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Symposium: The Post-Carbon World: Advances in Legal and Social Theory

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SYMPOSIUM

THE POST-CARBON WORLD: ADVANCES IN LEGAL AND SOCIAL THEORY

INTRODUCTION

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"[I]t is technically feasible for the U.S. to reduce [greenhouse gas] emissions 80% below 1990 levels by 2050 with overall net greenhouse gas emissions of no more than 1080 $MtCO_2e$, and fossil fuel combustion emissions of no more than 750 $MtCO_2$."[1]

"Based on the scientific results presented, current barriers to [100% wind, water, and solar sources of power for electricity, transportation, heating, cooling, and industry] are neither technical nor economic. As such, they must be social and political."[2]

"[S]ociety has all the technologies it needs to meet [its climate change and energy security] challenges . . . ."[3]

Architects of the Anthropocene at times betray an uncanny optimism. Consider a moment during the rise of industry in nineteenth-century Europe. Jean-Baptiste Say, the French economist, argued that "nature placed in reserve long before the formation of man immense provisions of fuel in coal

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[1] JAMES H. WILLIAMS ET AL., SUSTAINABLE DEV. SOLS. NETWORK & INST. FOR SUSTAINABLE DEV. & INT'L RELATIONS, PATHWAYS TO DEEP DECARBONIZATION IN THE UNITED STATES, at xi (2014).

[2] Mark Z. Jacobson et al., *100% Clean and Renewable Wind, Water, and Sunlight (WWS) All-Sector Energy Roadmaps for the 50 United States*, 8 ENERGY & ENVTL. SCI. 2093, 2115 (2015).

[3] MARILYN A. BROWN & BENJAMIN K. SOVACOOL, CLIMATE CHANGE AND GLOBAL ENERGY SECURITY: TECHNOLOGY AND POLICY OPTIONS 3 (2011).

mines."[4] One such fossil fuel reservoir was tucked beneath the English countryside by a benevolent creator, aware of our bent to "destroy more combustible materials than [we] could reproduce."[5] The "coal fields of Durham and Northumberland" were generously stocked—"adequate to furnish the present annual supply for more than 1,340 years."[6] Similarly, the atmosphere, known as a sink for steam combustion's "noxious gases" by the 1830s, was described as "immense," "vast," and even "unlimited."[7] On the strength of these reserves, which stretched to the depths and highest heavens, Europe marched headlong into the Industrial Age.

The pace of development quickened in spurts. Minerals replaced felled forests as sources of energy. Inputs for new economic sectors (ores for tin for food processing, copper for wires for electric power, rubber for belts for steam engines and motor vehicles) were mined in distant lands. Global mobility was assured through massive direct foreign investment in petrochemical plants, pipelines, and refineries in the wake of the Second World War.[8] These energy transitions—from wood to coal to hydrocarbons and uranium to synthetic and unconventional fuels—allowed us to do remarkable things. We used those energy sources to fell, till, plough, pave, raise, and plan our cities and crops while sending untold amounts of ancient biomass into the sky. But fossil-fueled industry, a "high-energy metabolic system,"[9] soon outpaced not only the assimilative benevolence of atmosphere and ocean, but also our "capacity for prediction and control."[10] By the time Intergovernmental Panel on Climate Change (IPCC) consensus reports moved from findings of "discernible" to "unequivocal" human-induced warming,[11] we found ourselves mired in a war against time and a vast

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[4] CHRISTOPHE BONNEUIL & JEAN-BAPTISTE FRESSOZ, THE SHOCK OF THE ANTHROPOCENE 204 (2016).

[5] *Id.*

[6] *Id.* at 204–05.

[7] *Id.* at 205–06.

[8] MARC LINDER, PROJECTING CAPITALISM: A HISTORY OF THE INTERNATIONALIZATION OF THE CONSTRUCTION INDUSTRY 126 (1994).

[9] JÖRG FRIEDRICHS, THE FUTURE IS NOT WHAT IT USED TO BE, at vii (2013).

[10] *See* Sheila Jasanoff, *Technologies of Humility: Citizen Participation in Governing Science*, 41 MINERVA 223, 223 (2003).

[11] INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, IPCC SECOND ASSESSMENT CLIMATE CHANGE 1995, at 5 (1995), https://www.ipcc.ch/pdf/climate-changes-1995/ipcc-2nd-assessment/2nd-assessment-en.pdf [https://perma.cc/Y6UJ-XMLR]; INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, IPCC FOURTH ASSESSMENT CLIMATE CHANGE 2007, at 10 (2007), https://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_full_report.pdf [https://perma.cc/M7TU-WBXR].

machine.[12] Heat waves killed tens of thousands.[13] Water shortages threatened treaties along nuclear-tipped national borders.[14] And as scientists adjusted sea level rise estimates ever-higher,[15] sunny day floods brought a cephalopod ashore in Miami[16] and an India-sized expanse of sea ice vanished under record polar temperatures.[17]

Yet despite decades of lagging federal subsidy and support for clean energy,[18] and notwithstanding the distinct challenge posed by industrial ecosystems to those who would rework them (compared to prior, single-focus development tasks such as the Manhattan Project or the Apollo moon shot),[19] a new technological optimism surfaced through melting permafrost. We find it in energy pathway projects, which build different energy scenarios—high use of renewable fuel sources, nuclear power plus carbon capture—around carbon emissions commitments and the world's carbon budget[20] to figure out whether we can hold global average temperature increases to within 2ºC or even 1.5ºC by end-of-century. For example, one such study looked at whether California could reduce carbon emissions 80% from 1990 levels by 2050.[21] It reviewed several generic pathways: energy efficiency improvements in key sectors, deep decarbonization of energy supply, electrification of

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[12] *See* CHARLES WEISS & WILLIAM B. BONVILLIAN, STRUCTURING AN ENERGY TECHNOLOGY REVOLUTION 2 (2009) ("[A] program to stimulate technological innovation in energy will need to approach the dimensions of a major military transformational effort.").

[13] Daniel Mitchell et al., *Attributing Human Mortality During Extreme Heat Waves to Anthropogenic Climate Change*, 11 ENVTL. RES. LETTERS 074006 (2016).

[14] Michael Kugelman, *Why the India-Pakistan War over Water Is So Dangerous*, FOREIGN POL'Y (Sept. 30, 2016), http://foreignpolicy.com/2016/09/30/why-the-india-pakistan-war-over-water-is-so-dangerous-indus-waters-treaty [https://perma.cc/VQ4J-3U33].

[15] P.R. Thompson et al., *Are Long Tide Gauge Records in the Wrong Place to Measure Global Mean Sea Level Rise?*, 43 GEOPHYSICAL RES. LETTERS 10,403 (2016).

[16] Alex Harris, *Octopus in the Parking Garage Is Climate Change's Canary in the Coal Mine*, MIAMI HERALD (Nov. 18, 2016), http://www.miamiherald.com/news/local/community/miami-dade/miami-beach/article115688508.html [https://perma.cc/F6PF-DYAC].

[17] *Sea Ice Hits Record Lows*, NAT'L SNOW & ICE DATA CTR. (Dec. 6, 2016), https://nsidc.org/arcticseaicenews/2016/12/arctic-and-antarctic-at-record-low-levels [https://perma.cc/6LJH-YG2D].

[18] MICHAEL J. GRAETZ, THE END OF ENERGY: THE UNMAKING OF AMERICA'S ENVIRONMENT, SECURITY, AND INDEPENDENCE 187 (2011).

[19] WEISS & BONVILLIAN, *supra* note 12, at 9.

[20] INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2014: SYNTHESIS REPORT (Rajendra K. Pachauri & Leo Meyer eds., 2014); NICHOLAS STERN, WHY ARE WE WAITING? THE LOGIC, URGENCY, AND PROMISE OF TACKLING CLIMATE CHANGE 286 (2015).

[21] MAX WEI ET AL., LAWRENCE BERKELEY NAT'L LAB., SCENARIOS FOR MEETING CALIFORNIA'S 2050 CLIMATE GOALS: CALIFORNIA'S CARBON CHALLENGE PHASE II VOLUME 1: NON-ELECTRICITY SECTORS AND OVERALL SCENARIO RESULTS, at iv (2014).

heating and transportation, and biofuels.[22] This and other studies display confidence that existing or near-commercial technology can achieve global and national carbon emissions reduction goals within a generation.[23]

We should be wary of such claims, and not for the preternatural precision they share with triumphal, early industrial-era estimates of fuel reserves in tomes such as the *Statistical Account of the British Empire*.[24] As much as the green energy transition promises an answer to the climate crisis, we have witnessed energy transitions, their motives and limitations, before. Energy systems do not simply switch from wood to coal, coal to oil, "bridge fuel" to photovoltaic cell and wind turbine. Energy sources exhibit remarkable staying power—in fact, more coal was burned last year than ever before.[25] These energy sources feed and are facilitated by technologies, institutions, economic frameworks, and corporations, elements of Thomas Hughes's "technological systems" that evolve over considerable periods of time, link physical artifacts, organizations, resources, consumers, regulations, and other elements,[26] and "acquire momentum as they grow."[27] In the words of Dale Jamieson, in the Anthropocene, "things, not people, are in control."[28] Thus, while we welcome efforts to model and predict how technologies will interact with an energy system's "physical deep structures,"[29] we should also survey the institutions that sustain energy systems, their durability, and the unintended

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[22] *See id.*

[23] *See, e.g.*, RISKY BUS. PROJECT, FROM RISK TO RETURN: INVESTING IN A CLEAN ENERGY ECONOMY 20 (2016) ("Seriously addressing climate risk requires reducing carbon emissions by at least 80 percent by 2050 in the U.S. and across all major economies. We find that meeting this goal is both technically and economically feasible using commercial or near-commercial technology."); THE WHITE HOUSE, UNITED STATES MID-CENTURY STRATEGY FOR DEEP DECARBONIZATION 16 (2016) ("While these goals are ambitious, continued rapid clean energy technology development and deployment around the world will create a virtuous cycle in which ambition drives down costs, in turn eliciting greater ambition.").

[24] II J.R. MCCULLOCH, STATISTICAL ACCOUNT OF THE BRITISH EMPIRE: EXHIBITING ITS EXTENT, PHYSICAL CAPACITIES, POPULATION, INDUSTRY, CIVIL AND RELIGIOUS INSTITUTIONS 4 (London, Charles Knight & Co. 1837).

[25] INT'L ENERGY AGENCY, COAL MEDIUM-TERM MARKET REPORT 2016, at 3 (2016), https://www.iea.org/publications/freepublications/publication/MediumTermCoalMarketReport2016ExecutiveSummaryEnglishversion.pdf [https://perma.cc/6WHX-UDUZ].

[26] Thomas P. Hughes, *The Evolution of Large Technological Systems*, *in* THE SOCIAL CONSTRUCTION OF TECHNOLOGICAL SYSTEMS: NEW DIRECTIONS IN THE SOCIOLOGY AND HISTORY OF TECHNOLOGY 51–80 (W. Bijker et al. eds., 1987).

[27] DAVID J. HESS, GOOD GREEN JOBS IN A GLOBAL ECONOMY 13 (2012).

[28] DALE JAMIESON, REASON IN A DARK TIME: WHY THE STRUGGLE AGAINST CLIMATE CHANGE FAILED—AND WHAT IT MEANS FOR OUR FUTURE 1 (2014).

[29] *See* Sheila Jasanoff & Sang-Hyun Kim, *Sociotechnical Imaginaries and National Energy Policies*, 22 SCI. AS CULTURE 189, 189 (2013).

consequences that result when discrete changes fail to take them into account.

As legal scholars interpret descriptive elements of IPCC and other reports and move from findings of pathways projects to normative claims of how to abandon a carbon-intensive economy, they must grapple with sociotechnical systems at different scales, using multiple levels of analysis and a mix of theoretical tools. Legal scholars need to understand their political economy, path dependence, and susceptibility to disruption in different contexts and as the target of new social movements. The contributors to this symposium issue of the *Brooklyn Law Review* are uniquely qualified to discuss how such research can, and should, proceed. They approach energy systems from varied disciplines, including sociology, environmental law, science and technology studies, energy law, and public policy. Yet the aim of this issue is not to showcase the range of perspectives that they bring to the green energy transition. We wish to invite collaboration across disciplines and consider how the research questions that legal scholars ask about the imperative to "decarbonize" state, national, and global economies could be advanced through a richer sense of sociotechnical systems, social movements, and institutional change. To ignore these concerns, to—paraphrasing symposium speaker Sheila Jasanoff—uncritically accept models, misread technology as only material, ignore "routine practices as repositories of power," and erase history and time as factors that shape development pathways is to invite unintended consequences, widening inequality, or worse.[30]

Unintended consequences feature prominently in these pages and in the history of energy transitions. One need only consider the tax credits for "alternative fuels" that led companies to add diesel to their production process[31] and farmers to grow crops on sensitive lands as feedstock for carbon-intensive fuels[32] to appreciate what may result from a failure to consider, among other things, the electricity markets in which renewable sources are substituted for fossil fuels,[33] the product life cycles of alternative fuels and vehicles,[34] or the "sacrifice zones" where fuel source shifts take place and exhausted artifacts of clean

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[30] Sheila Jasanoff, *New Modernities: Reimagining Science, Technology and Development*, 11 ENVTL. VALUES 253, 253 (2002).

[31] GRAETZ, *supra* note 18, at 190.

[32] GARY BRYNER & ROBERT J. DUFFY, INTEGRATING CLIMATE, ENERGY, AND AIR POLLUTION POLICIES 3 (2012).

[33] David B. Spence, *Paradoxes of "Decarbonization"*, 82 BROOK. L. REV. 447 (2017).

[34] Alexandra B. Klass & Andrew Heiring, *Life Cycle Analysis and Transportation Energy,* 82 BROOK. L. REV. 485 (2017).

energy are discarded.[35] David Spence explores three classes of unintended consequences ("paradoxes") that deep decarbonization may prompt. Goals such as "80% reduction," "100% renewables," and "no later than 2050," driven by climate change projections, carbon emissions budgets, and what is politically plausible, are crudely drawn: they are not set with the trigger points of each paradox in mind. In turn, climate change mitigation goals threaten a host of challenging welfare effects. Each paradox reflects a core tension in the electricity market that is a product of federal rules, the physical nature and extent of the power grid, relationships among fuel source complements and substitutes, and the technologies that produce renewable energy. The "reliability-cost" paradox is traced to decision rules that favor reliability over cost and cost over environmental performance and that require "just and reasonable" or "least-cost" rates and increments of power.[36] The "health paradox" is a product of the close ties between the relative competitiveness of coal- and natural gas-fired power plants and the co-pollutants of each process.[37] The "fairness paradox" confronts how energy consumers—themselves increasingly producers of distributed energy—interact with, maintain, and benefit from the power grid.[38] Deep decarbonization "requires the political will to intervene in electricity markets in ways that preempt" rules, reconsider system reliability or impose new costs, question assumptions regarding the environmental gains of discrete fuel sources, and frame the tradeoffs of rapid transition in clearer terms.[39]

Alexandra Klass and Andrew Heiring address unintended consequences through the evolution of life cycle analysis (LCA), from simple product comparisons to robust consequential methods that account for as many outcomes of a product or process as possible throughout its extraction, manufacturing, use, and disposal or recycling.[40] LCA is a tool that can unearth assumptions lodged in statute (e.g., the federal Renewable Fuel Standard in the Energy Policy Act of 2005[41]) that can privilege a fuel source for a generation. Klass and Heiring recast U.S. support for alternative liquid fuels (biofuels), the rise of

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[35] Shannon Elizabeth Bell, *Environmental Injustice and the Pursuit of a Post-Carbon World: The Clean Air Act's Unintended Consequences as a Cautionary Tale for Solar Energy Development*, 82 BROOK. L. REV. 529, 536 (2017).

[36] Spence, *supra* note 33, at 453–55.

[37] *Id.* at 471–74.

[38] *Id.* at 474–78.

[39] *Id.* at 471, 481–82.

[40] Klass & Heiring, *supra* note 34, at 487–89.

[41] Energy Policy Act of 2005, 42 U.S.C. §§ 15801–15811 (2012).

ethanol, and its unintended consequences—land use change and reduced carbon sinks, new sources of air and water pollution, lower fuel prices that increased fuel consumption, use of coal-powered electricity and thermal energy to convert corn to fuel, higher food and animal feed prices—as a failure of analytic power to defeat narrowly focused, perceived benefits (including lower vehicle emissions from ethanol) before they are codified.[42] Their story, which they repeat for federal and state subsidy of electric vehicles,[43] is also one of agency attempts to "graft" an analytic tool onto a mandate or requirement. The growth of electric vehicle impact studies, from tailpipe to broader life cycle analysis, shows that it is vitally important to approach complete LCA as part of initial policy design. In addition, we need design principles to inform Environmental Protection Agency (EPA), California Air Resources Board (CARB), and other agency LCA work, particularly as they look beyond energy efficiency to material and product efficiency to wring out further emissions reductions from a product or process.[44]

Shannon Elizabeth Bell's work is steeped in unintended consequences, which she reveals through ethnographies of energy "sacrifice zones."[45] Sylvester, Sundial, and Rawl, West Virginia are towns and unincorporated communities that Bell links through lived experience in the wake of amendments to federal law.[46] Coal dust covers a town, coal slurry impoundments proliferate, and coal waste breaches underground mines contaminating water supply as Bell points to another analytic shortcoming: the absence of equity discourse prior to the Clean Air Act Amendments.[47] Bell's work suggests a growing taxonomy of unintended consequences that have yet to be applied to community-scale impacts of the green energy transition, including the reduced cost and increased installation of photovoltaic cells that by 2050 will generate twenty million tons of waste annually.[48] It is part of a long tradition in social theory that began with Robert Merton and flourished in areas such as man-made disasters, organizational deviance, and the risk society.[49] The

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[42] Klass & Heiring, *supra* note 34, at 490–93.

[43] *Id.* at 511–27.

[44] *See generally* Julian M. Allwood et al., *Material Efficiency: Providing Material Services with Less Material Production*, 371 PHIL. TRANSACTIONS ROYAL SOC'Y 20120496 (2013).

[45] Bell, *supra* note 35, at 536–50.

[46] *Id.* at 543–46.

[47] *Id.* at 536–50; *see* 42 U.S.C. § 7401 (2012).

[48] Bell, *supra* note 35, at 550–56.

[49] *See, e.g.*, ULRICH BECK, RISK SOCIETY: TOWARDS A NEW MODERNITY 22 (Mark Ritter trans., 1992); BARRY A. TURNER & NICK F. PIDGEON, MAN-MADE DISASTERS (2d ed. 1997); Diane Vaughan, *Organizational Rituals of Risk and Error*, *in* ORGANIZATIONAL

article's interplay between field research and epidemiology in mountaintop removal counties in Central Appalachia shows the potential for sociology to offer a more complete account of the intermedia effects of statutes that are treated more coarsely in legal scholarship.[50] Existing tools of environmental justice analysis, such as EPA's Environmental Justice Screening and Mapping Tool[51] and the Council on Environmental Quality's Environmental Justice Guidance Under the National Environmental Policy Act,[52] fail to operate at levels of temporal, spatial, and sociocultural specificity that Bell's findings demand. And there is a limited window in which to identify and contend with community-scale effects, which raises issues of regulatory analysis[53] including some that were shared in public comments by environmental justice communities as the Clean Power Plan took shape.[54]

A second theme across these works is what may be gained when history and time are given their rightful place in the analysis of development pathways and legal change. Much of Paul Pierson's menu of how time shapes event sequences and the social order is here, including path dependence, intermittent conjunctures, slow-moving social processes, and institutions that evolve and expire.[55] Amy Stein's piece begins with a central puzzle that the decarbonization project faces: What explains the persistence of a carbon-based economy despite clean energy's promise of reduced emissions, lower marginal fuel costs, and less reliance on unsustainable or unstable fuel sources?[56] This sprawling question could be addressed in more digestible bits such as technological persistence (which Brian Arthur attributed to large fixed costs and economies of scale, learning effects, network economies, and adaptive expectations) or economic or

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ENCOUNTERS WITH RISK 33 (Bridget Hutter & Michael Power eds., 2005); Robert K. Merton, *The Unanticipated Consequences of Purposive Social Action*, 1 AM. SOC. REV. 894 (1936).

[50] *See* Bell, *supra* note 35.

[51] *EJSCREEN: Environmental Justice Screening and Mapping Tool*, EPA, https://www.epa.gov/ejscreen [https://perma.cc/9DF9-GUAF].

[52] COUNCIL ON ENVTL. QUALITY, ENVIRONMENTAL JUSTICE: GUIDANCE UNDER THE NATIONAL ENVIRONMENTAL POLICY ACT (1997), https://www.epa.gov/sites/production/files/2015-02/documents/ej_guidance_nepa_ceq1297.pdf [https://perma.cc/B22A-Y7KZ].

[53] *See* EPA, TECHNICAL GUIDANCE FOR ASSESSING ENVIRONMENTAL JUSTICE IN REGULATORY ANALYSIS 62–64 (2016), https://www.epa.gov/sites/production/files/2016-06/documents/ejtg_5_6_16_v5.1.pdf [https://perma.cc/V34X-HWKQ].

[54] *See, e.g.*, Center on Race, Poverty & the Environment, Climate Justice Comment Letter on Carbon Pollution Emissions Guidelines for Existing Stationary Sources: Electric Utility Generating Units (Dec. 1, 2014).

[55] PAUL PIERSON, POLITICS IN TIME: HISTORY, INSTITUTIONS, AND SOCIAL ANALYSIS (2004).

[56] Amy L. Stein, *Breaking Energy Path Dependencies*, 82 BROOK. L. REV. 559, 561–62 (2017).

political institutions (which Douglas North described as similarly prone to increasing returns).[57] The combined interactions of technological and institutional systems in the fossil fuel economy were described in Gregory Unruh's "carbon lock-in" thesis,[58] which Stein extends to the legal regimes that govern electricity generation.[59] Her article ties each feature of a path dependent process to energy infrastructure, from up-front investment to risk aversion and learning effects among lending institutions and utilities to the economies of scale of regional transmission organizations and adaptive expectations of energy analysts and the electricity industry. Stein extends the analysis to the entrenchment of legal and regulatory as opposed to physical infrastructure, which she notes has in some ways "remained relatively unchanged since the 1900s."[60] She does so by focusing on institutional "logics," which "define formal and informal rules of behavior and guide interpretation about why certain structures and practices exist."[61] Institutional logics are an understudied unit of analysis in energy law and attempts to explain its evolution: fossil fuel sectors build around multiple logics that, according to the authors of the seminal work on the topic, are part of a "contradictory interinstitutional system."[62] Stein teases out logics that underlie carbon lock-in, including the regulatory compact, rules that reflect a least-cost resource focus, and risk-aversion.[63] For example, when state public utility commissions require utilities to provide power at the lowest cost as measured within limited time horizons, they reject otherwise efficient innovations for the grid. These logics govern electricity generation in ways that constrain clean energy use, even as they pile up incompatible demands and contradictions that set the stage for new development paths.[64]

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[57] *See* W. BRIAN ARTHUR, INCREASING RETURNS AND PATH DEPENDENCE IN THE ECONOMY 112 (1994); DOUGLASS C. NORTH, INSTITUTIONS, INSTITUTIONAL CHANGE AND ECONOMIC PERFORMANCE 98–99 (1990).

[58] Gregory C. Unruh, *Understanding Carbon Lock-In*, 28 ENERGY POL'Y 817 (2000).

[59] Stein, *supra* note 56, at 564.

[60] *Id.* at 569.

[61] *Id.* at 570 (quoting Wesley D. Sine & Robert J. David, *Environmental Jolts, Institutional Change, and the Creation of Entrepreneurial Opportunity in the US Electric Power Industry*, 32 RES. POL'Y 185, 187 (2003)).

[62] *See* Roger Friedland & Robert Alford, *Bringing Society Back In: Symbols, Practices, and Institutional Contradictions*, *in* THE NEW INSTITUTIONALISM IN ORGANIZATIONAL ANALYSIS 232, 240 (Walter W. Powell & Paul J. DiMaggio eds., 1991); *see also* PATRICIA H. THORNTON ET AL., THE INSTITUTIONAL LOGICS PERSPECTIVE: A NEW APPROACH TO CULTURE, STRUCTURE, AND PROCESS 76–77 (2012).

[63] Stein, *supra* note 56, at 570–82.

[64] *Id.*

The response of Eric Biber, Nina Kelsey, and Jonas Meckling to an energy economy locked in fossil fuel production is one of political feasibility and the sequencing of policy choice. Their dynamic analysis is similar to Stein's, growing out of an historical-institutionalist account that builds on an increasing returns approach to path dependence.[65] Here, interest groups and coalitions are the actors that shape the indirect effects of policy development. Biber et al.'s research questions speak to the feedback effects of legal tools adopted at time *n*, including the feasibility of certain policies at time *n+1*, apart from their optimality.[66] The emphasis is not on static comparisons of the efficiency of, say, carbon taxes and cap-and-trade regimes, but the durability and level of entrenchment of policies (e.g., green industrial policy, carbon pricing) that are adopted in sequence. Stein and Biber et al. share a concern for the circumstances in which "policy history, sequencing, and feedback processes matter"[67] in setting the stage for a clean energy transition, and their findings may very well converge. For example, there is considerable overlap between Stein's suggestions for how the law may foster path divergence from a fossil fuel economy and the circumstances in which industrial and innovation policy—according to Biber et al.'s review of policy sequences in over fifty countries and subnational jurisdictions—lay the political groundwork for carbon pricing and other forms of economic regulation.[68] Biber et al.'s project promises a rich understanding of how political systems can evolve in the direction of carbon pricing. They consider variables such as sources of clean energy development that are amenable to interest group formation and coalition building, levels of electricity market deregulation, political structures that influence ease of enactment and resistance to repeal, and regulatory independence.[69]

Emily Hammond and Jim Rossi give a third account of carbon lock-in and delayed transition: the law's approach to stranded cost recovery.[70] Stranded costs are "the value of a regulated firm's investments left shipwrecked by changing regulatory circumstances."[71] Energy law endures a series of

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[65] Eric Biber, Nina Kelsey & Jonas Meckling, *The Political Economy of Decarbonization: A Research Agenda*, 82 BROOK. L. REV. 605 (2017).

[66] *Id.* at 615.

[67] *Id.* at 618; *see* Stein, *supra* note 56.

[68] *Compare* Stein, *supra* note 56, at 596–98, *with* Biber et al., *supra* note 65, at 616–17.

[69] Biber et al., *supra* note 65, at 615–18, 625–33.

[70] Emily Hammond & Jim Rossi, *Stranded Costs and Grid Decarbonization*, 82 BROOK. L. REV. 645 (2017).

[71] *Id.* at 646.

experiments with the stranded costs of physical infrastructure—nuclear and coal-fired power plants, natural gas pipelines—that lock in decades of operational life. What can we learn from these experiments and apply to a decarbonizing electricity grid? Hammond and Rossi point to three moments where regulators tried to mitigate the adverse financial impacts of energy policy change: the growth of excess nuclear power capacity as dozens of partially constructed plants were canceled in the 1970s and early 1980s, a restructured natural gas industry in the late 1980s that eased access and costs for pipeline providers, and the electric power industry's transition to competitive markets in the 1990s that rendered certain power plant assets less valuable.[72] From these natural experiments with stranded costs, Hammond and Rossi distill a common dynamic where mitigating the financial impacts of stranded costs after-the-fact distorts the cost of capital, ignores the social benefits of energy transitions, favors old infrastructure over new entrants, and delays change.[73] Their findings are then recast as a question for the clean energy transition: which forms of stranded cost recovery address uncertainty in a way that reduces system-wide costs of capital related to clean energy infrastructure?[74] Hammond and Rossi offer several forms of stranded cost recovery that target obstacles to decarbonization, limit price signal distortion, and recognize clean energy resource attributes that markets fail to price.

Two authors consider the green energy transition as change that occurs within social fields. This level of analysis differs from macro-level and single-case research of institutional change, turning instead to the setting in which institutional logics—rules and standards that guide action—play out. A "field" is a "a meso-level social order where [individuals and collectives] . . . interact with knowledge of one another under a set of common understandings about the purposes of the field, the relationships in the field . . . and the field's rules."[75] In other words, fields shape common understandings that actors draw upon to respond to challenges. Individuals and organizations in a field use, elaborate, and reinterpret logics, even adopting logics from proximate fields. But fields are bound by more than logics—as Neil Fligstein and Doug McAdam point out, fields are

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[72] *Id.* at 652–59 (cost of capital is distorted through loss aversion and compensation that conflates regulatory risk with technological and economic risk).

[73] *Id.* at 662–63.

[74] *Id.* at 686.

[75] Neil Fligstein & Doug McAdam, *Toward a General Theory of Strategic Action Fields*, 29 SOC. THEORY 1, 3 (2011).

animated by a diffuse account of what is going on (the "terrain" of the field that is shared by most actors), a sense of the relative position of actors within the field (i.e., those viewed as having more or less power), an understanding of the rules of the field ("what tactics are possible, legitimate, and interpretable for each of the roles in the field"), and interpretive frames that field actors use "to make sense of what others are doing."[76] This level of analysis helps us understand how social orders form and how they endure periods of stability and contention.

For example, Scott Frickel, Daniela Wühr, Christine Horne, and Meghan Kallman do not report on Title XIII of the Energy Independence and Security Act[77] (EISA) per se.[78] Rather, they study the interactive "smart meter field" encouraged by the statute, its members, patterns of relations among them that stabilize norms, practices, and meaning, and points of contestation and struggle within the field.[79] Fligstein and McAdam's field theory guides the project as the smart meter field, its participants (e.g., utilities, technology firms, universities, regulatory agencies) and relative positions are defined.[80] This approach looks beyond legal change and gives it context in the form of opportunities and constraints that play out in relation within a field. Frickel et al. zero in on a crucial source of conflict within the smart meter field in the state of Washington: "technological visions," or disparate understandings of the role of smart meters in the electricity grid that reflect differences in actor position and power in the field. These interpretive frames, which Frickel et al. distill from semi-structured interviews, suggest an unsettled field. Technological visions diverge: smart meters are "a means of economic efficiency, a tool for democratization, a machine-governed system," and stranded bits of a budding Internet of Things, struggling for interoperability across platforms.[81] Divergent interpretive frames contribute to an unsettled smart meter field, which poses a challenge to smart grid buildout in the wake of EISA's technological improvement mandate.

Thomas Beamish, Ryken Grattet, and Debbie Niemeier share Frickel et al.'s concern with social fields. In prior research,

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[76] *Id.* at 4.

[77] Energy Independence and Security Act of 2007, 42 U.S.C. §§ 17381–17382 (2012).

[78] *See* Scott Frickel, Daniela Wühr, Christine Horne & Meghan Elizabeth Kallman, *Field of Visions: Interorganizational Challenges to the Smart Energy Transition in Washington State*, 82 BROOK. L. REV. 693 (2017).

[79] *Id.* at 696–701.

[80] *Id.* at 696, 701–05.

[81] *Id.* at 722, 706 (footnote omitted).

Beamish looked at social fields as a locus of response to, for example, the Guadalupe Dunes oil spill[82] and clean energy mandates.[83] Here, Beamish et al. investigate a mechanism that defines and shapes social fields: legitimation. Legitimation is a "crucial aspect of policy design," given that climate change emerged when both top-down and incentive-based regulation held shaky support among key constituents along the political spectrum.[84] The starting point again is a policy imperative—carbon mitigation promoted by California's climate change initiatives AB 32 and SB 375.[85] SB 375 gave the California Air Resources Board the authority to set regional carbon reduction targets that state Metropolitan Planning Organizations (MPOs) pursue through land use and transportation planning. Beamish et al. delve into one MPO's strategies to legitimate a regional planning approach known as "blueprinting," an important element of SB 375.[86] Legitimation occurred through a structural design that avoided the extremes of command authority and neoliberal governance, MPO outreach that cultivated the primacy of the "citizen planner," data-driven tools to define preferences that fostered a sense of regional consensus, and alignment with professional standards and associations.[87] The ability to decouple blueprinting's legitimacy from its outcomes—most critically GHG emissions reductions—explains why California embraced a planning process that yields limited carbon mitigation at best.

Shobita Parthasarathy also seeks to avoid abstracting legal mandates, planning processes, and clean energy devices from the social arrangements that shape their development, details, and meaning. This is the theoretical realm of the "sociotechnical system," a research tradition that grows out of historical and sociological accounts of technological change as

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[82] *See, e.g.*, THOMAS D. BEAMISH, SILENT SPILL: THE ORGANIZATION OF AN INDUSTRIAL CRISIS (2002).

[83] *See, e.g.*, LOREN LUTZENHISER ET AL., MARKET STRUCTURE AND ENERGY EFFICIENCY: THE CASE OF NEW COMMERCIAL BUILDINGS, A REPORT TO THE CALIFORNIA INSTITUTE FOR ENERGY EFFICIENCY 4 (2001).

[84] Thomas D. Beamish, Ryken Grattet & Debbie Niemeier, *Climate Change and Legitimate Governance: Land Use and Transportation Law and Policy in California*, 82 BROOK. L. REV. 725, 758 (2017).

[85] Global Warming Solutions Act of 2006, CAL. HEALTH & SAFETY CODE §§ 38,501–38,599 (2006); Sustainable Communities and Climate Protection Act of 2008, 2008 Cal. Stat. ch. 728, at 5065 (codified as amended in scattered sections of the CAL. GOV'T CODE and the CAL. PUB. RES. CODE).

[86] Beamish et al., *supra* note 84, at 727, 738–40.

[87] *Id.* at 751–55.

well as evolutionary economics.[88] One concern among contributors to this volume is the electricity grid in the United States. This is a large-scale sociotechnical system that embodies "the generation and transmission infrastructure and the legal, organizational, and cultural practices associated with electricity production and consumption."[89] To study its transition is to consider the co-evolution of technology with its political, legal, and social institutions—the scaling-up of new technological niches, the mixing or hybridization of existing regimes, changes in the landscape such as new forms of ownership or organizational structures.[90] This demands a multilevel perspective beyond the focused, constructivist accounts of the uptake of artifacts that once dominated the literature and sketch a technology's interpretive flexibility, social negotiation, and closure at a microsocial scale.[91]

Parthasarathy embraces this work at both ends of the spectrum, from national repertoires of traditions, norms, and values that shape technical design details to the limits of cross-national technology transfer and local adoption. She writes about strategies to address both the incompatible "national styles" of innovation and local expertise barriers involved.[92] Her article begins with the technological optimism behind hundreds of alternative energy projects in developing countries, many of which promise the simple swapping of one artifact, such as a traditional biomass cookstove, for another to reduce carbon and other forms of air pollution.[93] She traces the limited success of these transfer projects to the national styles of innovation

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[88] *See, e.g.*, F.W. Geels, *The Dynamics of Transitions in Socio-Technical Systems: A Multi-Level Analysis of the Transition Pathway from Horse-Drawn Carriages to Automobiles (1860–1930)*, 17 TECH. ANALYSIS & STRATEGIC MGMT. 445 (2005).

[89] David J. Hess, *Industrial Fields and Countervailing Power: The Transformation of Distributed Solar Energy in the United States*, 23 GLOBAL ENVTL. CHANGE 847, 847 (2013).

[90] Frank W. Geels & Johan Schot, *Typology of Sociotechnical Transition Pathways*, 36 RES. POL'Y 399, 400 (2007).

[91] *See, e.g.*, THE SOCIAL CONSTRUCTION OF TECHNOLOGICAL SYSTEMS: NEW DIRECTIONS IN THE SOCIOLOGY AND HISTORY OF TECHNOLOGY (Wiebe E. Bijker et al. eds., 1987).

[92] *See, e.g.*, Shobita Parthasarathy, *Reconceptualizing Technology Transfer: The Challenge of Shaping an International System of Genetic Testing for Breast Cancer*, *in* SHAPING SCIENCE AND TECHNOLOGY POLICY: THE NEXT GENERATION OF RESEARCH (David H. Guston & Daniel Sarewitz eds., 2006); Shobita Parthasarathy, *Breaking the Expertise Barrier: Understanding Activist Strategies in Science and Technology Policy Domains*, 37 SCI. & PUB. POL'Y 355 (2010); Shobita Parthasarathy, *Regulating Risk: Defining Genetic Privacy in the United States and Britain*, 29 SCI. TECH & HUM. VALUES 332 (2004).

[93] Shobita Parthasarathy, *Grassroots Innovation Systems for the Post-Carbon World: Promoting Economic Democracy, Environmental Sustainability, and the Public Interest*, 82 BROOK. L. REV. 761, 765–66 (2017).

under which they were designed. Technology transfer involves more than physical design: it is a transfer of "particular norms, values, and ways of life."[94] Parthasarathy explains the approach to innovation in which clean cookstoves were developed, a linear, unidirectional process of designing new, nonobvious, standardized objects with clear norms and values for what constitutes innovative work and the necessity of markets to produce innovation in the public interest.[95] She contrasts this with systems of grassroots innovation that proceed from the creation of artifacts that are low-tech, low-cost, small-scale, and highly adaptable to local, even individual concerns.[96] The networks scout out and identify innovations, assess their usefulness where innovators live, engage in multiple forms of technology sharing, and consider building new social systems to accommodate the designs. These steps can broaden the scope of clean energy technology adoption as they address national-level innovation styles as well as the needs expressed by local communities.

Social movements are an important driver of the green energy transition, from their attempts to break expertise barriers to their role in multilevel perspectives of sociotechnical change. Uma Outka writes about how social movements introduce notions of social, distributive, and procedural fairness and justice that vie for prominence during periods of transition. For example, the environmental justice movement gathered force as a federal framework for environmental protection took shape last century. Now, climate justice advocates organize as that system strains to limit carbon emissions, account for the cumulative effects of single-media, single-pollutant damage to global sinks as well as neighborhoods and individuals, and protect vulnerable groups while tending to global averages such as temperature and concentration of atmospheric carbon.[97] Outka considers a range of fairness narratives that environmental and climate justice activists promote at different governance scales. She looks at, for example, the halting buildout of the federal government's use of legal and discretionary authority in the wake of Executive Order 12898 as well as the lack of analysis of the distribution of harms and benefits in the run-up to cap-and-trade regimes such as those envisioned to support the Clean Power Plan.[98] Given the challenges inherent

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[94] *Id.* at 764.

[95] *Id.* at 771–74.

[96] *Id.* at 774–76.

[97] Uma Outka, *Fairness in the Low-Carbon Shift: Learning from Environmental Justice*, 82 BROOK. L. REV. 789, 789–94 (2017).

[98] *Id.* at 795–804, 815–17.

in "grafting" fairness principles onto an established canon of law and the institutional barriers that result (most notably the failure of EPA's Office of Civil Rights to make a single formal finding of discrimination under Title VI as of the end of 2016),[99] Outka argues that time is of the essence as competing fairness frames by utility and industry lobbyists and community-based organizations clutter policy discourse. A key task for policymaking in the green energy transition will be to address fairness frames that "crowd[] out equity goals clarified by the [environmental justice] movement" before new legal infrastructure is in place.[100]

John Dernbach ends the issue with the context in which law and social theory aim to steer a "profound transformation," one with which the United States has "little legal or regulatory experience."[101] The logic that undergirds "deep decarbonization," an economy-wide, multigenerational migration of the energy, transportation, building, industrial, agricultural, and other sectors to near-zero net carbon emissions by mid-century, is spelled out. The imperative has an uncertain but sobering deadline. To achieve a greater than 50% probability of holding global average temperature increases within 1.5°C, the world economy must approach net zero carbon emissions by 2045-2050.[102] The amalgam of carbon budgeting, emissions target-setting, scenario-building, backcasting, and physically realistic modeling to bridge the "emissions gap" between national commitments and a low-carbon future is strikingly new, with much of the important work carried out in the last five years. In rapid response, there are now research teams of energy, technology, and economic analysts in sixteen countries (that represent nearly three-fourths of the world's carbon emissions) that work to outline "the full extent of the transformation required."[103] Backcasting locates an endpoint and blends technological and structural change to address supply and demand to meet a desired future. Its outputs read as a roadmap for collaboration among legal and social theorists, both within

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[99] Talía Buford, *Rare Discrimination Finding by EPA Civil-Rights Office*, CTR. FOR PUB. INTEGRITY (Jan. 25, 2017), https://www.publicintegrity.org/2017/01/25/20616/rare-discrimination-finding-epa-civil-rights-office [https://perma.cc/FU3E-443K].

[100] Outka, *supra* note 97, at 822.

[101] John C. Dernbach, *Legal Pathways to Deep Decarbonization: Lessons from California and Germany*, 82 BROOK. L. REV. 825, 828, 838–39 (2017) (quoting SUSTAINABLE DEV. SOLS. NETWORK & INST. FOR SUSTAINABLE DEV. & INT'L RELATIONS, PATHWAYS TO DEEP DECARBONIZATION: 2015 REPORT 3 (2015)).

[102] *Id.* at 833 tbl.1.

[103] *Id.* at 841 (quoting SUSTAINABLE DEV. SOLS. NETWORK & INST. FOR SUSTAINABLE DEV. & INT'L RELATIONS, PATHWAYS TO DEEP DECARBONIZATION: 2015 REPORT 35 (2015)).

and across central elements of a shifting energy system. For example, deep decarbonization in the United States calls for greater uptake of energy efficiency and fuel switching technologies and systems, dramatic growth in low-carbon electricity and biomass feedstock supply, strategies to ensure electricity grid reliability, and commercial-scale carbon capture and storage. Pathway projects build low-carbon scenarios from these elements, any one of which could derail a development path. Dernbach turns to two jurisdictions, California and Germany, each a first mover that has begun to synch multigenerational technical and legal paths to some effect.[104] But as legal systems rooted in near-term technological and economic feasibility strain to achieve carbon intensity and emissions gains on a wholly new scale, these jurisdictions already evince concerns our authors have begun to address: framing and legitimation effects, co-benefits and unintended consequences, dead-end policy choices such as shale gas absent CCS that threaten degrees of policy freedom, policy sequence effects, and the limits of technology adoption, even in the shadow of carbon pricing. As Dernbach explains, there is no "silver bullet," no single legal or policy "fix" to the climate crisis.[105] Our post-Paris, post-Clean Power Plan[106] warming world demands that legal and social theorists ratchet up their own capacity for critical analysis of the energy paths that stretch before us and those we must leave behind.

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[104] *Id.* at 844–59.

[105] *Id.* at 872.

[106] *See* Promoting Energy Independence and Economic Growth, Exec. Order No. 13,783, 82 Fed. Reg. 16093, 16095 § 4 (Mar. 28, 2017) ("Review of the Environmental Protection Agency's 'Clean Power Plan' and Related Rules and Agency Actions").