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Flow or Oscillate? The Mismatch between the Language Judges and Attorneys Use to Describe Electricity and the Actual Behavior of Electricity on the Grid

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In North Dakota v. Heydinger*, two Eighth Circuit judges disagreed about the constitutionality of a Minnesota statute regulating the electricity imported into the state. Their disagreement stemmed from the judges' conflicting understandings of the behavior of electrons.*

Judge James B. Loken described electrons as "flow[ing] freely" through the grid's transmission lines "without regard to state borders." Judge Diana E. Murphy, by contrast, contended that electrons do not "flow"; rather, they "oscillate in place." Whereas Judge Murphy's description of electrons comports with the language of physicists and engineers in the energy field, Judge Loken's language is incorrect.

This Note discusses the inaccurate and inconsistent language with which attorneys and judges describe electricity and the problems that result from this language. While many utilize the incorrect and outdated language of electrons and electricity flowing directly from a power plant to people's homes, others reject this language. This flawed description likely did not cause problems in energy law cases in the early and mid-1900s. Due to the highly-interconnected structure of today's electric grid, however, inaccuracies in the language that individuals use to describe electricity has caused fundamental disagreements in attorneys' and judges' interpretations of state and federal statutes. In order to avoid ongoing problems caused by these language discrepancies, attorneys and judges should conceptualize and describe the grid using language that

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accurately maps onto physicists' and electrical engineers' understandings of the grid.

INTRODUCTION

Do electrons "flow" or "oscillate"? This question might seem more appropriate for a science course than a legal discussion. Nevertheless, this seemingly minor distinction has caused judges and attorneys in recent energy law cases to arrive at opposite conclusions as to the constitutionality of laws and the balance between state and federal regulatory authority.

In *North Dakota v. Heydinger*, two Eighth Circuit judges disagreed about the constitutionality of a Minnesota statute regulating electricity imported into the state.[1] The statute bans the importation of power into Minnesota if the generation of that power would increase the state's effective annual carbon dioxide emissions.[2] Judge James B. Loken found the statute to be unconstitutional based on the notion that electrons "flow freely" through the grid's transmission lines "without regard to state borders."[3] He contended that when electrical generating facilities outside Minnesota inject electricity into the regional electric grid, those "electrons" might "flow into and be consumed in Minnesota."[4]

By contrast, Judge Diana E. Murphy found that the statute was not a per se violation of the U.S. Constitution, because individual electrons in the electricity transmission system "do not actually 'flow.'"[5] Rather, electrons "oscillate in place."[6] Only Judge Murphy's description of the oscillating behavior of electrons on the grid comports with the language used by electrical engineers,

1. North Dakota v. Heydinger, 825 F.3d 912, 921, 926 (8th Cir. 2016). The three-judge panel unanimously struck down the statute, but wrote three separate opinions. *Id.* at 913, 923, 927. One judge declined to reach the constitutional issue, finding it dispositive that the Minnesota statute was preempted by federal law. *Id.* at 927–29.
2. MINN. STAT. § 216H.03, subdiv. 3 (2016).
3. *North Dakota*, 825 F.3d at 921.
4. *Id.*
5. *Id.* at 924, 926.
6. *Id.* at 924.

energy economists, and physicists versed in the generation, transmission, and distribution of electricity.[7]

This type of disagreement regarding the behavior of electrons and electricity permeates the field of energy law. While many legal professionals rely on the inaccurate and outdated depiction of electrons flowing directly from a power plant to people's homes,[8] others reject this language.[9] This distinction likely did not cause problems in energy law cases in the early and mid-1900s.[10] Due to the highly interconnected structure of today's electrical transmission systems,[11] however, it has become increasingly important for lawyers and judges to accurately depict the behavior of electricity on the electric grid.

Today, judges and attorneys frequently arrive at fundamental disagreements about statutory interpretation based on their conflicting understandings of how electricity works. These conflicts create problems for both the judges who interpret statutes and the legislators who write statutes. In order to mitigate these problems, attorneys, judges, and legislators should endeavor to describe the grid using scientifically accurate language that depicts the grid as an interconnected system of undifferentiated electric energy.[12]

I. INACCURACY OF "FLOWING ELECTRONS" AND "DIRECTIONAL ELECTRICITY FLOW" LANGUAGE EMPLOYED IN *HEYDINGER*

In *Heydinger*, Judge Loken's descriptions of the electric grid characterize electrons as discrete, traveling entities that begin at an electricity "generation unit," "flow freely" through the grid's transmission lines, and ultimately "reach a particular end-use customer."[13] This "flowing electrons" language is inaccurate.[14] While it is correct to describe *electricity* or *electric current* as flowing through transmission lines, it is incorrect to describe *electrons* as flowing through transmission lines.[15] This Part describes the physical structure

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7. *See* Brief for Electrical Engineers, Energy Economists and Physicists as Amicus Curiae Supporting Respondents at 7–10, New York v. FERC, 535 U.S. 1 (2002) (No. 00-568).

8. *See, e.g.*, *id.*; City Pub. Serv. Bd. of San Antonio v. Pub. Util. Comm'n of Texas, 9 S.W.3d 868, 872 n.10 (Tex. App. 2000); Appellant's Reply Brief at 2, Powerex Corp. v. Dep't of Revenue, 357 Or. 40 (2015) (No. So6o859); *see* JOEL B. EISEN ET AL., ENERGY, ECONOMICS AND THE ENVIRONMENT: CASES AND MATERIALS 515 n.4 (Robert C. Clark et al. eds., 4th ed. 2015).

9. *See, e.g.*, *North Dakota*, 825 F.3d at 924–26; *see* Brief for the Federal Energy Regulatory Commission at 26, New York v. FERC, 535 U.S. 1 (2002) (Nos. 00-568, 00-809).

10. *Infra* Part IV.

11. Brief for Benjamin F. Hobbs et al. as Amici Curiae Supporting Petitioners at 15, EPA v. EME Homer City Generation, L.P., 134 S. Ct. 1584 (2014) (Nos. 12-1182, 12-1183); EISEN ET AL., *supra* note 8, at 68.

12. Brief for Electrical Engineers, Energy Economists and Physicists as Amicus Curiae Supporting Respondents, *supra* note 7, at 19.

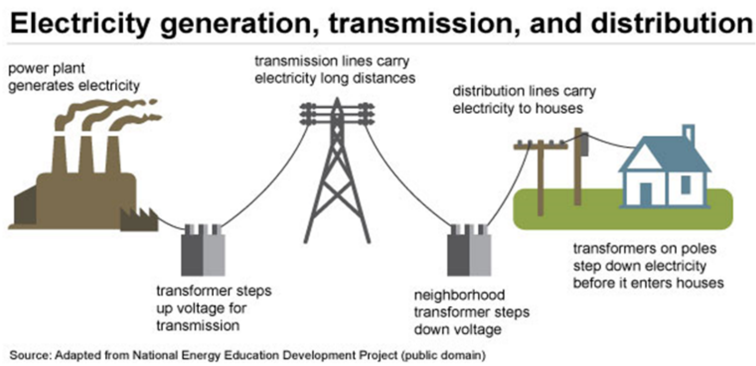
13. *North Dakota*, 825 at 921.

14. *See* Brief for Electrical Engineers, Energy Economists and Physicists as Amicus Curiae Supporting Respondents, *supra* note 7, at 7–10.

15. The distinction between the language of electricity flow and electron flow will be further explored in Part I.B. *See* Brief Amicus Curiae of Electrical Engineers, Energy Economists and Physicists in Support of Respondents, *supra* note 7, at 7–10.

of the U.S. electric power system and highlights the ways in which Judge Loken's "flowing electrons" language is inaccurate from a physics perspective.

A. Structure of the U.S. Power System



In its simplest form, the electric power system consists of (1) generation facilities, (2) transmission networks, and (3) distribution systems.[16] Generation facilities convert energy found in nature (e.g., chemical bonds and atoms) into electricity.[17] Large, stationary power plants generate most of the electricity consumed in the United States.[18] Most of these power plants generate electricity by using fuels such as coal, natural gas, uranium, oil, and water to turn a generator.[19] A system operator chooses which of these generation facilities to run at any given time based on each plant's operating costs and ramping ability.[20] Because electricity cannot be easily stored, the system operator must "almost instantaneously" increase or decrease the generating load whenever consumers turn power on or off.[21]

Generation facilities connect to high-voltage transmission lines, which serve as a conduit for electric current.[22] Over 450,000 miles of lines form the transmission grid, a "massive spider web[]" of interconnected, electrically charged wires that extends across the United States and into parts of Canada.[23] The U.S. transmission grid consists of three giant networks: the Western

16. WILLIAM STEVENSON, ELEMENTS OF POWER SYSTEM ANALYSIS 1 (4th ed. 1982).

17. *Electricity Generation*, INST. FOR ENERGY RESEARCH (Sept. 2, 2014), http://instituteforenergyresearch.org/electricity-generation.

18. *See* EISEN ET AL., *supra* note 8, at 68.

19. Brief for Electrical Engineers, Energy Economists and Physicists as Amicus Curiae Supporting Respondents, *supra* note 7, at 12; EISEN ET AL., *supra* note 8, at 67.

20. EISEN ET AL., *supra* note 8, at 67.

21. *Id.*

22. *Id.* at 69; STEVENSON, *supra* note 16, at 1.

23. *See* Brief for Benjamin F. Hobbs et al. as Amici Curiae Supporting Petitioners, *supra* note 11, at 15; *Top 9 Things You Didn't Know About America's Power Grid*, U.S. DEP'T OF ENERGY (Nov. 20, 2014, 10:07 AM), http://energy.gov/articles/top-9-things-you-didnt-know-about-americas-power-grid; *see also* EISEN ET AL., *supra* note 8, at 68.

Interconnection, the Texas Interconnection, and the Eastern Interconnection.[24] The Western Interconnection begins at the Rocky Mountains and extends across the western United States and southwestern Canada.[25] The Texas Interconnection occupies the State of Texas.[26] The Eastern Interconnection stretches across the rest of the United States and southeastern Canada.[27]

The transmission lines within each of these networks intertwine with one another such that there are often multiple paths between any two points on the network.[28] This interconnected structure enhances the reliability of the grid by providing alternate routes for electricity transport if any one of the transmission lines fails.[29] Therefore, the failure of one transmission line generally will not interrupt the overall transmission of electric current to the distribution system and, ultimately, to consumers.[30]

Transmission networks connect to distribution systems, which provide electricity to consumers.[31] Unlike transmission networks, most distribution systems are radial and closed; there is only one path between each consumer and the substation.[32] Therefore, the route of electricity transport in the distribution system is "absolutely certain."[33] Once electric current enters a local distribution system, it must be delivered to consumers and cannot step up in voltage and reenter the transmission network.[34]

B. Inaccuracy of "Flowing Electrons" and "Directional Electricity Flow" Language[35]

Judge Loken's language in *Heydinger* gives the wrong impression of the behavior of electrons and electric current within transmission networks. First, his "flowing electrons" language is incorrect as a technical matter because *electrons* do not "flow" through transmission lines.[36] Second, his use of

24. *See* EISEN ET AL., *supra* note 8, at 69.
25. *Id.*
26. *Id.*
27. *Id.*
28. Brief for Electrical Engineers, Energy Economists and Physicists as Amicus Curiae Supporting Respondents, *supra* note 7, at 12–13.
29. *Id.*
30. *See id.* at 13.
31. *See* STEVENSON, *supra* note 16, at 1–2. While most consumers receive their electricity directly from the distribution system, large industries often take electricity directly from the transmission network because they require the higher voltage electricity contained in the transmission lines. *See* EISEN ET AL., *supra* note 8, at 69.
32. Brief for Electrical Engineers, Energy Economists and Physicists as Amicus Curiae Supporting Respondents, *supra* note 7, at 13–14.
33. *Id.*
34. *Id.*
35. This Note is not intended to be a criticism of Judge Loken. The author is simply using Judge Loken's opinion in *Heydinger* as a recent example of the tradition among legal professionals of inaccurately describing the behavior of electricity and electric current within transmission networks.
36. *See* Brief for Electrical Engineers, Energy Economists and Physicists as Amicus Curiae Supporting Respondents, *supra* note 7, at 2.

"directional electricity flow" language inaccurately portrays the electric grid as a structure that transports discrete electricity entities directly from generation facilities to particular end-use consumers.[37]

1. "Flowing Electrons" Language

Judge Loken's statements that electrons "flow"[38] from electricity generators to consumers are incorrect because *electrons* do not flow at all. *Electricity* does flow through transmission lines.[39] However, it is inaccurate to describe electrons themselves as flowing through transmission lines.[40]

Transmission networks transport electricity through the propagation of electromagnetic waves.[41] These electromagnetic waves (i.e., electric current) flow through transmission lines at the speed of light, or 186,282 miles per second.[42] An electromagnetic wave generated at a power plant creates a ripple effect by inducing electrons to repel the electrons in the next atom.[43]

For instance, when electric current flows left to right in a transmission line, each "electron repels its right-hand neighbor, because they are both negatively charged and similar charges repel each other."[44] This ripple effect, initially induced by the electromagnetic wave at the power plant, further assists in the propagation of the wave throughout the transmission network.[45]

Electrons in transmission lines move in order to create this ripple effect; however, this movement constitutes "oscillation" rather than "flow."[46] Whereas electromagnetic waves travel at the speed of light, electrons in the grid travel less than one inch per second.[47] Transmission networks contain alternating electric current, which reverses its direction sixty times a second rather than moving in a single direction.[48] Therefore, electrons "oscillate back and forth, moving in unison one way, then back the other way."[49] Electrons in

37. *See id.*
38. *See id.* at 7–10.
39. *See id.* at 6.
40. *Id.*
41. *Id.* at 2.
42. *Id.*
43. *Id.*
44. *Id.* at 7–8.
45. *Id.* at 7–8 & n.7.
46. *Id.*
47. *Id.*
48. *See generally* Brief Amicus Curiae of Electrical Engineers, Energy Economists and Physicists in Support of Respondents, *supra* note 7, at 7; *Ask an Engineer: What's the Difference Between AC and DC?*, MIT SCHOOL OF ENG'G, http://engineering.mit.edu/ask/what%E2%80%99s-difference-between-ac-and-dc (last visited May 6, 2017).
49. Brief for Electrical Engineers, Energy Economists and Physicists as Amicus Curiae Supporting Respondents, *supra* note 7, at 7 (emphasis omitted).

transmission lines achieve no net movement over time.[50] They are instrumental in transmitting electricity but do not themselves travel with that electricity.[51]

2. *"Directional Electricity Flow" Language*

In addition to his inaccurate "flowing electrons" language, Judge Loken's description of electricity as flowing directionally from a particular power plant to a particular end-use consumer is also not in accord with physicists' and engineers' depictions of electricity.[52] This Note will refer to this type of language, which portrays electricity in the grid as flowing in a particular direction from a generation facility toward a particular end-use consumer, as "directional electricity flow" language. Judge Loken invokes the "directional electricity flow" image through his statement that "when a non-Minnesota generating utility injects electricity into the . . . grid . . . it cannot ensure that those electrons will not flow into and be consumed in Minnesota."[53] This language suggests that electricity is injected into the electricity grid and then flows directly toward a particular end-use consumer for its ultimate consumption.

Because transmission networks consist of multiple pathways which create a web-like structure,[54] it is "not possible" to track or control specific electricity flows within a transmission network.[55] Rather, electricity that enters a transmission network "energizes the entire grid."[56] Electric current distributes itself along the paths of least resistance on the interconnected transmission network.[57] The current "spreads out and flows on *each path* in inverse proportion to the electrical resistance . . . of that path."[58] Whenever electricity is consumed at one point on the grid, electricity rushes from surrounding points on the transmission network in order to reestablish grid-wide equilibrium.[59] The end-use consumer draws undifferentiated energy from the grid.[60]

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50. *Id.*
51. *Id.* at 8.
52. *See id.* at 2.
53. North Dakota v. Heydinger, 825 F.3d 912, 921 (8th Cir. 2016).
54. Brief for Benjamin F. Hobbs et al. as Amici Curiae Supporting Petitioners, *supra* note 11, at 15.
55. *See* Ann E. Carlson & William Boyd, *Evaluation of Jurisdictional and Constitutional Issues Arising from CAISO Expansion to Include PacifiCorp Assets*, 17 (Aug. 1, 2016), https://www.caiso.com/Documents/LegalEvaluationOfISOExpansion.pdf.
56. *See* Brief for Electrical Engineers, Energy Economists and Physicists as Amicus Curiae Supporting Respondents, *supra* note 7, at 2 (emphasis omitted).
57. Brief for Benjamin F. Hobbs et al. as Amici Curiae Supporting Petitioners, *supra* note 11, at 10–11.
58. *See* Brief for Electrical Engineers, Energy Economists and Physicists as Amicus Curiae Supporting Respondents, *supra* note 7, at 8–9 (emphasis in original).
59. Brief for Benjamin F. Hobbs et al. as Amici Curiae Supporting Petitioners, *supra* note 11, at 10–11.
60. *See* Brief for Electrical Engineers, Energy Economists and Physicists as Amicus Curiae Supporting Respondents, *supra* note 7, at 2.

In principle, Judge Loken correctly recognizes the uncontrollable nature of electricity flow on the grid resulting from its interconnected structure. However, the language he uses to describe this phenomenon is inaccurate[61] because it suggests a directional flow of discrete units of electricity from generation facilities to end-use consumers. Whereas Judge Loken characterizes electricity as flowing "from a generation unit" in order to "reach a particular end-use customer,"[62] physicists describe electricity as distributing itself and spreading out across transmission networks so that end-use consumers may draw undifferentiated energy from the grid.[63] Therefore, Judge Loken's "directional electricity flow" language is inconsistent with experts' representations of the behavior of electrons and electricity on the electric grid.

II. WIDESPREAD USAGE OF INACCURATE "FLOWING ELECTRONS" AND "DIRECTIONAL ELECTRICITY FLOW" LANGUAGE

Judge Loken's use of this inaccurate "flowing electrons" and "directional electricity flow" language is not an isolated incident. Judges, attorneys, scholars, and even public utility commissions frequently use language that either explicitly describes electrons as "flowing" or implicitly paints an image of electrons flowing from power plants directly to end-use consumers.[64] In *Heydinger*, Judge Loken's depiction of electrons was consistent with the amicus brief of the American Public Power Association, the National Rural Electric Cooperative Association, and the Missouri Joint Municipal Electric Utility Commission, which stated that "electrons flow" through the regional transmission network.[65] Similarly, an opinion written by the Supreme Court of Texas in 2000 stated that "[e]lectrons flow" through the Texas grid.[66] Furthermore, in the U.S. Supreme Court case *New York v. Federal Energy Regulatory Commission* (*New York v. FERC*), a group of engineers, energy economists, and physicists noted that the state public service commissions involved in the lawsuit based their argument on "an inaccurate and highly misleading, albeit popular, metaphor of electrons flowing down transmission wires the way water flows through a pipe or blood cells flow through a vein."[67] Finally, in his testimony in *Powerex Corp. v. Department of Revenue*, Professor

61. *See* Carlson & Boyd, *supra* note 55, at 17.

62. North Dakota v. Heydinger, 825 F.3d 912, 921 (8th Cir. 2016).

63. *See* Brief for Electrical Engineers, Energy Economists and Physicists as Amicus Curiae Supporting Respondents, *supra* note 7, at 2, 8–9.

64. *See, e.g.*, *id.* at 7–10; *but see* City Pub. Serv. Bd. of San Antonio v. Pub. Util. Comm'n of Texas, 9 S.W.3d 868, 872 n.10 (Tex. App. 2000); Appellant's Reply Brief, *supra* note 8, at 2; EISEN ET AL., *supra* note 8, at 515 n.4.

65. Brief for American Public Power Association, National Rural Electric Cooperative Association and Missouri Joint Municipal Electric Utility Commission as Amici Curiae Supporting Appellees at 15, North Dakota v. Heydinger, 825 F.3d 912 (8th Cir. 2016) (Nos. 14-2156, 14-2251).

66. *City Pub. Serv. Bd. of San Antonio*, 9 S.W.3d at 872 n.10.

67. *See* Brief for Electrical Engineers, Energy Economists and Physicists as Amicus Curiae Supporting Respondents, *supra* note 7, at 2, 5, 7–10.

Joel Fajans stated that "electric power as sold on the . . . grid involves the flow of electrons."[68]

Even when they do not explicitly refer to "electron[] flow,"[69] legal professionals often paint an inaccurate image of electrons flowing through transmission lines and directly toward particular end-use consumers. In *Transmission Access Policy Study Group v. FERC*, the utilities contended that "electrons will travel over any interconnected transmission line."[70] While the investor-owned utilities in this case did not directly state that electrons "flow," their description of electrons traveling over interconnected transmission lines nonetheless conveys the image of electrons flowing. Similarly, a note in *Energy, Economics, and the Environment: Cases and Materials*—a leading energy law casebook—describes the outcome of *Federal Power Commission v. Florida Power & Light Co.* by explaining that "generated electrons reached the interstate market in Georgia because [Florida Power and Light's] transmission lines were connected with . . . Georgia Power Company."[71] The textbook's description of electrons reaching the market in Georgia suggests that electrons flow through these transmission lines in order to reach consumers in Georgia.

Some legal professionals may not understand that their "flowing electrons" and "directional electricity flow" language is inaccurate; however, many individuals continue to use this language with full knowledge that it is incorrect. In the *Energy, Economics, and the Environment: Cases and Materials* casebook, the following footnote qualifies the book's inaccurate description of generated electrons reaching the interstate market in Georgia: "As a matter of physics . . . electrons do not travel through wires so much as transmit electromagnetic force, or voltage."[72] Similarly, despite contending that electric power "involves the flow of electrons" in *Powerex Corp. v. Department of Revenue*, Professor Fajans agreed that "individual electrons are not transferred from seller to buyer."[73] Finally, in *New York v. FERC*, the state public service commissions based their argument on the inaccurate idea that electrons and electricity flow directly "from power plants to retail customers who are first in line on transmission lines."[74] However, the public service commissions also admitted that it is "technically correct" to state that electricity

68. Appellant's Reply Brief, *supra* note 8, at 2 n.1.

69. Brief for American Public Power Association, National Rural Electric Cooperative Association and Missouri Joint Municipal Electric Utility Commission as Amici Curiae Supporting Appellees, *supra* note 65, at 15.

70. Brief for Investor Owned Utility Petitioners at 41, Transmission Access Policy Study Grp. v. FERC, 225 F.3d 667 (D.C. Cir. 1999) (No. 97-1715).

71. EISEN ET AL., *supra* note 8, at 515–16.

72. *Id.* at 515 n.2.

73. Appellant's Reply Brief, *supra* note 8, at 2 n.1.

74. Petitioners' Brief on the Merits at 45 n.28, New York v. FERC, 535 U.S. 1 (2002) (No. 00-568).

transmissions "affect the entire grid," rather than to imagine electrons and electricity flowing in a particular direction toward an end-use customer.[75]

III. ORIGINS OF "FLOWING ELECTRONS" AND "DIRECTIONAL ELECTRICITY FLOW" LANGUAGE

The widespread use of the "flowing electrons" and "directional electricity flow" language likely stems from the longstanding "water pipe" analogy employed by physicists, engineers, and educators.[76] It is challenging to explain the behavior of electricity.[77] Therefore, educators often describe electrical circuits by using a water pipe analogy, which instructs students to "[i]magine that electric current is like water flowing through a pipe."[78] In this analogy, the pipe represents the wire (i.e., transmission and distribution lines) in the circuit.[79] The water pressure that initially enters the pipe represents the voltage in the circuit.[80] The water flowing through the pipe represents electric current.[81] The width of the pipe represents resistance in the electrical circuit.[82] Educators use this analogy to describe the relationship between voltage, current, and resistance in an electrical circuit.[83] For instance, just as an increase in water pressure injected into a pipe increases the rate at which water flows through the pipe, an increase in voltage causes an increase in the electric current in a circuit.[84] Moreover, just as a narrower water pipe resists the flow of water more and reduces the rate of water flow, an increase in the resistance in an electrical circuit decreases the electric current in the circuit.[85]

This analogy is not unique to introductory educational materials;[86] more advanced educational texts and engineering practice guides also rely on water pipe analogies to describe electricity.[87] For instance, one electrical engineering textbook uses a water pipe analogy to explain how transistors in electronics

75. Brief for the State Public Service Commissions as Respondents on the Merits in 00-809 at 43, New York v. FERC, 535 U.S. 1 (2002) (Nos. 00-568, 00-809).

76. *See, e.g.*, LARRY GONICK & ART HUFFMAN, THE CARTOON GUIDE TO PHYSICS 131 (1990); DON H. JOHNSON, FUNDAMENTALS OF ELECTRICAL ENGINEERING I 63–64 (2016); WILLIAM KENT, THE MECHANICAL ENGINEER'S POCKET-BOOK: A REFERENCE-BOOK OF RULES, TABLES, DATA, AND FORMULAE, FOR THE USE OF ENGINEERS, MECHANICS, AND STUDENTS 1027 (1st ed. 1895).

77. CTaylor, *Voltage, Current, Resistance, and Ohm's Law*, SPARKFUN, https://learn.sparkfun.com/tutorials/voltage-current-resistance-and-ohms-law (last visited May 22, 2017).

78. GONICK & HUFFMAN, *supra* note 76, at 131.

79. *Water Analogy to Circuits*, UNIV. OF WATERLOO, https://ece.uwaterloo.ca/~dwharder/Analogy/ (last visited Apr. 10, 2017).

80. *Id.*

81. *Id.*

82. CTaylor, *supra* note 77.

83. *See DC Circuit Water Analogy*, GA. STATE UNIV., http://hyperphysics.phy-astr.gsu.edu/hbase/electric/watcir.html (last visited Apr. 10, 2017).

84. CTaylor, *supra* note 77.

85. *Id.*

86. *See* GONICK & HUFFMAN, *supra* note 76, at 131.

87. *See, e.g.*, KENT, *supra* note 76, at 1027; JOHNSON, *supra* note 76, at 63–64.

modulate the strong current provided by a source of electrical power.[88] One mechanical engineering reference book contains an entire table of "[a]nalogies [b]etween the [f]low of [w]ater and [e]lectricity."[89] Altogether, engineers have utilized water pipe analogies to describe electricity for over a century.[90]

The inherent difficulty in describing electricity, coupled with the widespread and longstanding usage of water pipe analogies to explain electricity, likely set the stage for the adoption of the "flowing electrons" and "directional electricity flow" language by legal professionals. In energy law proceedings and negotiations, lawyers must often break down complex electrical engineering and physics concepts to communicate both law and science to attorneys, judges, policy makers, or juries. In order to communicate these concepts, it seems reasonable that attorneys would adopt language and analogies that already enjoy widespread use in science and education.[91]

These methods of describing electricity all share the common idea of the transport of some electricity entity starting at a particular source (i.e., the pump in the water pipe metaphor and the generator on the electric grid) and flowing directionally toward a particular destination (i.e., the end of the pipe in the water pipe metaphor and the ultimate consumer on the electric grid). Despite their commonalities, however, the incorrect "flowing electrons" and "directional electricity flow" imagery adopted by today's energy attorneys employs slightly different language than that of the aforementioned water pipe analogies. Water pipe analogies accurately describe "electricity" and "electric current" as flowing through simple direct current (DC) circuits. By contrast, "flowing electrons" language inaccurately describes electrons (rather than electric current) as flowing through electrical circuits.[92] Moreover, the "directional electricity flow" language inaccurately describes discrete units of electricity flowing in set directions through today's interconnected grid, rather than the simple DC circuits that water pipe analogies generally describe.[93] Therefore, while longstanding water pipe analogies may have given rise to today's "flowing electrons" and "directional electricity flow" language, this language is nevertheless an inaccurate depiction of the behavior of electrons on today's electric grid.

The remainder of this Note explores the use of these water pipe analogy adaptations in select energy law cases from the 1920s through 2016, discusses the reasons why the "flowing electrons" and "directional electricity flow" language was not problematic in the early and mid-1900s, and analyzes the problems that have resulted in contemporary energy law cases due to the

88. JOHNSON, *supra* note 76, at 63–64.
89. KENT, *supra* note 76, at 1027.
90. *See id.*
91. *See* CTaylor, *supra* note 77.
92. *See supra* Part I.B.
93. *See id.*

mismatch between this once-unproblematic language and today's highly interconnected electric grid.

IV. *ATTLEBORO*: UNPROBLEMATIC USE OF "FLOWING ELECTRONS" AND "DIRECTIONAL ELECTRICITY FLOW" LANGUAGE IN THE EARLY AND MID-1900S

In the early and mid-1900s, "flowing electrons" and "directional electricity flow" language adequately approximated the physical structure of electric grids. One early electricity transmission case, *Public Utilities Commission of Rhode Island v. Attleboro Steam & Electric Co.*, demonstrates why this language was not problematic, in light of the segmented and local transmission grids that existed in 1927. This Part will explore the use of "directional electricity flow" language in *Attleboro* and then explain why the inaccuracy of this language was not problematic at the time.

A. Attleboro *Case Background*

Attleboro was a 1927 dormant Commerce Clause dispute that arose when a Rhode Island company agreed to sell energy to a Massachusetts company.[94] The Rhode Island company, Narragansett Electric Lighting Company (Narragansett Company), owned a generating plant in Providence, Rhode Island.[95] The Massachusetts company, Attleboro Steam & Electric Company (Attleboro Company) provided electricity for the city of Attleboro, Massachusetts and the surrounding areas.[96] In 1917, Narragansett Company entered into a contract with Attleboro Company whereby Narragansett Company agreed to sell to Attleboro Company, at a specified base rate, all electricity required by the city of Attleboro and the adjacent territory for a period of twenty years.[97] By 1924, Narragansett Company sought to increase the base rate of the electricity it provided to Attleboro Company because, due to the increased cost of generating electricity, Narragansett Company was suffering an operating loss and was not receiving a return on its investment in rendering service to Attleboro Company.[98] On review, the Rhode Island Public Utilities Commission determined that Narragansett Company's proposed increased rate was reasonable and ordered that this new rate be put into effect.[99]

The Attleboro Company challenged the constitutionality of the Commission's order.[100] Specifically, Attleboro Company argued that this order violated the Commerce Clause of the U.S. Constitution by imposing a "direct

94. Pub. Utils. Comm'n v. Attleboro Steam & Elec. Co., 273 U.S. 83, 84, 89 (1927).
95. *Id.* at 84.
96. *Id.*
97. *Id.* at 84–85.
98. *Id.* at 85–86.
99. *Id.*
100. *Id.* at 86, 89.

burden on interstate commerce."[101] The Supreme Court agreed. Because the order regulated the rates charged by Narragansett Company for the *interstate* service to Attleboro Company, it placed a "direct burden upon interstate commerce."[102] Therefore, the Court held that the Commission's order violated the Commerce Clause's grant of exclusive authority over the regulation of interstate commerce to Congress, rather than the states.[103]

B. *Unproblematic "Directional Electricity Flow" Language in* Attleboro

In the *Attleboro* opinion, the Court employed "directional electricity flow" language. The Court contended that "[t]he transmission of electric current from one state to another, *like that of gas*, is interstate commerce, . . . and its essential character is not affected by a passing of custody and title at the state boundary not arresting the *continuous transmission to the intended destination*."[104] The phrases "like that of gas" and "continuous transmission to the intended destination" constitute "directional electricity flow" language because they portray electricity as an entity that flows directionally from a particular generation facility to a particular end-use consumer.

The Court's analogy suggests that electric current behaves like natural gas. Natural gas travels from production facilities to end-use consumers by flowing directionally through underground pipelines.[105] Compressor stations along the pipelines reduce the volume of the gas and ensure that the gas remains highly pressurized so that it can be "push[ed] . . . through the pipe" in a particular direction.[106] Interstate gas pipelines include a large number of valves that enable the control of natural gas flow by acting like "gateways" that can stop gas flow to certain sections of pipelines.[107] Therefore, by describing the behavior of electric current as "like that of gas," the Court suggests that, like gas, electric current flows in a particular direction along a contained and controllable avenue of transport.

Similarly, by describing electricity's "continuous transmission to the intended destination,"[108] the Court suggests that electricity flows through transmission lines in a directional and controllable manner. The language of

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101. *Id.* at 86.

102. *Id.* at 89–90.

103. *See id.* at 90.

104. *Id.* at 86 (emphasis added and internal citations omitted).

105. *See The Transportation of Natural Gas*, NATURALGAS.ORG, http://naturalgas.org/naturalgas/transport/ (last visited Apr. 10, 2017).

106. *See id.*

107. *See id.*

108. *Attleboro Steam & Elec. Co.*, 273 U.S. at 86 (internal citations omitted). Judge Sanford's language is similar to the language employed by the Rhode Island Supreme Court, which described electricity as "generated in one state, and conveyed directly to a purchaser in another state." Attleboro Steam & Elec. Co. v. Pub. Utils. Comm'n, 46 R.I. 497, 501 (1925). The Rhode Island Supreme Court also stated that "[t]he transportation of the electricity is continuous from this state to its ultimate destination in another state." *Id.*

transmitting something to its intended destination suggests that some entity intends for the electricity from a particular generation facility to travel to a particular end-use consumer, and that that entity can control and track electricity along a directional path toward its final destination. Thus, by depicting electric current as an entity that flows directionally from a generation facility to a particular end-use consumer, the Court's language constitutes "directional electricity flow" language.[109]

Due to the segmented structure of the grid in 1927, Justice Sanford's use of "directional electricity flow" language in *Attleboro* did not create confusion or interpretation problems. Rather, this "directional electricity flow" language portrayed an accurate image of electric current as it behaved on the grid that existed at that time.

In 1927, the city of Attleboro and its adjacent territory received all of its electricity from a single generating plant in Providence, Rhode Island.[110] All of the electricity consumed in Attleboro and the surrounding area originated at Narragansett Company's one generating plant in Rhode Island and travelled along one set of connected transmission lines in order to reach Attleboro Company's station in Massachusetts.[111] Attleboro Company then sent this electricity directly to its customers via distribution lines, which only allowed electric current to flow in a single direction.[112] Because Attleboro Company's station connected to a single set of transmission lines, which connected to a single generating facility, Attleboro Company could not have been receiving electric current from any other generating facility besides the facility owned by Narragansett Company. Therefore, the Court's language suggesting the directional flow of electricity from Narragansett Company's one generating plant to Attleboro Company and its customers accurately depicted the state of the electrical system at issue.

C. Unproblematic "Flowing Electrons" Language in Attleboro

Moreover, if the Court had employed "flowing electrons" language in *Attleboro*, it likely would not have created confusion or language interpretation problems, despite being scientifically incorrect.[113] As discussed previously, *electrons* do not flow.[114] Although electricity and electric current do flow, electrons themselves oscillate in place.[115] Nevertheless, the *Attleboro* Court's failure to make this distinction likely would not have been problematic in this case because the language approximates well enough the behavior of electric

109. Refer to Part I.B for an explanation of the concept of "directional electricity flow" language.
110. *See Attleboro Steam & Elec. Co.*, 273 U.S. at 84.
111. *Id.*
112. *See* EISEN ET AL., *supra* note 8, at 69.
113. *See supra* Part I.B.
114. *See id.*
115. Brief for Electrical Engineers, Energy Economists and Physicists as Amicus Curiae Supporting Respondents, *supra* note 7, at 7.

power as it flowed from Narragansett's one generating facility to Attleboro Company and its customers.

Ultimately, both the "flowing electrons" and "directional electricity flow" language would have served to communicate the general idea of a directional flow of an electric power entity from a single seller in Rhode Island to a single purchaser in Massachusetts. Therefore, both of these would have sufficiently communicated the reasoning in *Attleboro* that enabled the Court to reach its ultimate holding.

D. Generally Unproblematic Use of "Flowing Electrons" and "Directional Electricity Flow" Language in Energy Cases in the Early and Mid-1900s

In the early and mid-1900s, descriptions of electricity mirroring the *Attleboro* Court's understanding likely approximated the behavior of electricity closely enough so as to not cause major problems in other energy law cases at the time. In *Attleboro*, the limited number of electricity generators,[116] the isolated nature of electrical systems, and the local nature of electricity sales ensured that all of the electricity purchased by Attleboro Company would flow from the lone seller's generating facilities and directly to Attleboro Company's station. This grid structure, which permitted the unproblematic use of "flowing electrons"[117] and "directional electricity flow" language in *Attleboro*, exemplified the structure of the grid across the country during the early and mid-1900s. At this time, vertically integrated utilities, which generally "operated as separate, local monopolies," sold most of the nation's electricity.[118] Vertically integrated utilities "construct[] their own power plants, transmission lines, and local delivery systems."[119] Because vertically integrated utilities dominated the market at the time, consumers in most areas sourced their electricity from a single, local provider.[120] Moreover, transmission lines in the early and mid-1900s often extended from a limited number of generating facilities directly to customers in the area.[121] In 1917, electric systems were "isolated" and "usually operated as individual units."[122] In 1927, only 10.7 percent of the electricity generated in the United States was transmitted across

116. In *Attleboro*, the Attleboro Company could have chosen to provide energy to its customers either by using its own generating plant or by using Narragansett Company's generating plant. Attleboro Company chose to purchase all of its needed electricity from Narragansett Company and dismantled its own preexisting generating plant. Pub. Utils. Comm'n v. Attleboro Steam & Elec. Co., 273 U.S. 83, 84 (1927).

117. "Flowing electrons" language was not actually used in *Attleboro*. However, its hypothetical use would not have been problematic.

118. New York v. FERC, 535 U.S. 1, 5 (2002).

119. *Id.*

120. *Id.*

121. *See id.* at 16.

122. STEVENSON, *supra* note 16, at 2, 5.

state lines.[123] Well into the 1930s, transmission networks remained relatively local, and interconnected networks were rare.[124] Therefore, it was more or less accurate for courts to claim that electricity flowed directly from the generating facility of one company to a particular end-use consumer. The isolated and local structure of electrical networks across the country minimized the degree to which courts' "flowing electrons" and "directional electricity flow" language diverged from the reality of the grid in the early and mid-1900s.

V. *HEYDINGER* AND *NEW YORK V. FERC*: MODERN STATUTORY INTERPRETATION PROBLEMS CAUSED BY "FLOWING ELECTRONS" AND "DIRECTIONAL ELECTRICITY FLOW" LANGUAGE

Over the past seventy years, the electric grid has become dramatically more interconnected.[125] Today's increased interconnection causes electricity to behave differently on the grid than it did on the segmented grid of the early and mid-1900s. Therefore, the "flowing electrons" and "directional electricity flow" language that once sufficiently portrayed the behavior of electricity in the grid has now become obsolete.

This Part will first explore the physical changes in the U.S. power sector since the early and mid-1900s. It will then use two recent energy law cases, *Heydinger* and *New York v. FERC*, to demonstrate the problems that result from some judges' and attorneys' uses of inaccurate "flowing electrons" and "directional electricity flow" language to describe electricity on today's grid.

A. Dramatic Changes in the Electric Grid Since the Early and Mid-1900s

Since the early 1900s, growth in electricity demand and advances in technology increased the interconnection of transmission lines, and ultimately produced the modern "inherently interstate" electric grid. Electricity demand has increased substantially since the early 1900s.[126] In order to meet this rise in demand, the United States rapidly increased its installed generating capacity.[127] Between 1920 and the early 1970s, the United States nearly doubled its installed generating capacity every ten years.[128] Moreover, technological advances beginning in the 1930s both diversified the sources of electricity

123. *See* Brief for the State Public Service Commissions as Respondents on the Merits in 00-809, *supra* note 75, at 26.
124. *See New York*, 535 U.S. at 16.
125. Brief for Benjamin F. Hobbs et al. as Amici Curiae Supporting Petitioners, *supra* note 11, at 20–21.
126. *Historic and Projected U.S. Electricity Demand, 1950-2050*, ROCKY MOUNTAIN INST., http://www.rmi.org/RFGraph-US_electricity_demand (last visited Apr. 10, 2017).
127. STEVENSON, *supra* note 16, at 2, 4.
128. *Id.*

generation and increased the total number of generating facilities in the United States.[129]

In the early 1900s, improvements in transmission technology likewise increased the feasibility of long-distance transmission.[130] With these technological advancements, utilities sought to interconnect their isolated energy systems with adjacent utility networks in order to enhance reliability and efficiency.[131] By connecting with neighboring networks, communities could obtain electricity from nearby plants in other states at times when purchasing this electricity was less expensive than purchasing electricity from in-state power plants.[132] Moreover, with access to a larger interconnected network, utilities could call on neighboring companies for additional power instead of relying solely on their own generating facilities to meet sudden increases in customer demand.[133] Due to these efficiency and reliability advantages, the electricity transmission systems in the United States transformed from a "quilt of small, local generators" and "local monopolies" to a massive, interconnected "spider web[] of high-voltage transmission lines."[134] As the transmission network grew progressively interconnected, generation facilities around the country began to serve increasingly distant customers.[135]

Today, any electricity that enters the grid (outside of Texas, Hawaii, and Alaska) "becomes part of a single, synchronized, inherently multi-state, electromagnetic waveform" from which customers draw "*undifferentiated* electric energy."[136] It is therefore no longer accurate to describe either the electrons or the electricity on today's grid as flowing directionally from a particular generator to a particular consumer.[137]

B. Conflicting Statutory Interpretations Caused by the Use of "Flowing Electrons" and "Directional Electricity Flow" Language to Describe Electricity on Today's Grid

Because today's electrical transmission systems are inherently interstate, it has become increasingly important for lawyers and judges to accurately depict

129. Brief for Benjamin F. Hobbs et al. as Amici Curiae Supporting Petitioners, *supra* note 11, at 13–14; *New York*, 535 U.S. at 7.

130. Brief for Electrical Engineers, Energy Economists and Physicists as Amicus Curiae Supporting Respondents, *supra* note 7, at 18; Brief for Benjamin F. Hobbs et al. as Amici Curiae Supporting Petitioners, *supra* note 11, at 13–14.

131. Brief for Benjamin F. Hobbs et al. as Amici Curiae Supporting Petitioners, *supra* note 11, at 13.

132. EISEN ET AL., *supra* note 8, at 79–80.

133. *Id.*

134. Brief for Benjamin F. Hobbs et al. as Amici Curiae Supporting Petitioners, *supra* note 11, at 12–13.

135. *See id.* at 14.

136. Brief for Electrical Engineers, Energy Economists and Physicists as Amicus Curiae Supporting Respondents, *supra* note 7, at 19 (emphasis added).

137. *See id.*

the behavior of electricity. The mismatch between the outdated "flowing electrons" and "directional electricity flow" language employed by some practitioners and the physical structure of today's grid has caused controversies and disagreements in recent energy law cases. While some attorneys and judges utilize this inaccurate "flowing electrons" and "directional electricity flow" language to interpret issues of constitutionality and jurisdiction in energy law,[138] others more accurately conceptualize the electric grid as an undifferentiated charged system.[139] Two recent cases, *North Dakota v. Heydinger* and *New York v. FERC*, demonstrate the fundamental disagreements in statutory interpretation that result from some legal professionals' continued reliance on "flowing electrons" and "directional electricity flow" language.

1. North Dakota v. Heydinger

In *Heydinger*, two Eighth Circuit judges disagreed about whether a Minnesota statute violated the dormant Commerce Clause.[140] This subpart will first outline the legal principles underlying the dormant Commerce Clause. Then, it will describe the Minnesota statute at issue in *Heydinger*, the Minnesota Next Generation Energy Act (MNGEA). Ultimately, it will demonstrate how two judges' competing understandings of the behavior of electricity caused them to arrive at completely different interpretations of the MNGEA and two opposite conclusions regarding whether this statute is a per se violation of the dormant Commerce Clause.

a. Legal Background: Dormant Commerce Clause

The Commerce Clause of the U.S. Constitution grants Congress the power "[t]o regulate Commerce . . . among the several States."[141] By granting Congress the authority to regulate interstate commerce, the Commerce Clause implies that the states cannot regulate interstate commerce. This implication, referred to as the dormant Commerce Clause, restricts states from "engaging in economic protectionist behavior that discriminates against or burdens interstate commerce."[142]

In order to determine whether a state law is an unconstitutional violation of the dormant Commerce Clause, courts consider, among other things, the "extraterritoriality principle."[143] Under this principle, a state law violates the dormant Commerce Clause if it "controls the conduct of those engaged in

138. *See, e.g.*, North Dakota v. Heydinger, 825 F.3d 912, 921 (8th Cir. 2016).
139. *See, e.g.*, *id.* at 924.
140. *Id.* at 921–22, 926–28.
141. U.S. CONST. art. I, § 8, cl. 3.
142. Alexandra B. Klass & Elizabeth Henley, *Energy Policy, Extraterritoriality, and the Dormant Commerce Clause*, 5 SAN DIEGO J. CLIMATE & ENERGY L. 127, 131 (2014).
143. *Id.* at 133.

commerce occurring wholly outside the state."[144] For instance, a state statute exerts unconstitutional extraterritorial control when it "requires people or businesses to conduct their out-of-state commerce in a certain way."[145]

b. North Dakota v. Heydinger *Case Background*

Non-renewable power sources have traditionally comprised the majority of Minnesota's energy portfolio.[146] Recently, however, Minnesota has made an effort to decrease its reliance on non-renewable sources.[147] In 2007, Minnesota enacted the MNGEA as part of its efforts to "reduce statewide greenhouse gas emissions across all sectors producing those emissions . . . to a level at least 30 percent below 2005 levels by 2025."[148] The MNGEA provides that

> [N]o person shall: (1) construct within the state a new large energy facility that would contribute to statewide power sector carbon dioxide emissions; (2) import or commit to import from outside the state power from a new large energy facility that would contribute to statewide power sector carbon dioxide emissions; or (3) enter into a new long-term power purchase agreement that would increase statewide power sector carbon dioxide emissions.[149]

North Dakota, which houses eight coal-fired power plants, exports most of its power generation to Minnesota.[150] In 2011, the State of North Dakota and North Dakota electric power cooperatives challenged the MNGEA by alleging that its provisions regulating the import of power into Minnesota violated the dormant Commerce Clause and were preempted by the Clean Air Act and the Federal Power Act (FPA).[151] The District Court for the District of Minnesota found these provisions to be a "per se violation of the dormant Commerce Clause" on the grounds that they constituted "impermissible extraterritorial legislation."[152] A three-judge panel at the Eighth Circuit affirmed the decision of the district court and held that the MNGEA should be struck down.[153]

c. Clashing Judge Opinions Regarding the Constitutionality of the MNGEA Caused by "Flowing Electrons" and "Directional Electricity Flow" Language

While each judge on the Eighth Circuit panel agreed on the judgment in *Heydinger*, Judge Loken and Judge Murphy disagreed about whether the

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144. *Id.*
145. *North Dakota*, 825 F.3d at 919.
146. Klass & Henley, *supra* note 142, at 171.
147. *Id.* From 2000 to 2010, the proportion of Minnesota's energy produced by coal-fired power plants decreased from 66 percent to 53 percent. *Id.*
148. MINN. STAT. § 216H.02, subdiv. 1 (2016).
149. MINN. STAT. § 216H.03 subdiv. 3 (2016).
150. Klass & Henley, *supra* note 142, at 171.
151. North Dakota v. Heydinger, 15 F. Supp. 3d 891, 903, 907–08 (D. Minn. 2014).
152. *Id.* at 919.
153. North Dakota v. Heydinger, 825 F.3d 912, 923 (8th Cir. 2016).

MNGEA violated the dormant Commerce Clause.[154] Their contrasting conclusions stemmed from differences in the language they used to describe the electric grid. Judge Loken employed inaccurate "flowing electrons" and "directional electricity flow" language.[155] Judge Murphy, by contrast, accurately portrayed the electric grid as a charged system with vibrating electrons.[156] Judge Loken's and Judge Murphy's contrasting portrayals of the behavior of electrons and electricity on the grid caused them to interpret Minnesota's ambiguous MNGEA statute in fundamentally different ways.

Where the MNGEA states that "no person" shall "import or commit to import from outside the state power from a new large energy facility that would contribute to statewide power sector carbon dioxide emissions,"[157] the definitions of "person" and "import" are ambiguous. The word "person" could refer to either (1) any individual or entity inside or outside the state of Minnesota or (2) Minnesota consumers that acquire electricity through Minnesota utilities' bilateral contracts.[158] The word "import" could refer to either (1) the "physical flow of electrons" across the Minnesota state border or (2) the act of a Minnesota load-serving entity (e.g., a Minnesota utility) investing in out-of-state generation to serve its Minnesota customers.[159] The contrasting ways in which Judge Loken and Judge Murphy construed the ambiguous language in the MNGEA determined whether or not each judge found a violation of the dormant Commerce Clause.

Judge Loken's reliance on inaccurate "flowing electrons" and "directional electricity flow" language caused him to construe the MNGEA as impermissible, extraterritorial legislation. Judge Loken expressed concern that electrons could "flow" from a non-Minnesota generator and be consumed in Minnesota.[160] Moreover, Judge Loken invoked the imagery of "directional electricity flow" when he stated that "when a non-Minnesota generating utility injects electricity into the . . . grid . . . it cannot ensure that those electrons will

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154. *Id.* at 921. The three-judge panel unanimously struck down the statute, but wrote three separate opinions. *Id.* at 913, 923, 927. Judge Loken struck down the MNGEA as a violation of the dormant Commerce Clause. *Id.* at 921–22. While Judge Murphy found that the MNGEA did not violate the dormant Commerce Clause, she nevertheless struck down the statute because it was preempted by the Federal Power Act. *Id.* at 926–27. Judge Steven Colloton declined to reach the dormant Commerce Clause issue, finding it dispositive that the MNGEA was preempted by the federal Clean Air Act. *Id.* at 929.

155. *Id.* at 921; *see* Brief for Electrical Engineers, Energy Economists and Physicists as Amicus Curiae Supporting Respondents, *supra* note 7, at 7–10.

156. *North Dakota*, 825 F.3d at 924; *see* Brief for Electrical Engineers, Energy Economists and Physicists as Amicus Curiae Supporting Respondents, *supra* note 7, at 7–10.

157. MINN. STAT. § 216H.03, subdiv. 3 (2016).

158. Brief for American Public Power Association, National Rural Electric Cooperative Association and Missouri Joint Municipal Electric Utility Commission as Amici Curiae Supporting Appellees, *supra* note 65, at 5–6.

159. *Id.*

160. *See* Brief for Electrical Engineers, Energy Economists and Physicists as Amicus Curiae Supporting Respondents, *supra* note 7, at 7–10.

not flow into and be consumed in Minnesota."[161] This language suggests that electricity in the grid flows directly toward a particular end-use consumer for its ultimate consumption.

Due to Judge Loken's reliance on this inaccurate understanding, he found that the MNGEA exerts extraterritorial control by regulating "activity and transactions taking place *wholly outside* of Minnesota."[162] Under this reasoning, a non-Minnesota generating utility cannot ensure that the electrons it injects into the grid will not flow across the Minnesota state border and be consumed in Minnesota.[163] Therefore, an energy facility that injects electricity into the regional electric grid as part of an entirely out-of-state transaction may not be able to avoid importing power "that would contribute to [Minnesota's] power sector carbon dioxide emissions."[164] This unintentional cross-border flow of electrons constitutes importation of electricity into Minnesota, which triggers the MNGEA's provision barring any person from importing or committing to import from outside the state power from a "new large energy facility that would contribute to statewide power sector carbon dioxide emissions."[165] An out-of-state regional utility would need to "either unplug from the [grid] or seek regulatory approval" from the Minnesota Department of Commerce and the Minnesota Public Utility Commission in order to avoid violating the MNGEA.[166] Thus, Judge Loken reasoned that the MNGEA's provision regulating the import of power into Minnesota has the "practical effect of controlling conduct beyond the boundaries of Minnesota," and therefore violates the extraterritoriality principle.[167]

By contrast, Judge Murphy's accurate portrayal of the electric grid as a charged system with vibrating electrons led her to construe the MNGEA in a way that does not exert extraterritorial control in violation of the dormant Commerce Clause. Judge Murphy explained that electrons on the grid do not flow;[168] rather, electrons oscillate in place, and the energized grid behaves as an undifferentiated electromagnetic wave.[169] Additionally, Judge Murphy noted that grid operators cannot dispatch electricity directionally. Electricity injected onto the grid by a generating facility energizes the entire interconnected, regional grid. Consumers, in turn, "draw undifferentiated energy from that grid."[170] Because there is no way to trace any directional flow of electricity on the grid from generators to local distribution substations, Judge Murphy reasoned that it would be "impossible" for Minnesota to enforce the

161. North Dakota v. Heydinger, 825 F.3d 912, 921 (8th Cir. 2016).
162. *Id.* at 921 (emphasis in original).
163. *Id.*
164. *Id.* at 924.
165. MINN. STAT. § 216H.03 subdiv. 3 (2016); *North Dakota*, 825 F.3d at 922.
166. *North Dakota*, 825 F.3d at 921.
167. *Id.*; § 216H.03 subdiv. 3.
168. *North Dakota*, 825 F.3d at 924.
169. *Id.*
170. *Id.*

MNGEA in the manner Judge Loken described.[171] Next, because this characterization of the statute would be impossible to enforce, Judge Murphy reasoned that the legislature likely intended the MNGEA's "person" and "import" language to apply only to the parties of bilateral contracts between Minnesota utilities and new, large energy facilities located outside Minnesota.[172] Under this construction of the MNGEA, the statute does not apply to parties operating wholly outside the state of Minnesota. It only subjects out-of-state companies to Minnesota laws when these companies enter into commerce within Minnesota. Thus, under this reasoning, the MNGEA complies with the extraterritoriality principle and is not a per se violation of the dormant Commerce Clause.[173]

Judge Loken and Judge Murphy's competing understandings of the behavior of electricity caused the judges to arrive at two completely different interpretations of the MNGEA and two opposite conclusions regarding whether the MNGEA is a per se violation of the dormant Commerce Clause.

2. New York v. FERC

In *New York v. FERC*, the Supreme Court determined that the FPA permits FERC to regulate unbundled retail transmission rates of electricity.[174] This subpart will first outline FERC's regulatory authority over interstate transmission under the FPA. Then it will describe the FERC order at issue in *New York v. FERC*, Order 888. Ultimately, it will demonstrate how two parties' competing understandings of the behavior of electricity caused them to arrive at completely different interpretations of FERC's jurisdiction under the FPA.

a. Legal Background: The FPA

The FPA grants FERC authority over the "transmission of electric energy in interstate commerce."[175] FERC has jurisdiction over "all facilities for such transmission," but it does not have jurisdiction over facilities used "only for the transmission of electric energy in *intrastate* commerce."[176] In *Federal Power Commission v. Florida Power & Light Co.*, the Supreme Court clarified the definition of interstate commerce as it applies to the transmission of electricity. The Court defined "interstate transmission" as any transmission of electricity that is "commingled" with that of another state by virtue of being transported on an interconnected, interstate electric grid.[177] Therefore, all transmission of

171. *Id.* at 924–25.
172. *Id.* at 924–26.
173. *Id.* at 925–26.
174. *See* New York v. FERC, 535 U.S. 1, 28 (2002).
175. 16 U.S.C. § 824(a) (2012).
176. § 824(b)(1) (emphasis added).
177. Fed. Power Comm'n v. Fla. Power & Light Co., 404 U.S. 453, 463–66 (1972).

electricity in U.S. electric grid (Texas, Alaska, and Hawaii notwithstanding) is subject to FERC jurisdiction.[178]

b. New York v. FERC *Case Background*

Public utilities own many of the transmission lines in the United States. In order to deliver electricity to their wholesale and retail customers, the electricity generation competitors of these utilities must often use the transmission lines owned by the utilities. The utilities' ownership and control over transmission lines throughout the early and mid-1900s gave them the power "either to refuse to deliver energy produced by competitors or to deliver competitors' power on terms and conditions less favorable than those they appl[ied] to their own transmissions."[179] Therefore, utility control over transmission lines served as an obstacle to competition among generators. [180]

When Congress enacted the Energy Policy Act of 1992, it expanded FERC's historically limited authority and allowed FERC to introduce more competition-based policies within the transmission sector.[181] With this newly expanded authority, FERC promulgated Order 888, which aimed to introduce competition into wholesale electric power markets.[182] Order 888 mandates "functional unbundling" of wholesale generation and transmission services.[183] This requires utilities to set separate rates for its wholesale generation, transmission, and ancillary services.[184] Order 888 also requires "all public utilities that own, control or operate facilities used for transmitting electric energy in interstate commerce . . . [t]o file open access non-discriminatory transmission tariffs" with FERC.[185] This requirement opens power supply markets to competition by ensuring that utilities cannot refuse access or charge discriminatory transmission rates to their competitors.

In *New York v. FERC*, the State of New York challenged Order 888 and asserted that FERC did not have jurisdiction over unbundled retail transmissions rates.[186] The D.C. Circuit rejected this assertion, finding instead that FERC did not exceed its jurisdiction by regulating unbundled retail transmissions of electricity.[187] The Supreme Court affirmed.[188]

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178. *See id.* at 471; *see* EISEN ET AL., *supra* note 8, at 515–16.
179. *New York*, 535 U.S. at 8–9.
180. *See id.*
181. EISEN ET AL., *supra* note 8, at 640.
182. *Id.* at 642.
183. *New York*, 535 U.S. at 11.
184. *Id.* at 2.
185. Promoting Wholesale Competition Through Open Access Non-Discriminatory Transmission Services by Public Utilities, 61 Fed. Reg. 21,540, 21,541 (May 10, 1996) (to be codified at 18 C.F.R. pts. 35, 385).
186. *New York*, 535 U.S. at 2.
187. Transmission Access Policy Study Grp. v. FERC, 225 F.3d 667, 694–695 (D.C. Cir. 2000).
188. *New York*, 535 U.S. at 28.

c. Clashing Party Interpretations of FERC Jurisdiction Caused by "Directional Electricity Flow" Language

The parties[189] in *New York v. FERC* interpreted the scope of FERC jurisdiction over interstate transmission in fundamentally different ways. Their clashing interpretations stemmed from New York's use of "directional electricity flow" language and FERC's rejection of this inaccurate description of the behavior of electricity on the grid.[190]

New York used "directional electricity flow" language in its statement that "most electricity used in the United States is generated in the state where it is used."[191] New York based this statement on its contention that "most energy passes from power plants to the retail customers who are first in line on transmission lines with suitable capacity."[192] This language inaccurately suggests that electricity enters the end of a transmission wire at a generating plant and then flows directly toward a particular end-use consumer for its ultimate consumption.[193]

New York then interpreted the FPA's grant of FERC jurisdiction over "transmission of electric energy in interstate commerce"[194] through this inaccurate lens of "directional electricity flow" language. The state argued that, in order to establish federal jurisdiction to regulate unbundled retail transmissions of electricity, "FERC would have to show that essentially every electron used by a retail customer in each state (other than Hawaii, Texas, and Alaska) is generated in a different state."[195] Because FERC cannot prove that every consumed electron is generated in another state, New York concluded that FERC does not have jurisdiction to regulate unbundled retail transmission.

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189. The petitioners in *New York v. FERC*, will be referred to as "New York" for purposes of brevity. The complete list of petitioners consisted of: the Public Service Commissions of New York, Arkansas, and Florida; The National Association of Regulatory Utility Commissioners; The Public Utilities of Idaho, North Carolina, and Wyoming; The New Jersey Board of Public Utilities; the Virginia Corporation Commission; The Washington Utilities and Transportation Commission; The Vermont Department of Public Service; The National Association of State Utility Consumer Advocates; and Ohio Consumers' Counsel. Final Reply Brief of Petitioners/Interveners Public Service Commissions of New York, Arkansas and Florida, The National Association of Regulatory Utility Commissioners, The Public Utility of Idaho, North Carolina, and Wyoming, The New Jersey Board of Public Utilities, the Virginia Corporation Commission, The Washington Utilities and Transportation Commission, The Vermont Department of Public Service, The National Association of State Utility Consumer Advocates, and Ohio Consumers' Counsel, New York v. FERC, 535 U.S. 1 (2002) (No. 97-1715). FERC was the respondent in *New York v. FERC*. Brief for the Federal Energy Regulatory Commission, *supra* note 9.

190. *See* Petitioners' Brief on the Merits, *supra* note 74, at 5; *see* Brief for the Federal Energy Regulatory Commission, *supra* note 9, at 27.

191. Petitioners' Brief on the Merits, *supra* note 74, at 5.

192. *See id.* at 45 n.28.

193. *See* Brief for Electrical Engineers, Energy Economists and Physicists as Amicus Curiae Supporting Respondents, *supra* note 7, at 19–23.

194. 16 U.S.C. § 824(a) (2012).

195. Petitioners' Brief on the Merits, *supra* note 74, at 45 n.27.

Thus, by New York's reasoning, FERC Order 888 is invalid because it oversteps the bounds of FERC's jurisdiction.[196]

FERC, by contrast, noted that New York's depiction of a grid where utilities are "[p]hysically isolated" and where electricity travels directly from a generating station to nearby consumers has "become a thing of the past."[197] FERC then compared electricity injected onto today's interconnected grid to "molecules of water from different sources (rains, streams, etc.) . . . commingled in a reservoir."[198] Like this water, the electricity generated by all of the power plants connected to one of today's multi-state grids "energizes the entire transmission grid with one single, continuous electromagnetic waveform that by its very nature moves in interstate commerce."[199] Therefore, because FERC has jurisdiction over the transmission of electricity in interstate commerce, it has jurisdiction over unbundled retail transmission on an interstate grid that "commingles" its electricity without regard to the source or its ultimate consumer.[200] Furthermore, even if a particular utility could prove that its transmission service transmits *most* of its electricity within the state, this would not impair FERC's jurisdiction because the FPA did not condition FERC's transmission jurisdiction upon the proportion or volume of electricity being transmitted in interstate commerce. Rather, FERC has jurisdiction over transmission facilities (other than local distribution facilities) unless they are used "*only* for the transmission of electric energy in *intrastate* commerce."[201]

New York's use of inaccurate "directional electricity flow" language compared to FERC's accurate depiction of the electric grid caused[202] these two parties to arrive at completely different interpretations of FERC's jurisdiction under the FPA. New York's use of flawed "directional electricity flow" language caused the state to interpret the FPA narrowly and conclude that FERC does not have jurisdiction over unbundled retail transmission of electricity on the interstate grid. [203] FERC's proper portrayal of the grid as an interconnected, charged system caused it to interpret the FPA broadly and assert jurisdiction to regulate unbundled retail transmission.[204] The Supreme

196. *See id.* at 48–49.

197. *See* Brief for the Federal Energy Regulatory Commission, *supra* note 9, at 26.

198. *See id.*

199. *See* Brief for Electrical Engineers, Energy Economists and Physicists as Amicus Curiae Supporting Respondents, *supra* note 7, at 23.

200. *See* Brief for the Federal Energy Regulatory Commission, *supra* note 9, at 19.

201. 16 U.S.C. § 824(b)(1) (2012) (emphasis added); *see* Brief for the Federal Energy Regulatory Commission, *supra* note 9, at 28.

202. In the alternative, it is possible that New York's use of inaccurate language was a result, rather than a cause, of its desire for more limited FERC jurisdiction. New York might have chosen to employ misleading "directional electricity flow" language in this litigation as a tool to defend its position and attempt to gain more state control as a policy matter.

203. *See* Petitioners' Brief on the Merits, *supra* note 74, at 48–49.

204. *See* Brief for the Federal Energy Regulatory Commission, *supra* note 9, at 19.

Court affirmed FERC's interpretation of the FPA and found that FERC has jurisdiction over unbundled retail transmission on the interstate grid.[205]

In *Heydinger* and *New York v. FERC*, legal professionals' incorrect descriptions of electricity spurred conflicting conclusions regarding the constitutionality and scope of energy statutes. In *Heydinger*, one judge's incorrect language caused disagreement as to the constitutionality of a Minnesota law.[206] In *New York v. FERC*, one party's mistaken descriptions of electricity stirred disagreement as to whether FERC acted within its jurisdiction under the FPA.[207] The following Part discusses the problems resulting from this inaccurate language, extending beyond just the disparate outcomes of the energy law cases in which this inaccurate language is employed.

VI. PROBLEMS THAT ARE LIKELY TO RESULT FROM CONTINUED USE OF "FLOWING ELECTRONS" AND "DIRECTIONAL ELECTRICITY FLOW" LANGUAGE

Beyond the conflicts that arose in the foregoing cases, legal professionals' inaccurate descriptions of electricity cause broader problems for the litigation of energy law cases and the regulation of energy matters by state and federal actors. This Part will first discuss these current problems and will then explore the recent developments in the U.S. power sector that suggest the persistence or increasing incidence of these problems as attorneys and judges continue to incorrectly describe the nature of electricity.

A. Current Problems Caused by the Inconsistent and Inaccurate Use of "Flowing Electrons" and "Directional Electricity Flow" Language

The usage of inaccurate "flowing electrons" and "directional electricity flow" language by some legal professionals and resulting disagreements in interpretations of state and federal statutes (for example, the MNGEA and the FPA) creates problems both for the judges and attorneys that interpret statutes and the state legislatures that write statutes.

Because some judges conceptualize the grid based on incorrect notions of the behavior of electricity whereas others reason using language that accurately depicts today's grid, judges risk coming to divergent conclusions regarding the validity of the same statute. This inconsistency is problematic because it could cause a law regulating one state's energy portfolio to be upheld whereas a functionally identical statute in another state would be struck down as a violation of the dormant Commerce Clause. This lack of clarity regarding the interpretation of energy statutes could also increase the inefficiencies in our judicial system. For instance, if attorneys interpret the limits of FERC

205. New York v. FERC, 535 U.S. 1, 16–17 (2002).

206. North Dakota v. Heydinger, 825 F.3d 912, 922, 924 (8th Cir. 2016).

207. *See* Petitioners' Brief on the Merits, *supra* note 74, at 48–49; Brief for the Federal Energy Regulatory Commission, *supra* note 9, at 19.

jurisdiction based on incorrect notions of how electricity behaves on the grid, this could cause courts to devote their valuable time and resources to lawsuits involving baseless assertions that FERC has acted beyond its jurisdiction.

These difficulties with statutory interpretation complicate the job of state legislators crafting energy policies. Judge Loken's and Judge Murphy's divergent conclusions regarding the constitutionality of the MNGEA failed to resolve uncertainty about the bounds of states' powers to enact laws governing energy procurement. If states cannot predict whether judges will interpret a statute in accordance with the way in which electricity actually behaves on the grid, this uncertainty erects barriers to states' abilities to pass energy laws that fit appropriately within state powers and do not violate the U.S. Constitution.

B. Ongoing Problems that Will Result from the Use of "Flowing Electrons" and "Directional Electricity Flow" Language in the Face of Increasing Regionalization of U.S. Energy Markets

Recent changes in the U.S. power sector indicate that these types of problems will persist if attorneys and judges continue to incorrectly describe the nature of electricity. The U.S. electric industry "is in the midst of rapid and ongoing changes."[208] Today's "electric power sector is regionally interconnected and highly dynamic—and becoming more so every day."[209]

The United States' dependence on electric energy has nearly doubled since 1977.[210] In an effort to meet increasing demand for reliable, affordable, and sustainable energy, several states are pursuing measures to increase regional coordination of energy generation and delivery.[211] In 2014, the California Independent System Operator[212] and PacifiCorp, a neighboring utility, formed an Energy Imbalance Market to trade excess supply and demand across their regional electric grid.[213] Today, the California Independent System Operator and PacifiCorp are working to achieve full coordination of the two largest transmission grids in the western United States and provide customers with access to generation resources across a much broader service area.[214] The

208. EISEN ET AL., *supra* note 8, at 29.

209. Brief for Benjamin F. Hobbs et al. as Amici Curiae Supporting Petitioners, *supra* note 11, at 1.

210. *Id.* at 5.

211. *See, e.g.*, Brief for Benjamin F. Hobbs et al. as Amici Curiae Supporting Petitioners, *supra* note 11, at 20; *Fast Facts: Regional Energy Market Background*, CAL. ISO (July 12, 2016), https://www.caiso.com/Documents/RegionalEnergyMarket-FastFacts.pdf; *FAQ: Expanding Regional Energy Partnerships*, CAL. ISO (Apr. 2015), https://www.caiso.com/Documents/FAQ-ExpandingRegionalEnergyPartnerships.pdf.

212. ISOs and RTOs are non-profit entities that operate the transmission wires owned by the utilities. EISEN ET AL., *supra* note 8, at 652.

213. *See* Brief for Benjamin F. Hobbs et al. as Amici Curiae Supporting Petitioners, *supra* note 11, at 20; *Western Grid Coordination*, PACIFICORP, http://www.pacificorp.com/about/eim.html (last visited Apr. 10, 2017).

214. *FAQ: Expanding Regional Energy Partnerships*, CAL. ISO, *supra* note 211.

United States' two largest multistate regional transmission operators are also pursuing greater regional coordination by working to form a common energy market that would cover all or part of twenty-three states and the District of Columbia.[215] Several states now require their utilities to be part of an independent system operator or regional transmission operator.[216] Furthermore, FERC recently mandated that all utilities undertake regional transmission planning, whether or not they participate in a regional organized wholesale energy market.[217]

These rapid changes in the regionalization of energy markets could lead to more disputes regarding the roles of state and federal regulators in managing the generation, transmission, and distribution of electricity. Moreover, increasing reliance on out-of-state energy around the country could complicate ongoing state efforts to regulate their individual electricity mixes. *Heydinger* is just one in a series of recent lawsuits challenging the constitutionality of states' efforts to promote renewable energy or reduce greenhouse gas emissions. In 2015, the Tenth Circuit upheld a Colorado statute requiring "electricity generators to ensure that 20 [percent] of the electricity they sell to Colorado consumers come from renewable sources."[218] In 2013, the Ninth Circuit upheld California's Low Carbon Fuel Standard, which is aimed at decreasing the carbon intensity of the state's transportation fuel market.[219] With recent state efforts to decrease carbon emissions and promote renewable energy, some states are concerned about the effects of the increased grid regionalization on their respective abilities to control which generation resources (renewable versus non-renewable) will be dispatched in order to meet their energy needs.[220] As lawsuits regarding the jurisdictional validity of state energy regulations continue to arise, so will the difficulties that result from the inconsistent and inaccurate descriptions of electricity.

C. Recommendations

In order to avoid ongoing difficulties resulting from the use of "flowing electrons" and "directional electricity flow" language, attorneys and judges should describe and conceptualize the grid using language consistent with physicists' and electrical engineers' understandings of unified, charged transmission networks. In particular, legal professionals could use the more accurate water reservoir metaphor and could write energy laws from a transactional perspective rather than an electricity-importation perspective.

215. Brief for Benjamin F. Hobbs et al. as Amici Curiae Supporting Petitioners, *supra* note 11, at 20.

216. *Id.*

217. *Id.*

218. Energy & Env't Legal Inst. v. Epel, 793 F.3d 1169, 1170 (10th Cir. 2015).

219. Rocky Mountain Farmers Union v. Corey, 730 F.3d 1070, 1080, 1101 (9th Cir. 2013).

220. *FAQ*, CAL. ISO (Sept. 20, 2016), https://www.caiso.com/Documents/ISORegionalEnergyMarketFAQ.pdf.

Due to the complex nature of electricity, it could still be useful to employ some type of metaphor to conceptualize the behavior of electricity on the grid. Instead of using the misleading, water pipe analogy,[221] however, attorneys and judges could use a water reservoir metaphor. In *New York v. FERC*, FERC compared electricity injected onto today's interconnected grid to "molecules of water from different sources (rains, streams, etc.) . . . commingled in a reservoir."[222] In a water reservoir, a person taking water from the reservoir does not know whether the molecules in their water sample originated from a particular tributary stream, from rain consisting of the evaporated water from a particular location, or from some other source. Similarly, "once a company's generators are wired into the grid the energy on that interstate network cannot be differentiated in ownership or origin."[223] Just as a person pulls undifferentiated water from a reservoir, an end-use consumer draws undifferentiated energy from the electric grid.[224] Thus, this water reservoir metaphor more accurately represents the behavior of electricity on modern, regional grids.

Next, instead of writing laws that purport to control or track the movement of electricity on the grid or the importation[225] of electricity into a particular state, legislators should write laws controlling contracts between load-serving entities and generation facilities. By writing laws from a transactional perspective instead of from an electricity-importation perspective, state legislators can ensure that their laws are not interpreted as attempts to regulate all potential "flow" of electricity into their state. By taking a transactional approach, legislators will more easily be able to communicate the specific parties to which their laws apply, and judges will more easily be able to determine whether these laws violate the dormant Commerce Clause.

In *Heydinger*, ambiguity surrounding the words "person" and "import" gave rise to confusion about whether the MNGEA applied to any party that causes electricity to "flow" into Minnesota, or whether it applied only to the parties of bilateral power purchase agreements between a Minnesota utility and a new large energy generating facility.[226] By contrast, California's performance standard, which is written in the language of "financial commitment[s]," has

221. *See* Brief for Electrical Engineers, Energy Economists and Physicists as Amicus Curiae Supporting Respondents, *supra* note 7, at 2, 7–10.

222. *See* Brief for the Federal Energy Regulatory Commission, *supra* note 9, at 26.

223. *See* Brief for Electrical Engineers, Energy Economists and Physicists as Amicus Curiae Supporting Respondents, *supra* note 7, at 19–20.

224. *See id.* at 2.

225. *See, e.g.*, MINN. STAT. § 216H.03 subdiv. 3 (2016) (banning the importation of power that would increase the annual carbon dioxide emissions resulting from the generation of electricity used in Minnesota).

226. Brief for American Public Power Association, National Rural Electric Cooperative Association and Missouri Joint Municipal Electric Utility Commission as Amici Curiae Supporting Appellees, *supra* note 65, at 5–6.

explicitly defined the parties to which the law applies.[227] The California performance standard prohibits load-serving entities or local publicly owned electric utilities from "enter[ing] into a long-term financial commitment" where the carbon content of the baseload generation supplied exceeds 1100 pounds of carbon dioxide per megawatt hour.[228] This standard applies to contracts with both in-state and out-of-state generators.[229] Because coal-fired power plants cannot meet this standard, California's mandate effectively prevents California load-serving entities from entering long-term contracts to import electricity generated from baseload coal plants.[230] The bilateral contract language of California's performance standard limits its application to entities that are in commerce with the state of California. Therefore, California's performance standard has not encountered constitutional controversies[231] like that seen in *Heydinger*. By using the language of contracts rather than the language of electricity "import," legislators can avoid, altogether, confusion created by judges' and attorneys' inconsistent and inaccurate usage of "flowing electrons" and "directional electricity flow" language.

CONCLUSION

Since the early days of the U.S. electric grid, legal professionals have often described electrons and electricity as flowing through the electric grid in much the same way as water flows through a pipe.[232] Attorneys and judges also discuss directional electricity flow, which suggests that electricity from a particular generating facility flows through transmission lines directly toward specific end-use consumers. Both of these descriptions mischaracterize the behavior of electrons and electricity. Electrons do not "flow" through transmission lines. Rather, they "oscillate back and forth."[233] Furthermore, while electricity does flow, it does not flow directionally from a particular generator to a particular end-use consumer. Rather, electricity that enters a transmission network "energizes the entire grid."[234] While some legal professionals may not recognize that their conception of electrical energy is

227. *See* Carlson & Boyd, *supra* note 55, at 14.
228. *Id.*; Cal. Pub. Util. Code § 8341(a) (2016).
229. Carlson & Boyd, *supra* note 55, at 21–22.
230. *Id.* at 17.
231. *Id.* at 17, 21–22.
232. *See, e.g.*, City Pub. Serv. Bd. of San Antonio v. Pub. Util. Comm'n of Texas, 9 S.W.3d 868, 872 n.10 (Tex. App. 2000); Brief for American Public Power Association, National Rural Electric Cooperative Association and Missouri Joint Municipal Electric Utility Commission as Amici Curiae Supporting Appellees, *supra* note 65, at 15; GONICK & HUFFMAN, *supra* note 76, at 131; JOHNSON, *supra* note 76, at 63–64; KENT, *supra* note 76, at 1027; Brief for Electrical Engineers, Energy Economists and Physicists as Amicus Curiae Supporting Respondents, *supra* note 7, at 2, 7–10.
233. Brief for Electrical Engineers, Energy Economists and Physicists as Amicus Curiae Supporting Respondents, *supra* note 7, at 7 (emphasis omitted).
234. *See id.* at 9 (emphasis omitted).

incorrect, others continue to use "flowing electrons" and "directional electricity flow" language despite their knowledge that it is inaccurate.

In recent decades, transmission networks have become much more interconnected and regional.[235] As a result, the "flowing electrons" and "directional electricity flow" language that once sufficiently approximated the behavior of electricity on the grid is no longer relevant or accurate. Nevertheless, some attorneys and judges continue to use "flowing electrons" and "directional electricity flow" language. This reliance on inaccurate language by some legal professionals has caused conflicting reasoning and conclusions of the attorneys and judges involved in recent energy law cases. In *Heydinger*, one judge's incorrect language caused disagreement as to the constitutionality of a Minnesota law.[236] In *New York v. FERC*, one party's mistaken descriptions of electricity stirred disagreement as to whether FERC acted within its jurisdiction under the FPA.[237]

These fundamental disagreements create problems for judges, attorneys, and legislators. Some judges' misunderstandings of the behavior of electricity lead to lack of uniformity in judges' decisions and increase inefficiencies in our judicial system. These linguistic inaccuracies also erect barriers to states' abilities to pass energy laws that fit appropriately within their powers and do not violate the U.S. Constitution. In order to avoid ongoing difficulties resulting from the use of "flowing electrons" and "directional electricity flow" language, attorneys and judges should agree to describe the grid using language consistent with physicists' and electrical engineers' understandings of unified, charged transmission networks.

235. Brief for Benjamin F. Hobbs et al. as Amici Curiae Supporting Petitioners, *supra* note 11, at 20–21.

236. North Dakota v. Heydinger, 825 F.3d 912, 922, 924 (8th Cir. 2016).

237. *See* Petitioners' Brief on the Merits, *supra* note 74, at 48–49; Brief for the Federal Energy Regulatory Commission, *supra* note 9, at 19.

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