The Regulatory Contract in the Marketplace

*Emily Hammond**
*David B. Spence***

For decades, energy policy has struggled to reconcile two distinct visions for the future: the first seeks ever-more-competitive, efficient, and dynamic electricity markets, while the second seeks an ever-greener mix of electricity generation sources. Caught within this push-and-pull dynamic is the regulatory contract—a nineteenth-century concept that stands more for ordered regulation than competitive markets. This Article examines how piecemeal pursuit of two energy visions has produced mismatches between rapidly evolving markets and governance institutions that cannot change as quickly. To better evaluate these mismatches, the Article develops a framework that accounts not just for market operation and environmental externalities, but also the technical constraints of grid operation and electricity fuels. Relying on the experience of nuclear power, the Article creates an account of how a fuel source can be priced out of the market despite its apparent advantages in reliability and air emissions. With this understanding, the Article evaluates the political economy and governance challenges associated with diverse policy options aimed at better capturing valuable attributes of electricity. Ultimately, this analysis furthers our understanding of the regulatory contract in the marketplace, suggesting an updated vision for its role in mediating the competing goals for electricity markets.

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* Associate Dean for Public Engagement and Professor of Law, The George Washington University Law School.

** Professor of Law, Politics & Regulation, McCombs School of Business, University of Texas, and Professor of Law, University of Texas School of Law. The authors thank Donna Attanasio, William Boyd, Ann Carlson, David Dulick, Joel Eisen, Rob Glicksman, Felix Mormann, Dick Pierce, Jim Rossi, and Dan Stenger; as well as the participants in workshops at Arizona State University, UCLA, and the University of Utah.

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INTRODUCTION

The regulatory contract is undergoing a profound reformation.[1] Once a cornerstone of progress dating at least to the Industrial Revolution, the model—under which an entity "clothed with the public interest" assumes basic duties and submits to price regulation in exchange for a monopoly franchise—has been used to build everything

1. Broadly speaking, the term "regulatory contract" refers to the body of legal rules defining the relationship between regulated industries, such as public utilities, and the state. The term is referenced in *Jersey Century Power & Light Co. v. FERC*, 810 F.2d 1168, 1188 (D.C. Cir. 1987) (Starr, J., concurring); *see also* Alfred E. Kahn, *Who Should Pay for Power Plant Duds?*, WALL ST. J., Aug. 15, 1985, at 26 ("The essential basis of public-utility regulation is an implicit bargain between consumers and investors that, in exchange for a monopoly franchise, the company accepts . . . strict legal obligations . . . ."). The term is applied broadly for such relationships in regulated industries, but our focus here is on electric utilities.

from bridges to power lines.[2] In recent years, however, competitive markets have become the norm for many formerly regulated industries, leaving vestiges of regulatory regimes that fit awkwardly with competition.[3] This is nowhere more apparent than in energy policy, particularly as it struggles to reconcile two distinct visions for the future of electricity: the first seeks ever-more-efficient and dynamic markets; the second seeks ever-greener, low-impact electricity.

Pursuit of both visions has effected significant change in how electricity is valued—and at the intersection of this push-and-pull dynamic is the regulatory contract. In many states, the model of state-regulated utilities providing monopoly electricity service to customers has been replaced by merchant generators operating on dynamic wholesale markets.[4] In those markets, the Federal Energy Regulatory Commission ("FERC") operates not so much as a rate-setting agency, but as the overseer of regionally operated markets and private wholesale bargaining.[5] In states that have embraced retail competition, state public utility commissions ("PUCs") fill a similar role. In traditionally regulated states, PUCs continue to set rates, but struggle to efficiently interface between their retail interests and those of the wholesale market.[6] Thus, the regulatory contract is no longer a straightforward arrangement between states and traditional utilities.

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2. Munn v. Illinois, 94 U.S. 113, 126 (1876) (upholding price regulation of grain elevators because they were "affected with a public interest"); *see also* Proprietors of the Charles River Bridge v. Proprietors of the Warren Bridge, 36 U.S. 420, 557 (1837) (McLean, J., concurring) (referencing contractual relationship between the government and bridge proprietors); *Jersey Cent.*, 810 F.2d at 1189 (providing a description of electric utility regulation).

3. The debate between those who favor markets and those who favor regulations undergirds many of the issues we address here. One can find tensions between the two throughout the scholarly literature, spanning decades. *See, e.g.*, Stephen Breyer, *Analyzing Regulatory Failure: Mismatches, Less Restrictive Alternatives, and Reform*, 92 HARV. L. REV. 549, 550 (1979) ("Too many arguments made in favor of government regulation assume that regulation, at least in principle, is a perfect solution to any perceived problem with the unregulated marketplace."); Ryan Bubb & Richard H. Pildes, *How Behavioral Economics Trims Its Sails and Why*, 127 HARV. L. REV. 1593, 1597–99 (2015) (illustrating that prevailing preference in behavioral law and economics for market-based approaches to market failures artificially excludes traditional regulatory tools like direct mandates); Robert E. Litan, *Evaluating and Controlling the Risks of Financial Product Deregulation*, 3 YALE J. ON REG. 1, 21 (1985) (arguing deregulated financial institutions could behave in ways that increase risk); Cass R. Sunstein, *Empirically Informed Regulation*, 78 U. CHI. L. REV. 1349, 1362–63 (2011) (describing how behavioral economics bears on the market versus regulation debate).

4. *See infra* Part I (developing the evolution of electricity markets and explaining of rise merchant generators).

5. *See, e.g.*, Energy Policy Act of 2005, 16 U.S.C. § 824(o)(b)(1) (2012) (giving FERC authority to regulate bulk power system reliability); 18 C.F.R. §§ 35, 385 (2015) [hereinafter Order 888] (requiring open access for transmission); *see also* California *ex rel.* Lockyer v. FERC, 383 F.3d 1006, 1017 (9th Cir. 2004) (upholding FERC's permitting market-based rates).

6. *See infra* Section III.B (describing relevant litigation).

Rather, multiple regulatory entities and suppliers now actively influence how electricity is bought and sold.

Along with the move toward competitive markets, efforts to encourage cleaner electricity have also had a significant impact on the electricity sector. Indeed, some of these efforts have been intertwined with the move toward competitive markets. The energy crises of the 1970s, for example, produced the Public Utilities Regulatory Policies Act of 1978 ("PURPA"),[7] a statute aimed at both incentivizing cleaner electricity and ensuring its access to the grid.[8] State renewable portfolio standards ("RPSs") and Integrated Resource Planning ("IRP") also emerged from this era, further pushing alternative electricity resources that could compete in the market against traditional sectors, particularly for fossil-fueled electricity. The Clean Air Act ("CAA"),[9] for example, now regulates more pollutants from more plants, and more stringently, than ever before.[10] The Environmental Protection Agency's ("EPA") recent actions to limit greenhouse gas ("GHG") emissions from fossil-fueled generators are just the latest steps in that process.[11]

What are the impacts of these changes? Some argue that competitive pressures will bring about a utility "death spiral;"[12]

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7. Pub. L. 95-617, 92 Stat. 3117 (Nov. 9, 1978) (codified as amended at 16 U.S.C. §§ 2601–45).

8. *See infra* Section I.B (discussing these developments).

9. Pub. L. No. 88-206, 77 Stat. 392 (1963) (codified as amended at 42 U.S.C. §§ 7401–7671q).

10. *See, e.g.*, Clean Air Act Amendments of 1990, Pub. L. 101-549, 104 Stat. 2399 (1990) (adding provisions for toxics and acid rain); Massachusetts v. EPA, 549 U.S. 497, 500–01 (2007) (holding greenhouse gases to be within CAA definition of "air pollutant"); JAMES E. MCCARTHY & CLAUDIA COPELAND, EPA'S REGULATION OF COAL-FIRED POWER: IS A "TRAIN-WRECK" COMING? 7–28 (2011), https://www.fas.org/sgp/crs/misc/R41914.pdf [http://perma.cc/6TKW-P3SX] (discussing regulations for coal-fired power).

11. *See, e.g.*, ENVIRONMENTAL PROTECTION AGENCY, CARBON POLLUTION EMISSION GUIDELINES FOR EXISTING STATIONARY SOURCES: ELECTRIC UTILITY GENERATING UNITS, 80 Fed. Reg. 64,662 (Oct. 23, 2015) (to be codified at 40 C.F.R. pt. 60), http://www.epa.gov/airquality/cpp/cpp-final-rule.pdf [http://perma.cc/5LJZ-ZFLD] [hereinafter CLEAN POWER PLAN] (establishing emission guidelines to reduce greenhouse gas emissions from existing fossil fuel-fired electric generating units); Standards of Performance for Greenhouse Gas Emissions from New Stationary Sources: Electric Utility Generating Units, 79 Fed. Reg. 1430, 1430 (proposed Jan. 8, 2014) (to be codified at 40 C.F.R. pt. 60) (proposing a new source performance standard for carbon-dioxide emissions from fossil fuel-fired electric utility generating units).

12. Liam Denning, *Lights Flicker for Utilities*, WALL ST. J. (Dec. 22, 2013), http://on.wsj.com/1zELmhT [http://perma.cc/6GJ4-B7GF] (using the term "death spiral" to describe impacts of market changes on traditional utilities); *see also* EDISON ELEC. INST., DISRUPTIVE CHALLENGES: FINANCIAL IMPLICATIONS AND STRATEGIC RESPONSES TO A CHANGING RETAIL ELECTRIC BUSINESS 3 (2013), http://www.eei.org/ourissues/finance/documents/disruptivechallenges.pdf [http://perma.cc/3XGC-A6GR] ("[A]n old-line industry with 30-year cost recovery of investment is vulnerable to cost-recovery threats from disruptive forces."). *But see* William Pentland, *Why the Utility "Death Spiral" is Dead Wrong*, FORBES (Apr. 6, 2014), http://www.forbes.com/sites/williampentland/2014/04/06/why-the-utility-death-spiral-is-dead-

environmental regulation will produce a "train wreck"[13] of inadequate generating capacity, and both forces will set grid reliability back decades.[14] Others welcome disruptive technologies and business models,[15] arguing that a green, market-based system is impossible without a complete overhaul of traditional utility law.[16] The stakes are high: electricity disruptions cost billions of dollars;[17] poorly designed markets are vulnerable to manipulation;[18] more than half a million people die each year from the health impacts of coal-fired emissions;[19] and the need to mitigate and adapt to climate change is only growing

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wrong/ [http://perma.cc/T82N-35EG] (arguing utilities' good credit ratings belie the death spiral argument).

13. *See* MCCARTHY & COPELAND, *supra* note 10, at 1–3 (summarizing the train wreck argument).

14. *See, e.g.*, STEVEN FINE ET AL., POTENTIAL IMPACTS OF ENVIRONMENTAL REGULATION ON THE U.S. GENERATION FLEET: FINAL REPORT 10–14 (2011), http://www.pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Integrated_Resource_Plan/2011IRP/EEIModelingReportFinal-28January2011.pdf [http://perma.cc/F4ZZ-AQ7A] (summarizing potential impacts for unit retirements, capacity additions, pollution control installations, and capital expenditures). *But see* SUSAN F. TIERNEY & CHARLES CICCHETTI, THE RESULTS IN CONTEXT: A PEER REVIEW OF EEL'S "POTENTIAL IMPACTS OF ENVIRONMENTAL REGULATION ON THE U.S. GENERATION FLEET" 1–4 (2011), http://ccicchetti.com/uploads/Tierney_and_Cicchetti_-_EEI_Peer_Review_-_Summary_-_May_2011-1.pdf [http://perma.cc/9LQQ-DUDB] (criticizing Fine et al., *supra*, for being based on worst-case assumptions).

15. *See, e.g.*, Joel B. Eisen, *An Open Access Distribution Tariff: Removing Barriers to Innovation on the Smart Grid*, 61 UCLA L. REV. 1712, 1716–18 (2014) (arguing for regulatory changes to enable disruptive grid technologies); Jim Rossi & Thomas Hutton, *Federal Preemption and Clean Energy Floors*, 91 N.C. L. REV. 1283, 1285 (2013) (criticizing preemptive federal law for stifling innovation).

16. Our analysis herein assumes the continuing importance of at least some central-station, grid-supplied power, at least for the next few decades.

17. U.S.-CANADA POWER SYS. OUTAGE TASK FORCE, FINAL REPORT ON THE AUGUST 14, 2003 BLACKOUT IN THE UNITED STATES AND CANADA 1 (2004), https://reports.energy.gov/ BlackoutFinal-Web.pdf [http://perma.cc/P8DC-UWWE].

18. For discussions of the manipulation of wholesale electricity markets in California, see Jacqueline Lang Weaver, *Can Energy Markets Be Trusted?: The Effect of the Rise and Fall of Enron on Energy Markets*, 4 HOUSTON BUS. & TAX L.J. 1, 41–46 (2004); and David B. Spence & Robert Prentice, *The Transformation of American Energy Markets and the Problem of Market Power*, 53 B.C. L. REV. 131, 154–64 (2012).

19. Jennifer Duggan, *China's Coal Emissions Responsible for "Quarter of a Million Premature Deaths*," THE GUARDIAN (Dec. 11, 2013), http://www.theguardian.com/environment/2013/dec/12/china-coal-emissions-smog-deaths [http://perma.cc/A3WS-CC6X]; M. Rajshekhar, *Premature Deaths Due to Emissions from Thermal Plants to Rise Two-Three Times in India*, ECON. TIMES, Dec. 9, 2014, http://articles.economictimes.indiatimes.com/2014-12-09/news/56879425_1_dioxide-india-urban-emissions [http://perma.cc/D3G4-ZJD3].

more urgent.[20] The governance challenges and implications alone are staggering, and, at this point, anything but clear.[21]

Policymakers, courts, and scholars have made important contributions to understanding each of these issues.[22] What is missing from the discussion, however, is an integrative framework—an analytical approach that permits disciplined consideration of how all of the concerns raised above work together. In this Article, we develop a tripartite framework, one that integrates: (a) the economic considerations that dominate market competition and impact the attractiveness of various fuel sources for investors;[23] (b) the technical constraints within which the grid, and its associated generation technologies, operate;[24] and (c) the negative environmental externalities associated with each fuel for electricity.[25] Implicit in our approach is the view that the market-based and environmental imperatives need not trump one another, notwithstanding the tensions

20. *See* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007 SYNTHESIS REPORT: SUMMARY FOR POLICY MAKERS 2–4 (2007), http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf [http://perma.cc/D8Q6-J3XE] (synthesizing comprehensive set of reports).

21. *See, e.g.*, ONEOK, Inc. v. Learjet, Inc., 135 S. Ct. 1591, 1595–98 (2015) (considering preemptive sweep of Natural Gas Act's provisions that are read *in pari materia* with similar Federal Power Act provisions); PPL EnergyPlus, LLC v. Solomon, 766 F.3d 241, 255 (3d Cir. 2014), *pet'ns for cert. filed sub noms.* CPV Power Dev., Inc. v. PPL EnergyPlus, LLC, 2014 WL 6737445 (U.S. Nov. 26, 2014) (No. 14-634) and Fiordaliso v. PPL EnergyPlus, LLC, 2014 WL 6998396 (U.S. Dec. 10, 2014) (No. 14-694) (holding New Jersey's effort to compensate a new generation for capacity market disparities was preempted by Federal Power Act); PPL EnergyPlus, LLC v. Nazarian, 753 F.3d 467 (4th Cir. 2014), *cert. granted sub nom.* Hughes v. PPL EnergyPlus LLC, 2015 WL 6112868 (Oct. 19, 2015) (holding a Maryland Public Service Commission order preempted under field and conflict preemption); Elec. Power Supply Ass'n v. FERC, 753 F.3d 216, 224–25 (D.C. Cir. 2014), *cert. granted*, 135 S. Ct. 2049 (May 4, 2015) (holding Order 745 invalid as beyond FERC's jurisdiction and concluding that the pricing rationale was arbitrary and capricious).

22. *See generally* William Boyd, *Public Utility and the Low-Carbon Future*, 61 UCLA L. REV. 1614, 1682–1708 (2014) (exploring the awkward fit between markets and the traditional concept of public utility, particularly as related to climate change issues); Jody Freeman & David B. Spence, *Old Statutes, New Problems*, 163 U. PA. L. REV. 1, 58–62 (2014) (surveying FERC's attempts to adapt Federal Power Act to clean energy goals); Jim Rossi, *The Electricity Deregulation Fiasco: Looking to Regulatory Federalism to Promote a Balance Between Markets and the Provision of Public Goods*, 100 MICH. L. REV. 1768, 1778–81 (2002) (exploring problem of providing public goods in markets); David B. Spence, *Can Law Manage Competitive Energy Markets*, 93 CORNELL L. REV. 765, 806–08 (2008) (describing the problem of capacity assurance in competitive markets); Richard J. Pierce, Jr., *The Past, Present, and Future of Energy Regulation*, 31 UTAH ENVTL. L. REV. 291, 296–307 (2011) (arguing that climate change mitigation is of utmost importance and providing an overview of pros and cons of various fuel-related changes); Amy Stein, Distributed Reliability (2015) (unpublished manuscript) (on file with authors).

23. We use the shorthand "cost" to refer to this part of the framework. *See infra* Section I.C.1.

24. We use the shorthand "reliability/flexibility" to refer to this part of the framework. *See infra* Section I.C.2.

25. We use the shorthand "environmental externalities" to refer to this part of the framework. *See infra* Section I.C.3.

between them. Moreover, any vision of the energy future ought to seek to maximize reliability and flexibility. Obtaining low-cost, low-impact, and reliable/flexible electricity is a tall order, but we believe that a self-conscious analysis of exactly what the trade-offs are is a prerequisite to reaching that goal.

This article examines the ways in which the move toward competition and markets is changing the balance in that tripartite framework of cost, reliability/flexibility, and environmental impacts. We illustrate these changes using the example of nuclear power. Nuclear power, once heralded as the clean energy of the future,[26] has been priced out of the market despite its apparent advantages: the absence of carbon or other emissions, its inexpensive fuel, its reliability, and its admirable safety record in the United States. Using our framework, we show how policies generated by the struggle between the environment imperative and the market imperative, as mediated by politics and risk perceptions, have led to this counterintuitive outcome. This analysis helps identify various policy options that can better reconcile the parameters of cost, environmental impact, and reliability.[27] Bringing our analysis full circle, we then construct a typology of policy options. Some of the options we present are prompted by our analysis in this Article; others are drawn from current experimentation and proposals developed in the existing literature. The examples reveal increasing heterogeneity at the subnational level. By paying careful attention to how these options fit within our tripartite framework, we can identify the mechanisms by which they would either alter the markets or alter the value of what is traded on the markets. This exercise provides insights into the practicability of each option. It also reveals future research needs—most critically, the need to consider how various proposals would complement or hinder one another if implemented simultaneously.[28]

Ultimately, this analysis also furthers our understanding of the regulatory contract in the marketplace.[29] The move to a green, competitive electricity market has not eliminated the regulatory

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26. *See infra* Section II.B (describing early optimism).

27. As described in more detail *infra* Part I, we use "reliability" as shorthand for a host of features that impact reliability, including being available when called on and having the ability to respond quickly.

28. The need is particularly strong as states grapple with the implications and uncertainties of EPA's proposed Clean Power Plan. *See infra* Section III.B (describing states' reluctance to adopt policy options in light of uncertainty regarding the Clean Power Plan).

29. This analysis may also be relevant to other traditionally regulated industries that interface with markets, such as communications. *See* Barbara van Schewick, *Network Neutrality and Quality of Service: What a Nondiscrimination Rule Should Look Like*, 67 STAN. L. REV. 1, 16–27 (2015) (providing a framework for considering future net neutrality rules).

contract; it has only changed that contract. The law continues to charge regulators with many of the same duties under competition as it did under price regulation. And holders of private capital continue to rely on those legal institutions in deciding whether to invest in the provision of electric services. But where investors were once guaranteed a fair return by regulatory fiat under the old system, they now must earn a return in a competitive electricity market. We show how these changes create new roles for all parties to the contract.

Part I of this Article begins with an overview of the shift from traditional rate regulation to competitive markets for electricity.[30] To ensure an appreciation for the technical aspects of electricity, this part provides an overview of how the electric grid is operated.[31] Next, Part I lays out our analytical framework, providing details on how three criteria—cost, reliability/flexibility, and externalities—are valued (or not) in electricity markets.[32] The final section of Part I considers the theory and practice of markets, drawing heavily from the economics literature to further contextualize our framework.

In Part II we turn to the example of nuclear power to demonstrate how a combination of regulatory pressures, risk perception mechanisms, and market flaws has prevented competitive markets from fully valuing nuclear power's desirable attributes. This includes an analysis of the "nuclear risk premium,"[33] identifying where it comes from, why it exists, and how it is that this low-emission, reliable technology is disadvantaged in competitive markets.

In Part III we explore the broader lessons to be gleaned from the nuclear example, first by delving into the political economy of modern electricity markets and the governance challenges posed by the changing regulatory contract. Next, we examine a series of policy options that address the market's failure to optimize cost, reliability/flexibility, and environmental value.[34] In so doing, we consider various objections and legal hurdles to the options and conclude with some observations about the general implications of our analysis for regulators and regulated industries. In Part IV's conclusion, we express the hope that our framework furthers the search for a principled analysis for the energy policy decisions that matter most today and that will arise in the future.

30. *See infra* Section I.A.

31. *See infra* Section I.B.

32. *See infra* Section I.C.

33. *See infra* Part II.

34. *See infra* Section III.A.

I. ELECTRICITY MARKETS AND THE GRID

The last three decades have seen dramatic change in the relationship between energy regulators and prospective investors in electricity generating plants. That change has played out in an iterative back-and-forth between market participants and policymakers.[35] It has yielded a new regulatory environment that relies increasingly on market forces to provide the capital investment that sustains the electric system and entails considerably more risk for prospective investors than their twentieth-century counterparts ever faced. In order to understand why that is, it is necessary to understand how electricity markets work, how the electric grid works, and the roles of different types of generation sources in the electric system—both historically and today. This Part takes up that task.

A. The Evolution of Modern Markets

Built on the back of a regulatory contract, the American electric grid developed to serve the relatively localized needs of investor-owned utilities ("IOUs").[36] IOUs generated most of the power they sold to their customers, and owned and operated the infrastructure over which they delivered that power. Although IOUs dominated the industry, other kinds of electric service providers—primarily municipal utilities and rural cooperatives—grew up in areas left unserved by IOUs.[37] Regardless of the type of provider, however, each was a monopoly providing service in its own geographic service area. Each service area included a set of distribution lines, served by higher-voltage transmission lines, and the grid soon grew into an enormous, interconnected set of systems of mostly alternating-current transmission and distribution lines.[38] These interconnected systems

35. *See* STEVE ISSER, ELECTRICITY RESTRUCTURING IN THE UNITED STATES: MARKETS AND POLICY FROM THE 1978 ENERGY ACT TO THE PRESENT 460 (2015) (describing this iteration as "muddling through").

36. An IOU is a privately owned, vertically integrated company providing electric service to retail customers. For summaries, see generally JILL JONNES, EMPIRES OF LIGHT: EDISON, TESLA, WESTINGHOUSE, AND THE RACE TO ELECTRIFY THE WORLD (2004) and JOHN F. WASIK, THE MERCHANT OF POWER: SAM INSULL, THOMAS EDISON, AND THE CREATION OF THE MODERN METROPOLIS (2008).

37. For description of other electricity providers, see *infra* notes 47–51 and accompanying text.

38. Generally, we use the term "transmission" to refer to the movement of electric current over longer distances at higher voltages (so-called bulk power transfers), and "distribution" to refer to the delivery of electricity at lower voltages from high-voltage transmission lines to end users. "Voltage" is a measure of the electric potential between two points and is the basis for rating transmission or distribution lines. Transmission lines typically move power at voltages exceeding

eventually came to comprise three grids in the continental United States: the Eastern Interconnection, the Western Interconnection, and the Texas Interconnection.[39] Within each of these three systems, electric current flows in the direction provided by the path of least resistance. In this way, virtually every generator of electricity is connected (however indirectly) with virtually every consumer of electricity.[40]

The amount of electricity being dispatched to the grid by generators at any given point in time must equal the amount being taken off the grid by consumers.[41] If loads are not balanced, the system will fail, causing blackouts and other problems. To keep loads in balance, the operators of the grid must marshal information about historic usage patterns, weather forecasts, generators' operational plans, and the like to estimate levels of supply and demand in the near- and longer-term future.[42] Using this information, operators have generation resources ready to dispatch power or demand-side resources ready to curtail usage, when needed.[43]

For most of the history of the American electric system, these balancing services were performed almost exclusively by IOUs, which provided monopoly service to their customers. IOUs generated most of the power they sold and supplied it over lines they owned.[44] Rate

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110 kilovolts ("kV"); some transmission lines, however, move power at voltages in excess of 1,000 kV. Distribution lines move power at less than 110 kV, typically between 4 and 34.5 kV. For a primer on these topics, see generally JACK CASAZZA & FRANK DELEA, UNDERSTANDING ELECTRIC POWER SYSTEMS (2d ed. 2010).

39. The Texas interconnection is separated from the remainder of the American grid primarily to avoid federal jurisdiction under the Federal Power Act ("FPA"). *See* David B. Spence & Darren Bush, *Why Does ERCOT Have Only One Regulator?*, *in* ELECTRICITY RESTRUCTURING: THE TEXAS STORY 9, 9 (L. Kiesling & A. Kleit eds., 2009).

40. The current is thus capable of flowing across state lines, and it is this interconnectedness that subjects most electricity transmission to federal regulation under the FPA. *See* 16 U.S.C. § 824(b) (2012) (claiming federal jurisdiction over the "transmission of electric energy in interstate commerce"); Fed. Power Comm'n v. Fla. Power & Light Co., 404 U.S. 453, 454–55, 469 (1972) (finding Federal Power Commission ("FPC") jurisdiction on this basis).

41. The North American power grid is maintained at a frequency of sixty Hertz ("Hz"). If the grid strays too far from this frequency, the system fails. CASAZZA & DELEA, *supra* note 38, at 47–48.

42. *See* Matt Davison et al., *Development of a Hybrid Model for Electrical Power Spot Prices*, 17 IEEE TRANSACTIONS ON POWER SYS. 257, 260 (2002) ("It is known that power demand is tightly linked to weather and follows predictable seasonal and diurnal patterns.").

43. *See* P. Jazayeri et al., *A Survey of Load Control Programs for Price and System Stability*, 20 IEEE TRANSACTIONS ON POWER SYS. 1504, 1504 (2005) (describing demand-side resources). Our technical description is considerably oversimplified. For more detail, see STEVE ISSER, *supra* note 35, at 121–34.

44. A sizeable minority of customers receive their electric service from government entities—municipal utilities or other governmental agencies, like the Tennessee Valley Authority—or rural

regulation protected consumers against monopoly pricing, and ensured that utilities would earn a reasonable rate of return on most of their investments in generation.[45] On those rare occasions when utilities found it necessary to buy wholesale power from a neighboring utility during times of shortage, they coordinated these transactions informally, knowing that the cost of the transaction would be recovered through rates.[46] FERC exercised ratemaking jurisdiction over wholesale power sales, and state PUCs regulated retail rates.[47]

For these reasons, merchant generators—those selling primarily into wholesale markets—were virtually unheard of prior to the late 1970s. The generation mix came to be dominated by utility-owned plants using conventional fuels—first coal, hydroelectric, and oil facilities, and later natural gas and nuclear facilities. Those same utilities controlled access to the transmission grid. The seeds of change, however, were sown earlier, with the passage of PURPA in 1978.[48] PURPA sought to diminish the barriers that IOUs posed to new entrants by requiring utilities to purchase power from so-called "qualifying facilities" ("QFs")—small power producers that used renewable fuels as well as cogeneration producers.[49] PURPA thus incentivized renewable generation, which led to the construction of hundreds of merchant wind, solar, biomass, small hydro, and gas-fired cogeneration facilities across the United States. These nonutility generators, in turn, created pressure for nondiscriminatory access to the electric grid so that they could sell their electricity directly to retailers or industrial customers.[50] In 1996, FERC promulgated Orders

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electric cooperatives. *See* JOEL B. EISEN ET AL., ENERGY, ECONOMICS, AND THE ENVIRONMENT 71–72 (4th ed. 2015) (surveying various types of service providers).

45. *Id.* at 464–500 (describing the basic principles of rate regulation); *see infra* text accompanying notes 235–45 (providing more detail on the applicable tests). For a discussion of these concepts, see Duquesne Light Co. v. Barasch, 488 U.S. 299, 307–16 (1989); Jersey Central Power & Light Co. v. Fed. Energy Regulatory Comm'n, 810 F.2d 1168, 1175–78 (D.C. Cir. 1987).

46. This informal coordination was managed through "power pools," voluntary associations of IOUs and municipal utilities established to facilitate coordination along utility boundary lines. CASAZZA & DELEA, *supra* note 38, at 56.

47. This wholesale/retail distinction still applies for purposes of jurisdictional authority. *See* 16 U.S.C. § 824(a) (2012). But note that its apparent bright line is deceptive. *See, e.g.*, sources cited *supra* note 21.

48. 16 U.S.C. §§ 2601–45 (2012).

49. A "cogeneration facility" is a facility that produces both electric energy and steam or some other form of useful energy (such as heat). 16 U.S.C. § 796(18)(A) (2012). A "small power production" facility is a facility that has a production capacity of not more than eighty megawatts and produces electric power from biomass, waste, renewable resources such as wind, water, or solar energy, or geothermal resources. 16 U.S.C. § 796(17)(A) (2012).

50. The Energy Policy Act of 1992 also created a new regulatory category of utility—Exempt Wholesale Generators ("EWGs")—which were in the business of selling electricity exclusively at wholesale and were exempt from the Public Utility Holding Companies Act ("PUHCA"), but were

888 and 889, which mandated: (a) unbundling electricity transmission from wholesale electricity sales and (b) that owners of transmission lines act as common carriers providing transmission service on a nondiscriminatory basis to affiliated and non-affiliated companies alike.[51] By separating wholesale sales from transmission services in this way and opening the transmission grid to third party (non-utility) buyers and sellers of electricity, FERC laid the groundwork for competition in wholesale electricity sales. Indeed, at the same time FERC began to authorize most wholesale sellers of electricity to charge market-based rates.[52]

Around the same time, some states began to introduce competition and market-based rates into their retail markets. States like California, Texas, and New York led the way.[53] As part of the process of opening retail markets to competition, incumbent utilities in these competitive retail markets sold most of their generation assets or spun them off into subsidiaries, further increasing the profile of independent merchant generators, marketers, and brokers within the industry.[54] Competition brought an increase in the number and volume of arms-length transactions on wholesale electricity markets and a geographic broadening of those markets, all of which strained the capacity of the transmission grid.[55] In response, FERC pushed owners

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subject to FERC jurisdiction. *See* Jeffrey D. Watkiss & Douglas W. Smith, *The Energy Policy Act of 1992—A Watershed for Competition in the Wholesale Power Market*, 10 YALE J. ON REG. 447, 464–68 (1993). The statute also authorized FERC to order transmission access under some circumstances. *See id.* at 459–64 (describing provisions).

51. Order 888, *supra* note 5; Open Access Same-Time Information System (Formerly Real-Time Information Networks) and Standards of Conduct, Order No. 889, 61 Fed. Reg. 21,737 (May 10, 1996) (codified at 18 C.F.R. pt. 37 (2015)) [hereinafter Order 889]; *see also* 16 U.S.C. § 824j-1 (2012) (providing for open access to transmission lines under some circumstances); New York v. Fed. Energy Regulatory Comm'n, 535 U.S. 1, 28 (2002) (upholding Order 888). Under Order 888, transmission providers are required to file open access transmission tariffs ("OATTs"), which must meet various criteria. *See* 18 C.F.R. § 35.28 (2015) (describing requirements).

52. *See* ISSER, *supra* note 35, at 148 (describing FERC's market-based pricing policy following Orders 888 and 889); *see also* California *ex rel.* Lockyer v. Fed. Energy Regulatory Comm'n, 383 F.3d 1006, 1011–13 (9th Cir. 2004) (upholding FERC's use of market-based rates).

53. *See* U.S. ENERGY INFO. ADMIN., THE CHANGING STRUCTURE OF THE ELECTRIC POWER INDUSTRY 2000: AN UPDATE 74–77 (2000), http://webapp1.dlib.indiana.edu/virtual_disk_library/index.cgi/4265704/FID1578/pdf/electric/056200.pdf [http://perma.cc/P9PT-CJ9A] (providing an overview of restructuring).

54. *See* ISSER, *supra* note 35, at 166 (noting the opportunity to sell power from the divested generation during this time period); *id.* at 181–84 (providing examples from Texas and California).

55. The U.S. Energy Information Administration ("EIA") tracks wholesale power transactions at individual trading hubs. At the NEPOOL hub (located in New England), there were about 1,500 trades completed in 2001, involving approximately 1.37 million megawatt-hours ("MWh") of electricity; in 2013, there were more than 6,700 trades involving 5.76 million MWh. U.S. ENERGY INFO. ADMIN., WHOLESALE ELECTRICITY AND NATURAL GAS MARKET DATA (2015), http://www.eia.gov/electricity/wholesale/#history [http://perma.cc/P437-27WZ].

of transmission lines to form "independent system operators" ("ISOs") and "regional transmission organizations" ("RTOs") to help manage the provision of transmission services and oversee wholesale power markets.[56]

Today, these ISOs/RTOs manage the day-to-day operation of wholesale power markets, schedule ancillary services (reserves necessary to balance load), and ensure there is sufficient long-term generating capacity to meet projected demand.[57] They can ensure adequate reserves in either or both of two ways. One way is by relying on the price signal to incentivize new investment, as is done in the ERCOT system in Texas.[58] A second approach is to create and manage separate capacity markets, in which owners of electricity generating facilities are paid to have capacity available in the event that it is needed in the future.[59] For example, in the PJM,[60] New England, and New York systems, the relevant ISOs run capacity markets like these.

Today, there are seven major ISOs or RTOs in the United States, managing a significant portion of the power grid.[61] In parts of the grid

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56. *See* Order 888, *supra* note 5, at § 35.28 (establishing requirements for ISOs); Regional Transmission Organizations, Order No. 2000, 65 Fed. Reg. 809, 841–911 (Jan. 6, 2000) (codified at 18 C.F.R. pt. 35.34(j)–(k) (2015)) (similar for RTOs). For purposes of this analysis, there is no meaningful distinction between ISOs and RTOs.

57. The term "reserves" refers to generating capacity that is currently unused but that is available to serve load. If that capacity is already running, so that the operator may dispatch its electricity to the grid on very short notice, it qualifies as "spinning reserves." "Regulation" services are the grid management activities that maintain frequency and voltages at their proper level, to ensure grid reliability. Willett Kempton & Jasna Tomić, *Vehicle-to-Grid Power Fundamentals: Calculating Capacity and Net Revenue*, 144 J. POWER SOURCES 268, 271 (2005).

58. THE BRATTLE GROUP, ESTIMATING THE ECONOMICALLY OPTIMAL RESERVE MARGIN IN ERCOT 1 (2014); *see also* William W. Hogan, *On an "Energy Only" Electricity Market Design for Resource Adequacy*, JFK SCH. OF GOV'T, HARV. UNIV. 34 (Sept. 23, 2005) (unpublished manuscript) (noting energy-only markets change, but do not eliminate, regulatory interventions); *infra* Section III.B.3 (describing ERCOT's approach to capacity).

59. *See* Forward Capacity Market, ISO NEW ENGLAND, http://www.iso-ne.com/markets-operations/markets/forward-capacity-market (last visited Sept. 16, 2015) [http://perma.cc/BKC8-5F8Q] (explaining capacity markets).

60. "PJM" began in 1927 as a power pool of three utilities. ISSER, *supra* note 35, at 210. It was loosely named for the three states that comprised most of its original territory: Pennsylvania, New Jersey, and Maryland. The ISO has grown well beyond those three states, but retains the name PJM. *Id.* at 123; *see also Territory Served*, PJM (last visited Aug. 14, 2015), http://www.pjm.com/about-pjm/who-we-are/territory-served.aspx [http://perma.cc/MV93-7H2N].

61. The seven are: the New England ISO (ISONE), covering the New England states; the New York ISO (NYISO); the PJM Interconnection (PJM), stretching from the Chicago area to the mid-Atlantic states; the Midcontinent ISO (MISO), stretching from Minnesota south to the south-central part of the country (excluding Texas); the Southwest Power Pool (SPP), covering portions of the plains states; the Electric Reliability Council of Texas (ERCOT); and the California ISO (CAISO). *Regional Transmission Organizations (RTO)/Independent System Operators (ISO)*, FERC (Sept. 17, 2015), http://www.ferc.gov/industries/electric/indus-act/rto.asp [http://perma.cc/R6CC-YMVY].

not so managed—mainly the southeast and the mountain west—the old system of IOU-centric markets, power pools, and traditional rate regulation prevails.

B. The Operation of Competitive Wholesale Markets

In competitive wholesale power markets, prices are determined by the forces of supply and demand rather than regulatory fiat. Prices are established in two settings: (a) longer-term bilateral power purchase agreements ("PPAs") and (b) real-time or day-ahead spot markets.[62] In the PPA setting, a generator or other wholesale seller bargains with a retailer or other buyer to reach a contractual agreement. Spot markets, by contrast, are multilateral, and the price is established through an auction—a bidding process that establishes a market-clearing price for individual time increments during the day.[63] Wholesale prices must satisfy the Federal Power Act's ("FPA") requirement that rates be just and reasonable,[64] and FERC has determined that both PPA prices and spot market prices can satisfy this standard.[65]

RTOs and ISOs not only oversee wholesale power markets; they also oversee the technical operation of the grid within their boundaries. The actual work of keeping the grid up and running is done by control area operators.[66] Despite the widespread use of PPAs, these grid operators do not take PPAs into account in their dispatch decisions. Rather, when the grid operator dispatches power from individual electric generating facilities to the grid, it does so on a least-cost basis. That is, from any status quo level of demand, as the next increment of power is needed to satisfy additional demand, the grid operator dispatches power from the available generating facility that is willing to provide the power at the lowest cost. Generally, grid operators

62. Most electricity retailers secure power using both PPAs and the spot market; in some wholesale markets all power deliveries are priced through the spot market, and PPAs serve only as a price hedging mechanism. *See* Bob Mango & John A.C. Woodley, *The Inevitable Commoditization of Electric Power Markets*, 132 FORTNIGHTLY 27, 31 (1994) (describing use of contracts as hedges for spot markets).

63. For a discussion of the operation of modern spot markets, see EISEN ET AL., *supra* note 44, at 625–726.

64. Federal Power Act (FPA) § 205, 16 U.S.C. § 824d (2012).

65. *See* Fed. Power Comm'n v. Sierra Pac. Power Co., 350 U.S. 348, 353–54 (1956) (applying the principle to power sales contracts under the FPA); United Gas Pipe Line Co. v. Mobile Gas Serv. Corp., 350 U.S. 332, 338 (1956) (applying the principle to natural gas contracts under the Natural Gas Act); *see also* California ex rel. Lockyer v. F.E.R.C., 383 F.3d 1006, 1011–13 (9th Cir. 2004) (upholding FERC's use of market-based rates).

66. ISSER, *supra* note 35, at 123 ("A control area is a geographic region with a control center responsible for operating the power system within that area.").

deviate from this priority rule only to ensure the security of the power system—to avoid severe congestion or other operational problems that could be associated with dispatching the least-cost unit. Thus, the grid operates on a "security-constrained, least-cost dispatch" or "security constrained economic dispatch" ("SCED") rule.[67] This rule protects ratepayers from paying unnecessarily high (unjust and unreasonable) rates and applies in both traditionally regulated systems and competitive wholesale markets.[68]

Ideally, competitive wholesale spot markets work in sync with the SCED principle. For each time increment during the day, sellers and buyers submit their bids indicating how much they are willing to accept and pay, respectively, for power. The RTO or ISO matches buyers' and sellers' bids and determines the market-clearing price, which all sellers will receive and all buyers will pay, for power dispatched to the system during that time increment. Sellers should bid into the market at a price that reflects their short-run marginal cost of supplying power (that is, the cost of providing one additional unit of power).[69] A large number of factors can influence the marginal cost of dispatching a particular plant at a particular time. For example, a thermal plant operating at less than full capacity will have a lower marginal cost of providing the next unit of power than it would if it had to provide the additional power from a cold start. Sometimes, the plant with the lowest marginal cost is located in the wrong place, such that dispatching power from that plant will cause transmission congestion that threatens the security of the system. Taking these and other factors into consideration, the operator may perform this market-clearing function for multiple locations (nodes) within the system, and may adjust prices to reflect congestion—so-called "nodal" pricing, or locational marginal pricing ("LMP").[70]

In theory, dispatch decisions could incorporate more than just the generator's costs. For example, social or external costs, such as estimated costs of pollution emitted by the generator, could be

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67. For a basic description of SCED, see FED. ENERGY REGULATORY COMM'N, SECURITY CONSTRAINED ECONOMIC DISPATCH: DEFINITION, PRACTICES, ISSUES AND RECOMMENDATIONS 5 (2006), http://www.ferc.gov/industries/electric/indus-act/joint-boards/final-cong-rpt.pdf [http://perma.cc/J785-DLMR].

68. *Id.*

69. *See* William W. Hogan, *Competitive Electricity Market Design: A Wholesale Primer*, JFK SCH. OF GOV'T, HARV. UNIV. 5 (Dec. 17, 1998), http://www.hks.harvard.edu/fs/whogan/empr1298.pdf [http://perma.cc/D8UG-YTNL] (describing relationship of short-run marginal costs to bidding).

70. *See* TIMOTHY J. BRENNAN ET AL., ALTERNATING CURRENTS: ELECTRICITY MARKETS AND PUBLIC POLICY 90–91 (2002) (explaining LMP).

considered as well.[71] In practice, however, no grid operator does so. Instead, the SCED principle means that public policies favoring renewable power influence dispatch decisions only indirectly, by impacting the price at which sellers will be willing to sell (and buyers to buy) power into the system at various time increments the following day. The production tax credit for renewable generators depresses the willingness-to-accept bids of qualified renewable generators, for example, by paying them approximately two cents per kilowatt-hour ("kwh") of power dispatched to the grid.[72] State renewable portfolio standards can have a similar effect on willingness-to-accept bids because sellers earn revenue from the sale of renewable energy certificates ("RECs") for each kwh dispatched to the grid.[73]

From this description it should be evident that competitive wholesale electricity markets entail much more price risk for parties on both sides of the market than traditionally regulated electricity sales. The PPA is one way to hedge that price risk. Least-cost dispatch rules may prevent the seller from delivering power to the buyer, but the sale obligation (at the contract price) remains, requiring a financial settlement between buyer and seller. Wholesale electricity market participants can also use energy derivatives to hedge risk.[74]

In sum, energy markets have undergone fairly profound changes over the last few decades, and the regulatory contract has changed along with them. Fifty years ago informal associations of IOUs kept the grid operating cooperatively, knowing that rate regulation insulated them from price risk. Now, in much of the country, those informal arrangements have been replaced by arms-length market transactions that subject the market participants to price risks. What is the role of the regulatory contract in this setting? Even where cost-of-service ratemaking remains the norm, the line between FERC's and PUCs' jurisdiction has shifted.[75] The Supremacy Clause dictates that states must permit state retailers to pass wholesale costs through to customers, and generators that sell into the wholesale markets must

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71. Indeed, economists and engineers have proposed algorithms for these kinds of "environmental/economic dispatch," or "social cost dispatch," systems. *See infra* Section III.C.

72. For most of the last three decades Congress has enacted tax credits for renewable power sources. The production tax credit has hovered around 2 cents per KWh. *See, e.g.*, 26 U.S.C. § 45 (2012) (1.5 cents/KWh).

73. *See* EPA, RENEWABLE ENERGY CERTIFICATES, http://www.epa.gov/greenpower/gpmarket/rec.htm (last visited Mar. 4, 2015) [http://perma.cc/PD2H-VFWQ] (describing renewable energy certificates).

74. *See* Spence & Prentice, *supra* note 18, at 150–54 (describing growth of energy derivatives markets).

75. The line is anything but clear. *See, e.g.*, sources cited *supra* note 21 (providing overview of litigation).

take the market price.[76] Thus we increasingly rely on spot markets to provide the best signals to investors about the optimal mix of fuel sources, storage, and demand-side resources, raising the question of whether markets can meet that challenge.[77]

C. Electric Generation: Serving Markets and the Grid

In competitive wholesale electricity markets, generators and other wholesale sellers seek to maximize revenue from the sale of power. By contrast, grid operators seek to keep the grid and wholesale power markets running smoothly and efficiently. In this Section, we evaluate the attractiveness of different electricity generation sources from the grid operator's point of view, using the tripartite framework we set forth in the Introduction: (1) cost; (2) reliability/flexibility; and (3) environmental externalities. Obtaining reliable electric service that is as inexpensive as possible requires a mix of different kinds of electricity generation—some that can operate efficiently at high outputs in order to supply base load[78] and others that can react efficiently to sudden changes in demand by ramping up and down quickly and at a reasonable cost. Moreover, fuel diversity also protects the public against the cost effects of sudden or sharp increases in the price of a particular fuel. Toward this end, state utility laws typically articulate the goal of a diverse generation mix.[79] The environmental and

76. Miss. Power & Light Co. v. Miss. *ex rel.* Moore, 487 U.S. 354, 371–72 (1988); *see* Nantahala Power & Light Co. v. Thornburg, 476 U.S. 953, 962 (1986) ("[I]nterstate power rates filed with FERC or fixed by FERC must be given binding effect by state utility commissions determining intrastate rates."). The latter point, as it relates to capacity markets, is the subject of *PPL EnergyPlus, LLC v. Solomon*, 766 F.3d 241 (3d Cir. 2014), *pet'ns for cert. filed sub noms.* CPV Power Dev., Inc. v. PPL EnergyPlus, LLC, 2014 WL 6737445 (U.S. Nov. 26, 2014) (No. 14-634) and Fiordaliso v. PPL EnergyPlus, LLC, 2014 WL 6998396 (U.S. Dec. 10, 2014) (No. 14-694); and *PPL EnergyPlus, LLC v. Nazarian*, 753 F.3d 467 (4th Cir. 2014), *cert. granted sub nom.* Hughes v. PPL EnergyPlus LLC, 2015 WL 6112868 (Oct. 19, 2015).

77. *See generally* Richard J. Pierce, Jr., *Completing the Process of Restructuring the Electricity Market*, 40 WAKE FOREST L. REV. 451 (2005) (identifying flaws that undermine these goals).

78. The term "base load" refers to the portion of demand that is relatively constant and in need of service most of the time. By contrast, "peak load" refers to higher levels of demand that exist (and must be served) for only relatively short periods of time. *See* U.S. ENERGY INFO. ADMIN., GLOSSARY, at http://www.eia.gov/tools/glossary/index.cfm [http://perma.cc/8K7U-NKE4] (providing definition of base load, peak load, and many other energy terms).

79. *See, e.g.*, DEL. CODE ANN. tit. 26, § 1007 (2015) (directing Delaware state regulators to ensure that utilities consider fuel diversity in acquiring new capacity); FLA. STAT. § 366.05 (2015) (authorizing Florida commission to require installation of particular generation sources upon finding insufficient fuel diversity in state's generation mix); *id.* § 403.519 (directing Florida Public Utilities Commission to consider need for fuel diversity and supply reliability when determining need for new power plant); N.Y. PUB. SERV. LAW § 164 (McKinney 2015) (making fuel diversity one of the evaluative criteria in New York's electric generation siting approval process).

social costs of electricity generation are not a direct component of grid dispatch and are not directly valued on the wholesale market. However, they are of concern to EPA and the states from a regulatory standpoint, which puts pressure on the electricity market structure. This in turn raises a number of important questions about the boundaries of regulators' jurisdiction (both horizontal and vertical), a point to which we return in Part III.

There are tradeoffs to be made among minimizing out-of-pocket cost to ratepayers, having a generation mix that is both reliable and flexible, and minimizing environmental externalities. Each of the major electricity generation source types—coal, natural gas, nuclear, hydro, wind, and solar[80]—bring different strengths and weaknesses to the task of serving these three goals.

1. Cost

In competitive markets, IOUs and investors jealously guard their cost data,[81] but many entities publish estimates of the relative costs associated with different electricity fuels. We begin with the "levelized cost of energy" ("LCOE"). The LCOE represents the real-dollar cost per kilowatt-hour of building and operating an electricity generation plant over the financial and operating life of the plant. Thus, it includes capital costs, fuel costs, fixed and variable operating and maintenance ("O&M") costs, and financing costs.[82] Investors care about LCOE because it represents an estimate of the average amount of money the plant owner must earn over the plant's life in order to break

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80. We focus on these six sources because the first four comprise the majority of electric generation today (92% in 2013), and because the last two, along with natural gas, comprise the majority of projected future growth in generation (more than 95%). *See What is U.S. Electricity Generation By Source*, EIA.GOV, http://www.eia.gov/tools/faqs/ faq.cfm?id=427&t=3 [http://perma.cc/7P28-NKYE] (last visited Mar. 4, 2015); *Natural Gas Solar and Wind Lead Power Plant Capacity Additions in First Half of 2014*, EIA.GOV (Sept. 9, 2014), http://www.eia.gov/todayinenergy/detail.cfm?id=17891 [http://perma.cc/R2C7-U37B]. Our consideration of solar power focuses on central station solar serving the grid, not distributed rooftop solar. Note that this list does not include non-generation resources such as energy storage, demand response, or efficiency; these resources supply energy or load reductions to the grid, respectively, but in much smaller amounts. Nevertheless, the framework we develop in this Article can be applied to these other resources as well. *See* Joel B. Eisen, *Who Regulates the Smart Grid?: FERC's Authority Over Demand Response Compensation in Wholesale Electricity Markets*, 4 SAN DIEGO J. CLIMATE & ENERGY L. 69, 93–96 (2013) (analyzing jurisdictional issues associated with demand response); *infra* Section III.A.1 (discussing FERC's approach to demand response).

81. Thus, we are unable to present figures for bid prices in the wholesale markets.

82. U.S. ENERGY INFO. ADMIN., LEVELIZED COST AND LEVELIZED AVOIDED COST OF NEW GENERATION RESOURCES IN THE ANNUAL ENERGY OUTLOOK 2015 1 (June 2015), http://www.eia.gov/forecasts/aeo/pdf/electricity_generation.pdf [hereinafter EIA LCOE ESTIMATES] [http://perma.cc/8J6M-47KY].

even on the investment.[83] These estimates are based on a large number of assumptions, and here, for illustrative purposes only, we present data from two sources—the Energy Information Administration ("EIA") and the consulting firm Lazard.[84] These estimates are for new construction[85] and generally reflect the *existing* regulatory landscape.[86] We provide more detail on the contours of that landscape in Part II, but note for now that different sources face different regulatory regimes, as well as very different assumptions about their *future* regulatory landscape.[87]

Figure 1. Levelized Cost Estimates for Generation Sources[a]

Generation Source	**EIA LCOE Estimate** 2013 $/MWh	**Lazard Estimate** 2014 $/MWh
Coal	95.1	66-151
Natural Gas – Combustion Turbine	141.5	179-230

83. Of course, there are numerous other ways to conceptualize and understand the cost of energy. *See id.* at 1–2 (discussing limitations to LCOE and alternative metrics). We use LCOE for illustrative purposes; it is widely recognized as a convenient metric. *See id.*

84. *Id.*; LAZARD, LAZARD'S LEVELIZED COST OF ENERGY ANALYSIS—VERSION 8.0 (Sept. 2014), http://www.lazard.com/media/1777/levelized_cost_of_energy_-_version_80.pdf [hereinafter LAZARD'S LCOE ESTIMATES] [http://perma.cc/4Y2J-B8A9]. Assumptions relate to plant size, plant capacity factors, cost of capital, fuel costs, and various other market conditions. Given the numerous assumptions inherent in LCOE estimates, care should be taken to understand these assumptions before comparing the figures presented in various studies. For other studies, see BLACK & VEATCH, COST AND PERFORMANCE DATA FOR POWER GENERATION TECHNOLOGIES (Feb. 2012), http://bv.com/docs/reports-studies/nrel-cost-report.pdf [http://perma.cc/KSX3-KTFC]; MASS. INST. OF TECH., THE FUTURE OF NUCLEAR POWER (2003 & 2009 update), http://web.mit.edu/nuclearpower/ [hereinafter MIT STUDY] [http://perma.cc/WU6W-3B92].

85. EIA's figures assume plants will begin operating in 2020, except for new nuclear plants not under construction, which would begin operating in 2022. EIA LCOE Estimates, *supra* note 82, at 1.

86. Subsidies for some fuel sources are calculated by EIA, but not presented here. EIA LCOE Estimates, *supra* note 82, at 3. EIA also assumed an added 3% to the cost of capital for greenhouse-gas intensive technologies, reflecting investor concerns rather than the regulatory landscape. *See id.* at 3; *see also* U.S. ENERGY INFO. ADMIN., ASSUMPTIONS TO THE ANNUAL ENERGY OUTLOOK 6 (2015), http://www.eia.gov/forecasts/aeo/assumptions/pdf/ introduction.pdf [hereinafter EIA ASSUMPTIONS] [http://perma.cc/57AF-E5FR]. Lazard assumes carbon capture technology at the high end of its coal and CCNG estimates. LAZARD'S LCOE ESTIMATES, *supra* note 84, at 2.

87. For a different calculation of LCOE that considers the impact of a carbon cost, see MIT STUDY, *supra* note 84, at 6. This study predicts that a cost of $25 per ton of carbon would make the LCOE of nuclear fall below that of coal and natural gas. *Id.*

Generation Source	**EIA LCOE Estimate** 2013 $/MWh	**Lazard Estimate** 2014 $/MWh
Natural Gas – Combined Cycle	75.2	61-87
Nuclear b	95.2	124-132
Hydroelectric	83.5	No estimate reported
Wind – onshore	73.6	37-81
Solar – Photovoltaicc	125.3	60-86
Concentrated Solar	239.7	118-130

[a]Unless otherwise noted, reported estimates assume technologies currently in use, without carbon capture. The data reflected here do not include the value of subsidies.[88]

[b]EIA assumes advanced nuclear, reflecting current new construction and the assumption that only dual-reactor plants will be built.[89] Lazard also incorporates current new construction but assumes a single-reactor plant.

[c]The reported estimates are for central station PV rather than rooftop PV.

Several observations regarding the data deserve emphasis. First, the data indicate that traditional base load sources—coal and nuclear—are significantly more expensive than combined cycle natural gas ("CCNG"), new onshore wind farms, or (according to Lazard), new central station photovoltaic ("PV") solar plants. This observation is

88. *Cf.* Felix Mormann, *Beyond Tax Credits: Smarter Tax Policy for a Cleaner, More Democratic Energy Future*, 31 YALE J. ON REG. 303, 319–23, 339–60 (2014) (assessing the efficiency of federal tax incentives for renewables and proposing other more cost-effective methods).

89. The Advanced Nuclear technology assumes the Westinghouse AP1000 reactor design, which is being installed at the Vogtle site, as described *infra* Section II.C.1. *See* U.S. ENERGY INFO. ADMIN., UPDATED CAPITAL COST ESTIMATES FOR UTILITY SCALE ELECTRICITY GENERATING PLANTS 12-1 (Apr. 2014), http://www.eia.gov/forecasts/capitalcost/pdf/updated_capcost.pdf [http://perma.cc/X5YV-FQ9U] (describing assumptions).

consistent with the relative lack of planned new construction for coal and nuclear generation, and the growth of natural gas-fired and renewable generation.[90]

Second, a closer look at the components of LCOE provides a sense of the relative capital costs of newly constructed plants. On a per-megawatt-hour ("MWh") basis, the capital costs of nuclear, wind, solar PV, and coal are quite high compared to CCNG. EIA estimates the levelized capital cost at $70.1/MWh for a new nuclear facility (74% of LCOE), $109.8/MWh (88% of LCOE) for solar PV, $57.7/MWh (78% of LCOE) for wind, and $60.4/MWh for coal (64% of LCOE).[91] By comparison, the corresponding capital cost estimate for CCNG is only $14.4/MWh (19% of LCOE).[92] Note that for nuclear, high capital costs reflect longer construction periods (and hence, higher financing costs), more specialized components, and the need for highly skilled labor, among other things.[93]

Finally, note that the LCOE data reported in Figure 1 reflect assumptions about "capacity factors," that is, the percentage of time the plants will be dispatching into the grid over their projected lifetimes. Because investors must pay the capital costs of new plants upfront, they must try to predict capacity factors over the forty-plus year life of the plant. If these facilities have higher capacity factors than assumed in the analysis, their capital costs per MWh will be lower; if the facilities have lower capacity factors, capital costs per MWh will be higher.[94] Even in traditionally regulated markets controlled by vertically-integrated IOUs, capacity factors may be difficult to predict over the life of a plant, given reliance on SCED and the possibility of drastic changes in relative fuel prices, costs imposed by new regulations, and the rise of disruptive new technologies. However, in traditionally regulated markets, investors who overestimate their facility's capacity factors often expect that they will nevertheless recover their capital costs and

90. U.S. ENERGY INFO. ADMIN., ANNUAL ENERGY OUTLOOK 2014 MT-17, EIA.GOV (Apr. 2014), http://www.eia.gov/forecasts/AEO/pdf/0383%282014%29.pdf [http://perma.cc/L4ER-WSN3] ("Natural gas-fired plants account for 73% of capacity additions from 2013 to 2040 in the Reference case, compared with 24% for renewables, 3% for nuclear, and 1% for coal.").

91. EIA LCOE ESTIMATES, *supra* note 82, at 6.

92. *Id.*

93. *See* Lucas W. Davis, *Prospects for Nuclear Power*, 26 J. ECON. PERSPS. 49, 53–54 (2012) ("Nuclear power plants are characterized by high construction costs and relatively low operating costs.").

94. Many nuclear power plants have obtained amendments to their licenses permitting uprates, meaning they can now run at higher capacities than initially permitted; others have canceled their uprate requests in light of lower capacity needs. EIA ASSUMPTIONS, *supra* note 86, at 101.

a fair rate of return.[95] This is not so in competitive wholesale markets, where the SCED rule will ultimately determine plant revenues. Further, the capacity factors for intermittent renewables like wind, solar, and some hydro are not directly comparable to the others because their generating time is not driven by grid operators, but rather by natural conditions.[96]

Another factor important to investors, and included in LCOE, is the cost of fuel. Fuel costs are a key component of fossil-fueled plant's variable O&M costs and are thus an important component of those plants' short-run marginal costs (which will form the basis of market bid prices).[97] Natural gas prices are projected to remain relatively low, due in large part to the shale gas revolution, but they represent a relatively large share of the cost of a gas-fired plant. Wind and solar generation have no fuel costs, so their variable O&M costs approach zero. Nuclear also has competitively low fuel costs (lower than coal).[98] Thus, EIA estimates the variable O&M costs of natural gas the highest ($58-94/MWh), followed by coal ($29/MWh), nuclear ($12/MWh), hydro ($7/MWh), and both wind and solar ($0/MWh).[99] Taking all of the data discussed above into consideration (not only variable O&M), it stands to reason that in competitive energy markets, the cost criterion will point investors toward new gas-fired, wind, and solar power, and away from coal-fired and nuclear power.

Remember that these cost data reflect estimates for *new* generating facilities, averaged over the useful life of the facilities. But the U.S. generation fleet includes existing generating plants that have been operating for decades and may have recovered all or a significant portion of their capital costs through regulated rates.[100] To the extent

95. There are numerous provisos, some of which are considered *infra* Section II.C.

96. EIA LCOE ESTIMATES, *supra* note 82, at 3. Even comparing generators' capital costs on the basis of nameplate capacity (that is, dollars per unit of energy the generators can produce), the upfront investment in a nuclear plant is six or seven times that of a CCNG facility, and four times that of a solar PV or wind farm. *See* LAZARD'S LCOE ESTIMATES, *supra* note 84, at 11 (depicting forecasted LCOE over time for certain forms of solar power); *see also* BLACK & VEATCH, *supra* note 84, 9–48 (comparing the costs and performance projections for these different forms of energy production).

97. The marginal operating cost will also include fixed O&M, like service on debt, and, in the case of nuclear, payments for insurance, decommissioning, and waste management. *See infra* Section II.B.

98. EIA LCOE ESTIMATES, *supra* note 82, at 6.

99. *Id.*

100. Many of the coal-fired plants projected to retire in response to new EPA regulation of mercury and greenhouse gas emissions, for example, fit this description. Retrofitting these plants with new pollution control equipment will render them noncompetitive in wholesale power markets. For a detailed discussion of this issue, see David E. Adelman & David B. Spence, Cost-

that these plants can operate after their capital costs have been paid, they can offer power to the grid at prices that are below their levelized costs. For example, consider again nuclear power's low fuel costs compared to coal; the nuclear fuel costs also differ from coal in that they do not vary with plant output over the short run.[101] Thus, the short-run marginal costs for nuclear power ought to be nearly zero.[102] There are a variety of reasons, however, that the logic of marginal cost bidding (and of the SCED rule) in competitive spot markets does not ensure that plant owners will earn a positive return on investment. First, sometimes plants with competitive bids are not dispatched due to technical grid issues. Second, even if a plant is dispatched, the plant will not earn a positive return on investment unless the average market-clearing price over time exceeds the plant's long-run *average* costs.[103] Further, public policies and market forces have depressed short-run marginal costs in the industry. The shale gas revolution has depressed natural gas prices, and hence, marginal cost-based bids from natural gas-fired generators. As described in the next section, natural gas is a peaking fuel, so its costs tend to drive the clearing price. Increasing penetration of zero-marginal-cost renewables, along with renewables subsidies, also depresses bids from those sources such that spot prices in some markets are sometimes negative.[104] An additional competitor, providers of demand-response ("DR") services, ought to further depress market prices over the long run as well.[105] Overall, these forces increase the percentage of time when market-clearing prices fall below some plants' long-run average costs.

2. Reliability/Flexibility

As noted in the Introduction, we use the term reliability/flexibility to capture the ability of the various generating

Benefit Politics in U.S. Energy Policy 30–35 (Aug. 11, 2015) (unpublished manuscript) http://ssrn.com/abstract=2642459 [http://perma.cc/JN5E-DUFY].

101. *The Economics of Nuclear Power*, WORLD NUCLEAR ASS'N, http://www.world-nuclear.org/info/Economic-Aspects/Economics-of-Nuclear-Power/ [http://perma.cc/6MV5-E9V5] (last updated Sept. 2015).

102. *Nuclear Power & Short-Run Marginal Cost*, NUCLEAR ECON. CONSULTING GRP. (Oct. 1, 2014), http://nuclear-economics.com/nuclear-power-short-run-marginal-cost/ [http://perma.cc/2VQY-75FL]. As described in detail in Part II, however, nuclear power plants built in the 1970s and 1980s struggle to remain competitive.

103. Long-run average costs reflect the total of a plant's marginal costs averaged over its lifetime. *Id.*

104. *See id.*

105. *See generally* Eisen, *supra* note 80, at 70–85 (explaining the role of DR in energy markets and debate over how DR should be compensated in those markets).

fuels to meet the technical needs of the grid.[106] In considering this criterion, it is important to understand that grid reliability is promoted by a diversity of fuels because diversity makes the overall system flexible. Some generation sources can respond quickly to changing system needs, while others excel at providing the constant power needed to serve base load. A diverse mix ensures efficient use of these attributes. Generally, existing coal-fired and nuclear plants were designed to run at full capacity for extended periods to serve base load, and they do not cycle (turn on and off) or ramp up and down as efficiently as gas-fired or hydroelectric plants.[107] For example, by forcing a coal-fired power plant to cycle more frequently (or ramp more quickly) than its design specifications suggest, the operator imposes excess wear and tear on the plant, and emits more pollution per MWh of power produced than it would by remaining within design specifications.[108] Natural gas combustion turbines, by contrast, were designed for load following: they can cycle and ramp much more efficiently and quickly than coal-fired or nuclear plants.[109]

Because of their intermittency, neither wind nor solar facilities can provide the load-following services offered by fossil-fueled plants. To the contrary, their intermittency increases the load-following burden on grid operators by adding another source of short-term variation in addition to variations in demand.[110] Wind and solar facilities vary the amount of power they supply to the grid, but because their marginal costs are so low, their power tends to be dispatched to the grid whenever they are operating. When they are not operating—the wind stops

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106. Our focus here is on generation fuels; the full spectrum of ancillary services is beyond the scope of this Article. *See* ISSER, *supra* note 35, at 127 (describing ancillary services, which include frequency regulation, spinning reserves, and nonspinning reserves). Non-generation resources can also provide reliability value, and are discussed further *infra* Section III.C.

107. *See* MIT ENERGY INITIATIVE, MANAGING LARGE-SCALE PENETRATION OF INTERMITTENT RENEWABLES 26–27 (Apr. 20, 2011), http://mitei.mit.edu/system/files/intermittent-renewables-full.pdf [http://perma.cc/N5G7-UEK9] (describing cycling and ramping). The only hydroelectric plants that can follow load are those operated in storage mode. Many such plants, however, operate in run-of-the-river mode, meaning that the amount of water passing through the turbines is equal to the amount of flow entering the reservoir from upstream; this is done to keep the reservoir at a constant level. *See* EISEN ET AL., *supra* note 44, at 345–93 (setting forth legal regime for hydropower).

108. J. Nicolas Puga, *The Importance of Combined Cycle Generating Plants in Integrating Large Levels of Wind Power Generation*, ELEC. J., Aug.–Sept. 2010, at 33, 37 (2010).

109. New CCNG turbines can also ramp relatively quickly compared to other sources. *See generally* BLACK & VEATCH, *supra* note 84, at 9–48 (listing ramp rates and "quick start" rates for various generation technologies); MIT ENERGY INITIATIVE, *supra* note 107, at 11, 27 (providing various ramping rates and noting that ramping a nuclear plant quickly requires more operator involvement, increasing the risk of operator error).

110. *See* MIT ENERGY INITIATIVE, *supra* note 107, at 18–21 (describing system impacts of intermittent generation).

blowing or the sun stops shining for example—grid operators must call on other resources to balance loads.[111]

Because reliability/flexibility is dependent on a mix of generation characteristics, it is also sensitive to the availability and cost of fuel. Like coal, uranium is relatively inexpensive and worldwide reserves are considered substantial.[112] Moreover, both coal-fired and nuclear power plants have storage capacity: coal can be stockpiled onsite, and nuclear fuel assemblies last about eighteen months to two years. This capacity hedges the risk of supply interruptions, further enhancing these sources' reliability for electricity generation. The history of natural gas-fired power is different. Historically, natural gas prices were relatively high and volatile, reflecting both periodic insecurity about domestic supply and the relative lack of storage capacity on the interstate pipeline system.[113] The shale gas revolution, however, now holds the prospect of price stability and ample domestic supply for the future.[114] But natural gas-fired power plants are still dependent on the interstate and local pipeline systems through which they acquire their fuel; fuel is typically not stored on site, and many gas-fired plants rely on interruptible gas service for their fuel supply.[115]

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111. For this reason, many have argued that natural gas pairs well with intermittent renewables because of its load-following capabilities. *See, e.g.*, Puga, *supra* note 108, at 37. Demand-side resources also have a role to play in this regard. Eisen, *supra* note 80, at 79–80.

112. Davis, *supra* note 93, at 58–59. Also like coal, uranium is available domestically. However, currently only about 17% of uranium delivered in the United States is of U.S. origin. U.S. ENERGY INFO. ADMIN., 2013 URANIUM MARKETING ANNUAL REPORT 1 (2014), http://www.eia.gov/uranium/marketing/pdf/2013umar.pdf [http://perma.cc/2PR5-CPVF]. More than half the enrichment, however, takes place in the United States. *Id.* at 2. The Nuclear Energy Institute reports that efforts are underway to revitalize the U.S. uranium production industry. *Nuclear Fuel Supply: Abundant Supplies of Uranium*, NUCLEAR ENERGY INSTITUTE, http://www.nei.org/Issues-Policy/Nuclear-Fuel-Supply (last visited Sept. 11, 2015) [http://perma.cc/4M29-38XQ].

113. In the 1970s the country faced a severe natural gas shortage, triggering forms of rationing. Subsequent price deregulation triggered production increases. *See* Richard J. Pierce, Jr., *The Evolution of Natural Gas Regulatory Policy*, NAT. RESOURCES & ENV'T, Summer 1995, at 53, 53–54, 84. However, by the end of the twentieth century analysts were anticipating the need to import LNG to serve domestic demand, and the Energy Policy Act of 2005 included provisions intended to incentivize terminal construction. 15 U.S.C. § 717b (2012).

114. *See* Don Mason, *Report Predicts 20 Years of Stable Natural Gas Prices*, FUEL FIX (Jan. 16, 2014), http://fuelfix.com/blog/2014/01/16/report-predicts-20-years-of-stable-natural-gas-prices/ [http://perma.cc/3VBD-K52U] (crediting shale gas revolution for projections of price stability).

115. *See* Communication of Operational Information Between Natural Gas Pipelines and Electric Transmission Operators, 78 Fed. Reg. 70,164, 70,165 (Nov. 22, 2013) (codified at 38 C.F.R. pt. 38 (2015)) (permitting natural gas and electric transmission operators to share non-public information to facilitate reliability and integrity for interconnected systems). *See also* Coordination of the Scheduling Processes of Interstate Natural Gas Pipelines and Public Utilities, 151 FERC ¶ 61,049 (Apr. 16, 2015) (addressing disparate scheduling issues for natural gas and electricity sectors); FED. ENERGY REG. COMMM'N, WINTER 2013–2014 OPERATIONS AND MARKET PERFORMANCE IN RTOS AND ISOS 8 (Apr. 1, 2014), http://www.ferc.gov/legal/staff-reports/2014/04-

Of course, for wind, solar, and hydro plants, their "fuels" are produced locally and essentially free of charge. Rather, the primary threat to reliability for these technologies is weather-induced intermittency—the possibility that the sun won't shine, the wind won't blow, or river flows will be too low. For that reason, EIA classifies these three technologies as "non-dispatchable," meaning that they cannot be counted on to deliver power when needed the way fossil-fueled and nuclear plants can.[116] Moreover, we can make a distinction between the predictability of power from these sources and its variability. Wind power, in particular, can be variable in ways that affect generation output. Forecasters may be able to predict *that* the blades of the wind turbine will be turning one hour from now; however, it may be difficult to predict exactly *how fast* they will be turning (and therefore, how much power the turbine will be generating). Proponents of wind and solar power argue that a suite of geographically distributed wind and solar power plants could be counted on to serve a specified level of load reliably because the sun won't stop shining, or the wind stop blowing, everywhere at the same time.[117]

3. Environmental Externalities

All electric generation technologies produce negative environmental externalities—harm to health, safety, and the environment over their full life cycle.[118] Extracting coal, natural gas, uranium, and silicon (or other minerals used in manufacturing PV cells) creates safety hazards for workers as well as air, water, and soil pollution. Manufacturing power plant components and PV cells, not to mention the construction of generating facilities themselves, entails additional risks. Fossil-fueled, nuclear, and concentrated solar power all use large amounts of water. Fossil-fueled combustion discharges pollutants into the air, produces water effluent, and, in the case of coal combustion, generates solid wastes (such as coal ash). Hydroelectric facilities interrupt fish migration routes, flood land, change water chemistry, and interrupt scenic vistas, as do wind farms. The list goes on.

01-14.pdf [http://perma.cc/D6PX-FCDD] (concluding significant electric generator outages occurred during polar vortex, often related to gas curtailments, lack of fuel diversity, and frozen coal).

116. *See* EIA LCOE ESTIMATES, *supra* note 82, at 6 tbl.1.

117. *See e.g.*, MICHAEL MILLIGAN & RORY ARTIG, RELIABILITY BENEFITS OF DISPERSED WIND RESOURCE DEVELOPMENT 2, 9 (1998).

118. For a source-by-source overview of these externalities and the regulatory regimes governing them, see generally EISEN ET AL., *supra* note 44.

Here, we explore the externalities of electricity *generation* that produce the most salient and direct harms to human health and the environment.[119] Of course, many of these harms are better conceived of as risks, characterized by a predicted magnitude of harm multiplied by the probability that the harm will occur.[120] Researchers can thus conduct risk assessments of the adverse health impacts resulting from the air emissions associated with fossil fuel combustion or characterize the water quality risks associated with the discharge of heat in effluent from thermal power plants. There is often a gap between risk as assessed mathematically and risk as perceived by stakeholders—a topic we examine in more detail in Part II.

First, it is well established that air emissions from fossil-fueled combustion entail significant risks to health and the environment. Coal combustion, in particular, emits carbon dioxide (CO_2, the most common greenhouse gas), and nitrogen oxides (NO_x, precursors of both acid rain and ground-level ozone (smog)); so does natural gas, though in smaller amounts.[121] In addition, coal combustion is a major source of emissions of: (a) sulfur dioxide (SO_2, a precursor of acid rain), (b) particulate matter (PM, an inhalation hazard), and (c) mercury (Hg, ingestion of which poses a risk to neurological development).[122] Methane—the primary component of natural gas—is itself a greenhouse gas far more potent than CO_2.[123] Indeed, even though coal combustion emits twice the carbon dioxide of natural gas combustion, there is an ongoing scientific debate over whether coal-fired or natural gas-fired power produces more GHG emissions over its full life cycle.[124] Natural gas, however, produces a tiny fraction of the deadly PM emitted by coal combustion. Of course, EPA regulates all of these emissions to at least

119. We so limit our analysis with some hesitation. The externalities associated with fuel extraction (coal, natural gas, uranium, and silicon) and hydropower development are considerable. *See* NAT'L RESEARCH COUNCIL OF THE NAT'L ACAD., HIDDEN COSTS OF ENERGY 64–153 (2010) (providing analysis of electricity fuels); James Conca, *How Deadly is Your Kilowatt? We Rank the Killer Energy Sources*, FORBES (June 10, 2012), http://www.forbes.com/sites/jamesconca/2012/06/10/energys-deathprint-a-price-always-paid/ [http://perma.cc/DQZ5-9K6S] (considering entire fuel cycle).

120. *See infra* Section II.B. (describing differences between risk assessment, risk perception, and risk management).

121. Natural gas-combustion produces half the CO_2 emissions of coal combustion and "a small fraction" of the NOx emissions. EISEN ET AL., *supra* note 44, at 258.

122. Natural gas combustion produces "a small fraction" of the amounts of SO_2 and PM produced by coal combustion, and no mercury emissions. *Id.*

123. Ramon A. Alvarez et al., *Greater Focus Needed on Methane Leakage from Natural Gas Infrastructure*, 109 PROCEEDINGS OF THE NAT'L ACAD. OF SCI. 6435, 6435 (2012).

124. *See generally id.* (summarizing these issues).

some extent under the Clean Air Act,[125] though its GHG emissions regulation is neither finally determined nor fully implemented.[126]

Second, coal-fired and nuclear power production entail particularly thorny waste disposal issues. For coal-fired power, the problem is coal combustion residuals, a high-volume waste[127] commonly called fly ash,[128] and the storage of which has resulted in several high-profile spills of toxic ash into rivers over the last decade.[129] These accidents triggered an EPA decision to regulate coal ash storage and disposal under the Resource Conservation and Recovery Act ("RCRA").[130] For nuclear power the problem is spent fuel and other radioactive wastes. These include low-level wastes, which are produced in relatively high volumes but which pose less danger to human health and the environment, and high-level wastes, especially the used nuclear fuel itself, which are currently being stored across the country in spent fuel pools or canisters.[131] Both are highly regulated, but continue to perpetuate decades-long political and legal conflicts.[132]

125. Clean Air Act, 42 U.S.C. § 7401 (2012) (regulating PM, NOx and SO_2 as conventional pollutants). For a description of that regulatory scheme, see David B. Spence & Emily Hammond, *Electric Power Generation Fuels*, *in* GLOBAL CLIMATE CHANGE AND U.S. LAW (Jody Freeman & Michael Gerrard eds., 2d ed. 2014). EPA just recently began to regulate mercury emissions from coal-fired plants; however, those regulations were held arbitrary and capricious in Michigan v. EPA, 135 S. Ct. 2699, 2712 (2015).

126. *See* Freeman & Spence, *supra* note 22, at 28–42 (2014) (summarizing EPA's efforts).

127. *See* AM. COAL ASH ASS'N, 2012 COAL COMBUSTION PRODUCT (CCP) PRODUCTION & USE SURVEY REPORT, http://www.acaa-usa.org/Portals/9/Files/PDFs/revisedFINAL2012CCPSurveyReport.pdf [http://perma.cc/5NC6-TK9H] (showing that in 2012, coal-fired power plants in the United States generated over 109 million tons of CCRs).

128. Spence & Hammond, *supra* note 125, at 472–73 (explaining that when coal is burned for electricity generation, it creates both "fly ash"—the PM that is collected in pollution control equipment under the CAA—and "bottom ash"—the heavier ashes that are too heavy to be airborne and that are collected through the bottom of coal furnaces. It can contain a variety of heavy metals like lead, arsenic, and chromium).

129. *See, e.g.*, Cape Fear River Watch, Inc. v. Duke Energy Progress, Inc., 25 F. Supp. 3d 798, 812 (E.D.N.C. 2014) (granting in part and denying in part Duke Energy's motion to dismiss CWA complaint involving coal ash spill); *see also* Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals From Electric Utilities, 75 Fed. Reg. 35128, 35146–48 (June 21, 2010) (describing additional catastrophic spills). For EPA's final rule, *see* Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals from Electric Utilities, 80 Fed. Reg. 21302 (Dec. 19, 2014).

130. Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals From Electric Utilities, 75 Fed. Reg. 35,128 (June 31, 2010); *see* Scott Judy, *Duke Energy Fined $102M for Clean Water Act Violations*, ENG'R. NEWS-REC., May 14, 2015, http://enr.construction.com/infrastructure/environment/2015/0514-duke-energy-fined-102m-for-clean-water-act-violations.asp [http://perma.cc/7FGL-2L3Z] (describing settlement with Department of Justice for CWA crimes and showing that the CWA also provides a means for enforcement).

131. *See* Spence & Hammond, *supra* note 125, at 486–87.

132. *See* Low-Level Radioactive Waste Policy Amendments Act of 1985, 42 U.S.C. § 2021c (2012); New York v. United States, 505 U.S. 144, 188 (1992) (invalidating portions of the Act on Tenth Amendment grounds). Emily Hammond Meazell, *Presidential Control, Expertise, and the*

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As is evident from the discussion above, the three attributes in our framework—cost, reliability/flexibility, and environmental externalities—are not uniformly distributed amongst the fuel sources for electricity. We turn now to a diagnostic account of the theory and practice of markets and regulation. This discussion helps situate the interaction of our three attributes within the economic literature, and also suggests reasons why the electricity markets have difficulty minimizing cost and environmental externalities while also maximizing reliability/flexibility.

D. Markets: Theory and Practice

The under-supply of sufficiently reliable and green power is a frequent lament in energy policy circles. Economic theory tells us that a well-functioning competitive market will maximize social net benefits, thereby providing society with a generation mix that balances cost, reliability/flexibility, and environmental attributes[133] in a way that maximizes our collective utility.[134] According to that view, regulation ought to be aimed at getting prices "right" and otherwise creating conditions that mimic textbook competition.[135] An alternative view places less faith in the ability of markets to produce socially optimal outcomes and insists on a role for government intervention in markets to correct certain kinds of market failures.[136]

In particular, many economists prescribe getting prices right as the solution to electric reliability problems. More specifically, some economists worry that in competitive wholesale markets, prices based

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Deference Dilemma, 61 DUKE L.J. 1763, 1764–810 (2012) (summarizing the history of high-level waste policy in the United States) [hereinafter Hammond, *Deference Dilemma*]; *see also* Nuclear Waste Policy Act of 1982, 42 U.S.C. §§ 10101–270 (2012) (designating Yucca Mountain as geologic repository for high-level waste); In re Aiken County, 725 F.3d 255, 261–67 (D.C. Cir. 2013) (mandating that NRC continue with licensing process for Yucca Mountain).

133. We use the term "attributes" here because a perfect market would not produce externalities, which are a form of market failure.

134. More specifically, such a market will produce a distribution of goods that is Pareto optimal, in that no other distribution of goods can make one or more members better off without making one or more members worse off. *See* GEORGE C. HOMANS & CHARLES CURTIS, JR., AN INTRODUCTION TO PARETO 277–81 (1934).

135. *See generally* LYNN KEISLING DEREGULATION, INNOVATION, AND MARKET LIBERALIZATION: ELECTRICITY RESTRUCTURING IN A CONSTANTLY EVOLVING ENVIRONMENT (2008) (conceptualizing electricity markets as complex adaptive systems in which price signals will stimulate innovation and create value).

136. *See, e.g.*, Boyd, *supra* note 22, at 1620 (conceptualizing the electricity markets as a "common, collective enterprise of building and elaborating the institutions, regulatory structures, and business models that will be necessary to realize a low-carbon future").

on marginal costs will not attract sufficient investment in new capacity—referred to as the "missing money" problem.[137] The reason that money is "missing," they say, is because consumers are insulated from the movement of wholesale prices by fixed-price retail contracts or tariffs, and because many wholesale markets operate under price caps imposed by regulators.[138] In the economist's perfect world, all users (including residential, commercial, and industrial consumers) would be equipped with smart meters enabling both wholesale and retail power prices to fluctuate freely in real time (so-called "dynamic pricing"), thereby allowing both supply and demand to respond to price changes. Temporary price spikes would induce immediate demand reductions, and ultimately, lower prices; if not, sustained high prices would provide a sufficient reward for investment in adequate generation resources, ensuring reliability.[139]

Even where smart meters enable retailers to offer dynamic pricing, full implementation has remained elusive, notwithstanding that numerous pilot studies have demonstrated its benefits.[140] Many consumers seem to prefer the security of fixed-price contracts, fearing downside risks and failing to appreciate the possibility of saving money in the long run.[141] This same loss aversion dynamic may influence prospective investors in power plants even more powerfully, not only for behavioral reasons[142] but for logical reasons as well. Economists describe the problem as one of "asset specificity." In a competitive market, when a firm's assets are constructed at a particular location for a particular purpose, that firm faces the risk that its contractual counterparties (those from whom it buys or to whom it sells) will act opportunistically, taking advantage of the firm's lack of alternative

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137. Peter Cramton & Steven Stoft, The Convergence of Market Designs for Adequate Generating Capacity: A White Paper for the California Electricity Oversight Board 8–11 (Apr. 25, 2006), http://works.bepress.com/cramton/34/ [http://perma.cc/7RFS-RPZH] (describing the missing money problem).

138. *See id.* (providing examples); Pierce, *supra* note 77, at 468–77 (canvassing state restructuring experiences).

139. *See* Hogan, *supra* note 58, at 6–8 (explaining idealized energy-only model).

140. *See, e.g.*, Ahmad Faruqui & Jennifer Palmer, *Dynamic Pricing and Its Discontents*, 34 REGULATION 16 (2011).

141. *See* Antoine Bechara et al., *The Role of the Amygdala in Decision-Making*, 985 ANN. N.Y. ACAD. SCI. 356, 389–99 (2003) (supporting the notion that the fear of loss invokes the emotional part of the brain, leading people to pay to avoid downside risk); Antoine Bechara et al., *Deciding Advantageously Before Knowing the Advantageous Strategy*, 275 SCI. 1293, 1294 (1997) (same).

142. We can distinguish loss aversion from risk aversion. *See* JAMES MONTIER, BEHAVIOURAL INVESTING: A PRACTITIONERS GUIDE TO APPLYING BEHAVIOURAL FINANCE 447–52 (2007) (explaining the behavioral psychology risk aversion literature and its impacts on investment decisions).

options to "hold up" the firm on price.[143] Power plants are characterized by asset specificity: they are often capital intensive, geographically immobile investments.[144] In these situations, it might be inaccurate to assume that arms-length transactions in the market will produce more efficient outcomes than would vertical integration.[145] One might therefore expect risk-averse investors to be more reluctant to invest in power plants in competitive electricity markets and for this dynamic to be particularly strong for especially long-lived investments with especially large up-front costs, such as nuclear (and to a lesser extent, coal-fired) power plants. Indeed, energy consultants contend that this dynamic is accelerating the reduction in fuel diversity, exacerbating grid reliability problems.[146] A future grid consisting mostly of gas-fired and renewable power (the only technologies experiencing growth) poses reliability challenges for grid operators. Integrating intermittent sources like wind and solar on a larger scale makes grid balancing more difficult. Gas-fired plants can back up wind because they can ramp efficiently, but they face their own reliability challenges: they cannot store fuel on site, are at the mercy of pipelines for supply, and natural gas prices have tended to be more volatile than fuel prices for any other generation source. In sum, the combination of incentives posed by the markets as they currently operate may decrease reliability over time.

Markets also struggle with pricing externalities, and the economics literature on environmental externalities has long recognized pollution as a kind of market (or pricing) failure. That literature goes back to Arthur C. Pigou[147] and generally endorses pollution taxation as the most efficient way to internalize environmental externalities, with marketable permits as a second-best

143. Paul L. Joskow, *Asset Specificity and the Structure of Vertical Relationships: Empirical Evidence*, *in* THE NATURE OF THE FIRM: THE ORIGINS, EVOLUTION, AND DEVELOPMENT 121–22 (Oliver E. Williamson & Sidney G. Winter eds., 1991); Benjamin Klein et al., *Vertical Integration, Appropriable Rents, and the Competitive Contracting Process*, 21 J.L. & ECON. 297, 297–325 (1978) (noting the particular trouble that asset specificity poses for spot markets).

144. Arguably, increased transmission capabilities would assuage this immobility somewhat.

145. Joskow, *supra* note 143, at 123–25 (noting that asset specificity was the norm in the electricity industry, Joskow argued prior to restructuring that reliance on anonymous spot market transactions to supply electricity is likely to fail "because the sinking of relationship-specific investments transforms a large numbers bargaining situation into a small numbers bargaining situation ex post," creating opportunities for buyers or sellers to extract rents from the other and a consequent disincentive to invest in capacity).

146. *The Value of US Power Supply Diversity*, www.IHS.COM (last visited Oct. 14, 2015), https://www.ihs.com/info/0714/power-diversity-special-report.html [http://perma.cc/9QG2-64XH].

147. ARTHUR C. PIGOU, THE ECONOMICS OF WELFARE 185–226 (AMS Press 1978) (1920). Pigou is commonly credited with providing the first argument in favor of pollution taxes to force polluters to internalize pollution costs they would otherwise shift to society.

alternative.[148] The Coase Theorem challenged the Pigovian prescription by arguing that governments are unlikely to get taxation levels right; instead it posits that if property rights are assigned to conflicting parties, they will negotiate an outcome more likely to maximize social benefits.[149] Others have been skeptical of market solutions; Garrett Hardin's famous "tragedy of the commons" analysis offered government regulation as the solution to such problems.[150]

In practice, American policymakers have historically eschewed market incentives as well as private litigation for resolving pollution problems.[151] Instead, prescriptive and proscriptive rules have been the norm—what most economists refer to somewhat derisively as command-and-control regulation. Most of the CAA's approach to regulating emissions from electricity generation falls into this category, as does the Nuclear Regulatory Commission's ("NRC") licensing regime for nuclear power plants.[152] The seemingly intractable difficulty of environmental law is that these pollutant- and industry-specific regimes represent ad hoc responses to the externality problem, producing neither socially optimal pollution levels nor a level playing field among generators competing in wholesale electricity markets. For example, various studies reveal coal combustion to produce negative social net benefits, imposing large mortality, morbidity, and environmental costs on society from non-GHG air pollutants alone.[153] One study estimated such costs at $53 billion per year, compared to less

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148. *See, e.g.*, WILLIAM J. BAUMOL & WALLACE E. OATES, THE THEORY OF ENVIRONMENTAL POLICY 134–52 (2d ed., Cambridge Univ. Press 1988); DAVID W. PEARCE & R. KERRY TURNER, THE ECONOMICS OF NATURAL RESOURCES 110–17 (1990); PIGOU, *supra* note 147, at 185–89 (addressing the problem of smoke produced by factory chimneys in England in the early twentieth century); *id.* at 187 n.2. Within EPA, economists have championed the case of market-based regulation since the early 1970s. Larry E. Ruff, *The Economic Common Sense of Pollution,* 19 PUB. INTEREST 69, 70–78 (1970).

149. *See generally* Ronald H. Coase, *The Problem of Social Cost,* 3 J.L. & ECON. 1 (1960) (basing the conclusion on some stylized assumptions, including that the transaction costs of negotiating were zero).

150. Garrett Hardin, *The Tragedy of the Commons,* 162 SCI. 1243, 1247 (1968); *see also* Coase, *supra* note 149, at 18 (noting unrealistic nature of assumption that transaction costs of bargaining to a solution are zero, and that it "is normally the case [that] a large number of people are involved and in which therefore the costs of handling the problem through the market or the firm may be high").

151. The major exceptions are the acid rain program enacted by Congress in 1990, which employs a marketable permit regime to effect reduction in sulfur dioxide emissions, and the use of renewable energy credits in many state RPS programs. *See* EISEN ET AL., *supra* note 44, ch. 5.

152. *See infra* Section II.A.

153. *E.g.*, Nicholas Z. Muller et al., *Environmental Accounting for Pollution in the United States Economy*, 101 AM. ECON. REV. 1649, 1669–70 (2011); *see also* sources cited *supra* note 119 (comparing life-cycle costs of various fuels).

than $1 billion per year for natural gas.[154] Thus, numerous sources argue that the regulated levels of air emissions permitted by the CAA for coal-fired power are too high.[155] Nuclear and renewables, of course, emit none of those same pollutants.[156]

In sum, the last few decades have seen both increasing reliance on markets and competition in public utility regulation and stricter environmental regulation of energy production facilities. These changes have taken place in a piecemeal, incremental manner, with little attention to how they interact.[157] As a result, the regulatory contract has been transformed; in the markets, short-run marginal cost has been elevated at the expense of reliability/flexibility and environmental attributes.[158] This transformation has produced numerous dysfunctions. The story of nuclear power provides a cogent example of how and why that is.

II. NUCLEAR POWER IN THE MARKETPLACE

As set forth in Part I, nuclear power is a low-carbon, highly reliable base load technology. Although it has limited ramping capability and high capital costs, its environmental and reliability attributes, combined with its relatively low short-run variable costs, suggest that it ought to be able to compete on all three components of our tripartite framework—costs, reliability/flexibility, and environmental externalities. Yet some plants are struggling to stay competitive in wholesale markets, and there has been little new construction activity. In this Part, we examine more closely the federal nuclear regulatory regime and its interaction with modern electricity

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154. Muller et al., *supra* note 153, at 1669.

155. *Id.* at 1672; *see also* Paul R. Epstein, et al., *Full Cost Accounting for the Life Cycle of Coal*, 1219 ANN. N.Y. ACAD. SCI. 73, 93 (2011) (positing that if coal's externalities were internalized, the price of electricity from that source would double or triple); Melissa Fry Konty & Jason Bailey, *The Impact of Coal on the Kentucky State Budget,* MTN. ASS'N FOR CMTY. ECON. DEV., http://www.maced.org/coal/documents/Impact_of_Coal-Exec_Summary.pdf [http://perma.cc/3XEF-VWF6] (last visited Oct. 14, 2015) (concluding net benefits of coal were negative); Press Release, National Academy of Sciences, Report Examines Hidden Health and Environmental Costs of Energy Production and Consumption in U.S. (Oct. 19, 2009), http://www.usclimatenetwork.org/resource-database/NAS%20study%20on%20costs%20of%20energy.pdf [http://perma.cc/LMS7-3PTU] (estimating annual non-climate related external damages from 406 coal-fired power plants to be $62 million, or about 3.2 cents per KWh).

156. Muller et al., *supra* note 153, at 1669.

157. ISSER, *supra* note 43, at 462–63; *see also* William W. Buzbee, *Recognizing the Regulatory Commons: A Theory of Regulatory Gaps*, 89 IOWA L. REV. 1, 22–27 (2003) (theorizing regulatory gaps that develop resulting from numerous regulators sharing jurisdiction over regulatory spheres and the resulting failure to remedy social ills).

158. As we shall explain *infra* Part III, the transformation of the regulatory contract is not limited to power generators operating in wholesale markets.

markets. We then develop an account of the nuclear risk premium and show how it relates to the story of nuclear power both historically and today by influencing the competitiveness of nuclear power. Although nuclear power provides a stark example, it assists in our development of a concrete narrative that shows how the regulatory contract is increasingly strained in the marketplace.

A. Federal Nuclear Power Regulation

As a high-capital cost, low-fuel cost, dependable source of electricity, nuclear power is similar to coal-fired power, the other traditional base load source of electricity. However, nuclear power produces far fewer externalities than coal-fired power. Indeed, the existing nuclear regulatory regime has minimized such externalities far more effectively than environmental regulation has for nuclear power's base load competitors.[159] Congress and the nuclear agencies developed this regulatory regime, however, against the implicit assumption that the traditional regulatory contract would make this regime economically feasible.

Beginning in 1946, Congress gave the Atomic Energy Commission ("AEC") "decisive control" over the entire field of nuclear energy.[160] This authority included both military and civilian nuclear energy, a lineage that even today contributes to negative risk

159. *See* sources cited *supra* note 119. For purposes of this section, we focus primarily on externalities associated only with electricity generation and describe the regulatory scheme unique to nuclear power. Some externalities associated with nuclear power are regulated under the same regime as those associated with other thermal generation. For example, both nuclear power and fossil-fueled generation must comply with the Clean Water Act's (CWA's) intake water and point-source discharge requirements. EPA National Pollutant Discharge Elimination System, 40 C.F.R. §§ 122, 125 (2015). Air emissions for nuclear power plants, however, are handled under the NRC licensing regime, while those of fossil-fueled plants are subject to the CAA. *See* Richard Goldsmith, *Nuclear Power Meets the 101st Congress, A "One-Act" Comedy: Regulation of Nuclear Regulatory Commission Licensees Under the Clean Air Act*, 12 VA. ENVTL. L.J. 103, 104–17 (1992) (providing general overview of the history of relevant regulations). Although new and proposed CAA regulations seek to reduce air-emission externalities of fossil-fueled power generation, those externalities persist and are not present for nuclear generation. *See* Muller et al., *supra* note 153, at 1669 (implying that nuclear energy was omitted from analysis because it does not emit the pollutants in question). Finally, some states require siting approval for all new generation, including environmental assessments and certificates of public convenience and necessity. EDISON ELEC. INST., STATE GENERATION AND TRANSMISSION SITING DIRECTORY (Oct. 2013), http://www.eei.org/issuesandpolicy/transmission/Documents/State_Generation_Transmission_Siting_Directory.pdf [http://perma.cc/K9ZN-3QDZ].

160. H.R. REP. NO. 80-1973, at 3 (1948); *see also* Edward H. Levi, *The Atomic Energy Act: An Analysis*, BULL. OF ATOMIC SCIS., Sept. 1, 1946, at 18 (describing AEC's "complete domination over atomic energy development in this country"). *See generally* Dean C. Dunlavey, *Government Regulation of Atomic Industry*, 105 U. PA. L. REV. 295 (1957) (providing a comprehensive, contemporaneous review of AEA of 1954).

perceptions of nuclear power and mistrust of AEC's successor agency, the NRC.[161] Intent on emphasizing civilian nuclear power development, Congress shifted AEC's mandate in 1954, and the agency's primary policy mission became facilitating the emergence of the entire civilian nuclear power industry.[162] Most of the American fleet of commercial reactors commenced construction in the 1960s and 70s, a period in which the cold-war threat of nuclear annihilation loomed in the public consciousness. As described above, this was also a period in which cost-of-service ratemaking encouraged capital investment in generation and transmission.[163]

The Atomic Energy Act ("AEA") vests responsibility with NRC for licensing nuclear power plants and ensuring their "adequate safety."[164] The licensing process is thorough, strict, and resource-intensive; it comprises site selection, design, and construction and operating phases.[165] Applicants must perform environmental reviews as required by the National Environmental Policy Act ("NEPA")[166] and various generic rules NRC has issued over the years.[167] Applicants must either be regulated public utilities or satisfy stringent financial qualifications to engage in the proposed activities,[168] and at the

161. *See, e.g.*, TERRENCE R. FEHNER & F.G. GOSLING, DEP'T OF ENERGY, ATMOSPHERIC NUCLEAR WEAPONS TESTING, 1951-1963, at 109–10 (2006), http://energy.gov/sites/prod/files/DOENTSAtmospheric.pdf [http://perma.cc/AP3R-TVTH] (describing thousands of dead sheep and other concerns about fallout from above-ground testing); Hammond, *supra* note 132, at 1780–81 (describing concerns about AEC that motivated creation of NRC).

162. Atomic Energy Act of 1954, ch. 1073, 68 Stat. 921 (current version at 42 U.S.C. §§ 2011–2297h-13 (2006 & Supp. 2009)); *see* Hammond, *supra* note 132, at 1780 (describing the history and structure of AEC).

163. *See* Harvey Averch & Leland L. Johnson, *Behavior of the Firm Under Regulatory Constraint*, 52 AM. ECON. REV. 1052, 1062 (1962) (arguing that a cost-of-service approach leads to overinvestment in capital); *see also* Leon Courville, *Regulation and Efficiency in the Electric Utility Industry*, 5 BELL J. ECON. & MGMT. SCI. 53, 72–73 (1974) (demonstrating this effect for power plants). *But see* W. Davis Dechert, *Has the Averch-Johnson Effect Been Theoretically Justified?*, 8 J. ECON. DYNAMICS & CONTROL 1, 16 (1984) (suggesting regulated firms under-invest in capital compared to unregulated firms).

164. 42 U.S.C. §§ 2131, 2232 (2012).

165. A prospective licensee may choose one of two procedural paths for obtaining the necessary licenses. The traditional path is set forth in 10 C.F.R. § 50 (2015); the newer path is set forth at *id.* § 52. *See* EISEN ET AL., *supra* note 44, at ch. 7; *see also* Nuclear Info. Res. Serv. v. NRC, 969 F.2d 1169, 1170 (D.C. Cir. 1992) (en banc) (upholding part 52 licensing scheme).

166. *See* 10 C.F.R. § 51.20 (2015) (listing types of actions requiring EIS under NRC's NEPA implementing regulations).

167. *See* Balt. Gas & Elec. Co. v. NRDC, 462 U.S. 87, 101 (1983) (noting "administrative efficiency and consistency of decision" are benefits of such generic rules).

168. On the history of the financial qualifications requirement, see Emily Hammond Meazell, *Deference and Dialogue in Administrative Law*, 111 COLUM. L. REV. 1722, 1760–63 (2011) [hereinafter Hammond, *Dialogue*]; *see also* Coal. for the Env't v. NRC, 795 F.2d 168, 170–73 (D.C. Cir. 1986) (detailing agency and court actions over time).

beginning of operations they must provide "reasonable assurances" that funds will be available for the plant's eventual decommissioning—which typically involves creating a trust fund.[169] In addition, operators must obtain the maximum amount of liability insurance that can be purchased on the market.[170] Finally, operators must pay for waste management, typically storing it onsite. Until 2013, licensees made payments to the Department of Energy (DOE) pursuant to the Nuclear Waste Policy Act in anticipation of sending spent fuel and other high-level radioactive wastes to a deep geological disposal site in Yucca Mountain, Nevada.[171] After development of Yucca Mountain stalled, the D.C. Circuit ordered DOE to stop collecting these funds,[172] but operators are nevertheless responsible for the costs of managing spent fuel onsite during operation and after decommissioning.[173]

The process imposes other costs on applicants and licensees that are not apparent from the outset. First, as plants age and licenses are renewed, replacement parts and upgrades will be needed. Second, during the lifetime of a license, NRC retains authority to modify or revoke the license if necessary to ensure adequate protection.[174] Moreover, NRC may not consider costs when determining what constitutes adequate protection.[175] Thus, NRC may unilaterally modify or add to existing licensed facilities' requirements (known as "backfitting")[176] in order to assure adequate protection without a cost-

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169. 10 C.F.R. § 50.75 (2015); *see* Pennington v. ZionSolutions LLC, 742 F.3d 715, 716–17 (7th Cir. 2014).

170. *See* The Price-Anderson Nuclear Industries Indemnity Act, 42 U.S.C. § 2210 (2012). If a nuclear accident occurs, this primary insurance provides the cap on nuclear power plant liability; taxpayers bear any excess. *Id.* § 2210(4)(A). The Act creates a fund that is administered by modifying the traditional the civil justice system in the event of an accident. *See* Duke Power Co. v. Carolina Envtl. Study Grp., 438 U.S. 59, 59–61 (1978) (upholding Price-Anderson Act against constitutional challenges).

171. Nuclear Waste Policy Act of 1982, 42 U.S.C. § 10101–270 (2012).

172. Nat'l Ass'n of Regulatory Util. Comm'rs v. DOE, 736 F.3d 517, 521 (D.C. Cir. 2013).

173. For an overview of these costs, see U.S. GOV'T ACCOUNTABILITY OFF., GAO-15-141, SPENT NUCLEAR FUEL MANAGEMENT: OUTREACH NEEDED TO HELP GAIN PUBLIC ACCEPTANCE FOR FEDERAL ACTIVITIES THAT ADDRESS LIABILITY app. V (2014) (showing capital costs in tens of millions and annual operating costs at $100,000 to $300,000 for operating sites and $2.5 million to $6.5 million at shutdown reactor sites).

174. 42 U.S.C. § 2232(a) (2012); *see* Carstens v. NRC, 742 F.2d 1546, 1557 (D.C. Cir. 1984) (emphasizing standard does not require zero risk); *see also* Nader v. Ray, 363 F. Supp. 946, 954 (D.D.C. 1973) (rejecting "complete," "entire," or "perfect" assurance of safety).

175. *See* Union of Concerned Scientists. v. NRC (*Concerned Scientists I*), 824 F.2d 108, 114 (D.C. Cir. 1987) ("In setting or enforcing the standard of "adequate protection" that this section requires, the Commission may not consider the economic costs of safety measures.").

176. 10 C.F.R. § 50.109 (2015).

benefit analysis.[177] Thus, even after licenses are granted and operators have internalized the costs described above, operators remain open to costly, unpredictable modification requirements for the lifetime of their licenses.[178] For example, following Fukushima, NRC considered a potential backfit modification estimated by the agency to require $15–30 million per reactor unit; industry argued the cost would be as much as twice that amount.[179] The possibility of added costs introduces an important element of risk into nuclear investments.

When one considers the many costs associated with siting, constructing, operating, and decommissioning a nuclear power plant, one can see why the levelized costs for nuclear are so high.[180] Simply stated, nuclear regulation requires owners of nuclear power plants to internalize more of their externalities than other sources of generation. Waste products, as discussed above, provide an example. Coal's CCRs contain a variety of heavy metals but are not regulated as hazardous wastes under RCRA.[181] As explained in Part I, CCRs are generated at a pace of more than one hundred million tons per year, and poor disposal practices have caused several catastrophic incidents.[182] Spent nuclear fuel, on the other hand, must be contained in extraordinarily robust fuel pools or dry casks that are regulated under the same defense-in-depth principles underlying nuclear generation facilities

177. If NRC determines that a particular course of action will lead to substantial enhancements beyond adequate protection, however, it will engage in a cost-benefit analysis. Union of Concerned Scientists. v. NRC (*Concerned Scientists II*), 880 F.2d 552, 556–57 (D.C. Cir. 1989) (upholding two-pronged approach to backfitting). NRC issued several backfit orders in response to lessons learned from the Fukushima disaster. *E.g.*, Order Modifying Licenses With Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events, NRC EA-12-049 (Mar. 12, 2012) (making adequate protection finding); *see also* Order to Modify Licenses With Regard to Reliable Hardened Containment Vents Capable of Operation Under Severe Accident Conditions, NRC EA-13-109 (June 6, 2013) (making substantial enhancements finding). *See generally* Emily Hammond, *Nuclear Power, Risk, and Retroactivity*, 48 VAND. J. TRANSNAT'L L. 1059 (2015) (evaluating NRC response to Fukushima and implications of backfitting rules).

178. This possibility was a source of concern early in the AEA's history. *See* Dunlavey, *supra* note 160, at 331 ("Most of these powers over the licensee provide no compensation to him for interrupting his business.").

179. U.S. GOV'T ACCOUNTABILITY OFF., GAO-15-98, NRC NEEDS TO IMPROVE ITS COST ESTIMATES BY INCORPORATING MORE BEST PRACTICES 3 (Dec. 2014). After industry complaints, the GAO was asked to investigate and report on NRC's cost estimate methods generally, and this particular estimate specifically. The GAO concluded that the cost estimate "is not reliable because it did not fully or substantially meet any of the four characteristics of a reliable cost estimate." *Id.* at 15.

180. *See supra* Section I.C.1.

181. Instead, EPA has chosen the lighter-handed regulation it reserves for solid (non-hazardous) wastes. *See* Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals from Electric Utilities, 40 C.F.R. § 257, 261 (2014).

182. *See supra* Section I.C.3.

themselves; this approach has an extremely impressive safety record.[183] And as described above, for years operators have also paid into the Nuclear Waste Fund for ultimate disposal of spent nuclear fuel.

Decommissioning provides another example. Nuclear power operators must uniformly pay in advance for decommissioning costs that may occur more than sixty years in the future.[184] By contrast, the experience of fossil-fueled and renewable power varies by state. In some states, generators seek permission to recover costs of decommissioning only once the decision to close a plant has been made.[185] Others require that bonds be posted at some date near the end of the expected life of the project; for example, the Oklahoma Wind Energy Development Act requires owners of wind energy facilities to provide evidence of financial security to cover decommissioning costs after the fifteenth year of operation.[186] In these and other ways, nuclear power internalizes costs that other sources of generation frequently do not. In the next section, we explore why that is.

B. The Nuclear Power Risk Premium

Because of their complexity and size, nuclear plants would be expensive in any event.[187] However, we hypothesize that nuclear power's price tag is higher than would be economically efficient because

183. *See* Continued Storage of Spent Nuclear Fuel, 10 C.F.R. § 51 (2014) (finding reasonable assurances of the safety of long-term spent fuel storage); *id.* (presenting table showing no noticeable predicted environmental impacts associated with short- or long-term storage, in nearly every category considered); *see, e.g.*, U.S. NUCLEAR REG. COMMISSION, NUREG-2157, GENERIC ENVIRONMENTAL IMPACT STATEMENT FOR CONTINUED STORAGE OF SPENT NUCLEAR FUEL app. E, at E-24 (2014) (presenting seven known incidents of spent fuel pool leaks and noting no releases have affected health of public).

184. *See supra* text accompanying note 169.

185. *E.g.*, *In re* the Application of Consumers Energy Co. for a Fin. Order Approving the Securitization of Qualified Costs, Case No. U-17473 (Mich. Pub. Serv. Comm'n Sept. 9, 2013) (seeking authority to issue bonds to pay for decommissioning of three coal-fired power plants); *id.* Op. & Order (Dec. 6, 2013) (granting in part and denying in part).

186. *See* Oklahoma Wind Energy Development Act of 2011, OKLA. STAT. tit. 17 § 160.14 (2012) (requiring decommissioning); *id.* § 160.15 (allowing evidence of financial security in the form of a bond, parent guaranty, or letter of credit). *But see* Paul Monies, *Oklahoma Corporation Commission Ends Wind Inquiry, Calls for Rules on Decommissioning of Turbines*, THE OKLAHOMAN (Dec. 2, 2014), http://newsok.com/article/5372275 [http://perma.cc/LBK3-JNMS] (stating that no rules have been promulgated under decommissioning provisions of statute; none of the state's wind farms has yet sought decommissioning).

187. As should be evident, our discussion here refers to commercial reactors currently in operation or under construction. Small modular reactors (SMRs) and other fourth-generation reactors hold promise, but they are not currently commercially viable. *Cf. infra* Section III.C.1 (discussing potential regulatory initiatives to speed SMR entry into the marketplace).

it includes what we refer to as a "nuclear risk premium."[188] Economists have provided estimates of the increased costs facing new nuclear construction stemming from uncertainty about the regulatory landscape, construction timetables, and future prices of competing energy fuels like natural gas.[189] In addition, risk perception operates as an explanatory variable for understanding not only those increased costs but also the robust licensing scheme described above. Scholars have documented that risk perception mechanisms can lead to inefficient levels of regulation.[190] This sort of inefficiency is present in the nuclear power regime, further undermining its cost competitiveness in the wholesale market.

First, we note that risk theory incorporates three distinct concepts: assessment, perception, and mitigation. Risk assessment—sometimes called engineering risk—is a methodology leading to an understanding of the probability that a hazard will manifest and the magnitude of the expected harm.[191] NRC uses probabilistic risk assessment (PRA) to evaluate risks associated with nuclear reactors.[192] For example, its first study of this nature was issued in 1975 and considered accident risks based on the frequency of initiating events and their expected consequences.[193] Following the Three Mile Island ("TMI") accident, NRC began developing and applying increasingly

188. As used in economic assessments of nuclear power, the "nuclear risk premium" refers to the cost of uncertainty and relates to investor reluctance to invest in more nuclear power given regulatory, construction, and fuel mix uncertainties. *See* MIT STUDY (2009 update), *supra* note 84, at 8 (outlining the difficulties of eliminating the "risk premium"). Our usage is slightly different in that it incorporates risk perception as an additional explanatory variable.

189. *Id.*

190. STEPHEN BREYER, BREAKING THE VICIOUS CIRCLE: TOWARD EFFECTIVE RISK REGULATION 3–29 (1993) (arguing that various defects lead to irrational regulation); CASS R. SUNSTEIN, LAWS OF FEAR: BEYOND THE PRECAUTIONARY PRINCIPLE 69 (2005) ("[R]egulators may end up engaging in extensive regulation precisely because intensive emotional reactions are making people relatively insensitive to the (low) probably that dangers will ever come to fruition.").

191. *See* Stanley Kaplan & B. John Garrick, *On the Quantitative Definition of Risk*, 1 RISK ANALYSIS 11, 11–27 (1981) (setting forth quantitative definition of risk); Elisabeth Paté-Cornell, *Risk and Uncertainty Analysis in Government Safety Decisions*, 22 RISK ANALYSIS 633, 635–36 (2002) (providing examples of probabilistic risk analysis). Notwithstanding the quantitative engineering methodologies that underlie risk assessment, the verbal formulation described above it familiar to legal jurisprudence, as demonstrated most famously by the Hand Formula. *See* United States v. Carroll Towing Co., 159 F.2d 169, 173 (2d Cir. 1947) (expressing risk assessment algebraically).

192. *See* NRC FACT SHEET, PROBABILISTIC RISK ASSESSMENT (Oct. 2007), http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/probabilistic-risk-asses.html [http://perma.cc/4X8S-2USW] (explaining that probabilistic risk assessment seeks to quantify discrete risks as well as how those risks interact in a complex system).

193. NRC, REACTOR SAFETY STUDY: AN ASSESSMENT OF ACCIDENT RISKS IN U.S. COMMERCIAL NUCLEAR POWER PLANTS, NUREG-75/014 (WASH-1400) (Oct. 1975), http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr75-014/ [http://perma.cc/R7RR-8XGA].

rigorous methods of risk assessment and explicitly committed to quantitative risk assessment methods.[194] NRC's Part 52 licensing procedures require applicants to perform a PRA and provide supporting analyses for design certifications and combined licenses.[195]

Risk mitigation—reducing the magnitude or likelihood of an anticipated hazard—is a fundamental goal of the licensing regime.[196] NRC's risk mitigation philosophy is captured in the term "defense-in-depth," a notion that encompasses redundancy and contingency planning[197] and implies multiple layers of preventative, mitigation, and emergency preparedness measures.[198] More specifically, nuclear reactors are designed and constructed using particular assumptions about the types of hazards that must be mitigated. This analysis uses the concepts of "design-basis events" and "beyond-design-basis events."[199] The design-basis concept requires facilities to be designed with safety systems in place to address both anticipated operational events and accidents.[200] For example, seismic risks and flooding are

194. *See* NRC, THREE MILE ISLAND: A REPORT TO THE COMMISSIONERS AND TO THE PUBLIC, NUREG/CR-1250, 147-52 (1980), http://www.threemileisland.org/downloads/354.pdf [http://perma.cc/ZT8H-PB46] (the "Rogovin Report") (addressing "increased use of quantitative risk assessment techniques").

195. *E.g.*, 10 C.F.R. §§ 52.47(23), 79(48) (2015).

196. This discussion focuses on the design and construction aspects of mitigating nuclear safety risks. However, these technological risk mitigation techniques are only part of the range of risk mitigation approaches relevant to this sector. Insurance, for example, is also considered a risk mitigation measure. *See generally* Hank Jenkins-Smith & Howard Kunreuther, *Mitigation and Benefits Measures as Policy Tools for Siting Potentially Hazardous Facilities: Determinants of Effectiveness and Appropriateness*, 21 RISK ANALYSIS 2 (2001) (providing additional examples); Paul Kleindorfer & Howard Kunreuther, *The Complimentary Roles of Mitigation and Insurance in Managing Catastrophic Risks*, 19 RISK ANALYSIS 727 (1999) (discussing cushions and insurance).

197. NRC, MITIGATION OF BEYOND-DESIGN BASIS EVENTS 3, http://www.nrc.gov/reactors/operating/ops-experience/japan-dashboard/emergency-procedures.html [http://perma.cc/AZE4-KY9V] [hereinafter NRC, MITIGATION] (collecting sources) (last visited Oct. 14, 2015); NRC, GLOSSARY: DEFENSE IN DEPTH, http://www.nrc.gov/reading-rm/basic-ref/glossary/defense-in-depth.html [http://perma.cc/Q6U8-APWJ].

198. NRC, MITIGATION, *supra* note 197, at 25. But as NRC's post-Fukushima Near-Term Task Force for Lessons Learned (NTTF) determined, the defense-in-depth and PRA approach are not efficiently combined in NRC's regulatory scheme. *See* NRC, NEAR-TERM TASK FORCE, RECOMMENDATIONS FOR ENHANCING REACTOR SAFETY IN THE 21ST CENTURY: THE NEAR-TERM TASK FORCE REVIEW OF INSIGHTS FROM THE FUKUSHIMA DAI-ICHI ACCIDENT 21 (July 12, 2001), http://pbadupws.nrc.gov/docs/ML1118/ML111861807.pdf [http://perma.cc/67BX-LPLV] [hereinafter NTTF Report] (discussing the benefits of a more organized framework for defense-in-depth application). Indeed, a major component of the NTTF's recommendations was to completely overhaul the regulatory framework to combine risk assessment and defense-in-depth "more formally." *Id.*; *see also id.* at 22 ("The Task Force recommends establishing a logical, systematic, and coherent regulatory framework for adequate protection that appropriately balances defense-in-depth and risk considerations.").

199. *Id.* at 15.

200. *Id.*

two hazards contemplated by the design basis.[201] Second, beyond-design-basis events are informally equated with safety enhancements—that is, requirements beyond adequate protection that would be mandated only if their benefits outweighed their costs.[202] As new information is gleaned, NRC can use backfit orders to require risk mitigation updates, prompting the regulatory uncertainty described above.[203]

Risk perception, the final component of risk theory, is our focus here. Risk perception deals with the many mechanisms by which the human brain perceives, understands, predicts, and responds to risk. Risk theory suggests a strong likelihood that perception imposes disproportionate costs on nuclear power in relation to other electricity fuel sources. One of the most straightforward ways to understand this disproportionality is by reference to research developing the "psychometric paradigm."[204] The psychometric paradigm uses statistical techniques to organize risk perceptions according to two variables.[205] The first is the extent to which a risk is dreaded—that is, "catastrophic, hard to prevent, fatal, inequitable, threatening to future generations, not easily reduced, increasing, involuntary and [personally] threatening."[206] The second variable relates to the familiarity of a risk—that is, its "observability, knowledge, immediacy of consequences, and familiarity."[207] Nuclear technology—power, waste disposal, and uranium mining—features prominently among the high-

201. *Id.*

202. *Id.*

203. *E.g.*, Hammond *supra* note 177 (describing rulemaking and backfitting orders following Fukushima); NTTF Report, *supra* note 198, at 16–17 (describing backfitting following the September 11, 2001 terrorist attacks and the TMI accident).

204. Note that a variety of risk perception mechanisms provide insights into nuclear power; we highlight the psychometric paradigm for its demonstrative usefulness. One of the most important alternative accounts for risk perception generally is cultural cognition theory ("CCT"), which attempts to account for variations among individuals by grouping them into cultural worldviews. For example, France is far more accepting of nuclear power than the United States. Paul Slovic et al., *Nuclear Power and the Public: A Comparative Study of Risk Perceptions in France and the United States*, *in* CROSS-CULTURAL RISK PERCEPTION: A SURVEY OF EMPIRICAL STUDIES 55, 57 (2000). The French, however, are more likely to hold hierarchical worldviews than individualistic Americans. *Id.* Thus, they are both more accepting of the risks associated with nuclear power, and more comfortable with the ability of elite experts to manage those risks. *Id.* at 87–90, 93–94, 98; *see also* MARY DOUGLAS & AARON WILDAVSKY, RISK AND CULTURE: AN ESSAY ON THE SELECTION OF TECHNICAL AND ENVIRONMENTAL DANGERS 1–15 (1982) (presenting early work on cultural theory). Other risk perception mechanisms relevant to low-probability, high-consequence risks like nuclear power are collected in SUNSTEIN, *supra* note 190 (describing the availability heuristic, probability neglect, loss aversion, system neglect, and affect, among others).

205. Paul Slovic, *Perception of Risk*, 236 SCIENCE 280, 281–82 (1987).

206. Paul Slovic et al., *Facts and Fears: Understanding Perceived Risk*, *in* SOCIETAL RISK ASSESSMENT: HOW SAFE IS SAFE ENOUGH? 181, 199 (1980).

207. *Id.*

dread, low-familiarity risks.[208] By contrast, examples of low-dread, high-familiarity risks are bicycles, shock from electric appliances, recreational boating, chainsaws, and trampolines.[209]

The higher a risk scores on the "dread" axis, the more people tend to want strict regulation in hopes of reducing that risk.[210] And indeed, the nuclear licensing scheme is one of the strictest in the United States,[211] in terms of both the substantive requirements for adequate protection and the procedural requirements associated with obtaining licenses. The substantive requirements are addressed above, but the procedural requirements are worth emphasizing here. Consider the famous *Vermont Yankee* decision,[212] which was borne of public opposition to nuclear power and the D.C. Circuit's concern that agencies were not taking seriously the public protection mandates of their organic statutes.[213] Imposing stricter procedures on agencies was viewed by some as an appropriate way for courts to police what they perceived to be inadequate risk regulation.[214] *Vermont Yankee* clamped down on courts' use of this method,[215] but those who oppose nuclear power (and other dread risks) are motivated to persistently seek more formalized procedures, which generally take more time than less formal

208. Slovic, *supra* note 205, at 282.

209. *Id.*

210. *Id.* at 283.

211. Similarly strict and detailed schemes are targeted at other dread risks, such as chemical weapons incineration. *See generally* Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction, Jan. 13, 1993, 1974 U.N.T.S. 316 (1993); Chem. Weapons Working Grp., Inc. v. U.S. Dep't of the Army, 111 F.3d 1485, 1487–89 (10th Cir. 1997) (describing the Army's implementing process); Final Programmatic Environmental Impact Statement and Record of Decision, 53 Fed. Reg. 5816 (Feb. 26, 1988) (Army's environmental impact statement for incineration); *see also* Federal Food, Drugs, and Cosmetics Act, 21 U.S.C §§ 348(f), 355(c)(1)(b) (2012) (discussing formal hearing procedures concerning the regulation of unsafe food additives and new drugs).

212. Vermont Yankee Nuclear Power Corp. v. Nat. Res. Def. Council, Inc., 435 U.S. 519 (1978).

213. This history is recounted in Emily Hammond Meazell, *Super Deference, the Science Obsession, and Judicial Review as Translation of Agency Science*, 109 MICH. L. REV. 733, 758–59 (2011).

214. This use of procedure dates at least to the origins of the APA. *See* Martin Shapiro, *APA: Past, Present, & Future*, 72 VA. L. REV. 447, 453 (1986) (describing the quasi-legislative and quasi-adjudicative functions of agencies under the APA); Sidney A. Shapiro, *A Delegation Theory of the APA*, 10 ADMIN. L.J. AM. U. 89, 98 (1996) (explaining that adoption of the APA "signaled that broad delegations of power and combined functions would be tolerated as long as they were checked by more extensive procedures"); *see also* McNollgast [Matthew D. McCubbins, Roger G. Noll & Barry R. Weingast], *The Political Origins of the Administrative Procedure Act*, 15 J.L. ECON. & ORG. 180, 181 (1999) ("By reducing administrative discretion, formal procedures create transaction costs that increase the time and resources needed to change policy.").

215. *But see* Jack Beermann & Gary Lawson, *Reprocessing* Vermont Yankee, 75 GEO. WASH. L. REV. 856, 858–59 (2007) (collecting literature arguing courts continue to impose unwarranted obligations on agencies).

approaches, notwithstanding that the existing procedures are already highly formalized and costly.[216]

In addition to attracting substantively and procedurally complex regulatory schemes, dread risks are also particularly susceptible to "punctuating events," that is, spectacular, high-profile, low-probability events that are processed by the brain as representative of the risks posed by a technology generally.[217] After Three Mile Island and Chernobyl, no new nuclear reactors were constructed in the United States for over thirty years, and worldwide construction likewise sharply declined. The safety questions and backfitting orders raised by these events contributed to the notorious construction delays for plants in progress. Finally, public opposition to nuclear power grew significantly, contributing to regulatory delays and a lack of political support for the technology. To be clear, we note that punctuating events can highlight needed and appropriate changes.[218] But they can also prompt knee-jerk responses from elected officials, regulators, and the public that contribute to overregulation and regulatory uncertainty.[219] With longstanding and strong opposition finding fresh motivation with each punctuating event, agency and industry plans in these areas tend to encounter "extensive delay and escalating costs that have been widely regarded as attributable to public opposition."[220]

This form of cost uncertainty is extraordinarily difficult to quantify,[221] but it is certainly present for nuclear power. Of course,

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216. *See* Citizens Awareness Network, Inc. v. United States, 391 F.3d 338, 343 (1st Cir. 2004). Other features of regulatory design, such as redundancy and complexity, likely also relate to risk perceptions, but a full account is beyond the scope of this paper. *See* Jason Marisam, *Duplicative Delegations*, 63 ADMIN. L. REV. 181, 224 (2011) ("[B]ureaucratic redundancies are most often worthwhile when the redundant agency provides a significant benefit by safeguarding against high-magnitude harm.").

217. For an overview of such issues, see generally Paul Slovic, RISK, MEDIA AND STIGMA: UNDERSTANDING PUBLIC CHALLENGES TO MODERN SCIENCE AND TECHNOLOGY (James Flynn & Howard Kunreuther eds., 2001); *see also* Slovic, *supra* note 205, at 283–84 (describing enormous costs TMI imposed on society in terms of stricter regulation and increased opposition to nuclear power, despite that it caused relatively little actual harm).

218. Sea-Coast Anti-Pollution League v. Nuclear Regulatory Comm'n, 690 F.2d 1025, 1028 (1st Cir. 1982) (describing how Three Mile Island illustrated need for emergency planning for areas around nuclear power plants). *See generally* NTTF Report, *supra* note 198 (describing recommendations in response to Fukushima).

219. SUNSTEIN, *supra* note 190, at 206; Slovic, *supra* note 205, at 283–84.

220. Judith Bradbury & Steve Rayner, *Reconciling the Irreconcilable*, *in* UNITED NATIONS ENVIRONMENT PROGRAMME, IMPLEMENTING SUSTAINABLE DEVELOPMENT: INTEGRATED ASSESSMENT AND PARTICIPATORY DECISION-MAKING PROCESSES 15, 22 (Hussein Abaza & Andrea Baranzini eds., 2002).

221. For a study measuring risk perception's impact on home values near nuclear shipping routes, see Kishore Gawande & Hank Jenkins-Smith, *Nuclear Waste Transport and Residential Property Values: Estimating the Effects of Perceived Risks*, 42 J. ENVTL. ECON. & MGMT. 207 (2001); *cf.* Santa Fe v. Komis, 845 P.2d 753, 755–62 (N.M. 1992) (permitting additional compensation in

perceived risks do encompass some actual risks, which ought to be and are mitigated by the robust licensing scheme described above. In addition, some of the byproducts of dread serve other functions. Heightened agency procedures, for example, are a response to actual public concern and in that way serve important ideals that are at the core of government legitimacy.[222] What this discussion of risk perception illustrates, however, is that because nuclear power has unique risk perception attributes, it bears costs that other fuel sources do not bear. To some extent, this means that nuclear power most fully internalizes its costs. But it is also means that the role of risk perception cannot be ignored in considering how different electricity fuel sources and markets interact.

C. A Dynamic Account of the Nuclear Risk Premium

In its first decades of existence, commercial nuclear power went from "too cheap to meter" to uncompetitive on today's wholesale markets.[223] The nuclear risk premium is part of the reason why, but it is also important to understand the historical context in which the risk premium arose. Nuclear power plants in operation today were constructed on the assumption that electricity demand would skyrocket,[224] during a period when natural gas-fueled electricity generation was banned due to shortages,[225] oil prices were escalating, and national security was a prominent concern.[226] The traditional

takings case for lost value associated with perceived risk of property located on nuclear waste shipping route).

222. Emily Hammond & David L. Markell, *Administrative Proxies for Judicial Review: Building Legitimacy from the Inside-Out*, 37 HARV. ENVTL. L. REV. 313, 320–26 (2013) (mapping administrative law onto procedural justice norms).

223. Of course, nuclear power was never actually "too cheap to meter." Some commentators have argued that the phrase itself was essentially propaganda, lacking endorsement even from nuclear supporters. *See* VACLAV SMIL, ENERGY MYTHS AND REALITIES: BRINGING SCIENCE TO THE ENERGY POLICY DEBATE at 31–32 (2010) (attributing "too cheap to meter" to a 1954 speech by AEC Chairman Lewis L. Strauss to the National Association of Science Writers, and suggesting Strauss may have been referring to fusion); SMIL, *supra*, at 32 (describing a 1955 journal entry of David E. Lilienthal, stating that nuclear development "is characterized more by salesmanship, propaganda, and overzealousness than sense").

224. Expectations were for more than a 7% increase annually. U.S. ENERGY INFO. ADMIN., NUCLEAR PLANT CANCELLATIONS: CAUSES, COSTS, AND CONSEQUENCES 7 (1983).

225. Omnibus Budget Reconciliation Act of 1981, Pub. L. 97–35 § 1021(b), 95 Stat. 616 (1981) (codified as amended at 42 U.S.C. § 8341 (2012)); Powerplant and Industrial Fuel Use Act of 1978, 42 U.S.C. § 8312 (repealed 1987).

226. DEP'T. OF ENERGY, REDUCING U.S. OIL VULNERABILITY: ENERGY POLICIES FOR THE 1980'S 10–11 (1980). For an overview of the forecasts in the 1970s, see Richard J. Pierce, Jr., *The Regulatory Treatment of Mistakes in Retrospect: Canceled Plants and Excess Capacity*, 132 U. PENN. L. REV. 497, 500–02 (1984).

regulatory contract, complete with rate recovery of costs plus a fair return, was the norm. And it appeared both that large amounts of capacity would be needed to meet projected demands, and that coal and nuclear generation were so cost-superior to oil and natural gas generation that the latter two generation sources should be retired.[227] In other words, nuclear power appeared to be the best option for consumers.

Yet the projections that spurred significant investments in nuclear power failed to come to fruition. Demand did not increase as expected, deregulation of natural gas led to dramatically reduced prices, and the oil market did not behave as forecast.[228] Nuclear power plants turned out to be relatively expensive investments. Further, these developments coincided with the TMI accident and the Chernobyl disaster, which contributed to negative perceptions and prompted additional regulatory action.[229] Ultimately, nuclear construction costs ran as much as ten times what had been predicted, the timeframe for completion stretched to an average of twelve years, and utilities began canceling partially completed plants.[230] There is some debate about the reasons for the significant disparities between projected and actual historical costs.[231] Most accounts, however, cite regulatory delays, redesign requirements, and poor construction management and quality control.[232] In any case, these developments posed a challenge to the traditional regulatory contract, and some utilities encountered great difficulties when they found that they could not necessarily recover from their ratepayers (a) the full costs of completed plants[233] or (b) the costs of canceled plants.[234]

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227. Pierce, *supra* note 226, at 502.

228. *See id.* at 502–03 (describing outcome of these and other forecasts).

229. *See supra* notes 217–20 and accompanying text (describing the effect of such disasters on public opinion and regulatory schemes). Notably, most construction also took place during the Cold War, when worries of nuclear annihilation were prominent in the minds of many citizens; it was easy to link the imagery of nuclear weapons to nuclear power plants. *See* Dorothy Nelkin, *Anti-Nuclear Connections: Power and Weapons*, BULL. ATOMIC SCIENTISTS, Apr. 1981, at 36, 38–39 (1981) (linking anti-nuclear power and anti-nuclear proliferation movements).

230. *See* Pierce, *supra* note 226, at 504–05.

231. MIT STUDY, *supra* note 84, at 38. Notably, European reactor construction costs also significantly exceeded projections. *Id.*

232. For example, the part 50 licensing process enabled contentions to be raised and re-raised at each licensing phase, contributing to numerous delays. EISEN ET AL., *supra* note 44, ch. 7; *see also* MIT STUDY, *supra* note 84, at 38 (describing reasons for disparities between projected and actual costs of nuclear construction).

233. *See* Pierce, *supra* note 226, at 511–17 (describing state regulatory treatment of completed plants).

234. *Id.* at 517–20 (describing state regulatory treatment of canceled plants).

Consider, for example, *Duquesne Light Co. v. Barasch*,[235] which involved the issue of rate recovery for the costs associated with canceled nuclear plants. There, the Supreme Court upheld a state statute requiring rates to be set without consideration of expenditures for plants that were planned but never built.[236] The story was typical: several utilities planned to construct seven nuclear power plants, but determined after the Arab oil embargo and TMI that the plants should be cancelled.[237] One utility's share of preliminary construction costs exceeded $35 million, and it sought permission from the state PUC to recoup those costs in its rates by amortizing them over a ten-year period.[238] Following an investigation, an administrative law judge determined that the expenditures, and the ultimate cancellation, were reasonable and prudent at the time they were made.[239] But an intervening state statute required that construction costs could be included in rates only when facilities became "used and useful."[240] Acknowledging the regulatory contract, the Court began by noting that public utilities are bound by a statutory duty to serve the public notwithstanding their ownership by private investors.[241] But the Court refused to intervene on the utilities' behalf. It recognized that denying recovery of plant costs would neither jeopardize the financial integrity of a company, nor leave it without sufficient operating capital or with the inability to raise future capital.[242] In this case, the denied costs represented only a small portion of the utility's overall rate base, leaving the utility with a sufficient rate of return.[243]

Decisions like *Duquesne* undermined investors' expectation that the costs involved in obtaining a nuclear operating license would largely be borne by ratepayers.[244] Cost recovery for completed plants, of course,

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235. 488 U.S. 299 (1989).

236. *Id.* at 301–02.

237. *Id.*

238. *Id.* at 303.

239. *Id.*

240. *Id.* at 303–05.

241. *Id.* at 307.

242. *Id.* at 312.

243. *Id.* at 311–12.

244. Contributing to the uncertainty are examples to the contrary. *See, e.g.*, Pennington v. ZionSolutions LLC, 742 F.3d 715, 716 (7th Cir. 2014) (describing how decommissioning trusts are typically funded by charges to ratepayers); Yankee Atomic Elec. Co. v. United States, 73 Fed. Cl. 249, 251 (Fed. Cl. 2006) (referencing ratepayers bearing costs of spent fuel storage and amounts paid to Nuclear Waste Fund); Legis. Util. Consumers' Council v. Pub. Serv. Co., 402 A.2d 626, 633–39 (N.H. 1979) (upholding state PUC's inclusion in rate base of construction work-in-progress to finance nuclear power plant construction); *cf.* Grand Council of Crees (of Quebec) v. FERC, 198 F.3d 950, 957 (D.C. Cir. 2000) (holding that the environmental challenge to FERC exercise of ratemaking authority was outside the statute's zone of interests; noting that the environmental

had always been subject to certain limitations—most commonly, the requirement that an investment be prudent or that a facility be used and useful.[245] Since investors expected that nuclear plants would be necessary to serve growing demand, they never considered the possibility that a "prudent" investment might be cancelled—that is, that it might never become "used and useful."

1. Overcoming Barriers to New Construction

This history of disappointed rate recovery expectations continues to dampen enthusiasm for new nuclear projects.[246] In regulated states, investors have learned the painful lesson that cost recovery is not guaranteed; in restructured states, cost recovery is not a feature of the landscape, and the "missing money" problem means that wholesale rates are unlikely to incentivize even needed new capacity.[247] Asset specificity will further disincentivize large capital investment.[248] Of the 100 reactors operating today, all had broken ground by 1977.[249] The levelized cost estimates set forth in Part I implicitly reflect these concerns, which have only been exacerbated by subsequent punctuating events—most recently, the Fukushima disaster of 2011.[250]

Despite these developments, there has been some movement in new reactor construction, though to date new construction is limited to

considerations are relevant "as the need to meet environmental requirements may affect the firm's costs"). For a case involving new nuclear construction, see Georgia Power's Application for the Certification of Units 3 and 4 at Plant Vogtle and Updated Integrated Resource Plan, No. 27,800, 2010 WL 2647607 (Ga. Pub. Serv. Comm'n June 17, 2010) (finding that Georgia Power's proposed inclusion of construction work-in-progress in rate base would benefit ratepayers).

245. *See* Pierce, *supra* note 226, at 511–13. Many jurisdictions also provide some recovery during construction. *See, e.g.*, Mid-Tex Elec. Coop., Inc. v. FERC, 773 F.2d 327, 330–36 (D.C. Cir. 1985) (discussing FERC's history with the allowance for funds used during construction ("AFUDC") and construction work in progress ("CWIP") methods of cost recovery).

246. MIT STUDY, *supra* note 84, at 38 ("[T]he specter of high construction costs has been a major factor leading to very little credible commercial interest in investments in new nuclear plants."); *cf.* Nuclear Energy Inst., Construction Work in Progress: An Effective Financial Tool to Lower the Cost of Electricity 3–4 (Feb. 2012), http://www.nei.org/CorporateSite/media/filefolder/CWIP.pdf?ext=.pdf [http://perma.cc/M4HH-HL4X] (describing importance of state CWIP legislation for nuclear power construction).

247. *See supra* Section I.D.

248. *Id.*

249. *Nuclear Reactor Operational Status Tables, Table 3: Nuclear Reactor Characteristics and Operational History*, U.S. ENERGY INFO. ADMIN. (Nov. 22, 2011), http://www.eia.gov/nuclear/reactors/stats_table3.html [http://perma.cc/XXE5-BC4X].

250. *See* NTTF Report, *supra* note 198, at 7–14 (describing the events that occurred during the Fukushima disaster).

two traditionally-regulated states[251]—Georgia and South Carolina.[252] This activity is attributable to several circumstances. First, all of the granted and pending license applications were filed in a period from 2007–09, when natural gas prices (and, therefore, the marginal costs of electricity) were high and the hydraulic fracturing boom had not fully taken hold.[253] In addition, coal was increasingly under scrutiny for its GHG emissions, and Congress was considering a number of climate change bills that would have increased the cost of emitting GHGs.[254]

Second, a number of incentives were also at play. As described in more detail in Part III, both states permitted the nuclear utilities to recover the carrying costs of construction through their rates.[255] In addition, the Energy Policy Act of 2005 ("EPAct 2005") included major incentives for new nuclear plants that were focused on lowering the risks for first movers.[256] These incentives included regulatory risk insurance, which authorized DOE to enter into as many as six contracts with sponsors of new nuclear power.[257] Under these contracts, the government promised to pay the principal and interest on debt, as well as extra costs incurred for purchasing replacement power due to licensing delays.[258] Notably, this risk insurance covered agency delay as well as litigation expenses, regardless of the ultimately prevailing

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251. *See infra* Section III.B (describing state initiatives to rebalance electricity markets).

252. These are, respectively, the Southern Nuclear Operating Company's Vogtle Units 3 and 4, and South Carolina Electric and Gas's V.C. Summer Units 2 and 3. Note that the TVA has also resumed construction of its Watts Bar Unit 2, which had been suspended in 1985. *See Watts Bar Unit 2 Reactivation*, U.S. NUCLEAR REGULATORY COMM'N, http://www.nrc.gov/info-finder/reactor/wb/watts-bar.html (last visited Feb. 3, 2015) [http://perma.cc/2H7X-2L6D]. Eight applications for combined licenses are pending, some of which are for reactors in restructured states. *Combined License Applications for New Reactors*, U.S. NUCLEAR REGULATORY COMM'N, http://www.nrc.gov/reactors/new-reactors/col.html (last updated July 1, 2014) [http://perma.cc/Q7BK-2VPA]. The pending applications are for units in Maryland (restructured), Michigan (restructured), Florida, Pennsylvania (restructured), Virginia, and Texas (restructured). *Id.*

253. *U.S. Natural Gas Wellhead Price*, U.S. ENERGY INFO. ADMIN. (Aug. 31, 2015), http://www.eia.gov/dnav/ng/hist/n9190us3m.htm [http://perma.cc/4WQ6-ZFKK].

254. *See* American Clean Energy and Security Act of 2009, H.R. 2454, 111th Cong. (2009); Global Warming Pollution Reduction Act of 2007, S. 309, 110th Cong. (2007); *see also* MIT STUDY (2009 update), *supra* note 84, at 6 (emphasizing that including cost of carbon in LCOE estimates would make nuclear more competitive with both coal and natural gas).

255. *See infra* Section III.B.

256. *See* MIT STUDY (2009 update), *supra* note 84, at 8–9 (discussing the "risk premium" associated with nuclear and need to gain proven experience if premium is to be reduced).

257. 42 U.S.C. § 16014 (2012).

258. The regulatory risk insurance was structured so that the first two licensed reactors were covered for 100% of these costs (with a $500 million limit), while the next four were covered at 50% (with a $250 million limit). *See* Standby Support for Certain Nuclear Plant Delays, 10 C.F.R. § 950.27 (2015).

party.[259] In this way, federal law aimed, at least briefly, at some of the risk-perception induced costs associated with nuclear power.[260]

EPAct 2005 also included a nuclear production tax credit for the first 6000 MW of new nuclear capacity for the first eight years of operation. However, construction was required to begin by January 1, 2014 to meet eligibility requirements.[261] Thus, only the four reactors currently under construction meet these criteria. Finally, EPAct 2005 authorized loan guarantees for clean energy projects, under which the federal government can guarantee up to eighty percent of a nuclear plant's estimated costs. To be eligible for such loans, applicants must have been granted a combined operating license from NRC. Thus, few applicants are eligible, and so far DOE has closed on a loan only for one project—the Vogtle project in Georgia.[262] For this plant, at least, the specter of unrecoverable cost overruns has been diminished. Prospective new entrants today, however, face the same hurdles as before.

2. Competing on the Markets

The discussion above helps explain why investors are reluctant to construct new nuclear plants, but it does not necessarily explain why existing plants are finding it so difficult to compete on the wholesale markets. Nuclear industry groups typically explain that low natural gas prices and policies giving preferences to renewables are to blame.[263] But what does that really mean? With respect to low natural gas prices, recall that low fuel costs for generators translate to low short-run marginal costs and low bids into the spot markets.[264] This is also true for renewables, which have zero fuel costs once installed, and which can bid lower prices to the extent they also generate RECs or benefit from production tax credits. But there is more to the story for nuclear power, as alluded to in Part I.

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259. *Id.* § 950.14(a).

260. *See* Justin Gundlach, Note, *What's the Cost of a Nuclear Power Plant? The Answer's Gonna Cost You: A Risk-Based Approach to Estimating the Cost of New Nuclear Plants*, 18 N.Y.U. ENVTL. L.J. 600, 643–45 (2011).

261. I.R.S. Notice 2006-40, 2006-18 I.R.B. 856 (May 1, 2006).

262. *See* GOV'T ACCOUNTABILITY OFFICE, STATUS OF DOE LOAN PROGRAMS, BRIEFING TO APPROPRIATIONS COMMITTEES 20 (Feb. 2013).

263. Press Release, Nuclear Energy Inst., NEI Warns Wall Street Analysts of Flawed Electricity Markets (Feb. 13, 2014), http://www.nei.org/News-Media/Media-Room/News-Releases/NEI-Warns-Wall-Street-Analysts-of-Flawed-Electrici [http://perma.cc/H638-CGEE]; *Nuclear Power in the United States*, WORLD NUCLEAR ASS'N (Sept. 2015), http://www.world-nuclear.org/info/Country-Profiles/Countries-T-Z/USA--Nuclear-Power/ [http://perma.cc/35K5-YPCR].

264. *See supra* Section I.C.1.

For fossil-fueled power, more fuel must be burned to increase the energy output of a plant; thus, those sources' marginal costs are closely tied to the cost of fuel and the efficiency of the plant.[265] But nuclear power depends on fuel that is loaded every eighteen to twenty-four months; this happens on a regularly scheduled basis and corresponds with intense, unrelated maintenance activity.[266] Small changes in output related to grid demand do not change this schedule *or the fuel costs*; with this understanding, we can say that nuclear power's short-run marginal costs are zero.[267] Moreover, because nuclear plants need to run continuously, they bid into the market as "price takers," meaning they will take the spot price, even if that price is negative.[268] Recall, however, that firms need operating profits to cover their fixed costs. If, on average, a firm receives spot prices below its long-run average costs, the firm will not be profitable. For nuclear power, those costs include a highly trained workforce, backfits, upgrades, insurance payments, fuel management, and final waste disposal.[269] In other words, the comprehensive regulatory scheme, which beneficially internalizes costs that for other fuels are externalities, also contributes to higher long-run average costs compared to other fuel sources. When spot market prices are low, nuclear power can become unprofitable. Indeed, several plants have closed for this reason,[270] and many others appear to be at risk of closure.[271]

D. Lessons Learned

The experience of nuclear power makes several points concrete. First, the regulatory contract, once a cornerstone of investor

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265. *See supra* Section I.C.1.

266. NUCLEAR ECON. CONSULTING GRP., NUCLEAR POWER & SHORT-RUN MARGINAL COST 2–3 (2014), http://nuclear-economics.com/wp-content/uploads/2014/10/2014-10-01-NECG-Commentary-2-Nuclear-Power-SRMC.pdf [http://perma.cc/GZY5-GW8W].

267. *Id.* In a regulated state, the relevant calculation would include the cost of fuel averaged over the expected plant output for the one-and-a-half to two-year operating period. *Id.* at 2.

268. *Id.* at 4.

269. *See supra* Sections II.B–C.

270. *See* Jennifer Levitz & Rebecca Smith, *Vermont Nuclear Power Plant Shut Down as Industry Evolves*, WALL ST. J. (Dec. 29, 2014), http://www.wsj.com/articles/vermont-nuclear-power-plant-shut-down-as-industry-evolves-1419903597 [http://perma.cc/BSS8-46SA] (citing "economic facts, especially related to the natural-gas market," and collecting examples of other shutdowns).

271. *See* Julie Wernau & Alex Richards, *As Exelon Threatens to Shut Nuclear Plants, Illinois Town Fears Fallout*, CHI. TRIB. (Mar. 9, 2014), http://m.nuclearpowersillinois.com/news-resources/news-articles/as-exelon-threatens-to-shut-nuclear-plants-illinois-town-fears-fallout [http://perma.cc/AU8L-239D] (describing study finding that Exelon's Illinois reactors have not earned enough money to cover operating and ongoing capital expenses).

expectations and an assumption underpinning the nuclear regulatory regime, no longer offers prospective investors in nuclear power the comfort it once did. In restructured states, competition has replaced traditional rate regulation; even in traditionally-regulated states, cost recovery for large capital projects seems uncertain or open to negotiation, rather than a firm expectation. Second, the impact of new federal requirements is now felt differently in regulated states—where backfitting or licensing costs during construction, for example, are still recoverable—as opposed to restructured states—where the same large costs cannot be recouped on the market. And finally, in the wholesale spot markets where only short-run marginal costs matter, the flaws predicted by economists—asset specificity and the missing money problem—are manifesting themselves in the reality of nuclear power. The markets are blind to the costs nuclear power incurs to provide reliable base load and to internalize its environmental impacts. To be sure, many would argue that the atomic age should come to a close. But the stakes are high: as nuclear power is increasingly priced out of the market, scientists have observed corresponding increases in air pollution.[272] The loss of this low-carbon source of generation is also of great concern, as the need for GHG mitigation grows increasingly urgent.[273] And over time, there is a loss of diversity in fuel sources, putting corresponding pressure on reliability of the electric grid.

We have focused our discussion on nuclear power partly because it so clearly demonstrates how and why the markets fail to value important attributes for electricity. But these lessons have important ramifications for other grid resources. All else equal, price competition favors sources like coal that can shift more pollution costs to society, or sources like natural gas that do not face the large up-front capital costs and long construction times. This puts low-emission sources like nuclear and some renewables at a relative disadvantage. Nor are risk

272. *E.g.*, ILL. COMMERCE COMM'N ET AL., POTENTIAL NUCLEAR POWER PLANT CLOSINGS IN ILLINOIS: IMPACTS AND MARKET-BASED SOLUTIONS 115 (2015) [hereinafter ILLINOIS REPORT] (predicting, in the short-term, increased GHG emissions if nuclear power plants were retired due to the need for fossil-fueled base load); Pushker A. Kharecha & James E. Hansen, *Prevented Mortality and Greenhouse Gas Emissions from Historical and Projected Nuclear Power*, 47 ENVTL. SCI. & TECH. 4889, 4891–93 (2013) (modeling deaths prevented by use of nuclear power rather than coal); Brian Walsh, *Japan Mulls Nuclear Revival Not Even 3 Years After Fukushima*, TIME (Feb. 25, 2014), http://time.com/9684/japan-mulls-nuclear-revival-not-even-3-years-after-fukushima/ [http://perma.cc/G9FU-YUCT] (describing increased GHG emissions in Japan following moratorium on nuclear power).

273. *See* Suzanne Waldman, *Timeline: The IPCC's Shifting Position on Nuclear Energy*, BULL. ATOMIC SCIENTISTS (Feb. 8, 2015, 9:48 PM), http://thebulletin.org/timeline-ipcc%E2%80 %99s-shifting-position-nuclear-energy7975 [http://perma.cc/Q9UN-7XSP] (describing increasing note of urgency in Intergovernmental Panel on Climate Change ("IPCC") reports regarding need to use all available low-carbon fuels, including nuclear power).

perception issues limited to nuclear power. For example, they are increasingly a motivating force behind significant opposition to smart meters—a key piece of technology that would enable dynamic pricing as well as demand response.[274] These issues are also contributing to an increasing number of bans on hydraulic fracturing, which may impact the price of natural gas.[275] Overall, there is much work to be done if we are to achieve a low-cost, reliable, green grid.

III. REFORMING THE REGULATORY CONTRACT?

The story of nuclear power serves as the proverbial canary in the coal mine, laying bare the challenges associated with electricity markets and regulation as they exist today.[276] As the foregoing discussion demonstrates, the nuclear licensing regime was created in the time of a stronger, simpler regulatory contract, when regulators had more control over market entry and pricing, and nuclear plants did not compete directly with other generation sources on price. That same licensing regime persists now in the context of a system of market pricing that takes little notice of the added technical, safety, and environmental benefits that the technology provides. As a consequence, plants are closing prematurely, and new entrants are few and far between. In this Part, we look beyond the nuclear example to the more general challenge of balancing cost, reliability/flexibility, and environmental attributes in today's geographically broader, more competitive electricity markets.

The regulatory contract can no longer be conceived of as a set of obligations between a single regulator and utility; rather, it is better understood as a complex network of relationships, loosely bound by the contours of markets as well as the initiatives of multiple layers of government and private actors. Electricity markets are not *un*regulated: rather, they are regulated by a pastiche of governmental

274. *See* Joel B. Eisen & Emily Hammond, *Risk Perception and the Smart Grid*, *in* PROCEEDINGS: SEOUL NAT'L UNIV. INT'L SMART GRID CONF. (forthcoming 2015) (manuscript on file with authors) (citing examples; concerns include electromagnetic frequencies, fire hazards, and privacy).

275. *See* David B. Spence, *Responsible Shale Gas Production: Moral Outrage v. Cool Analysis*, 25 FORDHAM ENVTL. L. REV. 141, 155–59 (2013) (exploring behavioral dimensions of opposition to hydraulic fracturing).

276. Our focus has been electricity markets, but the experience of natural gas markets also demonstrates the point. *See* Phillips Petrol. Co. v. Wisconsin, 347 U.S. 672 (1954) (holding that the Natural Gas Act required FPC to regulate the price of natural gas at the well head into interstate commerce); Richard J. Pierce, Jr., *The Evolution of Natural Gas Regulatory Policy*, 10 NAT. RESOURCES & ENV'T, Summer 1995, at 53, 53–55, 84–85 (criticizing *Phillips* and tracing history of natural gas policy).

and quasi-governmental institutions whose collective regulatory leverage is lessened by the move toward market pricing. These regulatory institutions include FERC and state PUCs, state and federal environmental and power plant licensing agencies, and various regional governance entities like RTOs/ISOs and power pools.[277] Wholesale markets dispatch electricity on a least-cost basis, taking account of generators' reliability/flexibility attributes only as necessary to keep the grid running and not taking account of generators' environmental attributes at all.[278] Instead, the various generation technologies are subject to starkly different environmental regulatory regimes, each regime affecting the price of electricity differently.

This Part considers policy options that address these imbalances in the system. Specifically, we explore here the various ways in which modern electricity markets can better account for the reliability and environmental attributes of different generation technologies at the federal, regional, and state level. We preface that exploration, however, with the acknowledgment that federal law is not operating as a unified and unifying institution in electricity policy and that fragmented jurisdiction, both horizontal and vertical, is likely to be a continuing fact of modern electricity markets.[279] We assume that the myriad federal and state permitting and licensing regimes that impose barriers to entry on new power plants will not be consciously rationalized or folded into a single one-stop regulatory or licensing regime. Any such rationalization would require congressional action, and Congress is currently ill-equipped, or at least disinclined, to address these problems legislatively.[280] Congress could, for example, amend the Federal Power Act to require that "just and reasonable" rates include the cost of internalizing externalities and ensuring reliability, or that these attributes be explicitly priced in the market. Alternatively, Congress

277. *See supra* Sections I.A–B.

278. *Cf.* Del. Dep't Nat. Res. & Envtl. Control v. EPA, 785 F.3d 1, 13 (D.C. Cir. 2015) (describing potential of backup generators—operated to make up for DR—to harm the environment and decrease reliability).

279. These challenges are not new. *See, e.g.*, Peter Huber, *Electricity and the Environment: In Search of Regulatory Authority*, 100 HARV. L. REV. 1002, 1002 (1987) (lamenting irretrievable fragmentation of regulatory authority over electricity).

280. Many such statutory solutions have been offered. *See generally* BLUE RIBBON COMM'N ON AMERICA'S NUCLEAR FUTURE, REPORT TO THE SECRETARY OF ENERGY vii (2012), http://energy.gov/sites/prod/files/2013/04/f0/brc_finalreport_jan2012.pdf [http://perma.cc/3MUR-8XCK] (listing numerous recommendations, including new statute and new agency for managing spent nuclear fuel); Robin Kundis Craig & J.B. Ruhl, *Designing Administrative Law for Adaptive Management*, 67 VAND. L. REV. 1 (2014) (proposing amendments to Administrative Procedure Act); Lincoln L. Davies, *Power Forward: The Argument for a National RPS*, 42 CONN. L. REV. 1339 (2010) (arguing for a national RPS); SHI-LING HSU, THE CASE FOR A CARBON TAX: GETTING PAST OUR HAND-UPS TO EFFECTIVE CARBON POLICY (2d ed. 2011) (arguing for a carbon tax).

could also impose a carbon tax or other environmental tax on generation, establish a federal RPS or low-carbon emissions standard, or subsidize generation sources with environmental or reliability attributes not valued in the market. In the current climate of congressional gridlock, however, these kinds of federal legislative modifications to the regulatory contract seem more than unlikely—they seem fantastical.

It follows that jurisdictional conflicts between regulators are inevitable. States clash with regional entities, the federal government,[281] and each other over electricity market regulation. For example, states in the western half of the PJM market are in a perpetual battle with those in the eastern half over a variety of cost-allocation issues.[282] This is true despite an overarching federal structure; FERC itself opened the markets, specified the requirements for RTOs and ISOs, and retains oversight authority.[283] More and more frequently, however, this federal structure is challenged to delineate its jurisdictional lines with respect to both electricity markets and environmental law.[284]

Our updated conception of the regulatory contract requires acknowledging these multiple arenas for policy development and

281. EPA's Clean Power Plan has provoked state-federal conflict, including a claim that the plan violates states' Tenth Amendment rights. For a summary of that debate, see *Professors Freeman and Lazarus Debate Professor Tribe on the Clean Power Plan*, HARV. ENVTL. L. PROGRAM: EMMETT CLINIC POL. INITIATIVE (March 17, 2015), http://environment.law.harvard.edu/2015/04/01/professors-freeman-and-lazarus-debate-professor-tribe-on-the-clean-power-plan/ [http://perma.cc/Q9V6-GM97]; and *Richard Revesz Debates Laurence Tribe Over EPA Proposed Rule During Panel Testimony Before House Committee on Energy & Commerce*, N.Y.U. L. (March 17, 2015), http://www.law.nyu.edu/news/ richard-revesz-testifies-house-committee-on-energy-and-commerce [http://perma.cc/23AC-QCTL].

282. *See, e.g.*, Ill. Commerce Comm'n v. FERC, 756 F.3d 556, 558 (7th Cir. 2014) (describing competing interests and protracted litigation); *see also supra* text accompanying note 60 (describing litigation triggered by the efforts of two eastern PJM states—New Jersey and Maryland—to subsidize new generating capacity in their states, and thereby influence prices in PJM capacity markets).

283. Freeman & Spence, *supra* note 22, at 52–55.

284. *See supra* note 21 (collecting energy examples); *see also* United Air Regulatory Util. Grp. v. EPA, 134 S. Ct. 2427, 2449 (2014) (upholding in part, and rejecting in part, EPA GHG regulations under CAA). Often, these conflicts divide along political party lines. For example, EPA is in frequent conflict with states controlled by Republicans during Democratic presidencies, and states controlled by Democrats during Republican presidencies. During the George W. Bush administration, states sued EPA over a variety of Clean Air Act issues. *See generally* Massachusetts v. EPA 549 U.S. 497 (2007) (states sought to force EPA to regulate GHG emissions); New Jersey v. EPA 517 F.3d 574 (D.C. Cir. 2008) (state challenged EPA's approach to regulating mercury emissions). During the Obama Administration, states sued EPA over another set of Clean Air Act issues. *See generally* EPA v. EME Homer Generation, L.P., 134 S. Ct. 1584 (2014) (states challenged EPA's approach to regulating pollution transport); White Stallion Energy Ctr., LLC v. EPA, 748 F.3d 1222 (2014) (states challenged EPA's approach to regulating mercury emissions).

recognizing that ideological conflicts shape those developments. Therefore, we are realistic in limiting our consideration of *federal* policy options to those that federal agencies might adopt, finding room to act within their discretionary authority.[285] At the same time, federal law has left significant gaps for *subnational* institutional innovators—that is, for regional and state governance institutions.[286] This observation is consistent with recent federalism scholarship[287] emphasizing that states are more than mere experimenters seeking a common (often national) goal in new and different ways.[288] Rather, in an increasingly ideologically polarized polity, each state is striving to shape the regulatory contract in its own way,[289] and policy entrepreneurs now look to ideologically kindred states as venues within which to pursue their policy goals.[290] In other words, governance challenges provide opportunities for innovation.

With these considerations in mind, we turn to policy options that federal and subnational actors might use to rebalance electricity markets that have become skewed by the market failures and the uneven application of environmental regulation across generation technologies.[291] All of these policy options involve changes either to the

285. Along with our co-authors, we have made this point before. Freeman & Spence, *supra* note 22, at 80–81; Hammond & Markell, *supra* note 222, at 316.

286. EPA efforts to regulate GHG emissions from power plants recognize as much. *See* CLEAN POWER PLAN, *supra* note 11, at 242, 778, 1087, 1192–93 (emphasizing state flexibility). Local efforts have also blossomed. *See, e.g.*, Katherine A. Trisolini, *All Hands On Deck: Local Governments and the Potential for Bidirectional Climate Regulation*, 62 STAN. L. REV. 669, 743–44 (2011) (demonstrating the importance of local government efforts). *Contra* Cary Coglianese & Jocelyn D'Ambrosio, *Response, Policymaking Under Pressure: The Perils of Incremental Responses to Climate Change*, 40 CONN. L. REV. 1411, 1429 (2008) (contending subnational efforts undermine effectiveness of national efforts).

287. *See* Jessica Bulman-Pozen, *Partisan Federalism*, 127 HARV. L. REV. 1077, 1079–80 (2014) (contending that states implement plans rejected by the federal government due to ideological partisanship); Heather Gerkin, *Dissenting by Deciding*, 57 STAN. L. REV. 1745, 1748 (2005) (localities provide an opportunities for an electoral minority to become the deciders); William Boyd & Ann E. Carlson, *Accidents of Federalism: Rate Design and Policy Innovation in Public Utility Law* (forthcoming 2016) (manuscript on file with authors); Christina Rodriguez, *Federalism and National Consensus* (forthcoming) (manuscript on file with authors).

288. *See* New State Ice Co. v. Liebman, 285 U.S. 262, 311 (1932) (Brandeis, J., dissenting) ("It is one of the happy incidents of the federal system that a single courageous state may, if its citizens choose, serve as a laboratory; and try novel social and economic experiments without risk to the rest of the country.").

289. *See* Bulman-Pozen, *supra* note 287, at 1082–83 (emphasizing states as arenas of partisan conflict, including conflict with federal actors, while implementing federal regulatory mandates).

290. *Id.* at 1116–22 (arguing that people identify with parties, and with states based upon the dominant party or ideology within the state).

291. In setting forth these options, we have made the deliberate choice of organizing them according to the level of government at which they would be implemented. This organizational approach is somewhat artificial because some options rely on multi-jurisdictional cooperation, while others could be implemented without regard to jurisdiction. But we believe this organization

permitting regimes that act as barriers to entry to new generation, or to the ways competitive electricity markets value reliability and environmental performance. Provided the components of our tripartite framework are maximized, we are indifferent to the precise mix of electricity resources that would result from these initiatives (or be used to achieve improvements). But all change takes place against the status quo, so any change will create perceived winners and losers.[292] Consequently—and also because existing source-specific regulation sometimes distorts competition in electricity markets—some of the initiatives we present here are source-specific.

A. Federal Initiatives

Competitive electricity markets struggle to provide an electric generation mix that properly values reliability and the externalities of production, partly because of the piecemeal and asymmetric way in which regulatory regimes address those attributes.[293] Nevertheless, federal agencies have experienced some success in leveraging their already-existing statutory discretion to achieve policy objectives, notwithstanding the constant political pressures under which they too must operate.[294] Here we consider options at three key agencies. FERC oversees wholesale power markets and has some ability to influence the ways in which those markets value reliability and environmental performance. EPA, FERC, and NRC all act as gatekeepers for new

is preferable to an approach that would use the broad categories of market-based and regulatory options for two reasons. First, the distinction is not so neat; market-based approaches require a regulatory framework. Second, fundamental to policy comparisons are choices of institutional design; we prefer to make the benefits and drawbacks of such choices explicit.

292. EPA's Clean Power Plan, for example, is meant to apply broadly, but it has generated staggering opposition from many different groups that perceive a disadvantage to coal. *E.g.*, Petition for Extraordinary Writ to the United States Environmental Protection Agency, *In re* West Virginia, No. 15-1277 (D.C. Cir. Aug. 13, 2015) (coal company challenge to EPA's Clean Power Plan); *see also* NEI, Nuclear Energy Institute Comments on the EPA's Proposed Rule to Reduce Carbon Emissions from Existing Power Plants Under Section 111(d) of the Clean Air Act, (Dec. 1, 2014), http://www.nei.org/CorporateSite/media/filefolder/Policy/Environment%20-%20Water/NEIcommentsEPACleanPowerPlan.pdf?ext=.pdf [http://perma.cc/C8HH-X2HA] (commending EPA's contemplation of nuclear power but criticizing particulars).

293. *See generally* EISEN ET AL., *supra* note 44 (describing different federal regulatory regimes for hydro, coal, natural gas, nuclear, and renewables).

294. *See* Hammond, *Deference Dilemma*, *supra* note 132, at 1782–85 (describing the political climate leading to the Yucca Mountain stall). Admittedly, agencies have many masters. The executive, courts, legislative oversight, and stakeholders exert considerable pressure on agencies to implement particular policy objectives. But their ability to pursue such objectives notwithstanding congressional gridlock means that policy options at the federal agency level cannot be ignored.

generation through the administration of federal licensing or permitting regimes.

1. FERC Oversight of Wholesale Power Markets

Because its power over wholesale markets is not plenary under the FPA, FERC has addressed the problem of ensuring cleaner, reliable power only in careful, measured ways. Some scholars, however, have argued that it should take bolder action. For example, Richard Pierce has advocated that FERC push more aggressively to complete the nationwide transition to RTOs.[295] Having merely encouraged this transition in Order 889,[296] FERC could more fully exercise its authority over wholesale sales in interstate commerce to mandate such a transition.[297] In a market that resembles the competitive ideal—one that accurately prices externalities and reliability—such a transition could be beneficial. However, many of the dysfunctions we document are most acute in the RTO/ISO markets. As we have noted, electricity markets do not price externalities and reliability well. If our objective were to try to construct the economist's vision of a rational world built on a model of perfect competition, FERC policies pushing ever more competitive markets would make sense. In today's electricity markets, however, we believe those changes would not necessarily serve the needs of real electric consumers.[298] We acknowledge that such changes could enhance regional coordination, but they may also come at the cost of diminished state flexibility, as we explore in more detail below.

Others have argued that FERC should impose a carbon adder on wholesale sales of electricity.[299] The argument is that environmental externalities permit emitters of GHGs to charge lower prices than they otherwise would, making the markets inconsistent with the just and reasonable mandate. This, in turn, would trigger FERC's remedial

295. Richard J. Pierce, *Realizing the Process of Restructuring the Electricity Market*, 40 WAKE FOREST L. REV. 451, 493–94 (2005) (arguing for completing restructuring process but noting political and legal hurdles).

296. Open Access Same-Time Information System and Standards of Conduct, 18 C.F.R. § 37 (1996).

297. By definition, the transactions we describe in Part I between IOUs in non-RTO/ISO jurisdictions are wholesale sales, and interstate commerce is easily met in this context.

298. For a fuller discussion of the theoretical reasons for these failings in energy markets, see David B. Spence, *Economics, Ideology and Regulation* (2015) (unpublished manuscript) (on file with authors).

299. Steven Weismann & Romany Webb, *Addressing Climate Change Without Legislation: How the Federal Energy Regulatory Commission Can Use Its Existing Legal Authority to Reduce Greenhouse Gas Emissions and Increase Clean Energy Use,* BERKELEY ENERGY & CLIMATE INITIATIVE 2–5 (2013), www.law.berkeley.edu/files/ccelp/FERC_Report_FINAL.pdf [http://perma.cc/4M2F-JRET].

power under FPA Section 206 to compel the carbon adders.[300] More generally, an environmental adder could be imposed on the bid price of sellers to better account for the full social costs of that electricity. But FERC has been reluctant to directly impose environmental considerations on the markets, and there is some question whether the scope of its authority extends so far.[301] The historical understanding of the regulatory contract seems to imply that FERC's authority to ensure rates are "just and reasonable" is limited to serving the *economic* interests of consumers and investors.[302] On the other hand, widespread market pricing of electricity also represents a stark departure from historical practice,[303] and the courts have supported the broadening of other FPA provisions beyond their narrower, historical understandings to include environmental considerations.[304] If the regulatory contract is better conceived as a legal and institutional arrangement contextualized by policy goals, perhaps there is room for argument favoring carbon or environmental adders.

Of course, externalities are not the only attribute of electricity that matters. Reliability and flexibility are important both for maintaining reasonable rates over time and for the technical operation of the grid. Furthermore, FERC's authority to ensure reliability/flexibility is far more settled than its ability to directly consider environmental factors. Thus, a reliability and/or flexibility adder—this time imposed on the bid costs of buyers—might have better

300. *Id.* at 5.

301. *See* Grand Council of the Crees v. FERC, 198 F.3d 950, 957–60 (D.C. Cir. 2000) (rejecting, on zone-of-interest standing grounds, tribe's argument that FERC should have considered environmental impacts as part of just-and-reasonable rate inquiry). FERC itself has taken this position. *See* 18 C.F.R. § 380.4 (2005) (categorical exclusion of rate filings from NEPA). FERC does have power to approve rates that take into account *state* environmental considerations. *See* Cal. Indep. Sys. Operator Corp., 141 FERC 61,237, at 29 (2012) (permitting tariff revisions to account for California's carbon cap-and-trade program); Cal. Pub. Util. Comm'n, 133 FERC 61,059, at 35 (2010) (permitting state rates to account for full avoided cost including environmental consideration); Jim Rossi & Tim Hutton, *Federal Preemption and Clean Energy Floors*, 91 N.C. L. REV. 1283, 1310 (2013) (arguing that FERC need not treat PURPA's avoided cost mandate as imposing a ceiling on state incentive rates).

302. *See Grand Council of the Crees*, 198 F.3d at 956. If FERC were to attempt this, it would likely face significant challenges in light of numerous Supreme Court decisions related to agencies' scope of authority. *E.g.*, Util. Air Regulatory Grp. v. EPA, 134 S. Ct. 2427, 2447 (2014) (holding that EPA lacked authority to impose PSD requirements on certain major sources on the sole basis of their GHG emissions); FDA v. Brown & Williamson Tobacco Corp., 529 U.S. 120, 160 (2000) (holding Congress never intended the FDA to regulate tobacco under the then-existing statutory scheme).

303. *See* ISSER, *supra* note 35, at 27 (describing the origins of FPA).

304. *See e.g.*, Scenic Hudson Pres. Conference v. Fed. Power Comm'n, 354 F.2d 608, 616, 620 (2d Cir. 1965) (requiring the Commission to take a broader view of the public interest in licensing a hydroelectric project, despite a tradition of focusing on energy and development factors).

traction, both as a jurisdictional and political matter.[305] As noted in Part I, reliability encompasses a suite of attributes (the ability to serve several different grid needs), and no single generation source has all of those attributes. Therefore, deciding the price of reliability would be a complex task.[306] But one could conceive of a system that rewards different reliability attributes like fuel certainty and rampability. Presumably, such an incentive would trigger changes in generation: gas-fired plants would be more likely to contract for firm supply, or would develop their own, more secure fuel sources; new nuclear facilities might be designed to ramp more efficiently, etc. In any case, the possibility of directly accounting for this attribute—beyond the indirect and incomplete approach of SCED—should be considered given its importance to the grid.[307]

FERC has not pushed for environmental or reliability adders in electricity markets, but in recent years it has adopted narrower rules that incentivize a greener grid at the margins, though some of those efforts have also bumped up against the potential limits of its jurisdiction. First, FERC adopted Order 719, aimed at facilitating the penetration of DR[308] in wholesale markets by requiring market overseers to accept aggregated DR bids.[309] FERC undertook these latter two initiatives pursuant to its remedial power under FPA section 206, reasoning that the just and reasonable mandate required fairness in access to the grid. In its DR initiative, FERC asserted that DR holds the potential to reduce peak demand, thereby reducing market clearing prices and minimizing cost.[310] It can promote grid reliability by providing an additional dispatchable resource during times of peak demand or grid constraints.[311] And by avoiding electricity generation,

305. *See* John S. Moot, *Subsidies, Climate Change, Electric Markets and the FERC*, 35 ENERGY L.J. 345, 372 (2014) ("[A]ny remedies should focus, as much as practicable, on protecting the market, not individual competitors.").

306. *Cf.* Elec. Power Supply Ass'n v. FERC, 753 F.3d 216, 237–39 (D.C. Cir. 2014) (Edwards, J., dissenting) (explaining FERC's approach to valuing DR).

307. We see no reason why, as a jurisdictional matter, FERC could not approve an RTO/ISO tariff that would impose either a carbon or reliability adder. And as described in Section III.3 *infra*, FERC has indeed approved new rules for PJM's capacity market that take some of these attributes into account.

308. DR is demand response, explained *supra* note 80.

309. Wholesale Competition in Regions with Organized Electric Markets, 73 Fed. Reg. 64,100, 64,101 (Oct. 28, 2008) [hereinafter Order 719].

310. Joel B. Eisen, *Who Regulates the Smart Grid? FERC's Authority Over Demand Response Compensation in Wholesale Markets*, 4 SAN DIEGO J. CLIMATE & ENERGY L. 69, 78–79 (2013).

311. *Id.*

DR can indirectly reduce emissions if the avoided generation is not nuclear or a renewable.[312]

Next, FERC acted to ease grid access for renewables by requiring transmission utilities lower some of the barriers to interconnection they had erected.[313] Order 1000 aimed to stimulate investment in new transmission by mandating that transmission utilities engage in regional planning and authorizing rate regimes that allow allocation of the costs of new lines more broadly.[314] As mentioned previously, states within PJM in particular have fought bitterly over cost allocation for transmission upgrades, at the expense of the reliability and environmental benefits of new transmission.[315] Order 1000 is a response to these and other concerns, and it is expected to increase reliability and facilitate integration of renewable generation on the grid.[316] However, cognizant of the argument that its authority to ensure just and reasonable rates may be limited to economic considerations, FERC was careful to clarify that its *purpose* was not to favor renewables; it stated "[b]ecause we are not mandating the consideration of any particular transmission need driven by a Public Policy Requirement, we disagree with [commenters] that we are favoring renewable energy resources over other types of resources."[317]

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312. *See id.* at 79 (arguing that DR has none or few of the negative environmental effects that dirty, inefficient plants running at peak times have). *But see* Del. Dep't of Nat. Res. & Envtl. Control v. EPA, 785 F.3d 1, 12–13 (D.C. Cir. 2015) (describing concerns that backup generators are replacing DR, diminishing environmental and reliability benefits). Note that FERC's authority to set uniform compensation rules for DR, as well as its method for doing so, are issues that are pending before the Supreme Court. Elec. Power Supply Ass'n v. FERC, 753 F.3d 216 (D.C. Cir. 2014), *cert. granted*, 135 S.Ct. 2049 (May 4, 2015) (No. 14-840) (holding Order 745 invalid as beyond FERC's jurisdiction and concluding pricing rationale was arbitrary and capricious).

313. *See, e.g.*, Integration of Variable Energy Resources, 77 Fed. Reg. 41,482, 41,484–85 (July 13, 2012) (stating that removing barriers to integration of variable energy resources will encourage renewable energy); *see also* Transmission Planning and Cost Allocation by Transmission Owning and Operating Public Utilities, 76 Fed. Reg. 49,842 (Aug. 11, 2011) [hereinafter Order 1000] (mandating transmission planning and standardized cost allocation).

314. *See* Order 1000, *supra* note 313, at 49,842–45 (noting the need for consideration of local public policy requirements in the transmission planning process).

315. *See supra* note 282 and accompanying text; *see also* Ill. Commerce Comm'n v. FERC (*ICC I*), 576 F.3d 470, 476 (7th Cir. 2009) (requiring allocation of costs of new PJM transmission line only to customers who benefit from new lines, and prompting FERC to promulgate Order 1000). *Compare* Ill. Commerce Comm'n v. FERC (*ICC II*), 756 F.3d 556, 564–65 (7th Cir. 2014) (rejecting PJM's broad allocation of the costs of the same PJM line addressed in ICC I, after FERC approved those costs on remand), *with* Ill. Commerce Comm'n v. FERC, 721 F.3d 764, 777 (7th Cir. 2013) (post-Order 1000 decision authorizing the broad allocation of the cost of a suite of new transmission lines planned for the MISO territory).

316. *E.g.*, Christopher J. Bateman & James T.B. Tripp, *Toward Greener FERC Regulation of the Power Industry*, 38 HARV. ENVTL. L. REV. 275, 307 (2014) (arguing that Order 1000 could streamline coordination by considering regional and local policy goals).

317. Order 1000, *supra* note 313, at 49,878.

In the absence of an explicit broadening of the meaning of "just and reasonable" by Congress, FERC seems relegated to measures like these. Its use of rulemaking and adjudication to promote investment in transmission reliability and a diversity of resources on the grid—including renewables and DR—can help rebalance competitive wholesale electricity markets in ways suggested by our tripartite framework.[318] As courts review FERC's actions in this regard, they should be careful to avoid reverting to the narrow historical meaning of "just and reasonable." After all, the courts have approved the widespread shift from individual rate-setting to market pricing in wholesale markets,[319] which has ushered in a fundamental transformation of the electricity sector—with markets moving toward increased reliance on renewable power and DR.

2. Changes to Federal Licensing and Permitting Regimes

As described above, existing environmental laws like the Clean Air Act, the Clean Water Act, and the Resource Conservation and Recovery Act aim to force thermal (and particularly fossil fueled) power plants to internalize externalities, but have done so less thoroughly than, say, nuclear licensing.[320] However, EPA has undertaken to strengthen these regulatory regimes, targeting coal-fired plants in particular, with new rules aimed at cross-border pollution, mercury emissions, disposal of coal ash, water use, and more.[321] Currently, the most important EPA initiative is the Clean Power Plan, which contemplates that states will replace coal-fired generation with natural gas, nuclear, and renewables to reduce GHG emissions.[322] States may also incorporate non-generation resources into their mix as a means of compliance.[323] Because it offers states an incentive to replace coal-fired power in the dispatch order with low- and zero-emission generation, the Clean Power Plan aims directly at the imbalance in competitive

318. FERC can also exercise its adjudicatory authority toward these ends; for example, it has approved changes to PJM's capacity market that are also expected to reduce cost, improve reliability/flexibility, and diminish environmental externalities. *See infra* Section III.C.

319. *See* California *ex rel.* Lockyer v. FERC, 383 F.3d 1006, 1013 (9th Cir. 2004); La. Energy & Power Auth. v. FERC, 141 F.3d 364, 365–366 (D.C. Cir. 1998) (approving market-based rates). *But see* Morgan Stanley Capital Grp., Inc. v. Pub. Util. Dist. No. 1 of Snohomish Cnty., 554 U.S. 527, 538 (2008) (declining to endorse or reject the conclusion reached in *Lockyer* and *La. Energy*).

320. *See supra* text accompanying notes 151–156 (describing regulation as most common approach).

321. *See* Freeman & Spence, *supra* note 22, at 28–42 (describing these initiatives); Spence & Hammond, *supra* note 125, at 469–74 (same)

322. CLEAN POWER PLAN, *supra* note 11, at 323–24.

323. *Id.* at 238–39.

electricity markets that arises from coal's externalities. But its impacts on reliability are disputed. Numerous commenters have raised concerns about reliability, the costs of compliance, and whether the Clean Power Plan will even make an impact in mitigating climate change. Others dispute those claims.[324] Whether the Clean Power Plan will survive judicial review appears an open question, but it is clear that if it is finalized, it will have impacts on each component of our tripartite framework.

In addition to EPA's regulatory leverage over power plants that emit pollutants, there are two federal agencies that exert general licensing jurisdiction over power plants. One, already discussed in detail, is NRC. The other is the FERC, which exercises licensing authority over hydroelectric projects under the FPA.[325] Hydroelectric power is renewable and relatively clean, but it engenders environmental opposition because of its impacts on recreation, stream ecology, and water allocations.[326] Moreover, it has been the source of considerable friction between states and the federal government.[327] However, as pressure builds to bring more low-emission generation onto the grid, FERC could, in connection with its licensing decisions, explicitly consider the role that hydroelectric power can play in state Clean Power Plan compliance. More generally, FERC could shift its policy stance toward projects that would store water in a reservoir during periods of low demand, and release the water through the turbines during peak demand periods, thereby raising and lowering the

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324. Numerous entities attempted to model the impacts to the generation mix when EPA first proposed its rule in 2014; projections varied considerably. *See, e.g.*, U.S. ENERGY INFO. ADMIN., ANALYSIS OF THE IMPACTS OF THE CLEAN POWER PLAN 14–27 (2015) (providing a summary of the results from projects of the new rule), http://www.eia.gov/analysis/requests/powerplants/cleanplan/pdf/powerplant.pdf [http://perma.cc/NM5E-49DK]; Michael Wara et al., *Peak Electricity and the Clean Power Plan*, 28 ELECTRICITY J. 18, 24–25 (2015); *see also* CLEAN POWER PLAN, *supra* note 11, at 15–17 (presenting modeled projections under final rule). For an analysis of the effects of the rule on reliability, and a summary of the various reliability related comments on the rule, see Adelman & Spence, *supra* note 100.

325. *See* Public Utility Act of 1935, Pub. L. No. 74-333, § 207, 49 Stat. 803, 842 (Aug. 26, 1935) (codified as amended at 16 U.S.C. § 803(a)(1) (2012)) (directing the Federal Power Commission (now FERC) to issue hydroelectric licenses on the condition that the applicant's plan is "best adapted to develop, conserve, and utilize in the public interest the water resources of the region").

326. For extended discussion of the way FERC resolves environmental disputes over hydroelectric projects, see J.R. DeShazo & Jody Freeman, *Public Agencies as Lobbyists*, 105 COLUM. L. REV. 2217, 2265–67 (2005) (finding FERC to be more responsive to environmental concerns when raised by a larger number of intervenors); David B. Spence, *Managing Delegation Ex Ante: Using Law to Steer Administrative Agencies*, 28 J. LEGAL STUD. 413, 450–51 (1999) (quantitative study concluding that FERC was more responsive to environmental concerns raised by environmental agencies, federal or state, than by environmental NGOs).

327. *See* PUD No. 1 of Jefferson Cnty. v. Wash. Dep't of Ecology, 511 U.S. 700, 723 (1994) (holding minimum streamflows developed through state certification process were acceptable state water quality standards).

reservoir frequently.[328] Environmental NGOs have opposed storage operation because reservoir level fluctuations disrupt the ecology of the reservoir and surrounding wetlands. However, as more intermittent wind and solar power comes on line, hydroelectric power could provide short-term, backup power (that is, electricity storage) for renewables and could do so with fewer emissions than fossil-fueled backup generators. FERC might, therefore, consider adopting a policy that provides greater weight to the value of hydroelectric storage as a way of displacing more emission-intensive forms of backing up intermittent renewable power.[329]

Finally, there is also room for improvement in NRC licensing. Despite the strongly preemptive and expansive nature of the nuclear licensing regime, it leaves considerable room for state innovation on second-order matters.[330] States have incorporated innovations in rate structures, licensing, and construction oversight designed to balance the need to provide clean, reliable electricity with the (state) mandate of just and reasonable rates.[331] This experience suggests the potential viability of new federal approaches to nuclear power plant licensing that might decrease the nuclear risk premium while still prioritizing safety and security. For example, there is currently insufficient coordination, and significant duplication, between federal and state licensing schemes. States often require status reports and updates, including safety information, just as NRC does.[332] While these problems

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328. This kind of storage operation could occur either at pumped storage projects, which pump water up to an elevated reservoir during off-peak periods and generate power during peak periods, or at conventional hydro stations, by merely letting water build up behind the dam until peak demand periods and releasing the water through the turbines only then. FERC has not licensed many pumped storage projects since the *Scenic Hudson* decision, which involved a pumped storage project. Scenic Hudson Pres. Conference v. Fed. Power Comm'n, 354 F.2d 608, 611 (2d Cir. 1965). And FERC tends to insist that most conventional projects operate in so-called "run of river" mode, keeping the reservoir height level by equalizing the flows into the reservoir from upstream with the flows released through the turbines.

329. Weissman & Webb, *supra* note 299, have also argued for expanded FERC policy with respect to hydrokinetic projects. *Id.* at 34–36.

330. *See* Rossi & Hutton *supra* note 15, at 1335–36 (arguing states and local authorities have been leaders in adopting clean energy solutions).

331. Note that although states may not reject nuclear power plants on safety grounds, they do have power, creatively exercised, to make or break nuclear within their borders. *Compare* Pac. Gas & Elec. Co. v. State Energy Res. Conservation & Dev. Comm'n, 461 U.S. 190, 203 (1983) (holding AEA did not preempt California moratorium on nuclear power; moratorium related to economic implications of nuclear waste), *with* Entergy Nuclear Vt. Yankee, LLC v. Shumlin, 733 F.3d 393, 428 (2d Cir. 2013) (holding AEA preempted various portions of Vermont statutes aimed at shuttering nuclear power plant). *But see generally* James W. Moeller, *State Regulation of Nuclear Power and National Energy Policy*, 12 J. ENERGY NAT. RESOURCES & ENVTL. L. 1 (1992) (arguing for stronger federal preemptive role).

332. *See infra* Section III.B.

could be mitigated by a regulatory scheme of shared authority[333] or a regime modeled on the French approach (federally-sponsored projects that would be turned over to private operators),[334] both options would require legislative intervention and are unlikely to come to fruition. Nonetheless, overhauling the federal regulatory scheme is an important option—and not necessarily one dependent on congressional action. In addition to the major 1980s changes to its licensing regime, NRC could take additional actions to try to reduce the nuclear risk premium.[335] The experience gained under the current regulations should be put to work in updating those regulations as necessary.[336]

Inefficient regulation imposes costs, and prospective new entrants are particularly disadvantaged with regard to licensing new plants and innovative reactor designs. In particular, others have noted the need for a different kind of licensing scheme for new nuclear technologies like small modular reactors (SMRs), which cannot hope for economic viability if they must proceed under the traditional licensing scheme.[337] NRC itself is studying the problem and should make such changes a priority.[338] Relevant to both attracting new entrants and retaining the existing nuclear fleet, NRC's Near-Term Task Force, which reported on lessons learned from Fukushima, has also recommended revamping NRC's safety regulations to better marry the

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333. *See* Policy Statement on the Regulation of Advanced Reactors, 73 Fed. Reg. 60,612, 60,613 (Oct. 14, 2008) (rejecting, on statutory mandate grounds, commenter suggestion for pilot licensing scheme whereby private bureaus would review SMR applications).

334. For an overview of the French system, see WORLD NUCLEAR ASS'N, NUCLEAR POWER IN FRANCE, http://www.world-nuclear.org/info/Country-Profiles/Countries-A-F/France/ (last updated Sept. 2015) [http:// perma.cc/VM4D-DM7G].

335. *E.g.*, Citizens Awareness Network, Inc. v. United States, 391 F.3d 338, 343–45 (1st Cir. 2004) (describing shift from part 50 to part 52 licensing scheme).

336. Moreover, more research is needed to align the insights of behavioral psychology to effective regulatory approaches designed to enhance the efficiency of regulation. *Cf.* SUNSTEIN, *supra* note 190, at 69 (suggesting research shows improper risk perception leads to inefficient regulatory behavior).

337. *See* Peter Taberner, *Licensing process to catapult US-SMR export potential*, NUCLEAR ENERGY INSIDER (Jan. 28, 2015), http://analysis.nuclearenergyinsider.com/small-modular-reactors/licensing-process-catapult-us-smr-export-potential [http://perma.cc/XAG9-SUQ5] (noting need for licensing process evolution). A significant issue for new U.S. nuclear energy is the availability of foreign markets, which is contingent on the law of export controls set forth in § 123 of the Atomic Energy Act. *See* Press Release, President Barack Obama, Message to Congress—Agreement for Cooperation Between the United States of America and the Government of the People's Republic of China Concerning Peaceful Uses of Nuclear Energy (Apr. 21, 2015), https://www.whitehouse.gov/the-press-office/2015/04/21/message-congress-agreement-cooperation-between-government-united-states- [https://perma.cc/G3EQ-2MYN] (emphasizing the importance of an American-Chinese relationship in trade and nuclear nonproliferation).

338. *See* Policy Statement on the Regulation of Advanced Reactors, 73 Fed. Reg. at 60,613 (describing initial efforts to address safety and licensing issues related to advanced reactors like SMRs); *see also* BLUE RIBBON COMM'N, *supra* note 280, at vii (listing recommendations).

defense-in-depth concept to probabilistic risk assessment.[339] And while the Nuclear Waste Policy Act has stalled perhaps past the point of any return, numerous recommendations for a new approach are on the table,[340] including an NRC rule issued in 2014.[341]

Overall, any of these initiatives would be aimed at reducing the cost of nuclear power. If it were more economical to construct, operate, and manage the back end of the fuel cycle, then presumably existing plants would be encouraged to continue operating and renew their licenses, promoting the reliability of the system both technically and with respect to preserving a diverse mix of fuel sources. Because nuclear power's emissions profile is so beneficial, the environmental advantages of nuclear power would also be retained. And perhaps investors would be more willing to consider new nuclear power and nuclear innovation to further reap these benefits. To be sure, the changes we mention would prompt significant backlash from groups opposed to nuclear power. The courts' response to such initiatives, moreover, may be difficult to predict.[342] Proposals like these seem likely to draw the attention of Congress and the President, though their reactions might depend on which party is in control of those institutions when proposals like these are floated, if they ever are. The inevitability of such hurdles, however, is a feature of the landscape for any major regulatory initiative influencing energy markets. Public choice theory, after all, also predicts that NRC might have an interest in reducing the nuclear risk premium; the agency stands to lose importance over time if the number of nuclear reactors dwindles.[343]

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339. See NTTF Report, *supra* note 198, at 15–23 (providing background information and recommendations for balancing defense-in-depth and risk considerations).

340. A number of such recommendations, issued by the Blue Ribbon Commission, would require statutory amendments. *See* BLUE RIBBON COMM'N, *supra* note 280, at viii (cataloguing needs for statutory change).

341. *See* Continued Storage of Spent Nuclear Fuel, 79 Fed. Reg. 56,238, 56,240 (Sept. 19, 2014) (finding reasonable assurances of safety of long-term spent fuel storage); *see also* Petition for Review, Nat. Res. Def. Council v. Nuclear Regulatory Comm'n, No. 14-1217 (D.C. Cir. Oct. 29, 2014) (challenging rule).

342. *See* Hammond, *Dialogue*, *supra* note 168, at 1733 (describing the spectrum of judicial deference).

343. *But see* Allison M. Macfarlane, Chairman, Nuclear Regulatory Comm'n, Remarks to the National Press Club (Nov. 17, 2014), http://www.nrc.gov/reading-rm/doc-collections/commission/speeches/2014/s-14-012.pdf [http://perma.cc/VQ4R-Q3XS] ("I believe it's time for the NRC to develop regulations specific to the decommissioning of nuclear power plants, both to help utilities through decommissioning and to structure public expectations of the process.").

B. State Initiatives

As noted in Part I, many states use RPSs to directly promote a greener generation mix, and RPSs have grown steadily in number and strength since the early 1980s; today two-thirds of the states have in place some form of RPS.[344] RPSs vary considerably in their design, but they typically specify some percentage of electricity sales within a state that must or should be attributable to renewable fuel sources.[345] In competitive markets, RPSs increase the price electricity retailers are willing to pay for clean power; in those states, ratepayers may pay more for power as a consequence. Developments in federal law, including the Clean Power Plan and a growing appreciation for other low-carbon resources like nuclear power, have pushed some states to revise their RPSs to emphasize carbon neutrality rather than renewable fuels per se. Ohio, for example, has a low-carbon standard, which requires that by 2025, half the mandated 25% carbon emissions reduction must come from renewables, while the other half must come from sources like third-generation nuclear power, energy efficiency, and clean coal technology.[346] These kinds of clean energy standards can be a powerful tool for greening the energy mix, but states have other tools as well.

States have considerable say in the types of electricity generation constructed within their borders. Some impose their own licensing regimes on new plant construction.[347] Some employ integrated resource planning ("IRP"), a way of evaluating and comparing proposed new generation.[348] IRP is conducted in some form in at least twenty-seven states.[349] State IRP processes only sometimes attempt to incorporate projected environmental impacts into electric generating capacity planning decisions but they could do so. Those that do pursue this objective do so by forcing utilities to consider demand-side resources (energy efficiency and conservation) in making decisions

344. For an up-to-date list, see DATABASE OF STATE INCENTIVES FOR RENEWABLES & EFFICIENCY, www.dsireusa.org (last visited Sept. 11, 2015) [http://perma.cc/54W6-PDTX].

345. *See id.* (describing programs in different states).

346. OHIO REV. CODE ANN. § 4928.64 (West 2012); *cf.* North Dakota v. Heydinger, 15 F. Supp. 3d 891, 907 (D. Minn. 2014) (striking down portions of Minnesota low-carbon standard on dormant Commerce Clause grounds).

347. *See* EISEN ET AL., *supra* note 44, at 78–79 (outlining several steps in the state licensing process).

348. *See* Energy Policy Act of 1992, Pub. L. No. 102-486, § 111, 106 Stat. 2776, 2795 (codified as amended at 16 U.S.C. § 2621(d)(7) (2012)) (directing utilities to implement ISP).

349. Rachel Wilson & Paul Peterson, *A Brief Survey of State Integrated Resource Planning Rules and Requirements*, SYNAPSE ENERGY ECON. 11 (April 28, 2011), http://www.cleanskies.org/wp-content/uploads/2011/05/ACSF_IRP-Survey_Final_2011-04-28.pdf [http://perma.cc/TC7N-CGPN].

about how best to meet projected future electric energy needs, or by requiring planners to consider the environmental costs new generating plants will produce.[350] A minority of states also articulate a goal of maintaining fuel diversity in capacity planning decisions, which could be a way of promoting long-term reliability in state licensing or IRP processes.[351] In addition to trying to value fuel diversity, several states employ adders to the estimated costs of power for new plants representing the cost of externalities generated by those plants over their lifetimes.[352] States' methodologies for valuing externalities vary considerably.[353] The key point, however, is that states can incorporate externalities into decisions about which plants to build, even if electricity markets do not incorporate these considerations directly into decisions about which plants to dispatch to serve load. Doing so would help rebalance markets consistent with our tripartite framework.

Note that incorporating externalities and reliability into capacity planning is most easily achieved where traditional rate regulation and vertically integrated utilities continue to predominate (mainly the southeastern United States). In those states, utilities can satisfy reliability and clean energy goals with far less risk of revenue losses; the tradeoff is that ratepayers may pay more for power in those states.[354] For example, states can permit utilities to recover the carrying costs of construction from ratepayers for capital-intensive projections. The Georgia Nuclear Financing Act, enacted just after Southern

350. For a helpful description of how Arizona, Colorado, and Oregon use integrated resource planning, see Rachel Wilson & Bruce Biewald, *Best Practices in Electric Utility Integrated Resource Planning*, REG. ASSISTANCE PROJECT, 6–16 (June 2013), http://www.raponline.org/document/download/id/6608 [http://perma.cc/SX9Q-J7AH].

351. *See supra* note 79 and accompanying text.

352. *See, e.g.*, Boyd, *supra* note 22, at 1695–96 (collecting examples); Wilson & Biewald, *supra* note 349, at 16–25 (same).

353. For one example, see MINN. STAT. § 216B.243(3)(a) (1994). The statute requires the Minnesota Public Utilities Commission to "quantify and establish a range of environmental costs associated with each method of electricity generation." *Id.* § 216B.2422(3)(a); *see also In re* Quantification of Envtl. Costs, 578 N.W.2d 794, 802 (Minn. Ct. App. 1998) (upholding PUC regulations); *In re Quantification of Environmental Costs*, 150 PUB. UTIL. REP. 4th (PUR) 130, 137 (1994) (explaining how environmental externalities are quantified in Minnesota); Jonas J. Monast & Sarah K, Adair, *The Triple Bottom Line for Electric Utility Regulation: Aligning State-Level Energy, Environmental, and Consumer Protection Goals*, 38 COLUM. J. ENVTL. L. 1, 40–41 (2013) (collecting further examples of state PUCs considering environmental factors in exercise of general authority). Valuation is a complex process, but resources are available. *See generally* NATIONAL RESEARCH COUNCIL, HIDDEN COSTS OF ENERGY: UNPRICED CONSEQUENCES OF ENERGY PRODUCTION AND USE (2009); Nicholas Muller & Robert Mendelson, *Efficient Pollution Regulation: Getting the Prices Right*, 99 AM. ECON. REV. 1714 (2009); Ian F. Roth and Lawrence L. Ambs, *Incorporating Exernalities into a Full Cost Approach to Electric Power Generation Life-Cycle Costing*, 29 ENERGY 2125 (2004).

354. There is considerable debate whether this is true. *See infra* text accompanying notes 355–58.

Company sought authorization from Georgia's PUC to construct the Vogtle units, permits Southern Company to collect from ratepayers the financing costs of Vogtle during its construction.[355] A South Carolina statute, by contrast, permits recovery of carrying costs for utilities seeking to construct base load plants, which are defined as new coal or nuclear generation with a generating capacity of 350 megawatts or greater.[356] As yet another example, Florida's PUC has issued a rule permitting recovery of carrying costs for new nuclear construction.[357] These initiatives are not without controversy; sustained opposition illustrates that even with state support, efforts to encourage particular fuels may be hindered.[358]

Nevertheless, the ability to recover costs through ratemaking may well explain why new nuclear reactor construction is currently taking place only in traditionally regulated states. Certainly the ability to guarantee rate recovery for construction carrying costs, as exemplified by Georgia's example, is far clearer in states that use traditional notions of the state regulatory contract, including cost recovery. Note, however, that this traditional approach to incentivizing investment is not unique to nuclear power, or to traditionally regulated state markets. Remember that even in competitive markets, the rates of transmission and distribution ("wires") companies remain regulated. So wires companies can recover their investments in smart meters and grid storage, for example, which are also aimed at enhancing grid reliability.[359]

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355. By its terms, the Act's most specific provisions applied only to nuclear plants certified by the state PUC between January 1, 2009 and July 1, 2009, making Southern the only eligible company. *See* GA. CODE. ANN. § 46-2-25(c)(3) (2009); Fulton Cty. Taxpayers Found. v. Ga. Pub. Serv. Comm'n, 700 S.E.2d 554, 557–58 (Ga. 2010) (holding plaintiffs lacked standing to challenge PUC certification and statute). Note that NRC's COL licenses were issued February 10, 2012. Contingent on cost recovery is Southern's duty to make frequent reports to the PUC. This reporting process has revealed that the current construction is over budget and behind schedule. *See also* Thomas Overton, *Even More Delays and Cost Overruns for Vogtle Expansion*, POWER (Feb. 2, 2015), http://www.powermag.com/even-more-delays-and-cost-overruns-for-vogtle-expansion/ [http://perma.cc/B42F-DZEW] (detailing new reports of cost overruns and delays, as well as construction litigation).

356. Base Load Review Act, S.C. CODE ANN. § 58-33-220(2) (2011). In the case of coal, the statute specifies that such plants are required to comply with Best Available Control Technology for air emissions, as defined by EPA. *Id.*

357. *See* FLA. ADMIN CODE ANN. r. 25-6.0423(6) (2007) (permitting a utility to petition the Florida Public Service Commission to recover carrying costs).

358. *See Fulton Cnty.*, 700 S.E.2d at 555 (upholding judgment in favor of the Georgia PSC arising out of Vogtle certification).

359. Recovery remains subject to PUCs' decision making and state law. *See* Eisen, *supra* note 15, at 17–20; *see also* Inara Scott, *Teaching an Old Dog New Tricks: Adapting Public Utility Commissions to Meet Twenty-First Century Climate Challenges*, 38 HARV. ENVTL. L. REV. 371, 372–73, 377 (2014) (noting challenges and solutions).

Conversely, recent experience suggests that restructured states whose generators participate in competitive wholesale markets cede some control over the generation mix in their states. Consider the following. In the early 2000s, two states in the eastern portion of PJM, New Jersey and Maryland, grew dissatisfied with wholesale electricity prices in eastern PJM. Policymakers in both states concluded that the PJM capacity market was not inducing sufficient investment in new generation facilities in eastern PJM and undertook to subsidize construction of new natural-gas fired generation within their state borders. Reasoning that these subsidies would distort prices in the PJM market, two different federal circuit courts, in 2014, overturned each of these two subsidy programs as preempted by the FPA, which grants the FERC exclusive authority to regulate wholesale rates.[360] A key part of both courts' rationale was that by restructuring, the states had thrown "[their] lot with the federal interstate markets" and relinquished their former regulatory autonomy.[361] Thus, even though the states still retained authority over siting and construction, by giving up their authority to set electricity rates under the traditional approach, they had also limited their ability to compensate for distortions that generators within their borders might encounter.[362]

Restructured states within competitive wholesale markets have looked at other ways to make up for perceived deficiencies, however. A study by the New York Independent System Operator ("NYISO"), for example, concluded that if the aging R.E. Ginna nuclear power plant in New York were to retire, its loss would result in numerous bulk-transmission system and non-bulk local distribution system reliability violations.[363] As a result, New York's Public Service Commission approved Exelon's request to seek a reliability support services agreement with a transmission owner in order to keep the plant

360. PPL EnergyPlus, LLC v. Solomon, 766 F.3d 241, 255 (3d Cir. 2014), *pet'ns for cert. filed sub noms.* CPV Power Dev., Inc. v. PPL EnergyPlus, LLC, 2014 WL 6737445 (U.S. Nov. 26, 2014) (No. 14-634) and Fiordaliso v. PPL EnergyPlus, LLC, 2014 WL 6998396 (U.S. Dec. 10, 2014) (No. 14-694) (holding New Jersey effort to compensate new generation for capacity market disparities was preempted by Federal Power Act); PPL EnergyPlus, LLC v. Nazarian, 753 F.3d 467, 476–77 (4th Cir. 2014), *cert. granted sub nom.* Hughes v. PPL EnergyPlus LLC, 2015 WL 6112868 (Oct. 19, 2015) (holding that a similar Maryland scheme is preempted by the Federal Power Act but noting limits on federal authority).

361. *Nazarian*, 745 F.3d at 473; *see also Solomon*, 766 F.3d at 248 ("New Jersey divorced the entities that generate electricity from those that supply it.").

362. *E.g.*, *Solomon*, 766 F.3d at 248. *But see* ONEOK, Inc. v. Learjet, 135 S. Ct. 1591, 1594 (2015) (holding Natural Gas Act did not preempt state-law antitrust claims against natural gas traders operating on both the wholesale and retail markets).

363. NEW YORK INDEP. SYS. OPERATOR, ADDITIONAL RELIABILITY STUDY FOR EXELON CORPORATION: EVALUATION OF THE IMPACT OF THE RETIREMENT OF THE GINNA NUCLEAR GENERATION STATION ON THE NEW YORK STATE TRANSMISSION SYSTEM 17 (2014).

operating despite its loss of a long-term power contract and inability to operate in the low-priced power market.[364] According to some estimates, the new power contract would charge over eighty percent more than wholesale rates.[365] But the Commission reasoned that the power source's reliability and carbon-free capability made it a key asset in the state's generation fleet.[366]

Other state activities in RTO/ISO regions echo the notion that reliability as an attribute is undervalued. Ohio's PUC, for example, is considering whether to permit a rate rider in its retail rates to make up for low wholesale rates in order to retain existing nuclear capacity.[367] Consider also the Illinois House of Representatives' recent resolution calling on various state agencies to prepare reports "showing how the premature closure of existing nuclear power plants in Illinois will affect" reliability and capacity for the Midwest region, increased GHG emissions, and the state's economy.[368] The resolution instructed agencies to include findings about potential market-based solutions to avoid premature closings of the state's nuclear power plants. Among the resolution's findings were the importance of nuclear power to meeting EPA's Clean Power Plan proposal, ensuring reliability and capacity, and preserving numerous nuclear-power related jobs in the state.[369] The report, issued January 25, 2015, considered several market-based solutions: relying purely on the existing market, a cap-and-trade program, a carbon tax, a low-carbon portfolio standard, and a sustainable power planning standard.[370] For all of the options, however, it recommended further research, cautioning that any approach directed at nuclear power plants "should be mindful of the looming

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364. Barry Cassell, *Exelon, Rochester Still Working on Life-Saving Deal for Ginna Nuclear Plant*, GENERATION HUB (Feb. 6, 2015), http://generationhub.com/2015/02/06/exelon-rochester-still-working-on-life-saving-deal [http://perma.cc/JHS2-XF25].

365. Naureen S. Malik & Jim Polson, *New York Reactor's Survival Tests Pricey Nuclear*, BLOOMBERG (Jan. 5, 2015), http://www.bloomberg.com/news/2015-01-05/new-york-reactor-s-survival-tests-pricey-nuclear.html [http://perma.cc/2L4V-KVXP].

366. *Id.*; *see also* NUCLEAR ENERGY INST., ECONOMIC IMPACTS OF THE R.E. GINNA NUCLEAR POWER PLANT 2 (Feb. 2015) (concluding plant is "significant economic contributor to the region and New York").

367. *But see Solomon*, 766 F.3d at 248–49, 255 (holding New Jersey's Long Term Capacity Pilot Program Act preempted by Federal Power Act because it regulated wholesale capacity prices; statute was aimed at encouraging construction of new, efficient power generating plants); *Nazarian*, 753 F.3d at 476–77 (similar).

368. H.R. 1146, 98th Gen. Assemb., at 8 (Ill. 2014).

369. *Id.* at 1–4. In addition, the resolution also called on FERC and RTOs to adopt rules and policies to help ensure the continued operation of nuclear power plants. *Id.* at 6.

370. ILL. COMMERCE COMM'N ET AL., POTENTIAL NUCLEAR PLANT CLOSINGS IN ILLINOIS, OVERVIEW 1 (Jan. 25, 2015), https://www.icc.illinois.gov/electricity/workshops/hr1146.aspx [http://perma.cc/A4W8-6YSZ].

Clean Power Plan compliance requirements."[371] So far, the low-carbon portfolio standard appears to have the most traction.[372]

C. Regional Initiatives

Regional entities, mainly RTOs/ISOs, administer some of the FERC policies aimed at greening the generation mix described in Section III.A. They also operate wholesale markets in ways that accommodate state initiatives, like RPSs, and can accommodate multi-state green initiatives. For example, the northeastern ISOs operate within the boundaries of the Regional Greenhouse Gas Initiative ("RGGI"), a voluntary carbon trading regime created by a group of northeastern states.[373] The carbon trading regime influences the bid prices of generators into wholesale markets by requiring them to purchase pollution rights in amounts that cover their actual emissions. There are few other examples,[374] suggesting the potential to do more but also reinforcing the governance issues described above. Notably, the Clean Power Plan envisions state cooperation to achieve GHG emission-reduction goals, suggesting federal support of region-driven approaches.

Reliability, by contrast, has generally been the concern of multiple layers of governmental and private sector actors, including FERC, the North American Electric Reliability Corporation ("NERC"),[375] regional reliability entities overseen by NERC,[376] RTOs/ISOs, and states. Every NERC region has an established reserve margin target, or desired amount of available generation over and

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371. ILLINOIS REPORT, *supra* note 272, at 158–59.

372. *See* Steve Daniels, *Exelon Proposes Surcharge on Power Bills; Legislation Expected Soon*, CRAIN'S (Feb. 24, 2015), http://www.chicagobusiness.com/article/20150224/NEWS11/150229921/exelon-proposes-surcharge-on-power-bills-legislation-expected-soon [http://perma.cc/9WGE-7TXR] (discussing the newly formed coalition of supporters behind such a "low-carbon portfolio" in Illinois).

373. REGIONAL GREENHOUSE GAS INITIATIVE, www.rggi.org [http://perma.cc/ATS5-QGFK] (last visited Mar. 6, 2015).

374. *Cf.* Frederic Tomesco & Lynn Doan, *California, Quebec Seek Partners to Grow Carbon Market*, BLOOMBERG (Sept. 24, 2014), http://www.bloomberg.com/news/articles/2014-09-24/quebec-california-seeking-to-boost-size-of-carbon-market [http://perma.cc/JJU2-F7LB] (describing the California-Quebec market).

375. Section 215 of the Energy Policy Act of 2005 directed FERC to appoint and oversee a national electric reliability organization. 16 U.S.C. § 824o (2012). FERC appointed NERC to this role in 2006. Order Certifying North American Electric Reliability Corporation as the Electric Reliability Organization and Ordering Compliance Filing, 116 FERC ¶ 61,062, at 4 (2006).

376. The boundaries of these regional entities correspond roughly to the boundaries of RTOs/ISOs in organized power markets. *See Regional Entities*, NERC, http://www.nerc.com/AboutNERC/keyplayers/Pages/Regional-Entities.aspx (last visited Mar. 6, 2015) [http://perma.cc/W86V-3AJE] (showing boundaries of the eight regional entities under NERC).

above anticipated peak demand. In NERC regions dominated by traditionally regulated, vertically integrated electric utilities, meeting the reserve margin target is a simple matter because utilities have an incentive to invest in generation.[377] In areas with wholesale markets overseen by RSOs/ISOs, capacity markets, mentioned in Part I, represent another way to try to meet reserve margin targets.

To date, capacity markets have not attempted to place a value on fuel diversity or social costs.[378] Indeed, it is the failure of competitive wholesale markets to reward the combination of reliability and low emissions that has led states like Illinois, New York, and Ohio to consider incentives to keep plants open, as described in the previous section. Capacity markets could explicitly incorporate fuel diversity into their selection criteria to avoid these problems. On the other hand, regional capacity planning presents collective action problems, which in turn can present federalism problems, as the above examples of New Jersey and Maryland reveal. Given the conflicts between states in the eastern and western portions of PJM,[379] it is not difficult to imagine that disputes will erupt within regional entities over attempts to value fuel diversity or social costs in capacity markets.

Nevertheless, FERC recently approved PJM's request to change its capacity market rules, beginning with the August 2015 capacity auctions. As modified on rehearing, the new rules enable non-generation resources to participate, discount fuel sources like wind and solar that are not dispatchable, and penalize resources that are not available if called upon.[380] Further, the new rules permit natural gas bidders to exceed the default offer gap if the exceedance is due to the extra costs of having contracted for firm supply.[381] It remains to be seen how the new rules will function, but it is notable that these rules single out specific generation source attributes in ways that favor reliability and diversity of fuel mix; if more resources are available at times of peak demand, the overall market clearing prices should be lower.

377. This effect is attributed to the cost-of-service approach to ratemaking. *See supra* note 163.

378. *See Exelon on the 2014 PJM Capacity Market Auction*, NEI (June 12, 2014), http://www.nei.org/News-Media/News/News-Archives/Exelon-on-the-2014-PJM-Capacity-Market-Auction [http://perma.cc/87KN-ED8R] (criticizing PJM capacity planning process because it "reveal[s] that the market does not sufficiently recognize the significant value that nuclear plants provide in terms of reliability and environmental benefits").

379. *Supra* text accompanying notes 282–84.

380. Order Denying Request for Clarification, Granting in Part Request for Rehearing, 152 FERC ¶ 61,064, at 3–4 (July 22, 2015); Order on Proposed Tariff Revisions, 151 FERC ¶ 61,208, at 4 (June 9, 2015).

381. 151 FERC ¶ 61,208, at 9–10.

The Texas grid operator has eschewed capacity markets in favor of letting wholesale prices rise to a cap of $9,000/MWh[382] (as compared with average prices of less than $50/MWh)[383] as a way of rewarding investment in new capacity. However, concerned that high prices alone might not be a sufficient incentive, Texas regulators have explored intervening in ancillary services markets to increase payments to providers of ancillary services (essentially, a reliability adder), which are very short-term reserves.[384] Traditionally, the grid operator dispatches reserves the same way it dispatches other generation resources, using the SCED rule. This idea would act as a kind of reliability adder in the ancillary services market.

In any of the wholesale markets, one could conceivably interject social costs into the dispatch system as well, through the use of adders in the dispatch process. The idea behind social cost dispatch is to modify current SCED rules by adding to each source's bid cost an estimate of that facility's marginal social costs (that is, estimated marginal value of its external costs). This is conceptually straightforward, but controversial and extremely complex in practice. In theory, such adders would be equivalent to the imposition of an optimal emissions tax,[385] imposed only on electric generators. The adder would, like the tax, force firms to internalize an optimal amount of external costs. Some scholars have proposed methods of full social cost (or "environmental/economic")

382. *See* POTOMAC ECONOMICS, LTD., 2014 STATE OF THE MARKET REPORT FOR THE ERCOT WHOLESALE ELECTRICITY MARKETS xxv (July 2015) (market monitor's report presenting real-time electricity prices for 2014).

383. *Id.* at i.

384. *See* PUB. UTIL. COMM'N OF TEX., PROJECT 40000: COMMISSION PROCEEDING TO ENSURE RESOURCE ADEQUACY IN TEXAS, http://www.puc.texas.gov/industry/projects/electric/40000/40000.aspx [http://perma.cc/W5XZ-QRGT] (providing information and documents).

385. Theoretically, the tax should be set at a price that will induce generators to reduce pollution to the point at which the marginal benefit of the next unit of pollution equals its marginal cost. THOMAS TIETENBERG, ENVIRONMENTAL AND NATURAL RESOURCE ECONOMICS 52–54 (1992).

dispatch,[386] but others believe it is unworkable.[387] EPA's proposed Clean Power Plan aims to reduce greenhouse gas emissions from the electricity sector by encouraging (but not requiring) states to dispatch cleaner sources of power—nuclear, natural gas, and renewables in place of coal,[388] thereby introducing environmental considerations into dispatch decisions directly.[389] But that plan has met with hostility from Republican appointees to FERC, precisely because it would represent a step toward an "environmental dispatch" model.[390] Thus, even if such costs could be calculated appropriately, the political viability of such an approach is questionable.

CONCLUSION

We have explored some of the ways in which the move toward less regulated, more competitive markets has shifted the way we balance cost, reliability/flexibility, and environmental externalities in the electric generation mix. If the foregoing discussion makes daunting the prospect of fully realizing the vision of an efficient, reliable, and

386. *See, e.g.*, Stephen Bernow et al., *Full-Cost Dispatch: Incorporating Environmental Externalities in Electric System Operation*, 4 ELEC. J. 20, 26–29 (1991) (advocating full social cost dispatch, while acknowledging difficult implementation problems). A number of engineers have proposed algorithms for accomplishing full social cost dispatch. *See, e.g.*, M.A. Abido, *Environmental Economic Power Dispatch Using Multiobjective Evolutionary Algorithms*, 18 IEEE TRANSACTIONS ON POWER SYSS. 1529, 1530–32 (2003); Simona Dinu et al., *Environmental Economic Dispatch Optimization Using a Modified Genetic Algorithm*, 20 INT'L. J. COMPUTER APP. 975, 976–79 (2011); Terje Gjengedal et al., *Environmental Objectives in Power Production Unit Commitment and Dispatch*, ACEEE SUMMER STUDY ON ENERGY EFFICIENCY IN BUILDINGS, at 9.59 (Aug.–Sept. 1992), http://aceee.org/files/proceedings/1992/data/papers/SS92_ Panel9_Paper08.pdf [http://perma.cc/Z2YH-4T66]; Mimoun Younes et al., *Environmental / Economic Power Dispatch Problem,* PROCEEDINGS: 2013 CONFERENCE ON ENVIRONMENT, ENERGY ECOSYSTEMS, AND DEVELOPMENT, 170, 170–73, http://www.europment.org/library/2013/venice/ bypaper/EEEAD/EEEAD-24.pdf [http://perma.cc/ VMC5-CQ8A].

387. Perhaps the most prominent scholar opposing full social cost dispatch is William Hogan. *See generally* William W. Hogan, *Electricity Market Design: Environmental Dispatch*, JFK SCH. OF GOV'T, HARV. UNIV. (Dec. 4, 2014), http://www.ksg.harvard.edu/hepg/Papers/ 2014/12.14/Hogan%20Presentation.pdf [http://perma.cc/5X5V-UKSG].

388. CLEAN POWER PLAN, *supra* note 11, at 34,856. The Plan would establish emissions budgets for each state based, in part, on assumptions about how much each state can dispatch cleaner technologies in place of coal-fired power.

389. This has provoked complaints from opponents of the proposed plan who argue that a system of "environmental dispatch" violates the just and reasonable rate requirement. *See generally* Hogan, *supra* note 387.

390. *See FERC Perspective: Questions Concerning EPA's Proposed Clean Power Plan and other Grid Reliability Challenges: H.R. Hearing Before the Comm. On Energy & Commerce, Subcomm. on Energy & Power*, 113th Cong. 7–9 (July 29, 2014) (written testimony of FERC Commissioner Philip D. Moeller), http://www.ferc.gov/CalendarFiles/20140729091755-Moeller-07-29-2014.pdf [http://perma.cc/M6CE-H9R4] (also arguing that environmental dispatch is unworkable).

green grid, it also suggests reasons for optimism.[391] There are many institutional actors at every governance level who are trying to realize this vision, and there is room for much more experimentation. This observation, however, returns us to our starting point: what do all of these developments mean for the regulatory contract? Once defined by two parties and a nineteenth-century purpose, the regulatory contract is now characterized by heterogeneity and complexity among regulated entities and regulators alike.

But more work is needed to fully align this concept with the clean, reliable, and cost-efficient grid. As we have shown, a number of mismatches between old regulatory regimes and competitive markets have resulted in a failure to value some attributes of electricity. The least-cost imperative helps sources whose long-run average costs fall below the projected long-run marginal costs at which competitive markets price wholesale power. The need to compete in those markets discourages polluting sources like coal-fired power plants from internalizing those externalities, or natural gas-fired plants from paying more for a firm fuel supply. However, the experience of nuclear power demonstrates these mismatches most starkly. Prospective new entrants are disincentivized to construct high-capital projects with an added risk premium; current players are being priced out of the markets, notwithstanding their reliable, clean contribution to the grid.

We have considered a number of policy options that would attempt to better maximize our tripartite framework. This context points to the need for further research that considers various policy options in tandem, rather than in isolation. If the regulatory contract is a network, its component parts must be examined with this in mind.[392] More generally, our analysis illustrates that the legal framework within which the markets operate shapes those markets. In other words, institutions matter. In electricity markets, those institutions have changed dramatically over the last three decades. The move from comprehensive regulation and administrative price-setting to competition and market prices has not provided us with an electric generation mix that satisfies all of the important attributes we seek.

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391. We are not alone in this optimism. *See* Boyd & Carlson, *supra* note 287 (framing the variety in state and regional electricity markets as part of the process of experimentation that will move us eventually toward a carbon-free grid).

392. Of course, any policy prescription must recognize that the hodgepodge of existing federal, regional and state initiatives we have described are not the product of any consensus agreement about the proper balance between cost, reliability, and environmental impact in the electric generation mix. Rather, they are the product of partisan and interest group conflict, and competition (more than cooperation) between those pursuing a vision of more competitive markets and those pursuing a vision of cleaner energy markets.

Thus, competition may bring certain types of efficiency, but it does not obviate the need for regulation. To the contrary, modern electricity markets under supply clean, reliable sources of electricity generation by focusing on minimizing costs. If we are to truly pursue a low-cost, reliable, and green grid, we must view the regulatory contract as a flexible mechanism—one that can incorporate a variety of policy options, at multiple governance levels, to change the inputs to the markets or even alter the markets themselves.