

William & Mary Environmental Law and Policy Review

Volume 36 (2011-2012)
Issue 2

Article 3

February 2012

Legal and Regulatory Impediments to Vehicle-to-Grid Aggregation

Matthew Hutton

Thomas Hutton

Follow this and additional works at: <https://scholarship.law.wm.edu/wmelpr>



Part of the [Energy and Utilities Law Commons](#), and the [Environmental Law Commons](#)

Repository Citation

Matthew Hutton and Thomas Hutton, *Legal and Regulatory Impediments to Vehicle-to-Grid Aggregation*, 36 Wm. & Mary Envtl. L. & Pol'y Rev. 337 (2012), <https://scholarship.law.wm.edu/wmelpr/vol36/iss2/3>

Copyright c 2012 by the authors. This article is brought to you by the William & Mary Law School Scholarship Repository.

<https://scholarship.law.wm.edu/wmelpr>

LEGAL AND REGULATORY IMPEDIMENTS TO VEHICLE-TO-GRID AGGREGATION

MATTHEW HUTTON* & THOMAS HUTTON**

ABSTRACT

This article begins by defining the “vehicle-to-grid” concept for a legal readership, and places it in context by discussing some major problems facing the United States electrical grid. There are several ways in which the vehicle-to-grid concept may potentially mitigate the grid’s problems as are described. Then, the article discusses the major legal and regulatory impediments to implementing a vehicle-to-grid program. Several of the hurdles are simply manifestations of uncertainties in the business environment. Others are more properly legal and regulatory impediments, but are expected to be surmountable. Therefore, the Article concludes that legal and regulatory impediments will not likely hinder the adoption of vehicle-to-grid programs.

I.	BACKGROUND	338
	A. <i>The Electrical Grid Faces Looming Challenges</i>	338
	B. <i>The V2G Concept</i>	343
	C. <i>The Benefits of V2G</i>	347
II.	LEGAL IMPEDIMENTS TO IMPLEMENTING V2G	350
	A. <i>Some Academic Questions: Allocating Property Rights and Problems of Monopsony</i>	352
	B. <i>Net Metering Legislation and Regulation</i>	354
	C. <i>Interacting with the FERC to Modify Tariff Definitions</i>	356

* Matt Hutton holds a Master of Science in Civil and Environmental Engineering from CalPoly and has also studied chemical and biomolecular engineering at Johns Hopkins University. His experience includes tracking patterns of energy production, distribution and consumption in the energy efficiency consulting field. He works for MicroBio Engineering, Inc., a California-based algae technology company.

** Tom Hutton is an associate with Van Ness Feldman, a law firm specializing in energy, environment, and natural resources law and policy. Note that the views expressed herein are not necessarily representative of the views of the firm or its clients. Tom is indebted to the Hon. Judge Richard D. Cudahy of the U.S. Seventh Circuit Court of Appeals, and Professor Jim Rossi of the Florida State University College of Law, for stoking his interest in energy policy and setting him on a path to build a career on it.

<i>D.</i>	<i>Reliability Considerations</i>	358
<i>E.</i>	<i>Warranty Problems</i>	360
<i>F.</i>	<i>Affirmative Incentives</i>	362
CONCLUSION	365

The vehicle-to-grid (“V2G”) concept is a proposal to take advantage of an anticipated widespread adoption of electric vehicles (“EVs”), supporting the reliability of the electrical grid and accessing previously untapped economic value. This is to be accomplished by allowing for bi-directional electricity transfers from EVs, thus enabling the electrical grid to draw on the energy stored in EV batteries to meet its occasional need for stabilization. The purpose of this Article is to explain the concept of V2G for legal readers, and to catalog the potential legal and regulatory impediments to implementing the idea.

I. BACKGROUND

A. *The Electrical Grid Faces Looming Challenges*

The electrical grid¹ in the United States faces formidable and interrelated challenges, and the challenges are expected to intensify in the coming years. First, the grid suffers from transmission constraints and a perennial shortage of new transmission construction, due to the prolonged and contentious nature of obtaining the required permits for transmission projects and the often-unattractive investment attributes of these projects.² The inadequacy of available electric transmission is a persistent and growing problem, even if it has drawn public attention only sporadically. It has

¹ “The grid” refers to the national network of high-voltage transmission lines responsible for delivering electricity to local utilities. SPENCER ABRAHAM, U.S. DEP’T OF ENERGY, NATIONAL TRANSMISSION GRID STUDY xi (2002), *available at* <http://www.ferc.gov/industries/electric/gen-info/transmission-grid.pdf> [hereinafter ABRAHAM, GRID STUDY]. This function of high-voltage “transmission” is usually administered by entities called Independent System Operators (“ISOs”) or Regional Transmission Organizations (“RTOs”). *Id.* at 16, 24. The “grid” also incorporates utilities, which are responsible for “distributing” power, at a lower, consumer-friendly voltage, to customers. *Id.* at 3.

² *See, e.g.*, EDWARD N. KRAPELS, ENERGY SEC. ANALYSIS, INC., GOODBYE GRIDLOCK (2): HOW TO END THE SHORTAGE IN TRANSMISSION INVESTMENT THAT LED TO THE NORTHEAST BLACKOUT 19 (White Paper 2003) (describing transmission projects, in an analogy now well-known among industry observers, as “as popular as root canals”).

been blamed, for example, for exacerbating the California energy crisis of 2001,³ and the Northeast blackout of 2003,⁴ but these occasional crises have yet to inspire systematic upgrades. Much of the stagnation can be blamed on the fact that state and local governments have vigorously defended their authority over transmission siting decisions, and on the uneasy union of localized costs and system-wide benefits inherent in transmission projects.⁵ The 2005 Energy Policy Act⁶ sought to spur transmission construction, and equipped the Federal Energy Regulatory Commission (“FERC”) with some new powers to second-guess state governments in the area of transmission permitting.⁷ But on the two instances that courts have considered this new FERC authority, they dealt it significant blows:

³ Richard J. Pierce Jr., *Environmental Regulation, Energy, and Market Regulation*, 15 DUKE ENVTL. L. & POL’Y F. 167, 177 (2005) (“Inadequate transmission capacity was one of the major causes of each of the price spikes and blackouts the U.S. has experienced in recent years, including the ten-fold increase in the price of electricity in California in 2001.”).

⁴ *Id.*; James W. Moeller, *Of Credits and Quotas: Federal Tax Incentives for Renewable Resources, State Renewable Portfolio Standards, and the Evolution of Proposals for a Federal Renewable Portfolio Standard*, 15 FORDHAM ENVTL. L. REV. 69, 175 (2004) (“The loss of a 345-kv transmission line, the report concludes, was ‘the event that triggered the uncontrollable cascade portion of the blackout sequence.’”) (citing U.S.-CAN. POWER SYS. OUTAGE TASK FORCE, INTERIM REPORT: CAUSES OF THE AUGUST 14TH BLACKOUT IN THE UNITED STATES AND CANADA 21 (2003)).

⁵ See David J. Hurlbut, *Multistate Decision Making for Renewable Energy and Transmission*, 81 U. COLO. L. REV. 677, 691 (2010) (“If the benefits of a transmission line extend beyond the regulator’s jurisdiction, assigning all the costs to jurisdictional rate-payers may be politically infeasible.”). For an excellent illustration of the problems of federalism in transmission line siting, see Jim Rossi, *Transmission Siting in Deregulated Wholesale Power Markets: Re-imagining the Role of Courts in Resolving Federal-State Siting Impasses*, 15 DUKE ENVTL. L. & POL’Y F. 315, 316–18 (2005) (describing an extended conflict among multiple state agencies, environmental groups, and competing utilities, plaguing one utility’s effort to construct a badly needed transmission line in the Long Island Sound).

⁶ Energy Policy Act of 2005, Pub. L. No. 109-58, 119 Stat. 594 (2005) (codified as amended in scattered sections of 7, 10, 15, 16, 22, 26, 30, 40, and 42 U.S.C.).

⁷ Generally, section 1221 of the 2005 Energy Policy Act added section 216 to the Federal Power Act, 16 U.S.C. § 824p, which requires the Secretary of Energy to study transmission congestion and allows it to designate certain areas of the country as “transmission congestion corridors.” 16 U.S.C. § 824(a) (2005). Within the corridors the FERC identifies, the Commission is empowered to issue a federal permit to build transmission lines, but only in the event that the state authorities fail to act on an application. See 16 U.S.C. § 824(b)(1). See generally Debbie Swanstrom & Meredith M. Jolivert, *DOE Transmission Corridor Designations & FERC Backstop Siting Authority: Has the Energy Policy Act of 2005 Succeeded in Stimulating the Development of New Transmission Facilities*, 30 ENERGY L. J. 415, 422 (2009); Thomas Hutton, *Energy Policy Act § 216: A Power Worth Preserving*, 39 ENVTL. L. REPORTER 11002, 11003–004 (2009).

first, majorly cabinning FERC's interpretation of the extent of its power,⁸ and then, significantly delaying its potential use.⁹ In short, anemic construction of new transmission remains a problem for the foreseeable future.

Further complicating the transmission inadequacy problem is the fact that utilities are being asked to derive an ever-increasing portion of their electricity from far-flung wind and solar energy sources. In that connection, a majority of states have adopted some form of renewable portfolio standard ("RPS"), each purporting to require utilities to draw a certain proportion of their energy from renewable sources by a particular year.¹⁰ Of course, an RPS is only one mechanism for imposing renewables on the utility industry, albeit one of the most popular. In addition, several states and localities have enacted a "feed-in tariff," an incentive structure under which utilities are obligated to purchase renewable electricity on prescribed terms.¹¹ Accordingly, the use of renewable sources has increased steadily over recent years, from supplying approximately 9.4% of electrical generation in 2000, to 10.3% in 2010.¹² Looking at the electricity sector as a whole, of course, conceals the growth in the use of individual sources; for instance, in the same period, the productivity of renewables grew by nearly fifty percent.¹³ The use of solar power more than doubled, and wind power increased by approximately a factor of fourteen.¹⁴

⁸ *Piedmont Envtl. Council v. FERC*, 558 F.3d 304, 309–10 (4th Cir. 2009), *cert. denied*, 130 S. Ct. 1138 (2010).

⁹ *Cal. Wilderness Coal. v. U.S. Dep't of Energy*, 631 F.3d 1072, 1095–96 (9th Cir. 2011) (rejecting the study that was prerequisite to exercising the 2005 Energy Policy Act permitting authority, on the ground that the DOE had failed to properly consult with the states, and remanding "for DOE to prepare a congestion study 'in consultation with the affected states.'").

¹⁰ By a recent count, twenty-seven states and the District of Columbia have renewable portfolio standards that at least purport to be binding, although most lack any sort of enforcement mechanism. See U.S. DEP'T OF ENERGY, OFFICE OF ENERGY EFFICIENCY & RENEWABLE ENERGY, STATES WITH RENEWABLE PORTFOLIO STANDARDS, http://apps1.eere.energy.gov/states/maps/renewable_portfolio_states.cfm (last visited Feb. 1, 2012). Five other states have renewable portfolio goals that are expressly voluntary. *Id.*

¹¹ See, e.g., California (S. 1969, 2006 Assemb., Reg. Sess. (Cal. 2006), codified in scattered sections of CAL. PUB. UTIL. CODE § 399, implemented by Cal. Pub. Util. Comm'n Resolution E-4137 (2008)); Vermont (Vermont Energy Act of 2009, H.B. 446, 2009 Assemb., Reg. Sess. (Vt. 2009), codified at VT. STAT. ANN. tit. 30, § 8005 (West 2011)); the city of Gainesville, Florida (Gainesville, Fla., Ordinance No. 080566 (Feb. 5, 2009), codified in scattered sections of GAINESVILLE, FLA., CODE OF ORDINANCES ch. 27, Utilities).

¹² Calculated from U.S. ENERGY INFO. ADMIN., ANNUAL ENERGY REVIEW 260 tbl.8.2a (2010), available at <http://www.eia.doe.gov/aer/txt/totalenergy/data/annual/pdf/are.pdf>.

¹³ *Id.*

¹⁴ *Id.* (net generation increase from 0.5 billion kilowatt-hours ("billion kWh") to 1.3 billion kWh for solar, and from 6.7 billion kWh to 94.6 billion kWh for wind). The American

One problem with the accelerating adoption of renewables, from the perspective of grid planners, is that renewable resources are often located far from heavily populated load centers.¹⁵ Exploiting the resources, therefore, places new demands on the transmission system and requires new construction projects. In other words, the policy impulse to rely more heavily on renewable sources of energy exacerbates the grid's transmission challenges.

Renewable energy sources present an additional challenge for the grid, arising from the fact that those sources are typically intermittent:

Unlike conventional resources, output of wind, solar, ocean and some hydro generation resources varies according to the availability of a primary fuel that cannot be stored. Therefore, the key differences between variable generation and conventional power plants are that variable generation exhibits greater variability and uncertainty in its output on all time scales.¹⁶

The amount of electricity produced by wind and solar plants fluctuates profoundly, in tandem with the intensity of wind and sunlight.¹⁷ The intermittent availability of renewable energy complicates the job of the electrical grid operators, who are expected to supply electricity commensurate with demand, irrespective of the weather or time of day.

What makes intermittency such a thorny problem is the grid's near-complete lack of any capability for storing electricity. The electrical grid is an elaborate and enormous just-in-time delivery system,¹⁸ considering

Reinvestment and Recovery Act of 2009, Pub. L. No. 111-5, 123 Stat. 115 (2009) (codified in scattered sections of the U.S. Code), serves as another good example of the recent policy emphasis on renewable sources of energy. "The American Recovery and Reinvestment Act ("ARRA") of 2009 included more than \$80 billion [including grants and loans combined] targeted towards clean energy investments, including funds for a smart grid compatible with renewable energy . . ." Katherine H. Regan, *The Case for Enhancing Climate Change Negotiations with a Labor Rights Perspective*, 35 COLUM. J. ENVTL. L. 249, 277 (2010). The emphasis seems to reflect a consensus among lawmakers that the further development of renewables is a general good.

¹⁵ See Steven Ferrey, *Restructuring a Green Grid: Legal Challenges to Accommodate a New Renewable Energy Infrastructure*, 39 LEWIS & CLARK ENVTL. L. 977, 997 (2009).

¹⁶ N. AM. ELEC. RELIABILITY CORP., SPECIAL REPORT: ACCOMMODATING HIGH LEVELS OF VARIABLE GENERATION 2 (2009), available at http://www.nerc.com/files/IVGTF_Report_041609.pdf.

¹⁷ See Ferrey, *supra* note 15, at 987, 993 (noting that both wind and solar power fluctuate depending on natural forces).

¹⁸ See *id.* at 985–86 (describing the components and functionality of the grid).

the absence of storage. Electricity must be produced within seconds of when it is consumed, and thus must be produced at least as rapidly as it is consumed.¹⁹ Consequently, the demands the grid will face must be anticipated, down to hourly and minute-by-minute increments, such that supply will always be adequate.²⁰ This means that suppliers must be prepared to compensate immediately for fluctuations in the availability of electricity in order to avoid service disruptions. One observer explains that “the grid will need to accompany more renewable resources with a whole new battalion of quick-start peaking power resources to fill in their potentially unpredictable, intermittent daily operation.”²¹

A third challenge facing the grid, especially pertinent to this discussion, is that many observers predict and hope for a significant increase in the number of electric vehicles²² on American roads in the coming years.²³ The rapid adoption of electric vehicles would have the salutary effects of decreasing the United States’ reliance on foreign sources of oil to power the short-haul transportation fleet, and also decreasing the emission of greenhouse gases.²⁴ Therefore, it is widely viewed as a desirable

¹⁹ *Id.* at 989–90.

²⁰ *Id.*

²¹ *Id.* at 994.

²² Note that there are both plug-in hybrid electric vehicles and purely electric vehicles. For V2G purposes, these variants are interchangeable, at least insofar as both will contain a battery with electricity that can be made available to the grid. See Christopher Guille & George Gross, *A Conceptual Framework for the Vehicle-to-Grid (V2G) Implementation*, 37 ENERGY POL'Y 4379, 4379 (2009). The use of the term “EV” in this Article encompasses both plug-in hybrids and all-electric vehicles, whereas the term “BV” represents battery vehicles in general.

²³ See ELECTRIFICATION COAL., *ELECTRIFICATION ROADMAP—REVOLUTIONIZING TRANSPORTATION AND ACHIEVING ENERGY SECURITY* 19 (2009), available at <http://www.electrificationcoalition.org/policy/electrification-roadmap> (describing the organization’s goal of deploying 14 million EVs by 2020, through policy initiatives and fleet adoption); DELOITTE CONSULTING, *GAINING TRACTION: A CUSTOMER VIEW OF ELECTRIC VEHICLE MASS MARKET ADOPTION IN THE U.S. AUTOMOTIVE MARKET* 16 (2010), available at http://www.deloitte.com/view/en_GX/global/industries/manufacturing/e3411d9873a6f210VgnVCM1000001a56f00aRCRD.htm (predicting the sale of approximately 465,000 EV units, or 3.1% of the U.S. market, in 2020). See generally NICHOLAS DEFORREST ET AL., *CTR. FOR ENTREPRENEURSHIP & TECH., UNIV. OF CAL., BERKELEY, IMPACT OF WIDESPREAD ELECTRIC VEHICLE ADOPTION ON THE ELECTRIC UTILITY BUSINESS: THREATS AND OPPORTUNITIES* 1 (2010), available at http://cet.berkeley.edu/dl/Utilities_Final_8-31-09.pdf (listing reasons to believe that EV adoption will soon increase).

²⁴ Of course, using electric vehicles avoids greenhouse gas emissions only to the extent that the portfolio of plants contributing electricity to the grid generates less greenhouse emissions than would a car’s traditional gasoline engine. See Ronald E. Minsk et al., *Plugging Cars into the Grid: Why the Government Should Make a Choice*, 30 ENERGY L.J. 317, 362–63 (2009). This is all but certain to be the case. *Id.* at 363 (discussing a study that

prospect.²⁵ Simultaneously, however, such a transformation would make the grid newly responsible for a major component of the national energy demand. The transportation sector accounts for approximately twenty-eight percent of the national energy demand.²⁶ This need has historically been met almost exclusively with liquid gasoline and diesel fuel,²⁷ therefore not burdening the electrical grid at all. Shifting any significant part of this demand to the electrical grid will reshape and enlarge the grid's service obligations.²⁸

B. *The V2G Concept*

The V2G concept aspires to turn the driving public's aggregated EV batteries into a resource that supports the stability of the electrical grid. The opportunity arises from the fact that a typical automobile is not in use for the overwhelming majority (approximately ninety-six percent) of its useful life.²⁹ For EVs, this means that most of the time the vehicle will be parked and plugged into an electricity source (an ordinary or modified wall socket). The V2G idea contemplates that the grid could draw small amounts of electricity from the battery, subject to the prior and continuing approval of the EV owner.³⁰

found using an EV “would reduce carbon emissions as compared to a petroleum-fueled vehicle, even if all of the exogenous electricity used to recharge the [EV] was generated at an old (relatively dirty) coal power plant”).

²⁵ See *id.* at 359, 362–63.

²⁶ ANNUAL ENERGY REVIEW, *supra* note 12, at 60 fig.2.1a.

²⁷ See *id.* at 59 fig.2.0 (indicating that ninety-four percent of the transportation sector's energy demand is met with petroleum and another two percent with natural gas; the remaining four percent attributable to “Renewable Energy” includes biofuel-petroleum blends).

²⁸ See MATT CROSBY ET AL., CAL. PUB. UTILS. COMM'N, LIGHT-DUTY VEHICLE ELECTRIFICATION IN CALIFORNIA: POTENTIAL BARRIERS AND OPPORTUNITIES 9 (White Paper 2006), available at <http://www.cpuc.ca.gov/nr/rdonlyres/ad8A4A5e-6ed9-4493-bdb6-326ab86a028e/0/cpucppdelectricvehiclewhitepaper2.pdf> (explaining “LDV electrification has the potential to increase total energy demand, substantially increase daily load capacity requirements, alter peak load shapes, increase transmission and distribution system demands, and result in net negative emissions of carbon dioxide (CO₂), while increasing the electricity sector's emission profile.”); Guille & Gross, *supra* note 22, at 4380 (“A study showed that, in 2020, with a 25% penetration in 13 US regions, 160 new power plants will be required if every BV owner plugs in the vehicle in the early evening—around 5 p.m.—when electric demand is still near the daily peak.”).

²⁹ Willett Kempton & Jasna Tomić, *Vehicle-to-Grid Power Fundamentals: Calculating Capacity and Net Revenue*, 144 J. POWER SOURCES 268, 268 (2005), available at <http://www.sciencedirect.com/science/article/pii/S0378775305000352> (stating that the average personal vehicle is in use only four percent of the time).

³⁰ In the words of another observer, “V2G is a kind of net metering for an ‘appliance’ that you can drive and that possesses enough electricity storage in its battery to allow the larger

Any V2G system will rely on some sort of entity to aggregate the numerous and dispersed EV batteries, because “[t]he battery storage of an individual [vehicle battery] is too small to impact the grid in any meaningful manner.”³¹ Such an aggregating entity would receive requests from the grid and call upon available EVs according to a prearranged methodology.³² The aggregator’s role has been described as follows:

The Aggregator who collects the [EVs] to create a group to act as the distributed energy resource . . . is the critical entity to make the V2G concept implementable. The Aggregator also provides interface with the independent system operator or regional transmission organization, i.e., the *ISO/RTO*, whose responsibility is to operate and control the bulk power system, and with the energy service providers (*ESPs*) who provide the electricity supply to customers through the distribution grid.³³

This sort of aggregation would allow grid operators to deal with a single entity, and to purchase electricity in a quantity sufficient to meet its needs.³⁴ In other words, it avoids the fanciful scenario of grid operators entering into a multitude of tiny transactions with geographically dispersed, individual EV owners.

The particular role the EVs would play is to supply “ancillary services” to the grid. The grid buys ancillary services to help it adjust for imbalances between supply and demand, which allows it to maintain the balance that is essential to the successful operation of the grid.³⁵ Being a supplier of ancillary services simply means having a prearranged relationship with the grid: the supplier is paid to be ready to provide or absorb

grid to take electricity back from it.” Bryan Lamble, *Of Nesting Dolls And Trojan Horses: A Survey Of Legal And Policy Issues Attendant To Vehicle-To-Grid Battery Electric Vehicles*, 86 CHI.-KENT L. REV. 193, 194 (2011).

³¹ Guille & Gross, *supra* note 22, at 4382.

³² *Id.* at 4384–86.

³³ *Id.* at 4380.

³⁴ *Id.* at 4382 (explaining that “an aggregation of *BVs* represents the total capacity of the batteries, an amount in MWs that constitutes a significant size and allows each *BV* to benefit from the buying power of a large industrial/commercial customer. . . . As a resource, the aggregated *BVs* constitute a significant capacity that may beneficially impact the operations of an *ISO/RTO*.”).

³⁵ Jacqueline Lang Weaver, *Can Energy Markets be Trusted? The Effect of the Rise and Fall of Enron on Energy Markets*, 4 HOUS. BUS. & TAX L.J. 1, 33 (2004).

electricity on demand, for a specified amount, and within a specified period of time.³⁶ If the ancillary service provider is actually called upon, it receives additional compensation for the electricity provided.³⁷

The grid's occasional supply-demand mismatches can create a need for "regulation up," where the grid draws electricity from the ancillary service provider, or "regulation down," where the ancillary service provider absorbs excess electricity.³⁸ Because "ancillary services [are] essential to keep the system balanced and prevent it from cascading into a blackout,"³⁹ grid operators are obligated to have them always available. Grid operators purchase ancillary services in terms of hour-long increments of availability (often called "capacity"), and actually draw on the resource in four-second to one-minute increments, depending on the particular grid operator.⁴⁰ Another important aspect of ancillary services is that even when the resource is called upon, the grid requires only small amounts of electricity.⁴¹ Ancillary services are thus to be distinguished from the "baseload" power supplied by large, full-time generators.⁴² In sum, V2G would not rely upon cars to supply the grid's anticipated daily needs; rather, EVs would provide an occasional "jolt" or "booster shot" to keep the grid from faltering.

Currently, the grid's ancillary service needs are met principally by natural gas-fired turbine generators (or "peakers").⁴³ Natural gas is the most expensive of the conventional electricity sources,⁴⁴ but it is suitable

³⁶ See Kempton & Tomić, *supra* note 29, at 271 (for example, spinning reserves "can provide power quickly, say within 10 min[utes], upon request").

³⁷ *Id.*

³⁸ Guille & Gross, *supra* note 22, at 4383. During the night, the principal need is for regulation down; during the day, both regulation up and regulation down are periodically needed. *Id.*

³⁹ *Grid Scale Energy Storage: Hearing Before the S. Comm. on Energy & Natural Resources*, 111th Cong. 3 (2009) (statement of Jon Wellinghoff, Acting Chairman, Federal Energy Regulatory Commission), available at http://energy.senate.gov/public/_files/ChairmanWellinghoffTestimonyFERC12102009.pdf [hereinafter *Wellinghoff Testimony*].

⁴⁰ WILLETT KEMPTON ET AL., A TEST OF VEHICLE-TO-GRID (V2G) FOR ENERGY STORAGE AND FREQUENCY REGULATION IN THE PJM SYSTEM: RESULTS FROM AN INDUSTRY-UNIVERSITY RESEARCH PARTNERSHIP 10 (2009), available at <http://www.udel.edu/V2G/resources/test-v2g-in-pjm-jan09.pdf>.

⁴¹ *Id.* at 11.

⁴² Kempton & Tomić, *supra* note 29, at 268, 270.

⁴³ See Alec Brooks & Tom Gage, *Integration of Electric Drive Vehicles with the Electric Power Grid—A New Value Stream* 6–7 (Oct. 2001) (unpublished conference presentation paper, International Electric Vehicle Symposium & Exhibition), available at <http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.201.6658>.

⁴⁴ See LAZARD LTD., LEVELIZED COST OF ENERGY ANALYSIS—VERSION 3.0, at 2–3 (2009), available at http://blog.cleanenergy.org/files/2009/04/lazard2009_levelizedcostofenergy.pdf.

for ancillary services because it offers the quickest reaction to changes in load (as opposed, for instance, to slow-adjusting coal and nuclear plants).⁴⁵

Ancillary services are thus a good place for V2G to start, because the grid's ancillary service needs arise infrequently and require the delivery of only a small amount of electricity for a short period of time. In addition, the grid's reliability occasionally requires that extra electricity be offloaded.⁴⁶ Thus, the need to have vehicles absorb *excess* electricity will often offset the need to have them supply electricity, such that the net charge of the battery will not ordinarily be depleted.⁴⁷

For a V2G aggregator, the most readily approachable subtype of ancillary service is called "frequency regulation," which strives to maintain the grid at its operating frequency of sixty hertz ("Hz").⁴⁸ Frequency regulation is the ancillary service that needs the smallest amount of electricity, but requires it to be supplied the quickest.⁴⁹ It needs a small amount of electricity delivered nearly immediately. Grid operators may call on regulation service providers about 400 times per day.⁵⁰ The next ancillary service that a V2G aggregator might provide is called "spinning reserves," which currently exists as "excess capacity in the form of spinning turbines whose electricity can be connected to the grid in minutes, if need be."⁵¹ Spinning reserves are called on much less frequently, approximately twenty times per year.⁵²

Pursuant to open-access transmission rules promulgated by the Federal Energy Regulatory Commission, grid operators are generally required to purchase ancillary services from the generator providing them at the lowest available cost.⁵³ Frequency regulation is typically

⁴⁵ *Wellinghoff Testimony*, *supra* note 39, at 4.

⁴⁶ KEMPTON ET AL., *supra* note 40, at 8.

⁴⁷ *Id.* at 24–25.

⁴⁸ "Regulation Service is the continuous balancing of resources with load to assist in maintaining scheduled interconnection frequency at 60 Hz." *See* Order Accepting Tariff Revisions, 127 F.E.R.C. 61,135 n.2 (May 15, 2009).

⁴⁹ Willett Kempton & Jasna Tomić, *Vehicle-to-Grid Power Implementation: From Stabilizing the Grid to Supporting Large-Scale Renewable Energy*, 144 J. POWER SOURCES 280, 282 (2005) [hereinafter Kempton & Tomić II, *V2G Power Implementation*].

⁵⁰ *Id.*

⁵¹ Weaver, *supra* note 35, at 33.

⁵² Kempton & Tomić II, *V2G Power Implementation*, *supra* note 49, at 282.

⁵³ *See* Promoting Wholesale Competition Through Open-Access Non-Discriminatory Transmission Services by Public Utilities, 61 Fed. Reg. 21,540, 21,541 & 21,581 (May 10, 1996) (codified at 18 C.F.R. pts. 35 & 385) [hereinafter FERC Order 888]; *see also* KEMA, INC. & ISO/RTO COUNCIL, ASSESSMENT OF PLUG-IN ELECTRIC VEHICLE INTEGRATION WITH ISO/RTO SYSTEMS, app. 8, at 52 (2010), available at <http://www.isorto.org/atf/cf/%7B5B4>

valued at between thirty dollars and forty-five dollars per megawatt hour (“MWH”), while spinning reserves are valued at approximately ten dollars per MWH.⁵⁴

There is also a possibility that later, following a successful early implementation of V2G and a much wider adoption of electric vehicles, V2G could be used to satisfy a larger proportion of the grid’s demands, including “peak shaving.”⁵⁵ Peak shaving is the deployment of stored electricity during periods when electrical demand is peaking and during which the highest-cost generation is being dispatched.⁵⁶ But, such a scenario can be realized only after the V2G concept is proven in the more manageable context of ancillary services.

C. *The Benefits of V2G*

The potential benefits of implementing vehicle-to-grid are manifold, but can be summarized in environmental, economic, and reliability categories.

First, V2G is an environmentally efficient scheme, insofar as it makes use of electricity that has already been generated. Each quantum of electricity supplied for ancillary services through V2G would avoid the need to produce the same amount, typically by burning natural gas at a peaker plant.⁵⁷

Second, the V2G idea would benefit the environment by subsidizing and thus encouraging the purchase of EVs. Estimates vary, but participating in a V2G system could allow an EV owner to recoup in the neighborhood of \$1500 to \$2500 annually.⁵⁸ This offsetting income stream makes the purchase of an EV that much more attractive. Obviously, there is no analogous benefit to owning a conventional, internal combustion automobile, because the cost of gasoline is simply a persistent economic loss to drivers.

E85C6-7EAC-40A0-8DC3-003829518EBD%7D/IRC_Report_Assessment_of_Plug-in_Electric_Vehicle_Integration_with_ISO-RTO_Systems_03232010.pdf [hereinafter KEMA, ASSESSMENT] (“CAISO, ERCOT, ISO-NE, NY-ISO and PJM all offer a regulation market and over the past 3 years have an average of \$35–\$40 per megawatt-hour annual market clearing price.”).

⁵⁴ KEMPTON ET AL., *supra* note 40, at 3.

⁵⁵ See DEFOREST ET AL., *supra* note 23, at 23; U.S. DEP’T OF ENERGY & NAT’L ASS’N OF REGULATORY UTIL. COMM’RS (NARUC), LIQUEFIED NATURAL GAS: UNDERSTANDING THE BASIC FACTS 7 (2005), available at http://www.fe.doe.gov/programs/oilgas/publications/lng/LNG_primerupd.pdf [hereinafter DOE & NARUC, LIQUEFIED NATURAL GAS].

⁵⁶ DOE & NARUC, LIQUEFIED NATURAL GAS, *supra* note 55, at 7.

⁵⁷ CROSBY ET AL., *supra* note 28, at 21.

⁵⁸ Kempton & Tomić, *supra* note 29, at 275–76.

Vehicle-to-grid also promises broad economic advantages. First, to leverage vehicle batteries is to exploit the value of what is now an entirely unexploited resource. Using EVs to meet grid ancillary service needs will avoid the use of natural gas-fired peaker plants (the fuel for which varies unpredictably between relatively expensive and wildly expensive).⁵⁹ “Additional off-peak load and on-peak capacity is particularly valuable to the extent it lowers average fixed costs of generation.”⁶⁰ This will have the effect of proportionately lowering the price of electricity delivered to ratepayers. Furthermore, if the ability of V2G succeeds in serving the grid’s ancillary service needs, it may then continue on to greater roles, and may help to avoid the *construction* of further peaker plants.⁶¹

Moreover, the increased attractiveness of purchasing an electric vehicle mentioned above can also be viewed as an economic benefit. This is because the widespread adoption of EVs would be beneficial for the United States economy, for reasons recently summarized as follows:

Because we consume so much oil, which is so highly valued and for which we have virtually no substitutes in the short-term, the price volatility in the world oil market inflicts significant economic damage on the United States, with nearly every recession over the past forty years being preceded by or occurring concomitant with an oil price spike.

In order to escape the economic consequences of oil price volatility, consequences that are quite severe, it is necessary to electrify the short-haul transportation system. Electrification offers at least six advantages over the status quo: using electricity promotes fuel diversity; electricity is generated from a domestic portfolio of fuels; electricity prices are less volatile than oil and gasoline prices; using electricity is more efficient and has a better emissions profile than gasoline; using electricity will facilitate reduction of greenhouse gas emissions; and electricity is a low-cost alternative.⁶²

⁵⁹ *Peaker Power Plant Fact Sheet*, ILL. ENVTL. PROTECTION AGENCY, <http://www.epa.state.il.us/air/fact-sheets/peaker-power-plant.html> (last visited Feb. 1, 2012).

⁶⁰ See CROSBY ET AL., *supra* note 28, at 32.

⁶¹ *Id.* at 32–33 (“This storage capacity has been valued at a 40% savings relative to procuring additional peak generation capacity.”).

⁶² Minsk et al., *supra* note 24, at 317–18.

Finally, there are reliability benefits to the V2G idea. By definition, EV batteries should be better at providing ancillary services than the existing resources, because batteries are capable of reacting quicker to the grid's needs.⁶³ As discussed above, the current method of supplying ancillary services is with natural gas-fired turbines. These turbines are fast enough to serve the grid's needs well, but they are less than instantaneous. The reaction time of batteries, in contrast, is nearly instantaneous.⁶⁴

Of course, the V2G concept is not without its skeptics. Not everyone believes that V2G can deliver the virtuous package of social and economic goods that its advocates promise,⁶⁵ and some of the criticisms are well taken. One author raises the specter of a heightened vulnerability to cyberterrorism, due to the complexity involved in adding so many new participants, and the fact that each new EV participant is a potential "entry point" for malevolent actors.⁶⁶ The same author argues that V2G presents an environmental risk by accelerating a battery's useful life and necessitating its more frequent disposal, and that a malfunctioning V2G system could cause batteries to combust.⁶⁷

A particularly salient economic criticism is that it seems with the greater adoption of EVs, the supply of V2G owners willing to supply the grid will correspondingly expand, and the value of any one driver providing the service will precipitously drop.⁶⁸ This effect may be so pronounced as to

⁶³ See Guille & Gross, *supra* note 22, at 4379, 4383 (comparing the faster reaction times of batteries versus power plants).

⁶⁴ *Wellinghoff Testimony*, *supra* note 39, at 4 ("[I]t has been demonstrated that distributed resources such as storage are more efficient than central station fast response natural gas-fired generators at matching load variations and providing ancillary services needed to ensure grid reliability."); see also Guille & Gross, *supra* note 22, at 4383 ("[T]he fast response capabilities of the *BV* batteries [are] of the order of *milliseconds*. Typically, such service is provided by plants with short response times, of the order of *minutes*."); John Timmer, *Testing the Electric Vehicle-to-Grid Connection*, ARS TECHNICA (Feb. 22, 2010), <http://arstechnica.com/science/news/2010/02/testing-the-electric-vehicle-to-grid-connection>.ars (quoting PJM's Kenneth Huber for the statement that "[b]atteries can move faster than our signal").

⁶⁵ See, e.g., DEFOREST ET AL., *supra* note 23, at 24 ("[A]lthough discussed often for its promise, V2G will not be viable in the next decade [and so f]or now, utilities need only to ensure their investments are based on V2G standards so they can support V2G in future years . . .").

⁶⁶ Lamble, *supra* note 30, at 207 & n.76.

⁶⁷ *Id.* at 208–09.

⁶⁸ See John Petersen, *Aggregation Will Destroy Niche Markets for Smart Grid Energy Storage*, SEEKING ALPHA (Mar. 3, 2010), <http://seekingalpha.com/article/191614-aggregation-will-destroy-niche-markets-for-smart-grid-energy-storage> ("[T]he fundamental premise [of V2G] is fatally flawed and the promised benefits to plug-in vehicle owners will never be realized because they violate the law of supply and demand.").

ensure that vehicle owners will not be able to recoup a respectable value for participating in V2G programs.⁶⁹ Of course, a potential counter-argument in the scenario where the use of EVs becomes widespread, is that vehicle-to-grid could potentially be used for bigger and bigger grid service duties, including directly accommodating the inherently intermittent flow of electricity from renewable resources, like wind and solar, and “peak shaving.”

Security, safety, and environmental issues must obviously be considered in any program affecting the electrical grid, given its pervasive and potentially dangerous character, and also its utter indispensability. V2G is no exception. Nevertheless, the information currently available does not seem to include problems that are atypical for a project affecting the electrical grid, or out of proportion for the scope of V2G specifically. For instance, regardless of whether V2G somewhat shortens the life of EV batteries, environmental problems related to the disposal of EV batteries will attend any wide adoption of EVs, and thus must be confronted.⁷⁰ The same is true regarding issues of EV battery safety. Cybersecurity concerns,⁷¹ real as they are, have hardly slowed the assignment of vital societal functions and information to online fora. In other words, these problems exist with or without V2G. The economic criticism is more ominous,⁷² but in any case it will not be answered by attorneys. Whatever the ultimate resolution of these questions, the short-term promise of V2G in meeting demand for ancillary services seems attractive, and many have considered it to be an idea worth pursuing.

II. LEGAL IMPEDIMENTS TO IMPLEMENTING V2G

Much as the electrical grid itself has not evolved with the use of distributed cars acting as power plants in mind,⁷³ the existing legal and

⁶⁹ See DEFOREST ET AL., *supra* note 23, at 24.

⁷⁰ See Lamble, *supra* note 30, at 209.

⁷¹ See *id.* at 207.

⁷² See *id.* at 210.

⁷³ In fact, distributed resources in general, including, for instance, residential solar installations, represent a paradigm shift from the traditional structure of the electrical grid. Historically, the grid developed with large, centralized plants transferring energy in one direction to utilities and then at a stepped-down voltage to individual customers. See ABRAHAM, GRID STUDY, *supra* note 1, at xi; LAUREL VARNADO & MICHAEL SHEEHAN, INTERSTATE RENEWABLE ENERGY COUNCIL, CONNECTING TO THE GRID: A GUIDE TO DISTRIBUTED GENERATION INTERCONNECTION ISSUES 9 (6th ed. 2009) (“Because the interconnection of DG challenges the century-old tradition of utility-owned centralized generation, it requires careful technical considerations and evokes new perspectives on ownership and control.”).

regulatory environment is not optimized to accommodate the V2G concept.⁷⁴ That is, for V2G to come to fruition as it has been envisioned, certain legal and regulatory changes need to be made. Typically, anyone advocating legal or regulatory changes can expect to meet resistance from the beneficiaries of the existing rules.⁷⁵ A key purpose of industry trade groups, for instance, is to stay abreast of the potential regulatory changes and to promote or oppose them in accordance with the interests of their constituents.⁷⁶ The changes that would be required to implement V2G do not represent a magical exception to the rule that regulatory changes, by changing the way that rights and obligations are defined and allocated, will “benefit” some and “burden” others.

But putting that general caveat aside, the regulatory changes necessary to implement V2G are not expected to be especially controversial. No serious opposition has materialized from industry groups where changes have been proposed. For instance, Delaware has enacted a package of reforms specifically designed to facilitate a V2G program.⁷⁷ The bill was cosponsored by politicians from both the Democratic and Republican Parties.⁷⁸ It passed unanimously in both the Delaware House and Senate, and the Governor signed it in a ceremony.⁷⁹

Thus, for V2G, it seems likely that the law will be less of an obstacle than the science and the business.⁸⁰ Nevertheless, it is well for legal practitioners to be aware of how the law can impact a new technological development, and to understand what will happen if reforms are not undertaken. Lawyers acting as social architects are obliged to consider whose interests may be harmed, even when those harmed are not vocal.⁸¹ But equally, when no loser emerges, we as attorneys should take care that the law does not get in the way of a good idea.

The purpose of this Article, in any case, is not so much to promote specific policy reforms. Policy changes relevant to V2G will be made, or

⁷⁴ See ABRAHAM, GRID STUDY, *supra* note 1, at xi.

⁷⁵ See Lamble, *supra* note 30, at 210.

⁷⁶ See Steven P. Croley, *Theories of Regulation: Incorporating the Administrative Process*, 98 COLUM. L. REV. 1, 35 (1998).

⁷⁷ See S.B. 153, 145th Gen. Assemb. (Del. 2007) (sponsored by Sen. Simpson (R), Sen. McDowell (D), Rep. Kowalko (D), and Rep. Hocker (R)).

⁷⁸ *Id.*

⁷⁹ See Press Release, Delaware Governor Jack Markell, Markell Signs Law Promoting Electric Vehicles (Sept. 21, 2009), <http://governor.delaware.gov/news/2009/09september/20090921-electricvehicles.shtml>.

⁸⁰ See Minsk et al., *supra* note 24, at 374; Lamble, *supra* note 30, at 210.

⁸¹ See, e.g., *id.* at 356.

not made, in a state and local context, case-by-case, and in light of numerous considerations not discussed here: for instance, the cost to consumers and the extent of local concerns with reliability. The modest purpose of this Article is simply to forecast and catalog the possible bumps on the road ahead.

A. *Some Academic Questions: Allocating Property Rights and Problems of Monopsony*

The first issue to discuss is the allocation of rights in what will be a valuable asset, the existing charge in a car battery. This is only a “legal impediment” in the narrow sense that it is an area of legal uncertainty, and it is far more likely to be resolved by emerging business practices than by any sort of formal rule-making or adjudication. It is more of an intellectual curiosity than a looming obstacle, but it nevertheless deserves some preliminary attention in any discussion of the legal implications of V2G.

Multiple parties will have a hand in any vehicle-to-grid program. At the absolute least, there is an electric utility company and an EV owner. For any program extending beyond a single utility’s service area, a regional grid market organization, like an ISO/RTO, will probably be involved.⁸² And, as discussed above, there is almost certain to be an aggregator coordinating the resources of multitudinous, transient cars.⁸³ Finally, to the extent that V2G services are to be supplied by cars parked away from home, this will lead to the involvement of a real property owner or lessee, and perhaps, a distinct owner of the hardware connecting the vehicle to the grid.⁸⁴

Who, then, is entitled to what portion of the economic benefit? The owner of the battery presumably “owns” the electricity stored therein, and certainly, an owner who charges an EV at home can expect to be billed for the electricity required to replenish the EV battery, just as with any

⁸² See Guille & Gross, *supra* note 22, at 4380.

⁸³ See *id.*

⁸⁴ See DEFOREST ET AL., *supra* note 23, at 24–25. Manufacturers of such hardware include General Electric, Ecotality, and Coulomb Technologies. *Charging Ahead*, GE, http://www.ge.com/innovation/electric_vehicles/index.html (last visited Feb. 1, 2012); *Technology Solutions*, ECOTALITY, <http://www.ecotality.com/companies/> (last visited Feb. 1, 2012); *Charging Stations*, COULOMB TECHNOLOGIES, <http://www.coulombtech.com/products-charging-stations.php> (last visited Feb. 1, 2012). The latter two are small California-based companies each marketing EV charging stations. *Corporate Overview*, ECOTALITY, <http://www.ecotality.com/company.php> (last visited Feb. 1, 2012); *About Us*, COULOMB TECHNOLOGIES, <http://www.coulombtech.com/about-contact.php> (last visited Feb. 1, 2012).

other appliance.⁸⁵ But, the technical matter of legal ownership can quickly become unimportant with the involvement of other parties. This is particularly true here, where the counterparty aggregator is an institutional repeat-player, where the EV owner has no other way of exploiting the resource, and where there is no other buyer for the ancillary service potential of the battery.

The question is an important one for EV owners. One could readily foresee the repeat-player organizations, like a utility or EV aggregator, keeping a low ceiling on the benefits paid to the car owner. The car owner, after all, will need to connect the EV to the grid, regardless of whether it is providing V2G services, simply to charge it for ordinary use. Moreover, given that any aggregator will need the approval of the grid planners to operate,⁸⁶ in some areas there may not be an opportunity for individual EV owners to choose among multiple competing aggregators.⁸⁷ In other words, the market may be inherently susceptible to monopsony. Although the service EV owners provide may be indispensably valuable to the grid, it may be quickly revealed as a fungible commodity available equally from multitudinous car owners. All of these considerations strongly militate toward a buyer's market for electricity from EV batteries.

Assuming EVs become widespread, and their use for ancillary services becomes accepted or prevalent, where is the leverage for EV owners? Delaware, perhaps anticipating this imbalance in bargaining positions, has provided by statute that electricity provided from car batteries to the grid must be compensated at the same rate at which the EV is charged.⁸⁸ But, as written, the Delaware statute protects only the entity supplying ancillary services to the grid.⁸⁹ If that entity is a V2G aggregator, then that company enjoys the benefit of the statute, but there is no express protection for the individual EV owners.⁹⁰ It may well emerge that to incentivize EV

⁸⁵ See Lamble, *supra* note 30, at 213.

⁸⁶ See KEMA, ASSESSMENT, *supra* note 53, at 35.

⁸⁷ See *id.* at app.8, at 50.

⁸⁸ DEL. CODE ANN. tit. 26, § 1014(g) (2011).

⁸⁹ *Id.* at § 1014(d)–(h).

⁹⁰ *Id.* at § 1010(c). Viewed in the broader context of the energy industry, it is unsurprising that V2G poses some awkward questions of rights in property. “Property rights” in electricity and power facilities do not fit comfortably into the more black-and-white framework that usually applies, e.g., to private ownership of real property. For instance, FERC Order 888 required owners of interstate transmission to provide non-discriminatory transmission on their power lines, i.e., it required them to allow competitors to use their power lines. See FERC Order 888, *supra* note 53; In re Promoting Wholesale Competition by Public Utilities, 75 F.E.R.C. ¶ 61,080 (Apr. 24, 1996).

owners to participate in V2G, some regulatory intervention will be needed to set a floor on the payments by aggregators to EV owners.

In sum, this first “impediment” of market structure is a defining feature for the future of V2G, and it involves some legal issues, at least insofar as there are potential regulatory and legislative solutions. However, in the short term, it will be addressed by economics and not law. In contrast, the remaining impediments are legal impediments in the classic sense; meaning, changes must be made to statutes, regulations, or contracts before V2G can flourish.

B. Net Metering Legislation and Regulation

The most readily apparent hurdle to implementing vehicle-to-grid is modifying state net metering laws to accommodate V2G.⁹¹ Traditionally, and absent regulatory reform to the contrary, state-regulated utilities are not obliged to purchase electricity produced by customers, derived from EVs or from anything else.⁹² It is simply not part of the utility’s relationship with consumers, which traditionally revolves around a one-way transfer from the utility to the consumer at a price approved by the state regulatory commission.⁹³

Net metering laws have emerged in approximately the last fifteen years, as part of an effort to encourage private investment in distributed generation, and particularly, solar panels, which can be installed on residential buildings.⁹⁴ In its simplest form, a net metering rule merely requires utilities to spin the meter backwards to recognize the electricity produced by the customer.⁹⁵ State-regulated net metering has been enacted

⁹¹ See Lamble, *supra* note 30, at 195, 212.

⁹² ISSUE: NET METERING, STATE ENVTL. RES. CTR., <http://www.serconline.org/netmetering/stateactivity.html> (last visited Feb. 1, 2012) (providing a list of states and the inclusion or absence of regulation obligating state-regulated utilities to purchase electricity produced by customers).

⁹³ See, e.g., IND. UTIL. REGULATORY COMM’N, A CONSUMER’S GUIDE TO UTILITY REGULATION 2, http://www.in.gov/iurc/files/IURC_Agency_Brochure_-_FINAL_7-22-09.pdf (last visited Feb. 1, 2012).

⁹⁴ STATE ENVTL. RES. CTR., *supra* note 92 (providing a list of states and the net metering laws which include provisions for solar energy).

⁹⁵ *Net Metering*, U.S. DEP’T OF ENERGY—THE GREEN POWER NETWORK, <http://apps3.eere.energy.gov/greenpower/markets/netmetering.shtml> (last visited Feb. 1, 2012) (“Net metering enables customers to use their own generation from on-site renewable energy systems to offset their consumption over a billing period by allowing their electric meters to turn backwards when they generate electricity in excess of their demand . . .”).

in some form in forty-three states and the District of Columbia.⁹⁶ Of course, these laws vary in what they require local utilities to purchase and at what price.⁹⁷ For instance, most net metering laws have caps on the total amount of electricity that utilities can be required to purchase.⁹⁸ They vary as well in the generosity of the rate the utility must pay to the distributed generator.⁹⁹

At the time of this writing, only one state, Delaware, has a net metering statute that explicitly includes vehicles among the sources of distributed generation that a utility is required to accommodate.¹⁰⁰ The remaining net metering statutes do not include vehicles among the enumerated distributed generation resources for net metering purposes.¹⁰¹

The lack of a statutory requirement for utilities to accommodate net metering from vehicles does not simply mean that utilities are not obligated to purchase electricity from car batteries; it effectively means that they will not do so. Because of the highly regulated context in which utilities operate, unless a program for the net metering connection of vehicles

⁹⁶ See RULES, REGULATIONS & POLICIES FOR RENEWABLE ENERGY, DATABASE OF STATE INCENTIVES FOR RENEWABLES AND EFFICIENCY, <http://www.dsireusa.org/summarytables/rrpre.cfm> (last visited Feb. 1, 2012).

⁹⁷ See STATE ENVTL. RES. CTR., *supra* note 92.

⁹⁸ See, e.g., CAL. PUB. UTIL. CODE § 2827(c)(1) (West 2006), *amended by* Cal. Legis. Serv. ch. 296, A.B. 1023 (West 2011) (limiting the utility's net metering obligation to "5 percent of the electric utility's aggregate customer peak demand."); N.Y. PUB. SERV. LAW § 66-j(3)(a)(iii) (McKinney 2011) (limiting the utility's obligation to "one percent of the corporation's electric demand for the year two thousand five"); VA. CODE ANN. § 56-594(E) (2007) (limiting the utility's obligation to "one percent of each electric distribution company's" forecasted peak load).

⁹⁹ See VARNADO & SHEEHAN, *supra* note 73, at 14 ("In a handful of states, including Missouri and Nebraska, [excess customer-generated electricity] is credited at the utility's avoided cost rate—as opposed to the utility's retail rate—and carried over to the customer's next monthly bill. This arrangement is obviously less favorable than annualized net metering to net-metered customers.")

¹⁰⁰ The statute provides as follows, in relevant part:

(g) A retail electric customer having on its premises 1 or more grid-integrated electric vehicles shall be credited in kilowatt-hours (kWh) for energy discharged to the grid from the vehicle's battery at the same kWh rate that customer pays to charge the battery from the grid, as defined in paragraph (e)(1) of this section. . . .

DEL. CODE tit. 26, § 1014(g).

¹⁰¹ Arizona's law is an otherwise relatively inclusive example of a net metering law allowing net metering for electricity derived from "Renewable Resources, a Fuel Cell, or CHP [combined heat and power]." ARIZ. ADMIN. CODE § 14-2-2302.13(c) (2009). "Renewable Resources" are further defined to include biogas, biomass, geothermal, hydroelectric, solar, or wind. *Id.* § 14-2-2301.14.

is certified by the regulatory commission, utilities are unlikely to undertake such initiatives independently. Indeed, since running a net metering program will reduce the utility's volume and create some administrative costs,¹⁰² a utility will almost certainly want to obtain regulatory approval for the program to ensure that it can recover some of the costs through its rates.

In sum, a prerequisite to V2G is for state legislatures to adopt statutory patches expressly providing for net metering of energy supplied by EVs (or in a few states, to adopt a net metering program for the first time, with the inclusion of a provision for EVs). Alternatively, a state public utility commission may be able to accomplish the same purpose by rule-making, where the applicable statutory language is amenable.

C. *Interacting with the FERC to Modify Tariff Definitions*

In order to implement V2G in wholesale energy markets (i.e., for V2G applications extending across state lines or across the service areas of multiple utilities), the Federal Energy Regulatory Commission will need to approve the proposed "tariff" or charge the grid will pay the V2G aggregator. Under Section 205 of the Federal Power Act,¹⁰³ the FERC has jurisdiction over the interstate transmission system, and it is charged in particular with reviewing the tariffs involved in interstate energy transactions to ensure that they are "just and reasonable."¹⁰⁴ Accordingly, the Commission has oversight responsibilities with respect to the organized interstate power markets administered by the ISOs and RTOs.¹⁰⁵ Pursuant to this power, in 2007 it issued FERC Order 890 requiring, among other things, that ISOs and RTOs allow "demand [side] resources" to participate in the ancillary services markets.¹⁰⁶

While FERC has already laid the foundation for ISOs and RTOs to tap vehicles for ancillary services,¹⁰⁷ to implement V2G in wholesale

¹⁰² *Net Metering: Hearing Before the Subcomm. on Energy of the Comm. on Energy and Natural Res.*, 111th Cong. 14, 52 (2009) (statement and responses of Christopher Cox, Managing Director, Sunworks, LLC).

¹⁰³ 16 U.S.C. § 824d (2006).

¹⁰⁴ *Id.*

¹⁰⁵ *What FERC Does*, FERC (Dec. 3, 2010), <http://www.ferc.gov/about/ferc-does.asp>.

¹⁰⁶ Preventing Undue Discrimination and Preference in Transmission Service, 72 Fed. Reg. 12,266, 12,326 (Mar. 15, 2007) (to be codified at 18 C.F.R. pts. 35 & 37).

¹⁰⁷ Jon Wellinghoff & Willett Kempton, Public Comments on DOE PHEV R&D Plan, External Draft (comment proposed Mar. 30, 2007), available at <http://www.ferc.gov/about/com-mem/wellinghoff/3-30-07-wellinghoff.pdf>.

electricity markets, a grid operator will need to file with the FERC to obtain the Commission's approval of the terms on which V2G services are purchased. By way of example, in 2009 the New York Independent System Operator ("NYISO") filed a proposed tariff with the FERC proposing to integrate certain grid storage facilities (but not EV batteries) into its market.¹⁰⁸ The FERC's resolution of the application, reproduced in relevant part below, illustrates the type of commission approval that will be prerequisite to integrating V2G into the wholesale grid.

NYISO states that it desires to integrate "non-traditional suppliers" of regulation service into its day-ahead and real-time markets. NYISO states that the first of these "non-traditional suppliers" [also referred to as Limited Energy Storage Resources, or LESRs] uses energy storage devices such as flywheels or batteries. These technologies act as a load when withdrawing energy or charging and as a generator when injecting energy or discharging.

NYISO states that the resources currently proposed for New York are limited because they can sustain maximum energy withdrawal or injection for no more than 15 minutes.

NYISO states that LESRs' ability to react almost instantaneously to instructions can assist in addressing the control issues presented by the integration of wind resources into the New York control area.

However, NYISO states that its current market rules and software processes were developed assuming that regulation service could be provided by resources for at least one hour. Therefore, NYISO states that it needs to change its

¹⁰⁸ Order Accepting Tariff Revisions, 127 F.E.R.C. ¶ 61,135, 2009 WL 1357219, at *1 (May 15, 2009).

tariff to take advantage of the benefits of LESRs, while treating them comparably to other generation facilities and maintaining NYISO's ability to meet all existing reliability criteria.

The Commission finds that NYISO's proposed tariff revisions are just and reasonable and not unduly discriminatory or preferential. Accordingly, NYISO's proposed revisions are accepted¹⁰⁹

Fortunately, as discussed elsewhere, the FERC has expressed its support, in concept, for V2G. For instance, the 2007 Energy Independence and Security Act ("EISA")¹¹⁰ directed the Commission to research and report on "smart grid" opportunities.¹¹¹ In 2009, pursuant to the EISA's direction, the Commission issued a Smart Grid Policy Statement, and expressed the Commission's "hope that smart grid interoperability standards would ultimately accommodate a wide array of advanced options for electric vehicle interaction with the grid, including full vehicle-to-grid capabilities."¹¹² Nevertheless, given FERC's statutory mandate to ensure just and reasonable rates, any promoter of V2G embarking on the project must anticipate helping the ISO or RTO to file revisions to its tariff.

D. *Reliability Considerations*

Because electricity is so foundational and indispensable to our modern society, any party seeking to provide generation or ancillary services to the grid will need to comply with certain interconnection standards. Such standards prevent disturbances by limiting grid access to those facilities following an agreed-upon set of operational protocols. As discussed above, the 2003 Northeast blackout highlighted the importance of each link in the grid by showing that a single localized failure could paralyze the system across much of the continent.¹¹³

¹⁰⁹ *Id.* at 1–2, 6.

¹¹⁰ Pub. L. No. 110-140, § 102(a), 121 Stat. 1492 (codified in scattered sections of 42 and 49 U.S.C.).

¹¹¹ *Id.* § 1302 (codified at 42 U.S.C. § 17382 (2010)).

¹¹² *Smart Grid Policy Statement*, 128 F.E.R.C. ¶ 61,060, 61,346 (July 16, 2009), available at http://www.nerc.com/files/Smart_Grid_7-16-09_Policy_Statement.pdf.

¹¹³ See *supra* note 4 and accompanying text.

Although they were designed to facilitate cooperation in the distribution of electricity, grid interconnection policies are a formidable regulatory hurdle for small and medium sized generators, in part, because the traditional purpose of these protocols was to accommodate large, central generators.¹¹⁴ As such, grid interconnection issues present a relatively greater barrier for small projects with limited financial resources.¹¹⁵ V2G installations, in particular, present a unique set of problems: the potentially transient availability of the V2G resource complicates interconnection issues, because one addition to a small size aggregator compared to one to a centralized power plant, results in different effects.

For [EV] aggregators to participate in [ancillary services markets], the ISO/RTOs must ensure that the aggregators have the ability to identify [EV] locations, ISO/RTO systems can support a validation process for [EV] transactions, and aggregators can provide a sufficient amount of aggregated load.¹¹⁶

In other words, participating EVs, or at least V2G aggregators, must be capable of communicating with grid operators.¹¹⁷ An additional interconnection issue for V2G is that participating EVs must be equipped with an “anti-islanding”¹¹⁸ capability. In the event of an outage (intentional or unintentional), cars participating in a V2G program must likewise cease contributing electricity to the grid, to protect utility workers who will assume the lines are uncharged.¹¹⁹

¹¹⁴ See VARNADO & SHEEHAN, *supra* note 73, at 18.

¹¹⁵ See R. BRENT ALDERFER ET AL., NAT’L RENEWABLE ENERGY LAB., NREL/SR-200-28053, MAKING CONNECTIONS: CASE STUDIES OF INTERCONNECTION BARRIERS AND THEIR IMPACT ON DISTRIBUTED POWER PROJECTS 18 (2000), *available at* <http://www.nrel.gov/docs/fy00osti/28053.pdf> (“Case-by-case procedural review and legal remedies [for denials of interconnection requests], where they exist, are not so much the solution as just a final barrier where the scale of the project can justify no effort beyond a simple and inexpensive way of asserting those rights.”).

¹¹⁶ KEMA, ASSESSMENT, *supra* note 53, at 10.

¹¹⁷ *Id.* app. 8, at 52.

¹¹⁸ See *id.* Anti-islanding is defined by the Institute of Electrical and Electronics Engineers as “a condition in which a portion of an Area Electric Power System (EPS) is energized solely by one or more Local EPSs through the associated point of common coupling (PCC) while that portion of the Area EPS is electrically separated from the rest of the Area EPS.” Z. YE, M. DAME, B. KROPOSKI, NAT’L RENEWABLE ENERGY LAB., NREL/TP-560-37200 GRID-CONNECTED INVERTER ANTI-ISLANDING TEST RESULTS FOR GENERAL ELECTRIC INVERTER-BASED INTERCONNECTION TECHNOLOGY iii (2005), *available at* <http://www.nrel.gov/docs/fy05osti/37200.pdf>.

¹¹⁹ KEMA, ASSESSMENT, *supra* note 53, app. 8, at 52.

The 2005 Energy Policy Act,¹²⁰ which was heavily motivated by the 2003 Northeast blackout,¹²¹ represented a major advancement in grid reliability and interconnection requirements. Pursuant to the Act, efforts to tailor reliability standards to accommodate vehicle-to-grid are in progress at the National Institute of Standards and Technology (“NIST”).¹²² Moreover, although meeting grid connection requirements is a challenge for V2G, a more fertile regulatory environment is possible even without reforms directed specifically toward electric vehicles. Rather, any broader efforts to facilitate the interconnection of relatively small distributed power sources, including grid storage and small solar installations, will likely benefit V2G programs as well.¹²³

E. Warranty Problems

Another potential legal issue facing promoters of V2G arises from the increased battery wear caused by repeated cycling.¹²⁴ As a matter of scientific fact, frequent, high current draws on an EV battery will hasten the end of its useful life.¹²⁵ Although proponents claim that the effect would be insignificant,¹²⁶ EV manufacturers will be understandably hesitant to

¹²⁰ Pub. L. No. 109-58, 119 Stat. 594 (2005), available at <http://doi.net/iepa/EnergyPolicyActof2005.pdf>.

¹²¹ See generally Steven Ferrey, *Power Future*, 15 DUKE ENVTL. L. & POL'Y F. 261, 276–77 (2005).

¹²² In particular, the NIST was commissioned by the Energy Independence & Security Act of 2007 (“EISA”) section 1305 to coordinate development of smart grid interoperability standards. FRED SISSINE, CONG. RESEARCH SERV., RL34294, ENERGY INDEPENDENCE AND SECURITY ACT OF 2007: A SUMMARY OF MAJOR PROVISIONS 20 (2007), available at http://energy.senate.gov/public/_files/RL342941.pdf. The Institute is investigating V2G and attempting to standardize requirements, under the auspices of the Smart Grid Interoperability Panel, Priority Action Plan 11, Task 5. NAT'L INST. OF STANDARDS & TECH., U.S. DEP'T OF COMMERCE, NIST SPECIAL PUBL'N NO. 1108, NIST FRAMEWORK & ROADMAP FOR SMART GRID INTEROPERABILITY STANDARDS, RELEASE 1.0 26 (2010), available at http://www.nist.gov/public_affairs/releases/upload/smartgrid_interoperability_final.pdf.

¹²³ Wind power and V2G share the attribute of variability, and policies aimed at tackling this problem in the context of wind power could also favorably impact the regulatory climate for V2G. V2G is also similar to an emerging suite of storage technologies, like flywheels and large batteries, in that they are likely to materialize as a distributed network of small systems rather than any centralized facility. Policies aimed at accommodating distributed power providers in interconnection requirements will benefit V2G technology.

¹²⁴ See ALEC N. BROOKS, AC PROPULSION INC., VEHICLE-TO-GRID REGULATION ANCILLARY SERVICE WITH A BATTERY ELECTRIC VEHICLE 30 (2002).

¹²⁵ *Id.* at 27.

¹²⁶ *Id.* at 1 (“The value created by the [V2G service provision] exceeds the battery wear out costs under most operating assumptions . . . it was noted that battery capacity increased

guarantee that insignificance. Therefore, it is very possible that participating in a V2G program will void EV battery factory warranties. Indeed, EV manufacturers are particularly likely to be wary of increasing their warranty liabilities with respect to EV batteries given that the battery is among the most technically complex, proprietary, and expensive parts of an EV.¹²⁷ It would obviously present a significant disincentive to participating in a V2G program if such use made owners immediately noncompliant with the warranty protecting the part of their vehicle that is the most expensive to replace.

Warranties for the early mass-marketed EVs do not explicitly address the issue of V2G operation. However, it seems likely that any battery use not expressly approved will not be covered, based on both public statements of company representatives,¹²⁸ and on available warranties themselves: for instance, the Nissan Leaf's warranty disclaims coverage for "Misuse, such as overloading, using the vehicle to tow, driving over curbs, or using the vehicle as a power source."¹²⁹ Thus, it seems that if the status quo continues to apply, the EV owner would risk losing warranty protection by participating in a V2G program.

There are several reasons, however, to think this should not be an insurmountable problem in the long term. First, the impact of V2G use on electric vehicle batteries should be minimal. As discussed above, ancillary services are principally bought and sold by "capacity," or availability, and not by actual use.¹³⁰ Thus, the number of times that the grid actually draws on a car's battery will be limited.¹³¹ Second, even when the battery is drawn

by about 10 percent during the testing."); Guille & Gross, *supra* note 22, at 4381 (also noting that providing V2G service could potentially extend EV battery life).

¹²⁷ See generally Minsk et al., *supra* note 24, at 356–57; Clifford Krauss, *For Oil Exec, an Electric Car Can Wait*, N.Y. TIMES: GREEN—A BLOG ABOUT ENERGY AND THE ENVIRONMENT (Feb. 10, 2011, 2:23 PM), <http://green.blogs.nytimes.com/2011/02/10/for-oil-exec-an-electric-car-can-wait/> (explaining that currently batteries cost \$800–\$1000 per kilowatt-hour).

¹²⁸ See Jim Motavalli, *Power to the People: Run Your House on a Prius*, N.Y. TIMES, Sept. 2, 2007, at J5 (quoting spokesman Chris Naughton of Honda, stating "We would not like to see stresses on the battery pack caused by putting it through cycles it wasn't designed for. . .").

¹²⁹ NISSAN, 2011 LEAF WARRANTY INFORMATION BOOKLET 9 (2011), <http://www.nissan-leaf.net/wp-content/uploads/2010/11/773306-2011-Nissan-Leaf-Warranty.pdf> (emphasis added). The 2011 Nissan Leaf Warranty also requires that battery maintenance be performed by certified shops only, and that owners make available stored vehicle system data and proof of annual battery maintenance. *Id.* at 8. These strict maintenance schedules and record-keeping requirements are likely to make owners wary of any battery operation they are not certain is permissible.

¹³⁰ See *supra* note 40 and accompanying text.

¹³¹ See *supra* notes 47–52 and accompanying text.

upon, the impact on the battery need not be different than simply driving the car. The contours of the draw on the battery are subject to prospective design by the aggregator,¹³² and it is further possible that the EV owner may be able to select from among a series of options presented by the aggregator.¹³³ Thus, it is possible to provide options advance, such that the draws on the batteries will be shallow which, in turn, will allay the warranty-related concerns of manufacturers.

In sum, the voiding of manufacturer warranties as a result of V2G use is an issue that will need to be confronted. Manufacturers can be expected to be wary about extending their warranty coverage to reach uses beyond the traditional use of the batteries. But there are good reasons to believe that they will understand the fairly benign nature of V2G use. Furthermore, it serves their long-term interest to see customers have an additional reason to own their product.

F. Affirmative Incentives

Establishing government incentives including subsidies is a more straightforward proposition than removing the systemic hurdles discussed above. Affirmative incentives are not the principal focus of this writing, but because this is an article discussing the law as it impacts the emergence of V2G, it is at least worth mentioning the two major proposals that have arisen.

As discussed above,¹³⁴ EV batteries are better positioned to respond to grid ancillary service needs than traditional gas-fired plants.¹³⁵ As valuable as this marginal speed is, until only very recently, no mechanism existed to reward it. Recognizing the reliability benefits of speed, however, in October of 2011 FERC enacted its first market reforms to reward fast-ramping technologies.¹³⁶ This and continued reforms rewarding quick reacting ancillary service providers will serve as an important incentive for V2G.

¹³² BROOKS, *supra* note 124, at 1, 2, 27–28.

¹³³ *Id.* at 17.

¹³⁴ *See supra* note 64 and accompanying text.

¹³⁵ *See supra* notes 59–61 and accompanying text.

¹³⁶ Frequency Regulation Compensation in the Organized Wholesale Power Markets, 76 Fed. Reg., 67,260, 67,260 (Oct. 31, 2011) (to be codified at 18 C.F.R. Part 35) (finding that “current compensation methods for regulation service . . . fail to acknowledge the inherently greater

Second, V2G will often benefit from legislation generically encouraging or requiring utilities to develop energy storage facilities. A good example of such legislation is California's recent AB 2514,¹³⁷ which Governor Schwarzenegger signed into law in September of 2010.¹³⁸ The bill mandates that each California utility procure "energy storage systems," or a specified threshold level of energy storage capacity.¹³⁹ The bill does not speak specifically to V2G, but nevertheless ensures a role for it. The bill defines an "energy storage system" as follows:

§ 2835. For purposes of this chapter, the following terms have the following meanings: . . .

(a)(1) "Energy storage system" means commercially available technology that is capable of absorbing energy, storing it for a period of time, and thereafter dispatching the energy. . . .

(2) An "energy storage system" may have any of the following characteristics:

(A) Be either centralized or distributed.

(B) Be either owned by a . . . local publicly owned electric utility, [or] a customer of a . . . local publicly owned electric utility . . .

(3) An "energy storage system" shall be cost effective and either reduce emissions of greenhouse gases, reduce demand for peak electrical generation, defer or substitute

amount of frequency regulation service being provided by faster-ramping resources," and requiring grid operators to amend their rules to remedy the problem); *see also* Statement of Commissioner LaFleur (Oct. 20, 2011), *available at* <http://www.ferc.gov/media/statements-speeches/lafleur/2011/10-20-11-lafleur-E-28.asp> ("I look forward to . . . following the continuing evolution of market designs which properly recognize the value of fast-ramping devices like batteries and flywheels to contribute to the grid in myriad ways.").

¹³⁷ A.B. 2514, 2009 Leg., 10th Reg. Sess. (Cal. 2010) Feb. 21, 2010, (amending CAL. PUB. RES. CODE § 2536 (West 2009) & CAL. PUB. UTIL. CODE §§ 454.3, 9615, 9620 (West 2009)), *available at* http://www.leginfo.ca.gov/pub/09-10/bill/asm/ab_2501-2550/ab_2514_bill_20100929_chaptered.html [hereinafter Cal. AB 2514].

¹³⁸ *Update: California Energy Storage Bill AB 2514 Signed Into Law by Governor, GREENTECHGRID* (Sept. 29, 2010), <http://www.greentechmedia.com/articles/read/vc-cmeas-gunderson-on-utility-scale-storage/>.

¹³⁹ Under AB 2514, the actual amount of energy storage capacity California utilities will be required to procure is the subject of a California Public Utilities Commission proceeding. The deadline for the CPUC's determination is not until 2013. *See* Cal. AB 2514 (amending CAL. PUB. RES. CODE § 2536(a)(2) (2009)).

for an investment in generation, transmission, or distribution assets, or improve the reliable operation of the electrical transmission or distribution grid.

(4) An “energy storage system” shall do one or more of the following:

(A) Use mechanical, chemical, or thermal processes to store energy that was generated at one time for use at a later time.¹⁴⁰

A V2G system fits comfortably within this definition. It would be a “distributed” source of electricity owned by a customer of a utility, within the meaning of Section 2835(a)(2);¹⁴¹ it would “improve the reliable operation of the electrical transmission or distribution grid” (by supplying ancillary services) within the meaning of Section 2835(a)(3); and it would store earlier-generated energy for use at a later time, within the meaning of Section 2835(a)(4).¹⁴²

Finally, establishing and continuing loan opportunities for V2G projects is, of course, another way to encourage commercial implementation. This controversial approach has met with mixed success in similar “smart grid” applications, for example: the American Recovery and Reinvestment Act of 2009 (“ARRA”)¹⁴³ added section 1705 to the 2005 Energy Policy Act, which focused project financing on power transmission systems.¹⁴⁴ Pursuant to the authorization in section 1705,¹⁴⁵ the Department of Energy guaranteed a \$43 million loan for Beacon Power Corporation to construct a twenty megawatt flywheel energy storage plant in New York.¹⁴⁶ The plant, which supplies frequency regulation services, entered service in January of 2011.¹⁴⁷ Although the company itself has failed, its energy storage facility continues to support the New York market.

¹⁴⁰ Cal. AB 2514.

¹⁴¹ *Id.*

¹⁴² *See id.*

¹⁴³ Pub. L. No. 111-5, 123 Stat. 115 (2009).

¹⁴⁴ *Id.* at § 406, 123 Stat. at 145 (codified at 42 U.S.C. § 16516 (2009)).

¹⁴⁵ *Id.*

¹⁴⁶ *See* Press Release, Dep’t of Energy, Department of Energy and Beacon Power Finalize \$43 Million Loan Guarantee for Innovative Energy Storage Project in New York State (Aug. 9, 2010), available at <http://energy.gov/articles/department-energy-and-beacon-power-finalize-43-million-loan-guarantee-innovative-energy>.

¹⁴⁷ *See* Press Release, Beacon Power, Beacon Power Begins Commercial Operations in New York (Jan. 24, 2011), available at <http://investors.beaconpower.com/releasedetail.cfm?ReleaseID=560475>.

CONCLUSION

The V2G idea is a source of excitement for many transportation and energy industry observers. The electrification of America's short-haul automotive fleet could bring about new opportunities for vehicle owners to derive value from their parked vehicles and for grid operators to gain access to a new energy resource. But, vehicle-to-grid cannot be implemented on a meaningful scale unless certain legal and regulatory challenges are addressed. Fortunately, several appear to be less than daunting. For instance, a V2G aggregator must comply with the regulatory requirements of an apparently receptive regulator, in the instance of tariff filings with the FERC.¹⁴⁸ Other impediments are simply manifestations of issues that can only be resolved by evolving business practices, including monopsony problems¹⁴⁹ and battery warranty issues.¹⁵⁰ In sum, despite legal and regulatory hurdles, there is cause for considerable optimism as to the prospects of V2G.

¹⁴⁸ *See supra* Part II.C.

¹⁴⁹ *See supra* Part II.A.

¹⁵⁰ *See supra* Part II.E.