20extraction (last updated Nov. 21, 2023).

81. *The difference between hydrometallurgy and pyrometallurgy*, *supra* note 77.

82. *Id.*

83. *Id.*

84. *Battery recycling takes the driver's seat*, *supra* note 74.

85. *Id.*

86. *The difference between hydrometallurgy and pyrometallurgy*, *supra* note 77.

87. *See id.*

88. *Id.*

89. *Id.*

90. *Id.*

91. *Battery recycling takes the driver's seat*, *supra* note 74.

2. Direct Recycling

Direct Recycling is a newer method of recycling that does not require the chemical breakdown of battery components.[92] It is the "recovery, regeneration, and reuse of battery components directly without breaking down the chemical structure."[93] This method is used less than pyrometallurgical or hydrometallurgical, but as Direct Recycling develops, it might be the best way to get as much value from the battery components as possible.[94] Research is ongoing to discover the most efficient way to recycle using this process.[95]

D. The Current State of America's Infrastructure

America's infrastructure was the envy of the world before years of underfunding and neglect allowed it to fall into disarray.[96] Roads, bridges, airports, and dams were constructed nationwide to build American infrastructure during the 1930s.[97] Unfortunately, the federal and state governments have failed to invest in and maintain infrastructure over the years, resulting in poor roads, bridges, airports, and dams that fail the growing population.[98] Without significant investment, electric vehicles will push the already failing infrastructure over the edge.

1. Electric Vehicle Charging Stations

First, electric vehicle charging stations are needed nationwide for electric cars to have a chance to replace ICEs.[99] A significant difference between gas pumps and charging stations is the time required to spend at each.[100] Currently, estimates show more than 145,000 gas stations in the United States.[101] The average time to fill up a car is around two minutes, so drivers spend less time filling up and can move on to their destination.[102] On

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92. *Direct Recycling of Materials*, RECELL ADVANCED BATTERY RECYCLING, https://recellcenter.org/research/direct-recycling-of-materials/ (last visited Apr. 24, 2024).

93. *Id.*

94. *Id.*

95. *Id.*

96. Becky Little, *9 New Deal Infrastructure Projects that Changed America*, HIST. CHANNEL, https://www.history.com/news/new-deal-infrastructure-projects-fdr (last updated Apr. 23, 2021).

97. *Id.*

98. James McBride et al., *The State of U.S. Infrastructure*, COUNCIL ON FOREIGN RELS., https://www.cfr.org/backgrounder/state-us-infrastructure#:~:text=Still%2C%20the%20group%20estimated%20that,product%20(GDP)%20by%202039 (last updated Sept. 20, 2023, 11:30 AM).

99. Dolsak & Prakash, *supra* note 11.

100. *Id.*

101. *Service Station FAQs*, API, https://www.api.org/oil-and-natural-gas/consumer-information/consumer-resources/service-station-faqs (last visited Apr. 24, 2024).

102. *Staying Safe at the Pump*, API, https://www.api.org/oil-and-natural-gas/consumer-information/consumer-resources/staying-safe-pump#:~:text=But%20the%20average%20fill%2Dup,be%20discharge

the other hand, the time it takes to charge an electric vehicle varies depending on the type of charger and how far an individual needs to go.[103] According to the Department of Transportation, a Level One charger gets two to five miles of range per hour of charge.[104] In comparison, a Level Two charger gets ten to twenty miles of range per hour of charge.[105] Lastly, a DC Fast charger provides 180-240 miles per hour of charge.[106] Another factor with EV chargers is that the different manufacturers of electric cars have different charging port shapes, which means that all vehicles cannot be charged using the same adapter.[107] Charging stations must be built nationwide before consumers can be required to switch to electric cars.

2. Roadways in the United States

In 2021, the United States roadways were given a grade of D on their infrastructure report card.[108] Currently, the United States has 4.19 million miles of roadways and 619,588 bridges.[109] Federal, state, and local governments maintain these roads.[110] Around 78% of the roadways are maintained by local governments, around 19% are maintained by the state, and 3% are owned and maintained by the federal government.[111] The Highway Trust Fund is the federal government's funding resource for roadways, sourced by the federal motor fuels tax.[112] The tax has not increased since 1993 and currently only has a 40% purchasing power due to inflation.[113] As a result of underfunding, there is a $786 billion backlog on roadway and bridge maintenance.[114] Repairing existing roads and bridges would total $560 billion of that backlog.[115] Each year, there is an increasing traffic volume on the roadways, further degrading the already failing roads.[116] Adding electric vehicles on the roadways will add to this growing problem because these

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d%20at%20the%20nozzle (last visited Apr. 24, 2023).

103. *Charger Types and Speeds*, U.S. DEP'T OF TRANSP., https://www.transportation.gov/rural/ev/toolkit/ev-basics/charging-speeds (last updated June 22, 2023).

104. *Id.*

105. *Id.*

106. *Id.*

107. *Id.*

108. *Roads: Report Card for America's Infrastructure*, AM. SOC'Y OF CIV. ENG'RS, https://infrastructurereportcard.org/wp-content/uploads/2017/01/Roads-2021.pdf (last visited Apr. 24, 2024).

109. *America's Infrastructure At-A-Glance*, AM. ROAD & TRANSP. BUILDERS ASS'N, https://transpoinfo.org/ (last visited Apr. 24, 2024).

110. *Id.*

111. *Id.*

112. *Funding & Future Need: Report Card for America's Infrastructure*, AM. SOC'Y OF CIV. ENG'RS, https://infrastructurereportcard.org/cat-item/roads-infrastructure/ (last visited Apr. 24, 2024).

113. *Id.*

114. *Id.*

115. *Id.*

116. *See id.*

vehicles weigh more than traditional vehicles.[117] The average ICE vehicle weighs between 2,500 and 6,000 pounds.[118] Meanwhile, the average EV weighs between 3,500 and 6,400 pounds.[119] The increased weight of these vehicles will increase the degradation of the United States' already failing roads.[120] Therefore, repairing and funding the United States' roadways is vital to ensuring growth and stability for years to come.

E. The United States Current Electric Grid

The electric grid is a network composed of multiple sections known as generation, transmission and distribution lines, and end-use.[121] Generation plants are the first step in the process, where energy is produced.[122] These plants are powered in many ways through hydroelectric dams, power plants, solar panels, and wind turbines.[123] The generators use different types of energy like fossil fuels, wind, solar, water, or nuclear energy.[124] Transmission and distribution consist of substations, transmission lines, and distribution lines.[125] Once the energy is generated at the plants, it goes to a substation where transformers increase the voltage so the energy can travel long distances.[126] Transmission lines carry the energy long distances with overhead or underground lines.[127] Overhead lines are used in less populated rural areas, whereas underground transmission lines are used in more densely populated areas.[128] These lines carry varying voltages depending on the grid system they belong to.[129] Next, once the transmission line has carried the electricity to its destination, another substation lowers the voltage to send it to the distribution lines.[130] Distribution lines move the lower voltage electricity shorter distances to the final delivery of end-use in businesses or

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117. Mark Pittman, *Electric Vehicles and the Impact on Infrastructure*, FORBES (Dec. 29, 2022, 6:45 AM), https://www.forbes.com/sites/forbestechcouncil/2022/12/29/electric-vehicles-and-the-impact-on-infrastructure/?sh=3ae7a0891835.

118. Dustin Hawley, *Average Weight of a Car*, J.D. POWER (Dec. 11, 2022), https://www.jdpower.com/cars/shopping-guides/average-weight-of-a-car.

119. *How much does an electric car battery weigh?*, HERTZ (June 16, 2023), https://www.hertz.com/us/en/blog/electric-vehicles/how-much-does-an-electric-car-battery-weigh#:~:text=The%20Nissan%20Leaf%20is%20one,between%203%2C487%20to%205%2C927%20lbs.

120. Pittman, *supra* note 117.

121. U.S. Dep't of Energy, *Understanding the Grid*, YOUTUBE (Jan. 14, 2016), https://www.youtube.com/watch?v=kh40ZX8AWTk.

122. *Id.*

123. *Id.*

124. *Id.*

125. *Id.*

126. *Id.*

127. *Transmission Lines*, U.S. DEP'T OF LAB., https://www.osha.gov/etools/electric-power/illustrated-glossary/transmission-lines#:~:text=Transmission%20lines%20carry%20electric%20energy,either%20overhead%20or%20underground%20lines (last visited Apr. 24, 2024).

128. *Id.*

129. *Id.*

130. *See id.*

homes.[131] Currently, power grids across the United States are struggling to meet the increased electricity demands of consumers.[132] The current grade for the country's electric grid is a C minus.[133] While investments have increased in this area, transmission and distribution systems are still unreliable for providing electricity to consumers.[134] Components supporting the grid are way past their fifty-year life span, with others reaching the second half of their life.[135] Maintaining and upgrading the electric grid is vital to the security and health of Americans nationwide.[136]

III. PROPOSED SOLUTIONS

There are many possible solutions for how the government could address electric vehicle battery recycling concerns, the timelines created by government regulations, and the impact the cars impose on the infrastructure. However, solutions that consider economic impacts and safety concerns should be the priority for the government and individuals. First and foremost, the recycling industry requires information to ensure effective extraction and recycling of materials; so, the best way to aid recycling is to ensure a flow of information between EV battery manufacturers and recyclers.[137] Second, a quick transition from ICEs to EVs is desired by governments and individuals, but current policies fail to consider the concerns associated with EVs.[138] By extending the timeline for a switch, the concerns with EVs can be addressed better.[139] Lastly, electric vehicles will increase the strain on the country's infrastructure, and the push for EVs seems to put the lack of investment in the area in the backseat.[140] Investment in infrastructure should always be a priority, but with the desire to transition to EVs, the country's infrastructure needs a significant upgrade to accommodate the cars.[141] These solutions help

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131. *What's the Difference Between Transmission and Distribution Power Lines?*, YSG SOLAR (Sept. 22, 2021), https://www.ysgsolar.com/blog/whats-difference-between-transmission-and-distribution-power-lines-ysg-solar#:~:text=The%20core%20difference%20between%20transmission,and%20lower%20voltage%20electricity%20transportation.

132. Milton Ezrati, *America's Electric Grid is Weakening*, FORBES (Mar. 24, 2023, 9:40 AM), https://www.forbes.com/sites/miltonezrati/2023/03/24/americas-electric-grid-is-weakening/?sh=26bfa99df7e9.

133. *Energy: 2021 Infrastructure Report Card*, AM. SOC'Y OF CIV. ENG'RS 1, 44 https://infrastructurereportcard.org/wp-content/uploads/2020/12/Energy-2021.pdf (last visited Apr. 24, 2024) (hereinafter 2021 Energy Report Card).

134. *Id.* at 45.

135. *2021 Energy Report Card*, *supra* note 133, at 45.

136. *See* Ezrati, *supra* note 132.

137. Telephone Interview with Jordan Vexler, Chief Operating Officer, Monterrey Iron Metal (Nov. 28, 2023).

138. *See* Crampton, *supra* note 2.

139. *See generally EPA's 67.5% Electric Vehicle Mandate: Too Far, Too Fast*, NADA (Mar. 12, 2024), https://www.nada.org/legislative/epas-new-electric-vehicle-mandate-too-far-too-fast (discussing how the current EPA regulations are going to cause problems in the industry).

140. *See supra* Section II.A.

141. *Id.*

manage the load the electric vehicles will place on the market and infrastructure while still allowing the industry to develop.

A. Transparency of Information Between Manufacturers and the Recycling Supply Chain

Electric vehicle battery recycling requires multiple parties to do their part to get the batteries recycled.[142] First, the car must be transported to a facility where it is dismantled to remove the battery from the vehicle.[143] Next, the battery is transported to the recycler, who must dismantle the pack into smaller modules to begin the recycling process.[144] Countless people handle these batteries—which can be dangerous—and need information to do so safely and effectively.[145] Business requires some secrecy to drive competition and innovation, but sharing information about batteries already on the market is a matter of safety and efficiency.[146]

1. Information Sharing Driven by the Industry

Understanding battery composition, content, and construction is vital in determining the most efficient way to extract and recycle electric vehicle batteries.[147] A simple solution would be to regulate electric vehicle batteries to require uniformity in the design and makeup, which would make recycling more straightforward.[148] However, regulations would decrease innovation and efficiency in the batteries moving forward, and because the technology is still developing, regulating the batteries would be less of a hindrance than a solution.[149] Instead of requiring uniformity in battery design and composition, there should be a flow of information about electric vehicle batteries' content, composition, location within the vehicle, and build.[150] This

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142. Interview with Jordan Vexler, *supra* note 137.

143. Jessica Dunn, *How Are EV Batteries (Actually) Recycled?,* UNION OF CONCERNED SCIENTISTS (Oct. 25, 2023, 2:34 PM), https://blog.ucsusa.org/jessica-dunn/how-are-ev-batteries-actually-recycled/#:~:text=Before%20recycling%2C%20a%20car%20dismantler,module%20are%20rectangular%20battery%20cells.

144. *Id.*

145. *See id.*

146. *See How are EV batteries dismantled safely here?*, BEBAT, https://www.bebat.be/en/blog/dismantle-ev-batteries-safely#:~:text=EV%20batteries%20have%20to%20be,both%20mechanical%20and%20electrical%20engineering (last visited Apr. 24, 2024).

147. *See Lithium-Ion EV Battery Recycling Policy Framework*, ALL. FOR AUTO. INNOVATION, 1, 4, https://www.autosinnovate.org/about/advocacy/Lithium-Ion%20EV%20Battery%20Recycling%20Policy%20Framework.pdf (last visited Apr. 24, 2024).

148. *See* Betsy Vereckey, *Does regulation hurt innovation? This study says yes,* MIT MGMT. SLOAN SCH. (June 7, 2023), https://mitsloan.mit.edu/ideas-made-to-matter/does-regulation-hurt-innovation-study-says-yes.

149. *Id.*

150. *See Electric vehicles and their batteries*, EVEXPERT, https://www.evexpert.eu/eshop1/knowledge-center/electric-vehicles-and-their-batteries (last visited Apr. 24, 2024).

information must reach different electric vehicle recycling supply chain areas, like recovery facilities, vehicle processors, and battery transporters.[151] By providing this information to the recycling industry, manufacturers could still offer the most efficient battery, and recycling the battery would be able to improve.[152] If the sector initiated this, they could determine who gets what information based on need and safety, allowing them to protect their processes.[153] For example, the composition of the batteries to be recycled and how the cells are structured within them is the information that end-of-the-supply-chain recyclers need.[154] Additionally, vehicle processors require information on how to safely remove the battery from the vehicle and discharge it before it is transported or recycled.[155]

Furthermore, those transporting the batteries need to know how to move them safely before discharge and handle problems that can occur even after discharge.[156] This information should also be shared with first responders because of accidents involving electric vehicles.[157] First responders need to know how to cope with electric vehicle fires and how to identify electric cars when they are on fire.[158] Identifying these vehicles is valuable to ensure they do not end up disposed of incorrectly.[159] If manufacturers shared information without requirements, it would jumpstart the progress in understanding how to best move forward with electric vehicle battery recycling.[160]

2. Creating a Federal Agency to Drive Information Sharing

If manufacturers refuse to start sharing information, then federal funding provided to automakers, battery manufacturers, and EV battery recycling facilities should be contingent on sharing information.[161] To encourage and organize the spread of this information, a federal agency

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151. Interview with Jordan Vexler, *supra* note 137.

152. *Id.*

153. *Id.*

154. *Id.*

155. *How are EV Batteries Dismantled Safely Here?*, BEBAT, https://www.bebat.be/en/blog/dismantle-ev-batteries-safely#:~:text=EV%20batteries%20have%20to%20be,both%20mechanical%20and%20electrical%20engineering (last visited Apr. 24, 2024).

156. *See generally EV battery transport: 5 challenges and how to overcome them*, CHARGED (May 9, 2023), https://chargedevs.com/whitepapers/ev-battery-transport-how-to-overcome-the-challenges/ (explaining the risks associated with transporting electric vehicle batteries).

157. *See* Kris Van Cleave, *As electric vehicles become more common, experts worry they could pose a safety risk for other drivers*, CBS NEWS (June 13, 2023, 7:52 PM), https://www.cbsnews.com/news/electric-vehicle-safety-heavy-battery/.

158. *See IAFC's Fire Department Response to Electric Vehicle Fires Bulletin*, IAFC, https://www.iafc.org/topics-and-tools/resources/resource/iafc-s-fire-department-response-to-electric-vehicle-fires-bulletin (last visited Apr. 24, 2024).

159. *See Identifying Hybrid and Electric Vehicles*, FIRE ENG'G (Apr. 19, 2013), https://www.fireengineering.com/technical-rescue/extrication-zone/identifying-hybrid-and-electric-vehicles/#gref.

160. Interview with Jordan Vexler, *supra* note 137.

161. *See Maps of Progress*, THE WHITE HOUSE, https://www.whitehouse.gov/build/maps-of-progress/ (lasted visited Apr. 24, 2024).

should be created to gather information from these sources to provide to others in need of the information.[162] For example, battery manufacturers would give the agency information about the batteries' composition, how to disassemble the battery, and how to safely discharge the battery.[163] This information is needed across the recycling supply chain and will help facilitate the recycling of electric vehicle batteries.[164] Additionally, automakers would provide information about the batteries' location within the vehicles and which vehicles the batteries are being placed in.[165] This information would include the makes, models, and other ways to identify electric cars to help further recycling and for safety dealing with the vehicles.[166]

Additionally, recyclers should provide information about the current recycling processes and the infrastructure for how batteries ultimately reach them.[167] This information would include the facilities' vehicles pass through, like vehicle processors, before reaching a recycling facility so that the agency can determine who in the industry requires the information.[168] By providing recycling information, manufacturers and recyclers can work together to improve techniques and processes to recover more material from the batteries.[169] The federal agency should provide information about electric vehicles from manufacturers to first responders nationwide.[170] First responders would use this information to identify electric cars in an accident and determine how to cope with the vehicle's battery fires.[171] Also, information about how to remove the batteries from the cars and how to safely discharge them should go to vehicle processors.[172] Furthermore, the agency would provide recyclers with information about how to disassemble the battery packs and how to safely discharge them so they can be efficiently recycled.[173] Also, battery manufacturers would receive information from recyclers about recycling processes, so they can work together to determine how to innovate battery production to make disassembly more manageable and ultimately lead to more effective recovery of materials.[174] Incentivizing those in the industry to share valuable information would create a flow of

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162. *See generally id.* (listing the federal agencies that control the distribution of money for specific government programs).

163. *See id.*

164. Interview with Jordan Vexler, *supra* note 137.

165. *Id.*

166. *Id.*

167. *Id.*

168. *Id.*

169. *See IAFC's Fire Department Response to Electric Vehicle Fires Bulletin*, *supra* note 158.

170. *Id.*

171. *Id.*

172. Interview with Jordan Vexler, *supra* note 137.

173. *Id.*

174. *Id.*

information for those involved in these processes.[175] Tying funds to required information sharing will ultimately help improve safety, efficiency, and innovation moving forward.[176]

B. Extending the Regulation Timeline for the Shift to Electric Vehicles

To ensure a smooth transition, federal and state governments must extend the timeline requirements on the regulations and laws implemented for the switch to electric vehicles.[177] The EPA's emission regulations are how the government enforces manufacturers' move to electric vehicles.[178] Current regulations aim to make 67% of light-duty vehicles and 25% of heavy-duty trucks electric by 2030.[179] States like California have also enacted laws and regulations to drive the electric vehicle movement.[180] However, if governments set realistic goals on a suitable timeline, electric cars would be able to reach the market without creating massive problems.[181] A study conducted by ABB Robotics and Automotive Manufacturing Solutions found that the auto industry does not believe the current timeline is feasible for making the big switch.[182] The question posed was, "When it comes to electrification, do you think it's realistic to shift to 100% electric vehicle production to meet the different regional targets from 2030 to 2040?"[183] Only eleven percent of automakers believed the transition to a fully electric fleet was feasible with the current timeline.[184] On the other hand, forty-one percent thought the transition could be made, just not on the current timeline.[185] A quality inspection equipment supplier stated:

> Unlike the tried and tested ICE development over more than 100 years, the rush to electrification is not based on a sound assessment of afterlife, sustainable methods of sourcing raw material, in a safe and humane manner. Raw material availability in the possession of a minor caliber of interested

175. *Id.*
176. *Id.*
177. *Id.*
178. *See Regulations for Greenhouse Gas Emissions from Passenger Cars and Trucks*, *supra* note 3.
179. Madeline Dawson, *EPA's New Standards Will Accelerate Transition to Electric Vehicles*, ENV'T & ENERGY STUDY INST. (May 17, 2023), https://www.eesi.org/articles/view/epas-new-standards-will-accelerate-transition-to-electric-vehicles.
180. *See Cars and Light - Trucks are Going Zero – Frequently Asked Questions*, *supra* note 4.
181. *See generally EPA's 67.5% Electric Vehicle Mandate: Too Far, Too Fast*, *supra* note 138.
182. Jonathan M. Gitlin, *The auto industry as pessimistic About 2030-2040 EV adoption timelines*, ARS TECHNICA (Mar. 9, 2023, 11:19 AM), https://arstechnica.com/cars/2023/03/supply-chain-shortages-may-make-ambitious-ev-adoption-goals-unlikely/.
183. *Id.*
184. *AMS & ABB Automotive Manufacturing Outlook Survey 2022*, AUTO. MFG. SOLS. & ASEA BROWN BOVERI (2022), https://new.abb.com/products/robotics/campaigns/abb-ams-automotive-manufacturing-outlook-survey.
185. *Id.*

> parties and manufacturers paying initial lip service to Government incentives and ideology/populism for the masses.[186]

The automakers also provided many different constraints the industry faces in achieving the targets set by governments.[187] Governments must consider the information coming from those building and preparing the vehicles and extend the timelines for emission requirements.

C. Increasing the Investments Made into Federal and State Infrastructure

Even without switching to electric vehicles, the United States must invest significantly in building its infrastructure. For example, due to the time required to charge a car, there needs to be more chargers available to drivers to make having an electric vehicle worthwhile.[188] An automotive industry survey showed that in North America 27% of the industry believed the most significant constraint on electric vehicle growth is a lack of charging infrastructure.[189] Investment in the infrastructure is one of the only ways to address the problem.[190] The Inflation Reduction Act invested $7.5 million in increasing the number of EV chargers.[191] Still, as this survey shows, resistance to electric vehicles is a concern for the automotive industry in North America.[192] Another concern for charging infrastructure is the various charging ports for the different brands of vehicles.[193] Depending on the charger that a driver wants to use, it might not be available for their car.[194] Uniformity for chargers across vehicle brands is where the market is moving, but if every car does not use the same type of charger, that will increase the infrastructure cost even more.[195] If state governments fail to allocate enough funding from the federal government to fund charging infrastructure in their budgets, electric vehicles will struggle on the market.[196]

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186. *Id.*
187. *Id.*
188. Dolsak & Prakash, *supra* note 11.
189. *AMS & ABB Automotive Manufacturing Outlook Survey 2022*, *supra* note 184, at 58.
190. *See id.*
191. *Fact Sheet: The Bipartisan Infrastructure Deal*, THE WHITE HOUSE (Nov. 6, 2021), https://www.whitehouse.gov/briefing-room/statements-releases/2021/11/06/fact-sheet-the-bipartisan-infrastructure-deal/.
192. *AMS & ABB Automotive Manufacturing Outlook Survey 2022*, *supra* note 184, at 58.
193. Andrew Goodwin, *Do All Electric Cars Use the Same Charger?,* ALL COPY PRODS. (May 16, 2023), https://www.allcopyproducts.com/blog/do-all-electric-cars-use-the-same-charger#:~:text=The%20short%20answer%20is%20no,are%20rapidly%20growing%20in%20popularity.
194. Keith Barry & Jeff S. Bartlett, *Automakers Move to a Common Plug Standard to Allow Their EVs to Use Tesla Superchargers*, CONSUMER REPTS., https://www.consumerreports.org/cars/hybrids-evs/tesla-superchargers-open-to-other-evs-what-to-know-a9262067544/#:~:text=Which%20Non%2DTesla%20EVs%20Can,offers%20a%20Magic%20Dock%20adapter (last updated Apr. 24, 2024).
195. *Id.*
196. *See id.*

The United States must significantly increase investment in the electric grid across the nation before it can support the influx of electric chargers.[197] The current state of our electric grid makes this an even more significant problem because, without investment, the grid faces the possibility of failure.[198] The Inflation Reduction Act, signed in 2021, invested $1.2 trillion and divided it between the states to boost their infrastructure.[199] Investment in the electric grid must take a higher priority than charging infrastructure in state and federal governments because the grid powers businesses, industries, schools, and homes.[200] Another concern is those who believe the grid needs to switch solely to renewable energy despite the fact the grid is currently struggling with reliability.[201] Individuals and groups would impose this problem on consumers to use their power most when the renewables are available, when the sun is shining and the wind is blowing.[202] Upgrading the grid, building more transmission lines, and using sources that provide reliable access to energy need to be the priority moving forward.[203] As the country continues to use more electricity every year, adding thousands of electric vehicle chargers will push the grid over the edge if governments fail to increase funding.[204]

States and the federal government must substantially invest in improving our roads and bridges for the safety of those driving and ensuring goods can move across the country.[205] The focus should be on preventing further degradation and improving roads and bridges.[206] Funding the maintenance of roads and bridges helps mitigate increased costs by neglect, which costs more to repair further down the line.[207] Instead of focusing on new, shiny infrastructure, the federal and state governments need to increase investments in maintaining or upgrading our current infrastructure.[208]

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197. *See* Jacob Knuston, *Why the high price of modernizing the U.S. power grid is worth it*, AXIOS (July 11, 2023), https://www.axios.com/2023/07/11/us-power-grid-modernize-climate-change.

198. *Id.*

199. Eric Van Nostrand, *Infrastructure Investment in the United States*, U.S. DEP'T OF THE TREASURY (Nov. 15, 2023), https://home.treasury.gov/news/featured-stories/infrastructure-investment-in-the-united-states.

200. *How the Electricity Grid Works*, UNION OF CONCERNED SCIENTISTS (Feb. 17, 2015), https://www.ucsusa.org/resources/how-electricity-grid-works.

201. Matt Simon, *The Grid isn't Ready for the Renewable Revolution*, WIRED (Oct. 6, 2021, 7:00 AM), https://www.wired.com/story/the-grid-isnt-ready-for-the-renewable-revolution/.

202. *Id.*

203. *See id.*

204. *Electricity Explained: Use of Electricity*, EIA, https://www.eia.gov/energyexplained/electricity/use-of-electricity.php#:~:text=Total%20U.S.%20electricity%20end%2Duse,3.4%25%20higher%20than%20in%202021 (last updated Dec. 18, 2023).

205. *Roads: Report Card for America's Infrastructure*, *supra* note 108.

206. *Id.*

207. *See 6 reasons why infrastructure maintenance is important for societies*, AUTORI (June 2, 2023), https://autori.io/en/blog/6-reasons-why-infrastructure-maintenance-is-important-for-societies#:~:text=Through%20minimizing%20disruptions%20and%20delays,quality%20of%20life%20for%20individuals.

208. *Id.*

Traditionally, The Highway Trust Fund is how the federal government invests in roads.[209] The funding comes from a federal motor fuels tax: where will that money come from if we shift to electric vehicles?[210] A proposed alternative for funding is mileage-based user fees, which would charge drivers based on the number of miles driven.[211] The drivers' concerns with this type of fee are privacy and equity issues.[212] Privacy concerns are that the government will track the movement of drivers to record the number of miles driven.[213] States have implemented pilot programs that provide choices, such as not tracking the time and place of trips, using private companies to gather data, or providing choices for how miles are reported to the government.[214] However, the concern is that this punishes those living in rural areas or those driving more miles than others.[215] Also, how quickly will the taxes have to increase to cover the costs?[216] Ultimately, the state and federal governments must develop better solutions to fund our roadways efficiently, whether through taxes or by taking money from other areas of government funding.[217]

Another concern is the weight of electric vehicles and how that will cause the roads to degrade significantly faster due to the increased weight of electric vehicles.[218] Due to the increased weight, single electric cars will impact the roadways, but trucks hauling multiple electric vehicles will subject the road to more pressure.[219] This increased weight will require even more maintenance and upkeep.[220] Therefore, governments must increase focus and investment in upgrading and maintaining our current roads and bridges instead of prioritizing the shift to electric cars.

IV. BENEFITS TO INFORMATION SHARING, REDUCED REGULATIONS, INCREASED INFRASTRUCTURE SPENDING, AND OVERCOMING COUNTERARGUMENTS

Electric cars are not the sole solution to the climate problem, but if they are going to be part of the market, they should be developed efficiently and

209. *Id.*
210. *Id.*
211. Owen Minott, *Mileage-Based User Fee Pilot Programs and the IIJA*, BIPARTISAN POL'Y CTR. (Feb. 11, 2022), https://bipartisanpolicy.org/blog/mileage-based-user-fee-pilot-programs-and-the-iija/.
212. *Id.*
213. *Id.*
214. Robert Poole Jr. & Christopher C. Douglas, *What Americans Think about Mileage-Based User Fees*, MACKINAC CTR. FOR PUB. POL'Y (May 31, 2022), https://www.mackinac.org/29860.
215. *Id.*
216. *Id.*
217. *See* Chad Shirley, *The Status of the Highway Tr. Fund: 2023 Update*, CONG. BUDGET OFFICE (Oct. 18, 2023), https://www.congress.gov/118/meeting/house/116425/witnesses/HHRG-118-PW12-Wstate-ShirleyC-20231018.pdf.
218. Pittman, *supra* note 116.
219. *Id.*
220. *See id.*

in the least destructive way. Despite the fact others will say that ICE vehicles were destructive in creation, society has the benefit of looking back and learning from those mistakes. Information sharing, extending the EV timeline, and increasing infrastructure investments are good ways to allow industries to develop the processes needed to enable electric vehicles not to destroy the market or economy.[221]

A. Information Sharing Helps Aid Innovation

The above proposed solutions will allow for continued innovation in the electric vehicle industry.[222] If the manufacturers and recyclers are not restricted, they can continue to create ways to make the batteries and recycling more efficient and better for the environment.[223] These industries have begun to research and look for ways to recycle these materials for future use; so they need *support*, not regulations, to continue improving.[224] If governments regulated batteries and recycling, the industries would focus more on their costs and have less time and resources to create or improve their ideas.[225] Making investments or grants in the industry contingent upon information sharing still allows manufacturers to innovate.[226] Also, it helps the recycling system and others make informed decisions, increasing efficiency and safety moving forward.[227]

B. A Longer Timeline Allows for Forward Movement Without Increased Future Problems

Slowing the movement to electric vehicles until other concerns are addressed does not prevent the switch people crave. It just helps alleviate the pressure of the cars and helps prevent massive consequences that the public and governments cannot handle.[228] If the federal and state governments set realistic goals and expectations about how they can transition to electric cars, more people would be willing to support the movement.[229] Electric vehicles have issues and concerns that should be addressed before they are forced to

221. *See supra* Part III.
222. *See* Vereckey, *supra* note 148.
223. *Id.*
224. *Id.*; *Direct Recycling of Materials*, *supra* note 148.
225. *See* Vereckey, *supra* note 148.
226. *See Maps of Progress*, *supra* note 161 and accompanying text (explaining how companies should have to meet information-sharing requirements before receiving federal funding).
227. *See Electric vehicles and their batteries*, *supra* note 150 and accompanying text (discussing how if recycling had access to more information about EV batteries, recycling processes could improve).
228. *See AMS & ABB Automotive Manufacturing Outlook Survey 2022*, *supra* note 184, at 43–45.
229. *See generally id*. (explaining how automakers and customers alike are concerned with the lack of preparation with electric vehicles).

become the market majority.[230] Some will say that if you do not build the cars, there is no reason to invest in the infrastructure and mechanisms to support them.[231] This thought process is used time after time for every major project, but why wait to address the problems before they become too much? Governments and environmentalists are focused on making a greener future, but they are in such a rush they fail to consider the consequences.[232] Slowing the transition allows businesses and governments to address concerns so they do not create more significant problems in the future.[233]

C. Increased Investment in Infrastructure Provides Overall Better Infrastructure

Infrastructure is the backbone of a nation because, without roads, bridges, and electricity, a country would be unable to operate effectively.[234] Unfortunately, the state and federal governments have neglected infrastructure in the United States for years.[235] If the government fails to focus on investing significantly in this area before people switch entirely to electric cars, it will create a massive problem.[236] Infrastructure is not a shiny and exciting way to fix the future, but it is a sound investment because it helps alleviate other problems. Some would instead use workarounds to continue to force the influx of electric vehicles.[237] For example, researchers believe that strategically placing charging stations and systems to delay vehicle charging times will help.[238] Researchers suggest that slower chargers at workplaces would decrease the need for charging at night.[239] The downside to solutions like these is that they fail to address the more significant problems of an overworked grid and could create safety issues because people need to have charged vehicles in emergencies.[240] The government

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230. *See supra* Part II.D. (discussing the issues that must be addressed before electric vehicles become a majority of the market).

231. *See generally* Ross Ortiz, *The Dire Consequences of Failing Infrastructure in America*, SOAPBOXIE (Oct. 21, 2023, 12:08 AM), https://soapboxie.com/government/The-Dire-Consequences-of-Failing-Infrastructure-in-America (discussing how it is now clear the issues our infrastructure has once it has become severely damaged)

232. *See* discussion *supra* Part II (discussing how the government has failed to address recycling, the timeline for the switch, and infrastructure concerns).

233. *See AMS & ABB Automotive Manufacturing Outlook Survey 2022*, *supra* note 184, at 43–45.

234. Maria Vagliasindi, *How Does Infrastructure Support Sustainable Growth?*, WORLD BANK BLOGS (Apr. 18, 2022), https://blogs.worldbank.org/digital-development/how-does-infrastructure-support-sustainable-growth.

235. *Modernizing U.S. Infrastructure: The Bipartisan Infrastructure Law*, *supra* note 10.

236. Pittman, *supra* note 116; Ezrati, *supra* note 131.

237. David L. Chandler, *Minimizing electric vehicles' impact on the grid*, MIT (Mar. 15, 2023), https://news.mit.edu/2023/minimizing-electric-vehicles-impact-grid-0315.

238. *Id.*

239. *Id.*

240. *See id.*

must address the struggling infrastructure before encouraging more EVs on the roads.

V. CONCLUSION

It is customary for governments to put the cart before the horse, pushing forward ideas without proper funding and infrastructure to support them. Understandably, individuals and industries want to see if a product or idea will work before they invest in the things required to support it. However, without significant focus and investment in infrastructure and end-of-life planning, electric vehicles will cause harm to everyday things we know we need but choose to ignore.[241] First and foremost, electric vehicle battery recycling needs more time to determine how to extract the materials best before millions of these batteries are thrust upon the industry.[242] Additionally, the industry needs more reliable and available information because a free flow of information about the batteries allows for informed and efficient decisions without decreasing innovation.[243]

Secondly, if the timeline for the switch to electric vehicles is extended, it does not prevent the cars from entering the market; it will enable a stabler switch to the cars.[244] Furthermore, it allows industry and others to inform consumers about the concerns and issues that must be addressed first.[245] Lastly, investments in infrastructure provide for better transportation no matter the car and increased stability of electricity for all.[246] Choosing to ignore the impact electric vehicles will have on infrastructure will only create more significant issues for the economy and governments. Electric cars could be part of the future, but if these issues are continuously mishandled or ignored, the cart will destroy more than it is said to repair.

241. *See* discussion *supra* Part III.C (discussing how vital infrastructure is to the United States and how unfunding has impacted growth and progress).

242. *See* discussion *supra* Part III.C (discussing how recyclers are still attempting to find ways to better recover battery materials).

243. *See Electric vehicles and their batteries*, *supra* note 150 and accompanying text (discussing how information sharing helps innovation more than regulation of EV batteries).

244. *See AMS & ABB Automotive Manufacturing Outlook Survey 2022*, *supra* note 184, at 43–45.

245. *See id.* (discussing the concerns manufacturers feel should be addressed before moving forward with the electric vehicle movement).

246. *See* Vagliasindi, *supra* note 234.