Georgia State University Law Review

Volume 39
Issue 4 *Summer 2023*

Article 12

2023

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SYNTHESIZING ENERGY TRANSITIONS

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ABSTRACT

This Article assesses the growing and cross-disciplinary literature on energy transitions to explore how it can guide law and policy reforms for the energy sector. The modern conception of energy transition centers primarily on clean energy—a shift away from fossil energy dependence. It also, however, incorporates equity as a core principle, as an increasing emphasis on energy justice and just transition seeks to create guiding norms for the energy sector's current state of change. The concept of energy transition is critical for describing and giving meaning to a fundamental societal shift at the local, regional, national, and global scales, aligned with the overarching goal enshrined in the Paris Agreement to sharply reduce greenhouse gas emissions contributing to climate change. The energy sector, being among the most significant contributors to global climate change, is not only essential to social and economic functionality and stability broadly but also intimately embedded in everyday life. Accordingly, various disciplines bring different emphases to understandings of transition in the energy context. Our synthesis of

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this wide-ranging literature demonstrates how the conceptual development of energy transitions across disciplines may enrich the application and depth of this concept in United States policy reform—particularly reforms designed to substantially increase investments in low-carbon energy sources, such as those enacted, for example, by federal legislation in 2021 and 2022.

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INTRODUCTION

The world is in the process of far-reaching energy transitions as public policy and market forces increasingly shift the energy sector toward cleaner energy resources. What might be broadly conceived as a global clean energy transition is instead many multi-faceted and multi-contextual energy transitions combining to affect this ongoing and accelerating change, aligned with international commitments to reduce greenhouse gas emissions with increasing ambition.[1]

The idea of "just transition" is rightly becoming a central concept for this transformative moment in the energy sector worldwide.[2] In the United States, the electric power sector has been steadily reducing reliance on coal, with renewable energy now supplying over 20% of electricity.[3] Globally, renewable energy comprised almost 29% of electricity in 2020, which was an increase from 27% in 2019.[4] These changes have impact beyond what the trend lines and pie charts tell us about energy transitions. From new infrastructure to retiring infrastructure, from burgeoning industries to waning industries, energy transitions affect individuals, communities, economies, and landscapes.

At its most basic level, just transition invokes a recognition that even transitions that are clearly beneficial in many respects and for many communities may create new or exacerbate existing inequalities and injustice in others.[5] Although the idea of just transition originated and extends beyond energy, policymakers, activists, and scholars across a

1. This shared international commitment is stated in the Paris Agreement, which entered into force in 2016 as an implementation measure for the United Nations Framework Convention on Climate Change. Paris Agreement to the United Nations Framework Convention on Climate Change art. 4, ¶1, Dec. 12, 2015, T.I.A.S. No. 16-1104.

2. *See, e.g.*, Ann M. Eisenberg, *Just Transitions*, 92 S. CAL. L. REV. 273, 275–76 (2019) (discussing the various meanings of "just transition" theory, including from an environmental standpoint, a labor standpoint, and a redistributive justice standpoint).

3. *What Is U.S. Electricity Generation by Energy Source?*, U.S. ENERGY INFO. ADMIN., https://www.eia.gov/tools/faqs/faq.php?id=427&t=3 [https://perma.cc/J5C5-M2MP] (Mar. 2, 2023).

4. INT'L ENERGY AGENCY, GLOBAL ENERGY REVIEW 2021, at 22 (2021), https://iea.blob.core.windows.net/assets/d0031107-401d-4a2f-a48b-9eed19457335/GlobalEnergyReview2021.pdf [https://perma.cc/NS33-HS9P].

5. *See* Eisenberg, *supra* note 2, at 278, 282.

range of disciplines are working to give meaning and practical import to the concept of just *energy* transition so that they might tangibly shape the direction of change for a sector that is essential to global climate change mitigation.[6]

As might be expected, the concept is not uniformly defined across disciplines, and our review of the cross-disciplinary literature suggests there are strengths in this diversity that can be harnessed toward effective reform. With that in mind, the aim of this Article is two-fold: first, to synthesize key conceptual points of emphasis from the cross-disciplinary literature on just transition, with a primary focus on the energy sector, and second, to translate that diversity to enrich the depth and application of this concept within U.S. energy policy reform.

Part I provides a cross-disciplinary literature review, not just to recount what has been said but to trace and synthesize key conceptual points of emphasis and differences that highlight how the diversity of thought in this space offers a sum greater than its parts. As the literature continues to expand, we cannot claim to have read exhaustively in every discipline, especially as new contributions continue to be made. Rather, our aim was to read widely and deeply enough to expand our own thinking on the topic as legal scholars approaching energy transitions from common yet distinct vantage points and to evaluate prospects for fruitful synthesis.

Part II draws from this review to interpret and synthesize conceptions of energy transitions in a way that can tangibly inform law and policy. This Part briefly explores how modern policy regimes—particularly in the area of supporting and financing low-carbon U.S. energy strategies—can begin to incorporate cross-disciplinary energy transition principles from numerous substantive areas. Lessons from the literature can inform policies designed to hasten the energy transitions to better account for past inequities; to harness and expand the co-benefits of low-carbon technologies, such as reducing energy

6. In the United States, the electric power sector was responsible for 25% of greenhouse gas emissions in 2020. U.S. ENV'T PROT. AGENCY, DATA HIGHLIGHTS: INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990-2020, at 4 (2022), https://www.epa.gov/system/files/documents/2022-04/us-ghg-inventory-1990-2020-data-highlights.pdf [https://perma.cc/CL8V-AZD7].

burdens, energy poverty, and exposure to conventional air pollutants; and to avoid perpetuating the inequities of the fossil fuel-based energy system in the low-carbon energy build-out.

With integrated, cross-disciplinary lessons in hand, the law and policy currently shaping energy transitions might better achieve just transitions for communities already experiencing dramatic changes to the physical and regulatory landscapes in the energy sector firsthand.

I. Disciplinary and Cross-Disciplinary Understandings of the Energy Transition

An incredibly rich literature on the energy transition—and specifically a *just* energy transition—has emerged in the past decade. This literature defines the transition, contextualizes different geographic manifestations of the transition (to some degree), and explores specific facets of the transition, analyzed here.[7]

Scholars in numerous disciplines—and working in ways that bridge disciplines—conceptualize the "energy transition" in diverse ways. Many of these conceptualizations overlap; others diverge. The aim of this Part is to highlight how a wide variety of disciplines and literatures, including geography, public policy, economics, health sciences, and political sciences, define and analyze the energy transition as compared to the legal literature. In many cases, the legal literature builds upon lessons from these many disciplines to propose legal and policy fixes to challenges created by the energy transition or ways of better harnessing opportunities presented by the transition.

We highlight different disciplines' approaches within "buckets" of substantive concepts that dominate the energy transition literature. As described in the Introduction, the energy transition is global, involves numerous technologies, and has different meanings for different

7. *See, e.g.*, Stephen Williams & Andréanne Doyon, *Justice in Energy Transitions*, 31 ENV'T INNOVATION & SOCIETAL TRANSITIONS 144, 145 (2019) (arguing that "transitions research needs to have a more explicit account of justice in its analysis" and advocating developing an "analytical framework" for conducting this analysis); *see* Bernhard Truffer, James T. Murphy & Rob Raven, *The Geography of Sustainability Transitions: Contours of an Emerging Theme*, 17 ENV'T INNOVATION & SOCIETAL TRANSITIONS 63, 63–64 (2015) (showing a special issue of place-based energy transition research).

communities. As a result, the range of substantive issues that arise beneath the umbrella concept of energy transition is far-reaching and highly varied. Some communities, previously dominated by fossil fuel development, are experiencing a decline in this development—or, in some places, a rise in such development as countries aim to export more fuel to nations that remain dependent on fossil fuels, at least in the short term.[8] Other communities now host more production of crops for biomass energy or new energy development in the form of solar, wind, or other renewables.[9] Still others have encountered more—and often unsustainable—mining for "energy minerals" needed for solar panels and batteries.[10]

The energy transition also has different meanings for different groups of people. Individuals, even whole communities, that have been historically well-represented in the fossil fuel industry may experience economic losses if not supported by their employers or government.[11] In contrast, other groups historically underrepresented in the energy workforce may experience a growth in job opportunities, contingent on the mandates and incentives that accompany the growth of low-carbon energy sources.[12] Some groups of people will also benefit more from low-carbon energy sources than others depending on access,

8. Jonathan Kemp, Madeleine McCowage & Faye Wang, *Towards Net Zero: Implications for Australia of Energy Policies in East Asia*, RSRV. BANK AUSTL.: BULLETIN, Sept. 2021, at 30, 35–36 (2021), https://www.rba.gov.au/publications/bulletin/2021/sep/pdf/towards-net-zero-implications-for-australia-of-energy-policies-in-east-asia.pdf [https://perma.cc/CK9M-95U8] (noting that under baseline scenarios and scenarios involving importing countries' net zero commitments, Australian exports of liquefied natural gas rise).

9. *See, e.g.*, Jennifer Baka, *What Wastelands? A Critique of Biofuel Policy Discourse in South India*, 54 GEOFORUM 315, 315 (2014); *Fact Sheet: President Biden's Leadership to Tackle the Climate Crisis at Home and Abroad Galvanizes Unprecedented Momentum at Start of U.N. Climate Conference (COP27)*, WHITE HOUSE (Nov. 7, 2022), https://www.whitehouse.gov/briefing-room/statements-releases/2022/11/07/fact-sheet-president-bidens-leadership-to-tackle-the-climate-crisis-at-home-and-abroad-galvanizes-unprecedented-momentum-at-start-of-u-n-climate-conference-cop27/ [https://perma.cc/6HWJ-XY4H].

10. INT'L ENERGY AGENCY, THE ROLE OF CRITICAL MINERALS IN CLEAN ENERGY TRANSITIONS 43–45 (2022); MARK P. MILLS, MINES, MINERALS, AND "GREEN" ENERGY: A REALITY CHECK 6, 8 (2020).

11. *See* Mark Haggerty & Nicole Gentile, *Quitting Fossil Fuels and Reviving Rural America*, CTR. FOR AM. PROGRESS (Sept. 1, 2022), https://www.americanprogress.org/article/quitting-fossil-fuels-and-reviving-rural-america/ [https://perma.cc/A6YV-EQDZ].

12. SANDY FAZELI, NAT'L ASS'N STATE ENERGY OFFS., ENERGY SECTOR WORKFORCE DIVERSITY, ACCESS, INCLUSION, AND THE POLICY CASE FOR INVESTMENT: RECOMMENDATIONS FOR STATE ENERGY OFFICE ACTION 3, 13, 15 (2021).

which can, in turn, depend on affordability of new technologies, the location of these new sources, and the location and pace of the phaseout of fossil fuel energy and its conventional air pollutants, not just greenhouse gas emissions.[13]

With these variations in mind, we identify six substantive categories into which we group our discussion of the cross-disciplinary literature on energy transition: (1) technological analysis of constraints and opportunities for transitioning to low-carbon energy; (2) industrial policy encompassing the factors that economically and structurally support this technological change, such as government subsidization, innovation, and private financing; (3) land-based impacts of low-carbon technologies in light of technological and economic constraints and the associated geospatial distribution of technologies; (4) socioeconomic impacts on workers within these spaces; (5) socioeconomic impacts on communities more broadly; and (6) health and quality of life impacts on individuals and communities. In short, these many substantive aspects of the energy transition literature explore how and why the transition will happen, where and how quickly it will proceed, and how this transition will impact individuals and communities differently due to varied technological, economic, and institutional opportunities and constraints.

13. *See* Shelley Welton & Joel Eisen, *Clean Energy Justice: Charting an Emerging Agenda*, 43 HARV. ENV'T L. REV. 307, 315, 329, 339, 362 (2019); Alexandria E. Dolezal, Note, *Power to the People: Distributing the Benefits of a Clean Energy Transition Through Equitable Policy, Legislation, and Energy Justice Initiatives*, 106 MINN. L. REV. 2441, 2441–42, 2449 (2022).

Table 1. Major substantive categories of energy transitions literature

Category	**Description: Transition away from fossil fuels**	**Description: Transition towards zero-and low-carbon energy**
Technological change	—	Feasibility and pace of transitioning to low-carbon technologies given technological constraints
Financing/innovation /industrial transition	Addressing stranded costs of infrastructure retired before the end of its useful life	Financing mechanisms for low-carbon energy infrastructure—public and private Cost impacts of the transition on consumers
Land use	Repurposing former fossil fuel sites	Energy justice: disproportionate impacts of low-carbon energy infrastructure Aesthetic and environmental impacts of low-carbon energy infrastructure
Economic and social impacts: workers	Job losses	With adequate retraining and re-skilling, potential jobs of equal quality and pay Inclusivity of clean energy

		workforce
Economic and social impacts: communities	Loss of community culture Loss of economic development and taxes	Gains in economic development for rural communities with under-investment Impacts of low-carbon technologies on community aesthetics, culture, and the environment
Health sciences	Differential reductions in co-pollutants as fossil fuel power plants are phased out	Increased life expectancy Fewer occupational hazards Exposure to non-air pollutants through disposal and use of clean energy technologies
International approaches to energy transition	Policy comparisons: approaches to justly phasing out fossil fuels	Varied approaches and differential opportunities/capacity for the implementation of low-carbon technologies

This is not a comprehensive literature review and analysis. Rather, this Part endeavors to emphasize the range of substantive concepts that define the energy transition and explore how a variety of disciplines similarly or differentially address the impact of legal and policy approaches to the energy transition.

A. Technological Change

A first step in understanding and analyzing the energy transition is to project the substantive shape of the transition—the types of technologies deployed, for example—and the rapidity of the transition based on technological, economic, and social opportunities and constraints. This Section focuses on the literature that primarily addresses the technological aspects of the transition, and the following sections analyze the socioeconomic components of the vast concept of energy transition. Understanding the shape and rate of the transition allows for in-depth analysis of energy justice—identification of which places and people may be disproportionately impacted (considering historical burdens as well), which places and people may have high or low levels of access to new and beneficial technologies, and the processes and substantive policies needed to address these impacts.[14]

It is important to note, however, that the projections discussed in this Section assume a type and rate of energy technology implementation that is not primarily shaped by sociological and political factors. The sections that follow explore how the technologies prioritized for the transition and the pace and location of their implementation will be, and already have been, substantially dictated by sociological factors. The idea of identifying feasible technologies and pathways for their implementation and considering the sociological implications of such technology as an afterthought is unrealistic and, more importantly, misguided.

In the U.S., several entities have attempted to project the types of low-carbon technologies that will dominate the future energy system,

14. For definitions of energy justice, see SHALANDA BAKER, SUBIN DEVAR & SHIVA PRAKASH, INITIATIVE FOR ENERGY JUST., THE ENERGY JUSTICE WORKBOOK 9 (2019) ("Energy justice refers to the goal of achieving equity in both the social and economic participation in the energy system, while also remediating social, economic, and health burdens on those historically harmed by the energy system (frontline communities)." (internal quotation marks omitted)); Benjamin K. Sovacool & Michael H. Dworkin, *Energy Justice: Conceptual Insights and Practical Applications*, 142 APPLIED ENERGY 435, 436 (2015) (defining energy justice as "a global energy system that fairly disseminates both the benefits and costs of energy services, and one that has representative and impartial energy decision-making").

and the rate of their adoption, through modeling.[15] The *Net-Zero America* report from Princeton models technological and behavioral changes that would have to occur to achieve net-zero U.S. greenhouse gas emissions by 2050, meaning "building an economy that emits no more greenhouse gases into the atmosphere than are permanently removed and stored each year."[16] This report, and others, select 2050 as the target date for eliminating nearly all greenhouse gas emissions because scientists estimate that this is the year by which such elimination must occur globally to keep global average surface temperature increase from the "pre-industrial average" below 2 degrees Celsius.[17] 2050 is the official target date for reductions under the UN Paris Agreement that addresses climate change.[18]

The Princeton report begins by noting a central technological and social challenge: two-thirds of all "final energy" used for performing tasks such as transportation or manufacturing is from fossil fuels.[19] Therefore, while one-third of greenhouse gas emissions reductions can come from electric power generation—converting it to zero-carbon sources—the bulk of changes will have to come from dispersed sources of greenhouse gas emissions in other sectors, from agriculture to building and industry.[20] Decarbonizing these sectors will require the use of electricity, zero-carbon fuels, or the continued use of fossil fuels coupled with carbon capture and storage.[21]

The report maps five different pathways to a net-zero U.S. in 2050, focusing on the least costly approaches and making different assumptions in each pathway about levels of energy demand and supply.[22] The pathways also deploy varied assumptions in three

15. *E.g.*, ERIC LARSON, CHRIS GREIG, JESSE JENKINS, ERIN MAYFIELD, ANDREW PASCALE, CHUAN ZHANG, JOSHUA DROSSMAN, ROBERT WILLIAMS ET AL., NET-ZERO AMERICA: POTENTIAL PATHWAYS, INFRASTRUCTURE, AND IMPACTS 5–7 (2021); JACKSON EWING, MARTIN ROSS, AMY PICKLE, ROBERT STOUT & BRIAN MURRAY, PATHWAYS TO NET-ZERO FOR THE US ENERGY TRANSITION 8–9, 32–36 (2022).

16. LARSON ET AL., *supra* note 15, at 6.

17. *Id.* at 4–5.

18. *See id.* at 5.

19. *Id.* at 12.

20. *Id.* at 10, 12.

21. *Id.* at 12.

22. LARSON ET AL., *supra* note 15, at 7, 23.

substantive areas, including the extent of electrification, the amount of solar and wind energy, and the amount of biomass relied upon to achieve net-zero emissions.[23] In all five pathways for lowest-cost approaches to net-zero emissions, coal is fully phased out by 2030—a significant implication for workers and communities tied to the coal industry.[24] Oil and gas use declines by 56%–100% from 2020 depending on assumptions about the amount of electrification of vehicles, other fossil fuel burning technologies, and the amount of renewable energy and biomass deployed.[25] All five pathways "rely on large-scale CO_2 capture and utilization or storage."[26]

Other reports addressing U.S. technological pathways to net-zero make similar quantitative assessments of pathways for the energy transition based on technology and cost factors.[27] These include, for example, reports by the International Energy Agency (global modeling–energy sector only) and the National Academy of Sciences (energy sector only).[28] Further, other literature builds on these quantitative analyses to identify consensus areas and explore the link between policy and the modeled pathways.[29] For example, Energy Pathways USA, convened by Duke University's Nicholas Institute for Energy, Environment & Sustainability in collaboration with the global Energy Transitions Commission, draws from quantitative modeling of the U.S. transition to net-zero to assess the extent to which recent U.S. policies may lead the nation down certain pathways and to assess policy changes needed to accomplish climate objectives.[30] Specifically, the report synthesizes other groups' quantitative analyses of pathways to net-zero, including the Princeton report, and draws

23. *Id.* at 23.
24. *Id.* at 27.
25. *Id.*
26. *Id.*
27. *See* INT'L ENERGY AGENCY, NET ZERO BY 2050: A ROADMAP FOR THE GLOBAL ENERGY SECTOR 3, 30 (2021), https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf [https://perma.cc/7X52-HPHQ]; NAT'L ACADS. SCIS., ENG'G, & MED., ACCELERATING DECARBONIZATION OF THE U.S. ENERGY SYSTEM ix, 1–2 (National Academies Press, 2021).
28. *See* sources cited *supra* note 27.
29. *E.g.*, EWING ET AL., *supra* note 15, at 1–2.
30. *Id.* at 1–2, 9, 35–36.

lessons from these analyses regarding "considerations for developing interim steps toward 2050 goals, technology needs, policy objectives, and possible sequencing and prioritization."[31]

Beyond projecting the feasibility and cost of implementing various technologies to achieve net-zero emissions or a similar target, scientists, economists, and scholars of public policy have also identified the specific policy and economic tools and attributes that they view as essential to implementing the technologies and practices critical to a viable net-zero strategy.[32] For example, in *The Meaning of Net Zero and How to Get It Right*, the authors identify eight "[a]ttributes of a credible net zero," including "front-loaded emissions reductions," meaning larger reductions as early as possible; "a comprehensive approach to emission reductions" in multiple sectors, not just energy; "cautious use of carbon dioxide removal"; "effective regulation of carbon offsets"; "an equitable transition to net zero"; "alignment with broader socio-ecological objectives," such as restoring natural ecosystems both to reduce carbon emissions and biodiversity losses; and "pursuit of new economic opportunities," including, for example "proactively" training the young workforce in developing countries.[33]

B. Financing, Innovation, and Industrial Change

Closely related to the technology-based energy transition literature is the industrial policy literature that explores "structural policies designed to strengthen the efficiency, scale[,] and international competitiveness of domestic industrial sectors."[34] "Green industrial policy," in turn, is defined as "government intervention to hasten the restructuring of the economy towards environmental sustainability,"

31. *Id.* at 8–9.

32. Sam Fankhauser, Stephen M. Smith, Myles Allen, Kaya Axelsson, Thomas Hale, Cameron Hepburn, J. Michael Kendall, Radhika Khosla et al., *The Meaning of Net Zero and How to Get It Right*, 12 NATURE CLIMATE CHANGE 15, 17–19 (2022).

33. *Id.*

34. Luc Soete, *From Industrial to Innovation Policy*, 7 J. INDUS. COMPETITION & TRADE 273, 273 (2007).

including "shifting economic trajectories away from traditional industries towards new, 'greener' technological industrial futures."[35] In Part II, we consider specifically how finance mechanisms and start-up strategies impact energy transitions and how lessons from the literatures explored in this Part can shape better strategies.

The structures that support innovation and technology deployment through subsidies vary and include, for example, educational policy—such as support or mandates for specific types of training targeted toward industrial development; financial support in terms of regulation that enables creative private financing mechanisms; direct governmental subsidies or loans; and support for linking research institutions and industry, among many other mechanisms.[36] Industrial policy also tends to have a strong nationalistic focus on bolstering sustainable technologies within a country or regional borders.[37] This complicates the "just" aspects of the energy transition by enhancing zero-carbon opportunities within specific geographic pockets while potentially creating international imbalances in the impacts of low-carbon technologies and access to beneficial technologies.[38]

C. Land Use Implications/Land Use and Siting

The above sections briefly explored literature that project the shape and pace of the energy transition and explore policies that support or impede this transition from the perspective of industrial change. This Section, and those that follow, focus on the impacts of the transition, which, in turn, serve as feedback loops that will influence the shape and pace of the transition as it unfolds.

35. Phil Johnstone, Karoline S. Rogge, Paul Kivimaa, Chiara Farné Fratini & Eeva Primmer, *Exploring the Re-Emergence of Industrial Policy: Perceptions Regarding Low-Carbon Energy Transitions in Germany, the United Kingdom and Denmark*, 74 ENERGY RSCH. & SOC. SCI., no. 101889, at 1, 1 (quoting Anna Pegels & Wilfried Lütkenhorst, *Is Germany's Energy Transition a Case of Successful Green Industry Policy? Contrasting Wind and Solar PV*, 74 ENERGY POL'Y 522, 523 (2014)).

36. *Id.* at 2–4.

37. *See, e.g.*, Pegels & Lütkenhorst, *supra* note 35 (focusing on the extent to which Germany has accomplished its central energy transition objectives in the wind and solar sector, one objective of which is "[s]trengthening Germany's leading global market position for climate-friendly technologies").

38. *See, e.g.*, Johnstone et al., *supra* note 35; Soete, *supra* note 34 (noting that industrial policy "typically contains an element of national champion").

The complexities of land use and its relationship to siting energy sources have been widely studied, but the literature is only beginning to explicitly analyze the link between the energy transition and energy justice.[39] Land use is uniquely situated within multiple bodies of research. It is central to the legal geography, energy law, and property law literature. Scholarship in these areas most often contemplates the *who* and *where* of energy siting.[40] Researchers typically pose questions such as: Who are the primary regulators? Who decides where a project will be developed? Who participates in the regulatory process? Where are renewable energy sources most concentrated? Where are renewable energy projects most feasible? Answers to these questions vary, but each incorporates an analysis of regulatory structures, sociopolitical factors, geospatial nuances, and economic principles.[41]

Within the regulatory context, zoning and land use planning are critical components of the transition process. The Princeton report suggests that the U.S. will need to deploy approximately 228,000 square miles of renewable energy—an area larger than Wyoming and Colorado combined—to achieve net-zero by 2050.[42] As climate impacts intensify and net warming goals fluctuate, practitioners and policymakers most often describe transition goals in terms of power

39. *See, e.g.*, Shalanda H. Baker & Andrew Kinde, *The Pathway to a Green New Deal: Synthesizing Transdisciplinary Literatures and Activist Frameworks to Achieve a Just Energy Transition*, 44 ENVIRONS: ENV'T L. & POL'Y J. 1, 5 (2020); Uma Outka, *Fairness in the Low-Carbon Shift: Learning from Environmental Justice*, 82 BROOK. L. REV. 789, 789 (2017).

40. *See* John R. Nolon, *The Land Use Stabilization Wedge Strategy: Shifting Ground to Mitigate Climate Change*, 34 WM. & MARY ENV'T L. & POL'Y REV. 1, 1 (2009); Hari M. Osofsky & Janet Koven Levit, *The Scale of Networks?: Local Climate Change Coalitions*, 8 CHI. J. INT'L L. 409, 410–13 (2008); J.B. Ruhl, *Climate Adaptation Law*, *in* GLOBAL CLIMATE CHANGE AND U.S. LAW 677, 678–79 (Michael B. Gerrard & Jody Freeman eds., 2d ed. 2014).

41. *See* Hari M. Osofsky & Jacqueline Peel, *Energy Partisanship*, 65 EMORY L.J. 695, 703–18 (2016); Garrick B. Pursley & Hannah J. Wiseman, *Local Energy*, 60 EMORY L.J. 877, 877 (2011); Steven Ferrey, *The "Green New Deal": Constitutional Limitations; Rerouting Green Technology*, 44 VT. L. REV. 777, 778, 781–82 (2020).

42. *See* LARSON ET AL., *supra* note 15, at 245 (reporting the need for approximately 590,000 square kilometers of onshore wind and solar energy, which is roughly 228,000 square miles). These figures only contemplate one transition scenario that incorporates an aggressive end-use electrification model. The land use estimates will vary based upon the energy sources that are considered in the carbon-free source assessment and the energy sources that are actually deployed. *See also* LIZA REED, LESLIE ABRAHAMS, ARMOND COHEN, JOSEPH MAJKUT, BRUCE PHILLIPS, ANDREW PLACE & JULIA PROCHNIK, HOW ARE WE GOING TO BUILD ALL THAT CLEAN ENERGY INFRASTRUCTURE? 6 (2021) (estimating 590,000 square kilometers occupied by solar and wind generation to achieve net-zero emissions).

outputs rather than land use needs.[43] No matter the metric, research suggests that the transition to low-carbon energy will require significant land disturbance and land use conversion.[44] Limited in breadth, the literature has only begun to engage with the transition's implications on land use at this projected scale.

The current literature does, however, deeply analyze the relevant stakeholders—the *who*—of the land use siting process.[45] Specifically, it examines the advantages and limitations of existing regulatory structures. States and localities serve as the primary governing bodies within the regulatory patchwork of entities that are involved in the renewable energy siting process.[46] Further, depending on a project's size and scope, the federal government may also impose requirements that complement, supplement, or preempt state and local regulations.[47] The siting process involves administrative approvals, public hearings, and other legislative actions that implicate procedural and distributive justice. In this way, the land use-centric literature is directly connected to that of environmental law and environmental justice.[48] The amalgamation of these literatures has influenced the conceptual development of energy justice and the just transition.

A related area of the law and social science literature explores residents' "not-in-my-backyard" reactions to renewable energy development, including growing movements by U.S. residents to ban

43. *See, e.g.*, OFF. OF ENERGY EFFICIENCY & RENEWABLE ENERGY, U.S. DEP'T OF ENERGY, SOLAR FUTURES STUDY vi, x (2021), https://www.energy.gov/sites/default/files/2021-09/Solar%20Futures%20Study.pdf [https://perma.cc/XN4V-LJXY]. The Department of Energy reports that solar deployment must grow on an average of sixty gigawatts between 2025 and 2030 to achieve a zero-carbon grid by 2050. *Id.* at 32–33; *Solar Futures Study*, OFF. ENERGY EFFICIENCY & RENEWABLE ENERGY, https://www.energy.gov/eere/solar/solar-futures-study [https://perma.cc/W9UJ-EAXL].

44. This conversion can entail expanding the permitted uses within existing zones or repurposing contaminated sites for energy uses. SAMANTHA GROSS, RENEWABLES, LAND USE, AND LOCAL OPPOSITION IN THE UNITED STATES 2, 11, 14 (2020), https://www.brookings.edu/wp-content/uploads/2020/01/FP_20200113_renewables_land_use_local_opposition_gross.pdf [https://perma.cc/GKJ5-WMGV].

45. *E.g.*, Outka, *supra* note 39.

46. Uma Outka, *The Renewable Energy Footprint*, 30 STAN. ENV'T L.J. 241, 291 (2011).

47. Ashira Pelman Ostrow, *Land Law Federalism*, 61 EMORY L.J. 1397, 1419 (2012); Hannah J. Wiseman, *Disaggregating Preemption in Energy Law*, 40 HARV. ENV'T L. REV. 293, 304 (2016); Danielle Stokes, *Renewable Energy Federalism*, 106 MINN. L. REV. 1757, 1778 (2022).

48. *See* Robert R. Kuehn, *A Taxonomy of Environmental Justice*, 30 ENV'T L. REP. 10681, 10703 (2000).

commercial wind and solar farms.[49] Social science (and some law and policy) literature tends to document and explore the reasons for this opposition while acknowledging varying levels of community support and opposition to renewable energy.[50] The bulk of legal literature, in turn, analyzes ways of addressing or overcoming such opposition through modifications of jurisdictional control, improved deliberative processes, modified decision-making structures, and payments addressing localized externalities.[51]

In addition to the regulatory complexities of siting renewables while addressing residents' concerns, the literature also explores the land use dichotomy between fossil fuel and renewable energy sources, or the *where*.[52] The *where* considers place-based elements, such as whether renewable energy is located in a rural or urban area[53] or if renewable energy projects are contemplated within building codes or land use plans.[54] For example, fossil fuels have greater energy density than renewable energy, which means they can concentrate a large quantity

49. GROSS, *supra* note 44, at 14.

50. *See, e.g.*, Ben Hoen, Jeremy Firestone, Joseph Rand, Debi Elliot, Gundula Hübner, Johannes Pohl, Ryan Wiser, Eric Lantz et al., *Attitudes of U.S. Wind Turbine Neighbors: Analysis of a Nationwide Survey*, 134 ENERGY POL'Y, no. 110981, 2019, at 1, 2, 9–10; Z. BEDNARIKOVA, R. HILLBERRY, N. NGUYEN, I. KUMAR, T. INANI, M. GORDON & M. WILCOX, AN EXAMINATION OF THE COMMUNITY LEVEL DYNAMICS RELATED TO THE INTRODUCTION OF WIND ENERGY IN INDIANA 49–50 (2020); David B. Spence, *Regulation and the New Politics of (Energy) Market Entry*, 95 NOTRE DAME L. REV. 327, 330 (2019) (documenting widespread opposition to renewable energy development by local chapters of national environmental groups); Lawrence Susskind, Jungwoo Chun, Alexander Grant, Chelsea Hodgkins, Jessica Cohen & Sarah Lohmar, *Sources of Opposition to Renewable Energy Projects in the United States*, 165 ENERGY POL'Y, no. 112922, 2022, at 1, 2; Stewart Fast, Warren Mabee, Jamie Baxter, Tanya Christidis, Liz Driver, Stephen Hill, J. J. McMurtry & Melody Tomkow, *Lessons Learned from Ontario Wind Energy Disputes*, 1 NATURE ENERGY 1, 1 (2016).

51. *See, e.g.*, K.K. DuVivier & Thomas Witt, *NIMBY to NOPE—Or YESS?*, 38 CARDOZO L. REV. 1453, 1453 (2017) (arguing for "statewide siting regimes for wind"); Sean F. Nolon, *Negotiating the Wind: A Framework to Engage Citizens in Siting Wind Turbines*, 12 CARDOZO J. CONFLICT RESOL. 327, 330, 357–58 (2011); Patricia E. Salkin & Ashira Pelman Ostrow, *Cooperative Federalism and Wind: A New Framework for Achieving Sustainability*, 37 HOFSTRA L. REV. 1049, 1082 (2009) (proposing a regime similar to cell phone tower siting for wind farms); Hannah J. Wiseman, *Taxing Local Energy Externalities*, 96 NOTRE DAME L. REV. 563, 601, 606 (2020) (proposing payments in the form of taxes, host community payments, or other financial measures to address localized externalities of renewable energy and other forms of energy).

52. *See* Welton & Eisen, *supra* note 13, at 361.

53. *Id.*

54. *See* JOHN R. NOLON, CHOOSING TO SUCCEED: LAND USE LAW & CLIMATE CONTROL 21 (2021); WAYNE M. FEIDEN & ELISABETH HAMIN, ASSESSING SUSTAINABILITY: A GUIDE FOR LOCAL GOVERNMENTS 21 (2011).

of energy into a small space.[55] Conversely, renewable projects have greater power density than fossil fuels, which means they require significant land surface area to produce a specific amount of energy.[56] Researchers estimate that "renewable power requires at least ten times more land area per unit of power produced."[57] Beyond the amount of land necessary for project viability, the literature also explores possible opportunities for co-location of renewable energy projects and battery storage facilities.

D. Economic and Social Impacts: Workers

One of the most common elements of the energy transition literature in multiple disciplines is a focus on the *people* and *communities* impacted by the transition—those losing and gaining jobs and gaining energy technologies and access to energy. This Section focuses on individual people impacted by transitions with respect to jobs and access to green energy technologies, and the following Section analyzes community impacts.

With respect to individual people, the literature explores substantive challenges, potential solutions, and the importance of procedures to ensure that workers' and other stakeholders' voices meaningfully influence the energy transitions.[58]

In the vein of job losses, the body of literature from non-profit groups, international governmental organizations, and a variety of academic fields emphasizes the importance of identifying and modeling which workers and communities will be impacted by

55. GROSS, *supra* note 44, at 2–3.
56. *Id.*
57. *Id.* at 3.
58. *See, e.g.*, INT'L ENERGY AGENCY, RECOMMENDATIONS OF THE GLOBAL COMMISSION ON PEOPLE-CENTRED CLEAN ENERGY TRANSITIONS 2 (2021) [hereinafter PEOPLE-CENTRED], https://iea.blob.core.windows.net/assets/07406f49-ebdb-4955-9823-69c52cce04dc/Recommendationsoftheglobalcommissiononpeople-centredcleanenergytransitions.pdf [https://perma.cc/5E47-6TV7] (noting how a people-centered energy transition focuses on a variety of substantive goals and "engaging people as active participants").

transitioning away from fossil fuels and the degree of impact;[59] retraining and "upskilling" workers to ensure that they find new jobs of equal or near-equal quality and pay;[60] understanding and addressing the cultural, place-based aspects of job losses (that is, the fact that new jobs are often not within the same community as jobs lost);[61] and engaging workers, governments, and industries in productive conversations and policy development.[62] The literature also focuses on specific types of work that can best support jobs of equal or higher quality and pay, including jobs within workers' communities, such as environmental remediation, mining for critical minerals rather than coal, and replacement of fossil fuels with low-carbon fuels at power plants and industrial operations.[63]

For workers who are unable to apply their skills to immediately available jobs within their existing communities, such as environmental restoration or a power plant operating on low-carbon fuel, the literature explores the suite of measures necessary to provide temporary unemployment support, retraining or upskilling (such as

59. *See, e.g.*, *id.* at 3 (noting the importance of "modelling employment and distributional impacts from coal closures"); INT'L LABOUR ORG., GUIDELINES FOR A JUST TRANSITION TOWARDS ENVIRONMENTALLY SUSTAINABLE ECONOMIES AND SOCIETIES FOR ALL 6 (2015), https://www.ilo.org/wcmsp5/groups/public/@ed_emp/@emp_ent/documents/publication/wcms_432859.pdf [https://perma.cc/BE56-FJGW] (noting the importance of "anticipating impacts on employment").

60. *See, e.g.*, PEOPLE-CENTRED, *supra* note 58, at 4; INT'L LABOUR ORG., *supra* note 59 (identifying a key element of a just transition as generating "decent jobs all along the supply chain, in dynamic, high value added sectors which stimulate the upgrading of jobs and skills"); Kieran Harrahill & Owen Douglas, *Framework Development for 'Just Transition' in Coal Producing Jurisdictions*, 134 ENERGY POL'Y, no. 1110990, 2019, at 1, 8 (noting the importance of "[r]e-training for workers from a primarily low-skill base" and noting vocational training programs in Germany, a "Coal and Electricity Transition Tuition Voucher" in Alberta, Canada, and a "Hi-Tech Precinct" in Victoria, Australia to "align industry and educational interests to support the development of a technology hub").

61. *See, e.g.*, PEOPLE-CENTRED, *supra* note 58, at 4 ("Energy industries and their supply chains are often geographically concentrated and can represent the social, economic and cultural underpinning of entire communities.").

62. *See, e.g.*, *id.* at 5 (noting social dialogue bodies and multi-stakeholder commissions).

63. *See, e.g.*, *id.* at 3–4, 8 (noting Japan's deployment of "ammonia as a fuel for existing thermal power plants, which can retain existing workforces while creating jobs in new supply chains," recommending "environmental restoration" as a mechanism for providing "community support measures in impacted mining regions," and noting a "shift [in] economic activity and jobs from traditional mining" to critical minerals mining); *The Platform*, JUST TRANSITION FUND, https://nationaleconomictransition.org/platform/ [https://perma.cc/7K5L-89A3] (emphasizing "workforce transition plans that prioritize the existing workforce either for immediate reclamation/remediation opportunities locally or jobs elsewhere").

training on the digital technologies necessary for economies that primarily operate on electricity), relocation, and pension support for workers near—but not yet at—retirement.[64] In addition, similar literature utilizes a "workforce transition mapping tool" to identify gaps in and the overlap between skills in declining (such as coal) and growing (such as solar) energy industries.[65]

With respect to labor gains, there are several distinct strains within the policy, non-governmental organization (NGO), and academic literature. First, there are numerous studies from economists and NGOs estimating the jobs produced by a "green energy" economy and the net increase or decrease in jobs as compared to a fossil-based economy.[66] Second, one large NGO and several peer-reviewed articles—written on the inclusivity of the workforce and the quality of green energy jobs—emphasize the need to model, measure, and address the inclusion of underrepresented groups in this growing workforce.[67] Finally, the NGO and policy literature, in particular, focus on broad-based training programs for green energy workers and any gaps in training that remain.[68]

64. *See*, *e.g.*, PEOPLE-CENTRED, *supra* note 58, at 4 (noting countries' renewable energy training programs and Canada's "training and re-tooling" program to "build a skilled workforce" in "energy efficiency").

65. Gilbert Michaud, *Examining Renewable Energy Transitions: A Tool to Enhance Workforce Development*, RENEWABLE ENERGY POL'Y INITIATIVE, Aug. 2020, at 1, 2, https://closup.umich.edu/research/examining-renewable-energy-transitions-tool-enhance-workforce-development [https://perma.cc/RAA5-X97J].

66. *See, e.g.*, Adie Tomer, Joseph W. Kane & Caroline George, *How Renewable Energy Jobs Can Uplift Fossil Fuel Communities and Remake Climate Politics*, BROOKINGS (Feb. 23, 2021), https://www.brookings.edu/research/how-renewable-energy-jobs-can-uplift-fossil-fuel-communities-and-remake-climate-politics/ [https://perma.cc/MM8E-MGZ6].

67. *See, e.g.*, SARAH TRUITT, JULIANA WILLIAMS & ARDELIA CLARKE, NAT'L RENEWABLE ENERGY LAB'Y, BUILDING A MORE DIVERSE, EQUITABLE, AND INCLUSIVE ENERGY EFFICIENCY WORKFORCE 2 (2022); MARK MURO, ADIE TOMER, RANJITHA SHIVARAM & JOSEPH W. KANE, METROPOLITAN POLICY PROGRAM, BROOKINGS, ADVANCING INCLUSION THROUGH CLEAN ENERGY JOBS 4 (2019), https://www.brookings.edu/wp-content/uploads/2019/04/2019.04_metro_Clean-Energy-Jobs_Report_Muro-Tomer-Shivaran-Kane_updated.pdf [https://perma.cc/65S6-E4S2]; FAZELI, *supra* note 12, at 3.

68. MURO ET AL., *supra* note 67, at 18–21; DAVID KEYSER & SUZANNE TEGEN, NAT'L RENEWABLE ENERGY LAB'Y, THE WIND ENERGY WORKFORCE IN THE UNITED STATES: TRAINING, HIRING, AND FUTURE NEEDS iii (2019), https://www.nrel.gov/docs/fy19osti/73908.pdf [https://perma.cc/A5X6-K6Z4].

E. Economic and Social Impacts: Communities

Communities that historically relied on fossil fuels for jobs and tax revenue are often deeply bound to these industries—not just economically but also from a cultural perspective.[69] Literature and case studies from coal mining towns highlight the deep sense of purpose and culture embedded within coal mining histories.[70] As an economic development leader from Sheridan, Wyoming, explains, the town has been a coal mining town since the 1890s, but the coal mines are reducing production and closing.[71] When asked to consider a proposal for a local solar energy project, residents asked why they would do so given that they live in a coal town.[72] Similarly, in Germany's Ruhr region, dominant land-owning coal companies initially refused to sell the land for municipal and state-supporting industrial development.[73]

Social sciences literature also examines the decline of fossil fuels through the lens of fiscal dependencies on fossil fuel revenues—embedded through historical decision-making processes—that later impede community redevelopment efforts and resilience.[74] This literature emphasizes that deindustrialization within these communities does more than directly impact communities by reducing revenues for critical services, such as public education, safety, and health.[75] These services are also necessary to support the growth of new industries and overall resilience of formerly fossil fuel-dependent

69. Jennifer Baka, Seth Blumsack, Caden Vitti & Hannah Wiseman, The Local Social and Economic Context of Energy Transitions 8 (Sept. 21, 2022) (unpublished manuscript), https://celp.psu.edu/wp-content/uploads/2022/04/CELP_EnergyTransitions_Apr2022.pdf [https://perma.cc/EV4A-GGCH].

70. *See id.*

71. *Id.* at 9.

72. *Id.*

73. ELKE DAHLBECK, STEFAN GÄRTNER, BENJAMIN BEST, JENNY KURWAN, TIMON WEHNERT & JANNIS BEUTEL, ANALYSIS OF THE HISTORICAL STRUCTURAL CHANGE IN THE GERMAN HARD COAL MINING RUHR AREA 30, 57 (2021).

74. *E.g.*, Kelli F. Roemer & Julia H. Haggerty, *The Energy Transition as Fiscal Rupture: Public Services and Resilience Pathways in a Coal Company Town*, 91 ENERGY RSCH. & SOC. SCI., no. 102752, 2022, at 1, 1–2.

75. *Id.* at 2.

facilities, so inadequate public services affect communities' potential to rebound from the decline of a local fossil fuel economy.[76]

A large body of social science, economic, and NGO literature explores factors that have allowed communities to successfully pivot away from fossil fuels and rebuild healthy economies, as well as those factors that reflect lesser success.[77] Often building on case studies, the literature emphasizes the importance of engaging workers in transition strategies and investing government resources in communities: in the case of Germany, for example, federal, state, and regional resources.[78] One primary example of this type of work is Kieran Harrahill and Owen Douglas's article, *Framework Development for 'Just Transition' in Coal Producing Jurisdictions*, which examines transitions away from coal in portions of Australia, Canada, and Germany and measures the success or failure of these transitions against four European Trade Union Institute success factors for just transitions.[79] These factors include social dialogue, re-employability, retraining, and role of the welfare state.[80] The article also recognizes that a failure to adequately address negative impacts of the energy transitions on communities and workers can weaken public support for the transitions.[81]

With respect to communities gaining low-carbon energy technologies, the literature focuses on ensuring equitable access to these technologies and their benefits, such as reduced pollution, and pairing quality of life improvements with clean energy implementations. For example, the International Energy Agency explores programs that enhance rural access to electrification by

76. *Id.* at 7–8.

77. *E.g.*, DAHLBECK ET AL., *supra* note 73, at 12–13; *see generally* Harrahill & Douglas, *supra* note 60. For a summary of the transition of the Ruhr Valley in Germany, see *Energy Transition Vignettes*, PA. ST. CTR. FOR ENERGY L. & POL'Y, https://celp.psu.edu/energy-transition-vignettes/ [https://perma.cc/D8YE-GQQR].

78. DAHLBECK ET AL., *supra* note 73, at 17; *Energy Transition Vignettes*, *supra* note 77.

79. *See generally* Harrahill & Douglas, *supra* note 60.

80. *Id.* at 5 tbl.1.

81. *Id.* at 4; *see also* Noel Healy & John Barry, *Politicizing Energy Justice and Energy System Transitions: Fossil Fuel Divestment and a "Just Transition,"* 108 ENERGY POL'Y 451, 451 (2017); Adam Mayer, *A Just Transition for Coal Miners? Community Identity and Support from Local Policy Actors*, 28 ENV'T INNOVATION & SOCIETAL TRANSITIONS, Sept. 2018, at 1, 1.

distributing off-grid solar technologies to rural communities or replacing cooking appliances with low-carbon, low-pollution stoves.[82] If targeted toward the most vulnerable populations and adequately subsidized, these programs can also reduce energy poverty—an important focus noted in the literature.[83] Furthermore, the literature explores how renewable energy development—frequently located in rural areas—can spur economic growth in areas that often have little investment.[84]

F. Health Impacts

Growing literature addresses the impacts of the energy transition on all individuals, not just workers. The health sciences literature in the energy transition space is primarily concerned with improving air quality and mitigating the related health effects of changing energy technologies.[85] While the terms "energy justice" and the "just transition" have not become prevalent in the health science literature, "climate justice," "resilience," "health equity," and "spatial justice" have.[86] Many researchers integrate these concepts into their model design and methodological analysis.[87] For example, several studies assessing air quality impacts incorporate factors such as health co-benefits of carbon dioxide reductions as a result of reduced emissions of particulate matter and other pollutants, including increased life expectancy and decreased morbidity.[88] Many of these studies measure and model air quality improvements associated with coal plant closures; they attempt to identify direct pollution reductions associated

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82. *See, e.g.*, PEOPLE-CENTRED, *supra* note 58, at 6–7.

83. *Id.* at 7.

84. *Id.* at 6.

85. *E.g.*, Gavin Pereira, Michelle L. Bell, Yasushi Honda, Jong-Tae Lee, Lidia Morawska & Bin Jalaludin, *Energy Transitions, Air Quality and Health*, ENV'T RSCH. LETTERS, Feb. 10, 2021, at 1, 3.

86. *See* Aaron S. Bernstein, Kristin L. Stevens & Howard K. Koh, *Patient-Centered Climate Action and Health Equity*, 328 JAMA 419, 419 (2022); Alina B. Baciu, Lourdes J. Rodriguez & Kirsten Bibbins-Domingo, *Spatial Justice and Implications for US Health Care*, JAMA HEALTH F., Oct. 21, 2021, at 1, 1.

87. *E.g.*, Baciu et al., *supra* note 86, at 2.

88. *See* Jonathan J. Buonocore, Ethan J. Hughes, Drew R. Michanowicz, Jinhyok Heo, Joseph G. Allen & Augusta Williams, *Climate and Health Benefits of Increasing Renewable Energy Deployment in the United States*, ENV'T RSCH. LETTERS, Oct. 29, 2019, at 1, 2, 4.

with closure of specific plants and pollution reductions from other factors, such as changes in the amount and direction of wind.[89]

Other peer-reviewed work estimates the health co-benefits of reducing carbon emissions by increasing renewable energy generation (and reducing air pollutants).[90] And additional studies examine the health impacts (primarily air quality-based) of technologies to which some communities are transitioning, such as biomass and waste-to-energy plants, which emit conventional air pollutants.[91] Further, social scientists have examined the factors that tend to induce individuals to switch from higher-carbon (and co-pollutant) technologies to lower ones, such as from dung or wood-burning cooking stoves to "clean fuels" such as gas and electricity.[92]

A growing subset of the energy transition health literature moves well beyond air quality, beginning to note the broader health and environmental impacts of clean energy technologies, such as use or disposal of solar photovoltaic panels and batteries.[93]

The literature also emphasizes reducing greenhouse gas emissions in an effort to ameliorate the health risks associated with climate

89. *E.g.*, Brian Strasert, Su Chen Teh & Daniel S. Cohan, *Air Quality and Health Benefits from Potential Coal Power Plant Closures in Texas*, 69 J. AIR & WASTE MGMT. ASS'N 333, 337–38 (2019); Lucas R.F. Henneman, Loretta J. Mickley & Corwin M. Zigler, *Air Pollution Accountability of Energy Transitions: The Relative Importance of Point Source Emissions and Wind Fields in Exposure Changes*, ENV'T RSCH. LETTERS, Oct. 29, 2019, at 1, 7.

90. Emil G. Dimanchev, Sergey Paltsev, Mei Yuan, Daniel Rothenberg, Christopher W. Tessum, Julian D. Marshall & Noelle E. Selin, *Health Co-Benefits of Sub-National Renewable Energy Policy in the US*, ENV'T RSCH. LETTERS, Aug. 12, 2019, at 1, 6–8; G. F. Nemet, T. Holloway & P. Meier, *Implications of Incorporating Air-Quality Co-Benefits into Climate Change Policymaking*, ENV'T RSCH. LETTERS, Jan. 22, 2010, at 1, 1–2; Kyle Siler-Evans, Inês Lima Azevedo, M. Granger Morgan & Jay Apt, *Regional Variations in the Health, Environmental, and Climate Benefits of Wind and Solar Generation*, 110 PROC. NAT'L ACAD. SCIS. 11768, 11768 (2013).

91. *See, e.g.*, Tom Cole-Hunter, Fay H. Johnston, Guy B. Marks, Lidia Morawska, Geoffrey G. Morgan, Marge Overs, Ana Porta-Cubas & Christine T. Cowie, *The Health Impacts of Waste-to-Energy Emissions: A Systematic Review of the Literature*, ENV'T RSCH. LETTERS, Dec. 1, 2020, at 1, 1, 3.

92. Matthew Shupler, Perry Hystad, Paul Gustafson, Sumathy Rangarajan, Maha Mushtaha, K G Jayachtria, Prem K. Mony, Deepa Mohan et al., *Household, Community, Sub-National and Country-Level Predictors of Primary Cooking Fuel Switching in Nine Countries from the PURE Study*, ENV'T RSCH. LETTERS, July 29, 2019, at 1, 1–2.

93. *E.g.*, Rachel Tham, Gayan Bowatte, Shyamali Dharmage, Geoffrey Morgan, Guy Marks & Christine Cowie, *Health Co-Benefits and Impacts of Transitioning from Fossil-Fuel Based to Cleaner Energy Sources in Higher-Income Countries: What Do We Know?*, *in* ISES-ISEE 2018 JOINT ANNUAL MEETING: ABSTRACT BOOK 1625, 1625 (2018).

change. Several identified "exposure pathways" include the physical and mental health effects of extreme weather events, forced migration, heat stress, inadequate food supply, and poor water quality.[94]

In the absence of equitable transition policies, the health science literature suggests that race and income impact exposure to poor air quality.[95] These healthcare inequities also underscore related economic challenges beyond the energy generation sector. For instance, healthcare "is among the most energy-intensive commercial sectors."[96] In participating in the transition process, the healthcare industry will need to consider the costs of retrofitting facilities and incorporating sustainable practices.[97]

G. International Approaches to the Energy Transition

Globally, conceptions of energy transitions vary in ways that reflect the significant differences in legal systems, natural resources, and energy needs or expectations. The literature, accordingly, surveys and innovates within national contexts, ranging from the primarily technical to community-scale and justice-centered perspectives.[98]

94. Andy Haines & Kristie Ebi, *The Imperative for Climate Action to Protect Health*, 380 NEW ENG. J. MED. 263, 267 fig.3 (2019).

95. *See* Jonathan A. Patz, Valerie J. Stull & Viljay S. Limaye, Opinion, *A Low-Carbon Future Could Improve Global Health and Achieve Economic Benefits*, 323 JAMA 1247, 1247 (2020).

96. Jonathan A. Patz, Howard Frumkin, Tracey Holloway, Daniel J. Vimont & Andrew Haines, *Climate Change: Challenges and Opportunities for Global Health*, 312 JAMA 1565, 1572 (2014); *accord* Khaled Bawaneh, Farnaz Ghazi Nezami, Md. Rasheduzzaman & Brad Deken, *Energy Consumption Analysis and Characterization of Healthcare Facilities in the United States*, 12 ENERGIES, Oct. 4, 2019, at 1, 1–2.

97. *See* Patz et al., *supra* note 96.

98. *See generally* Siddharth Sareen & Håvard Haarstad, *Bridging Socio-Technical and Justice Aspects of Sustainable Energy Transitions*, 228 APPLIED ENERGY 624 (2018) (assessing, from the disciplinary perspective of geography, points of intersection between socio-technical and justice aspects through case studies in Portugal); Tamara Antonia Krawchenko & Megan Gordon, *How Do We Manage a Just Transition? A Comparative Review of National and Regional Just Transition Initiatives*, 13 SUSTAINABILITY, May 28, 2021, at 1 (comparing, from the cross-disciplinary perspectives of public administration and geography, just transition climate policies and practices "across 25 countries and 74 regions alongside European Union-level policies"); SHAPING AN INCLUSIVE ENERGY TRANSITION (Margot P.C. Weijnen, Zofia Lukszo & Samira Farahani eds., 2021) (seeking, from the disciplinary perspectives of energy engineering and public administration, to link socio-technical systems with social values in energy transitions); ENERGY TRANSITION AND ENERGY DEMOCRACY IN EAST ASIA (Jusen Asuka & Dan Jin eds., 2022) (discussing, from the disciplinary perspective of East Asian and international studies, the shift to community-based energy transition and publicly owned utilities).

Goals and priorities for energy transitions are inevitably conceived in relation to a country's baseline energy systems and the degree to which those systems currently meet the needs of citizens.[99] For example, in countries with developing economies, such as many in the Global South, energy transition is inextricably linked with the effort to provide energy access to all.[100] The United Nations' *Transforming Our World: The 2030 Agenda for Sustainable Development* states the goal of universal access to reliable, affordable clean energy, including energy for clean cooking (Goal 7).[101] Although countries have made significant progress—the proportion of the global population without access to electricity has fallen from 1.2 billion people without electricity in 2010 to 733 million in 2020—over 2 billion people still lack access to clean cooking and global renewable energy, which is still below 20%.[102]

An alignment, of course, between universal access to energy, energy affordability, reliability, and clean energy is not compelled; it has to be cultivated through law and policy and with financial support from developed countries. Even as greenhouse gas reduction is a fundamental aim of the United Nations Framework Convention on Climate Change (UNFCCC), the global treaty structuring international climate cooperation since 1992, how this translates into domestic

99. *See* Dilip Ahuja & Marika Tatsutani, *Sustainable Energy for Developing Countries*, 2 SAPIENS, Nov. 27, 2009, at 1, 12.

100. *See* INT'L ENERGY AGENCY, FINANCING CLEAN ENERGY TRANSITIONS IN EMERGING AND DEVELOPING ECONOMIES 15 (2021), https://iea.blob.core.windows.net/assets/6756ccd2-0772-4ffd-85e4-b73428ff9c72/FinancingCleanEnergyTransitionsinEMDEs_WorldEnergyInvestment2021SpecialReport.pdf [https://perma.cc/72VK-UKDN]. For a brief explanation of the Global South, see *A 60 Second Guide to . . . The Global North/South Divide*, ROYAL GEOGRAPHICAL SOC'Y, https://www.rgs.org/CMSPages/GetFile.aspx?nodeguid=9c1ce781-9117-4741-af0a-a6a8b75f32b4&lang=en-GB [https://perma.cc/8ZDL-XKER].

101. Sustainable Development Goal 7, or SDG7, is one of seventeen SDGs outlined in the *Transforming Our World: 2030 Agenda for Sustainable Development* adopted by the United Nations General Assembly in 2015. For more on the Agenda and SDG7, see DEP'T ECON. & SOC. AFFS., UNITED NATIONS, TRANSFORMING OUR WORLD: THE 2030 AGENDA FOR SUSTAINABLE DEVELOPMENT, https://sdgs.un.org/sites/default/files/publications/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf [https://perma.cc/C24Z-XYKJ].

102. INT'L ENERGY AGENCY, INT'L RENEWABLE ENERGY AGENCY, STAT. DIV., UNITED NATIONS, WORLD BANK & WORLD HEALTH ORG., TRACKING SDG 7: THE ENERGY PROGRESS REPORT 2022, at 2–3, 2 fig.ES.1 (2022) [hereinafter TRACKING SDG 7], https://trackingsdg7.esmap.org/data/files/download-documents/sdg7-report2022-full_report.pdf [https://perma.cc/5EXE-MDTC].

energy transition policy country by country is far from uniform and derives from differing assumptions.[103] These differences are evident in the variation across countries' commitments to greenhouse gas reduction under the Paris Agreement, which currently structures implementation of the UNFCCC.[104] The Paris Agreement calls on each country that is a Party to the Agreement to articulate a nationally determined contribution (NDC) to climate change mitigation, with increasing ambition over time, and articulate how that commitment will be achieved through domestic policy of its own determination.[105] Submitted NDCs include widely divergent timeframes for emissions reduction, as well as divergent goals reflecting, among other things, the degree to which achieving basic energy access for all citizens is still a central motivation for energy transition.[106] The literature reflects these differences.

Whether the focus of just transition policy is jobs, environment, or broader societal goals is not a difference without meaning. Indeed, as Tamara Krawchencko and Megan Gordon note, "[e]ach approach has implications for where and to whom governments focus their policy support and investments."[107] In the literature engaging international case studies and comparative policy, the effect of these varied emphases shapes the perspective on just transition for fossil energy industries. For example, a study of the potential for job creation from

103. United Nations Framework Convention on Climate Change, pmbl., May 9, 1992, S. Treaty Doc No. 102-38, 1771 U.N.T.S. 107. The UNFCCC entered into force in 1994 and has near universal global participation with 198 Parties. *See 7. United Nations Framework Convention on Climate Change*, UNITED NATIONS TREATY COLLECTION (Apr. 6, 2023, 9:15 AM), https://treaties.un.org/pages/ViewDetailsIII.aspx?src=IND&mtdsg_no=XXVII-7&chapter=27&Temp=mtdsg3&clang=_en [https://perma.cc/3C2L-YCY5].

104. The Paris Agreement was signed in 2015 and entered into force in 2016. Paris Agreement to the United Nations Framework Convention on Climate Change, Dec. 12, 2015, T.I.A.S. No. 16-1104.

105. For information about and a repository of Nationally determined contributions submitted pursuant to the Paris Agreement to date see *Nationally Determined Contributions Registry*, UNITED NATIONS, https://unfccc.int/NDCREG [https://perma.cc/BDH2-BJKS].

106. *See* United Nations Framework Convention on Climate Change Secretariat, Nationally Determined Contributions Under the Paris Agreement, Synthesis Report by the Secretariat, FCCC/PA/CMA/2022/4, at 4, 10, 13, 22 (Oct. 26, 2022) [hereinafter NDC Synthesis Report], https://unfccc.int/sites/default/files/resource/cma2022_04.pdf [https://perma.cc/7YSB-CSYG] (detailing and seeking to synthesize differences across submitted NDCs).

107. Krawchenko & Gordon, *supra* note 98 (comparing just transition climate policies and practices in twenty-five countries and seventy-four regions alongside EU-level policies).

renewable energy in Vietnam also emphasizes the need to support affected workers in the Mekong Delta and other coal-dependent regions.[108]

Countries with significant fossil energy industries tend to be especially interested in carbon capture and sequestration and other technologies that may, in theory, allow those industries to continue with a reduced carbon impact.[109] This inclination to preserve fossil energy industries presents the potential for conflicts between the concept of just transition and energy and environmental justice: often, significant localized environmental harms—apart from greenhouse gas emissions—affect communities that host such industries, even as they may be dependent on these industries for jobs.

Globally, countries have unique energy resource profiles, much like the state-by-state variation in wind and solar resources within the U.S. Yet, even in countries with promising resource potential, opportunities to develop reduced and low-carbon technologies may be constrained by capacity limitations.[110] Governmental, financial, workforce, and gender-based capacity barriers have all been recognized as presenting obstacles to clean energy transitions.[111]

How to support greenhouse gas reductions in developing countries, including within the energy sector, has long been a point of focus and debate during international climate negotiations. The Clean Development Mechanism, for example, is an approach crafted under the Kyoto Protocol to the UNFCCC (the primary pre-Paris Agreement

108. FUTURE SKILLS AND JOB CREATION THROUGH RENEWABLE ENERGY IN VIETNAM: ASSESSING THE CO-BENEFITS OF DECARBONISING THE POWER SECTOR 2 (Ayodeji Okunlola, Laura Nagel, Sebastian Helgenberger, Nguy Thi Khanh, Nguyen Thi Mai Dung & Sarah Kovac eds., 2019) [hereinafter FUTURE SKILLS AND JOB CREATION], https://www.cobenefits.info/wp-content/uploads/2020/08/COBENEFITS-Vietnam_Employment_Exec-Report.pdf [https://perma.cc/SUG8-9T2J].

109. *See* IAN HAVERCROFT & CHRISTOPHER CONSOLI, THE CARBON CAPTURE AND STORAGE READINESS INDEX 2018: IS THE WORLD READY FOR CARBON CAPTURE AND STORAGE? 5 (2018), https://www.globalccsinstitute.com/archive/hub/publications/202108/ccs-readiness-index-2018global-ccs-institute-2018digital.pdf [https://perma.cc/5YGR-Q5DB].

110. TRACKING SDG 7, *supra* note 102, at 14 & fig.ES.7 (showing in Figure ES.7 per capita capacity, by renewable technology for developing countries overall and by region from 2000-2020, indicating wide variation); *see also* NDC Synthesis Report, *supra* note 106, at 10 (noting 74% of parties that have submitted an NDC "identified capacity-building as a prerequisite for NDC implementation").

111. TRACKING SDG 7, *supra* note 102, at 20, 47.

implementation measure) designed to encourage mutually beneficial cooperative project development, rewarding industrialized countries with credit for emissions reductions they helped to create within developing countries—especially the least developed countries—pursuant to the mechanism rules.[112] The UN has underscored that international public financing for clean energy projects in developing countries "is still insufficient to mobilize the larger volumes of investment needed" to achieve SDG7: universal, reliable, affordable access to clean energy for all.[113] For developing countries, capacity-building is a central theme—and barrier—for energy transitions.[114] In the spirit of mutual benefit expressed by the CDM concept, the literature on energy transitions continues to explore potential partnerships between developing and industrialized countries. For example, researchers have explored the potential for "green hydrogen" imports from North Africa to countries within the EU as a means for reducing EU emissions and promoting economic development for North African countries, which currently supply significant fossil energy to the EU.[115]

112. Kyoto Protocol to the United Nations Framework Convention on Climate Change, Dec. 11, 1997, 2303 U.N.T.S. 162 ("[T]aking into account their common but differentiated responsibilities"). The Kyoto Protocol was adopted in 1997 but did not enter into force until 2005 due to the United States' decision not to become a signatory. *See generally What is the CDM*, UNITED NATIONS CLIMATE CHANGE: CDM, https://cdm.unfccc.int/about/index.html [https://perma.cc/MX9L-E63U]. Another Kyoto Protocol measure, Joint Implementation (JI), is similar in purpose, but focused on economies in transition in eastern European and the former Soviet Union as beneficiaries. *See generally Joint Implementation (JI) – Home*, UNITED NATIONS CLIMATE CHANGE: JI, https://ji.unfccc.int/index.html [https://perma.cc/XLJ2-A8WG]. *See also* UNITED NATIONS CLIMATE CHANGE, ACHIEVEMENTS OF THE CLEAN DEVELOPMENT MECHANISM: HARNESSING INCENTIVE FOR CLIMATE ACTION 2001–2018, at 5 (2018), https://unfccc.int/sites/default/files/resource/UNFCCC_CDM_report_2018.pdf [https://perma.cc/QGF6-M6TE] (highlighting that renewable energy "projects registered under the CDM contribute about 100,000 Gigawatt hours in [renewable-source] electricity generation each year – enough to supply Ecuador, Morocco, Myanmar and Peru together"); Maxine Burkett, *Just Solutions to Climate Change: A Climate Justice Proposal for a Domestic Clean Development Mechanism*, 56 BUFF. L. REV. 169, 242 (2008) (discussing an innovative proposal to translate the CDM concept to the domestic US context to promote climate justice and just energy transitions and summarizing critiques of CDM implementation).

113. TRACKING SDG 7, *supra* note 102, at 18.

114. *See, e.g.*, FUTURE SKILLS AND JOB CREATION, *supra* note 108, at 18–19 (emphasizing the lack of skilled labor in renewable energy technologies as a barrier to the clean energy transition in Vietnam, and citing similar findings related to India and South Africa).

115. *E.g.*, Ad van Wijk & Frank Wouters, *Hydrogen–The Bridge Between Africa and Europe*, *in* SHAPING AN INCLUSIVE ENERGY TRANSITION 91, 91–92 (Margot P. C. Weijnen, Zofia Lukszo & Samira Farahani eds., 2021) (focused on the high solar and wind resource of the Sahara Desert).

The literature on energy transitions focused within the EU suggests that equity and justice considerations are more commonly integrated into energy developments at the community scale and less commonly in regional- and national-scale projects.[116] For example, Siddharth Sareen and Håvard Haarstad contrast three scales of solar projects in Portugal, tracing the diminishing focus on justice dimensions of the energy transition as project size increases.[117] The smallest community-scale project involved voluntary participants intentionally collaborating with others of like mind to reduce the environmental impact of their energy consumption.[118] A modest-sized but still grid-scale project involving a capitalized private entity highlighted the potential conflict between keeping energy justice a priority and protecting the private entity's commercial interests.[119] Their case study of a larger solar park developed with the guidance of a municipal council showed the local governmental role in prioritizing the concurrent creation of local jobs by attracting a solar manufacturing facility to the area.[120] This example aligns with the just transition focus on workers in energy transitions, yet the researchers are quick to acknowledge that not all similarly sanctioned projects have the same components—it is inspired, not required. Authorities at the national level, the researchers found, engaged in "little visible discussion of energy justice issues."[121] At the same time, the EU has, through law and policy, fostered new legal entities called "renewable energy

116. *See, e.g.*, Gavin Bridge, Stefan Bouzarovski, Michael Bradshaw & Nick Eyre, *Geographies of Energy Transition: Space, Place and the Low-Carbon Economy*, 53 ENERGY POL'Y 331, 337–38 (2013) (discussing spatial differentiation, and potential for the low carbon transition to "re-work established patterns of 'core' and 'periphery' at multiple scales" and "the range of choices that exist in how low carbon energy systems might be scaled").

117. Siddharth Sareen & Håvard Haarstad, *Bridging Socio-Technical and Justice Aspects of Sustainable Energy Transitions*, 228 APPLIED ENERGY 624, 625 (2018).

118. *Id.* at 627.

119. *Id.* at 628–29.

120. *Id.* at 629.

121. *Id.*

communities" to center ownership of new clean energy infrastructure within host communities.[122]

Although siting issues for renewable energy projects garner significant attention, other aspects of energy transitions are not suited to what Darren McCauley and Raphael Heffron call "the analytical framework of proximity."[123] Others have also noted the potential for non-proximity-based aspects of energy transitions to exacerbate inequality, underscoring the importance of energy justice as a guiding principle for more than law and policy of physical infrastructure.[124]

II. Incorporating Cross-Disciplinary Principles into Energy Transition Law and Policy

Recognizing the many disciplinary dimensions of just energy transitions leads to an analysis of the ways to integrate these concepts to enhance and accelerate decarbonization policies. Part I began to explore how legal literature to some degree engages in conversations with other fields—particularly in areas such as land use for renewable energy and associated community opposition to new renewable energy generation. But legal literature and policymakers could benefit from a more integrated understanding of the many substantive angles of energy transitions. This Part explores more generally how state and federal energy transition legislation could better incorporate lessons from multiple disciplines and how the policy for low-carbon industrial growth in particular has begun to encompass cross-disciplinary principles.

122. *See* Annalisa Savaresi, *The Rise of Community Energy from Grassroots to Mainstream: The Role of Law and Policy*, 31 J. ENV'T L. 487, 491–92 (2019) (discussing the 2018 EU Renewable Energy Directive and "renewable energy communities" as a mechanism for energy transition).

123. Darren McCauley & Raphael Heffron, *Just Transition: Integrating Climate, Energy and Environmental Justice*, 119 ENERGY POL'Y, Apr. 24, 2018, at 1, 3.

124. *See, e.g.*, Aad Correljé, *Perspectives on Justice in the Future Energy System: A Dutch Treat*, *in* SHAPING AN INCLUSIVE ENERGY TRANSITION 55, 55–72 (Margot P. C. Weijnen, Zofia Lukszo & Samira Farahani eds., 2021) (discussing equity implications of energy system decentralization, digitalization, and energy efficiency requirements); Outka, *supra* note 39, at 789–91.

A. A Lack of Comprehensive Energy Transition Legislation

The many facets of the energy transition explored in Part I highlight the fact that emerging energy transition policies within the U.S.—at the federal and state levels—are far from comprehensive. These policies address only limited components of the transition. For example, New York policy attempts to centralize the siting speed of new renewable energy projects while mandating payment to host communities.[125] And New Mexico policy addresses how the "stranded costs" of coal-fired power plants mothballed before the end of their useful life and encourages the siting of renewable energy in communities losing fossil fuel industries.[126] New Mexico also requires that zero-carbon generation companies hire minimum percentages of apprentices, thus aiding in green energy job training and retraining.[127] The Colorado Office of Just Transition, in turn, focuses primarily on the impacts of the energy transition on workforces and community revenue—a critical mission in light of Colorado's deeply rooted fossil fuel economy yet nonetheless a discrete lens.[128] These state efforts are important but are incomplete from the perspective of addressing all major energy transition issues.

In short, there is yet to exist a federal or state policy that comprehensively addresses energy transitions. A more comprehensive approach would address workers and communities losing jobs and industry; population groups gaining jobs (and perpetuation or avoidance of past workforce exclusivity and inequity); and communities and populations experiencing vast changes as a result of net-carbon energy expansions. Perhaps this is for the best, as comprehensive legislation has its downsides. More piecemeal efforts can place discrete issues of the energy transition within different agencies' wheelhouses: for example, directing labor issues and land use or environmental issues to separate offices. But discrete efforts risk

125. N.Y. EXEC. LAW § 94-c (Consol. 2023).
126. *See* N.M. STAT. ANN. § 62-18-3 (West 2023).
127. § 62-13-16.
128. *See The Office of Just Transition*, COLO. DEP'T LAB. & EMP., https://cdle.colorado.gov/the-office-of-just-transition [https://perma.cc/6Q2S-276M].

leaving unnoticed gaps in energy transition policy, and they may create inefficient overlap or a lack of needed coordination among programs aimed at, say, job retraining and remediation of former fossil fuel extraction sites by former fossil fuel workers. The enactment of New York's cumulative impacts law in 2023 provides an example of how environmental justice considerations can be infused into agency decisions to approve, fund, or directly implement environmental actions based on environmental, social, and economic impacts.[129] Law professor Dan Farber notes that the law's broad language may prevent economic development that might benefit those towns and new services, including hospitals that may be needed.[130]

Some federal legislation has begun to take a more comprehensive approach. For example, the Inflation Reduction Act of 2022 (IRA) provides larger incentives for the development of net-carbon strategies in so-called "energy communities"—in this context, meaning those that have historically relied largely on fossil fuels for economic growth and stability.[131] The IRA also channels clean energy subsidies toward lower-income and marginalized populations and addresses clean energy land use and siting issues by enhancing federal control over the siting of transmission lines.[132]

B. Enhancing Opportunities for Equity in the Formation of Low-Carbon Industries

Beyond highlighting gaps in general energy transition policies, synthesizing the literature on just energy transitions illustrates how

129. Stacey Halliday, Roy Prather, Julius Redd, Hilary Jacobs & Liz Johnson, *New York Enacts Environmental Justice Permitting Law*, BEVERIDGE & DIAMOND PC, https://www.bdlaw.com/publications/new-york-enacts-environmental-justice-permitting-law/ [https://perma.cc/MLY4-6W76]. The relevant portion of the law states: "The department shall not issue an applicable permit for a new project if it determines that the project will cause or contribute more than a de minimis amount of pollution to a disproportionate pollution burden on the disadvantaged community." N.Y. ENV'T CONSERV. LAW § 70-0118(3)(b) (Consol. 2023).

130. Dan Farber, *New York's New Environmental Justice Law*, LEGALPLANET (May 18, 2023), https://legal-planet.org/2023/05/18/new-yorks-new-environmental-justice-law/ [https://perma.cc/9W2F-68BE].

131. *See* Inflation Reduction Act of 2022, Pub. L. No. 117-169, 136 Stat. 1818.

132. *Id.* at 136 Stat. 2046–48.

equity issues, including economic disparities, access to capital, and health inequities, serve to bar access to the benefits of the energy transition for the entities, groups, and communities that experience inequities. The Justice40 Initiative, which is incorporated in President Joe Biden's Executive Order 14008, includes "a goal that 40[%] of the overall benefits of certain Federal investments flow to disadvantaged communities that are marginalized, underserved, and overburdened by pollution."[133] Through the IRA, the Infrastructure Investment and Jobs Act, and the American Rescue Plan, federal agencies have a mandate to integrate and implement environmental justice in their investments. Specifically, Justice40 seeks to "confront decades of underinvestment in disadvantaged communities[] and bring critical resources to communities that have been overburdened by legacy pollution and environmental hazards."[134] In this regard, the social sciences, including law, economics, policy, geography, energy history, and sociology, have considered how finance mechanisms and start-up strategies can impact the success of just energy transitions and enhance access to the benefits of transitions.

Law, for example, can provide a framework to ensure that the implementation of Justice40 is equitable and fair. Economic policies can support the development of innovative financing mechanisms that enable the participation of disadvantaged communities in clean energy and infrastructure projects. Geography can improve this law by identifying areas where communities are most vulnerable to environmental hazards and prioritizing investments in those areas. Industrial transition literature can help us understand how past energy policies have contributed to the marginalization of certain communities and inform the development of more equitable policies going forward. Finally, sociology can provide insights into the social and cultural factors that influence the success of just energy transitions and how legal frameworks must incorporate these factors by, for example, including tools to enhance all communities' access to clean

133. *Justice40: A Whole-of-Government Initiative,* WHITE HOUSE: ENV'T JUST., https://www.whitehouse.gov/environmentaljustice/justice40/ [https://perma.cc/U3RJ-HDA7].

134. *Id.*

energy incentives. Tools such as involving community leaders in the dissemination of information about incentives, broadening government communication to include multiple languages and avenues for distribution (beyond the internet), and streamlining and simplifying documents required to determine individuals' eligibility for benefits are all important in this regard.

Historically marginalized communities and communities that are especially vulnerable to sea level rise and natural disasters may lack technical and financial knowledge to develop a plan for decarbonization in their communities and lower their carbon footprints.[135] Access to funding, developed business models, and partnerships are areas that could be expanded to overcome some of these gaps for project development, design, and implementation, particularly in the renewable energy sector. Engaging local communities in project development can prevent unintended consequences and lead to a more integrated, community-led approach for energy transitions in the interim and long-term.[136] This community engagement reduces uncertainty and creates a stable policy environment to encourage investment in low-carbon energy technologies.[137]

1. Access to Funding Opportunities

Even as renewables are approaching price parity with fossil fuels, the upfront capital costs are a significant barrier to clean energy

135. *See* TIM GORE, MIRA ALESTIG & ANNA RATCLIFF, OXFAM, CONFRONTING CARBON INEQUALITY: PUTTING CLIMATE JUSTICE AT THE HEART OF THE COVID-19 RECOVERY 2 (2020), https://oxfamilibrary.openrepository.com/bitstream/handle/10546/621052/mb-confronting-carbon-inequality-210920-en.pdf [https://perma.cc/L5GZ-E879].

136. Stephen Axon & John Morrissey, *Just Energy Transitions? Social Inequities, Vulnerabilities and Unintended Consequences*, 1 BUILDING & CITIES 393, 405–07 (2020); *see also* Oluleke O. Babayomi, Davo A. Dahoro & Zhenbin Zhang, *Affordable Clean Energy Transition in Developing Countries: Pathways and Technologies*, ISCIENCE, May 20, 2022, at 1, 8; Henrik Lund, *Renewable Energy Strategies for Sustainable Development*, 32 ENERGY 912, 912 (2007); Jochen Markard, *The Next Phase of the Energy Transition and its Implications for Research and Policy*, 3 NATURE ENERGY 628, 632 (2018).

137. *See* Ronan Bolton, Timothy J. Foxon & Stephen Hall, *Energy Transitions and Uncertainty: Creating Low Carbon Investment Opportunities in the UK Electricity Sector*, 34 ENV'T & PLAN. C: GOV'T & POL'Y 1387, 1390–92, 1398–99 (2016).

deployment.[138] Having the technical capacity to navigate complex finance options may be beyond the reach of marginalized communities. Targeted grants, loans, and venture capital funds aimed at environmental justice communities to develop and commercialize new energy technologies may also be beyond their reach. On the other hand, feed-in tariffs, tax incentives, and public-private partnerships that could lower upfront capital costs for low-income and underserved communities tend to be overlooked as reliable alternatives for finance mechanisms.[139]

The costs of renewable energy technologies, the demand for energy infrastructure investments, and variations in socioeconomic factors impact overall energy access and use.[140] Yet exploring ways to leverage a variety of funding sources, including green bonds, crowdfunding, and peer-to-peer lending, can serve to expand financing models and policy support for energy transitions.[141] Meanwhile, widening the risk management framework and stakeholder engagement to align with additional finance options, including project finance, debt financing, equity financing, and government subsidies, can provide additional options to local communities.[142] This combination of private sector investment and government support can optimize financial support and bring capital to the start-up projects.[143]

138. *See* Nadia Ameli & Daniel M. Kammen, *Clean Energy Deployment: Addressing Financing Cost*, ENV'T RSCH. LETTERS, July 13, 2012, at 1, 2.

139. *See id.* at 8, 10.

140. *See* Kathleen Araújo, *The Emerging Field of Energy Transitions: Progress, Challenges, and Opportunities*, 1 ENERGY RSCH. & SOC. SCI. 112, 113 (2014).

141. *See* Raphael Bointner, Simon Pezzutto, Gianluca Grilli & Wolfram Sparber, *Financing Innovations for the Renewable Energy Transition in Europe*, 9 ENERGIES, Nov. 25, 2016, at 1, 2; Nadezhda Nikolaevna Kulikova, *Features of Financing Innovative Renewable Energy Development*, 2016 INT'L F. STRATEGIC TECH. 315, 315, 317.

142. *See* Patrick T.I. Lam & Angel O.K. Law, *Financing for Renewable Energy Projects: A Decision Guide by Developmental Stages with Case Studies*, 90 RENEWABLE & SUSTAINABLE ENERGY REVS. 937, 942 (2018).

143. *See* SATYAJIT BOSE, GUO DONG & ANNE SIMPSON, THE FINANCIAL ECOSYSTEM: THE ROLE OF FINANCE IN ACHIEVING SUSTAINABILITY 349 (2019).

2. Business Model Optimization

Start-up strategies can influence the business models that emerge in the clean energy sector. For example, some start-ups may focus on distributed energy solutions that empower communities to generate and manage their energy supply. These models can be more accessible and affordable for low-income communities and can help promote energy democracy. Having larger-scale energy companies work in community-based engagement can promote capacity through technological innovation and economies of scale.[144] Meanwhile, even companies with technically sound solutions may lack a clear value proposition, customer segments, and revenue streams.[145] A possible solution would be to have larger companies acquire start-ups to positively impact the larger company's value and align with environmental policies.[146] Yet due diligence in such acquisitions is critical.[147] The types of renewable energy will also impact the development of business models to reduce energy demand through energy efficiency.[148]

144. *See* Xiaoxia Bian, Peishu Chen, Zhengye Gao & Guochang Fang, *How to Promote the Energy Transition?—An Analysis Based on the Size and Technology Effect in New Energy Industry*, 10 FRONTIERS IN ENERGY RSCH., Jan. 10, 2023, at 1, 7; *see also* Joisa Dutra & Antonio Barbalho, *The Convergence of Business Models and Long-Term Financing in the Energy Transition*, 18 COMPETITION & REGUL. NETWORK INDUS. 256, 263 (2017).

145. *See* Kirsi Kotilainen, Ulla A. Saari, Jussi Valta, Saku J. Mäkinen & Sinan Kufeouglu, *Business Model Readiness of Start-Up Driven Energy Innovations – An Empirical Review*, INT'L CONF. ON EUROPEAN ENERGY MKT., no. 127, 2019.

146. *See* Ohsung Kwon, Sangmin Lim & Duk Hee Lee, *Acquiring Startups in the Energy Sector: A Study of Firm Value and Environmental Policy*, 27 BUS. STRATEGY & ENV'T 1376, 1378 (2018).

147. *See id.* at 1382.

148. *See* Frank W. Geels, Tim Schwanen, Steve Sorrell, Kirsten Jenkins & Benjamin K. Sovacool, *Reducing Energy Demand through Low Carbon Innovation: A Sociotechnical Transitions Perspective and Thirteen Research Debates*, 40 ENERGY RSCH. & SOC. SCI. 23, 24 (2018); Claudia Capozza, Marialuisa Divella & Alessandro Rubino, *Exploring Energy Transition in European Firms: The Role of Policy Instruments, Demand-Pull Factors and Cost-Saving Needs in Driving Energy-Efficient and Renewable Energy Innovations*, 16 ENERGY SOURCES, PART B: ECON., PLAN., & POL'Y 1094, 1104 (2021); A. Bumpus & S. Comello, Comment, *Emerging Clean Energy Technology Investment Trends*, 7 NATURE CLIMATE CHANGE 382, 383 (2017).

3. Partnerships and Cross-Sector Collaborations

Cross-sector collaboration between start-ups, government agencies, and community organizations is critical to ensure the energy transition benefits marginalized communities and vulnerable groups. Start-ups can partner with government agencies to develop policies that support the deployment of clean energy technologies in underserved communities. The start-ups can also build partnerships with community organizations to ensure that energy solutions are designed with such a focus. Barriers to entry include the lack of policy support and finance,[149] especially when a decentralized energy model is sought.[150] The convergence of social, economic, and political factors for renewable energy deployment suggests the broad scope of partnerships needed to overcome the complexity of these systems.[151] Prioritizing stakeholder engagement for low-carbon technologies can be a means to overcome other cross-sector institutional barriers.[152] The technological innovation, government policies, and market demand impact the adoption of clean technologies, so partnerships are crucial to recognize these market trends as deployment drivers.[153] These partnerships can also provide a means to support renewable energy transitions in the built environment through energy modeling and analytics.[154] For example, a regional innovation systems perspective can help with the understanding of the dynamics of energy transitions

149. *See* D.P. GOLDMAN, J.J. MCKENNA & L.M. MURPHY, FINANCING PROJECTS THAT USE CLEAN-ENERGY TECHNOLOGIES: AN OVERVIEW OF BARRIERS AND OPPORTUNITIES 2 (2005).

150. *See* Stephen Hall, Christoph Mazur, Jeffrey Hardy, Mark Workman & Mark Powell, *Prioritising Business Model Innovation: What Needs to Change in the United Kingdom Energy System to Grow Low Carbon Entrepreneurship?*, ENERGY RSCH. & SOC. SCI., no. 101317, 2020, at 1, 6.

151. *See* Arnulf Grubler, *Energy Transitions Research: Insights and Cautionary Tales*, 50 ENERGY POL'Y 8, 8 (2012); Staffan Jacobsson & Anna Bergek, *Transforming the Energy Sector: The Evolution of Technological Systems in Renewable Energy Technology*, 13 INDUS. & CORP. CHANGE 815, 816–17 (2004).

152. *See* Auriane Magdalena Koster & John Martin Anderies, *Institutional Factors that Determine Energy Transitions: A Comparative Case Study Approach*, *in* RENEWABLE ENERGY GOVERNANCE: COMPLEXITIES AND CHALLENGES 33, 56 (Evanthie Michalena & Jeremy Maxwell Hills eds., 2013).

153. *See* S. Sinan Erzurumlu & Yaman O. Erzurumlu, *Development and Deployment Drivers of Clean Technology Innovations*, 24 J. HIGH TECH. MGMT. RSCH. 100, 101, 107 (2013).

154. Massimiliano Manfren, Maurizio Sibilla & Lamberto Tronchin, *Energy Modelling and Analytics in the Built Environment—A Review of Their Role for Energy Transitions in the Construction Sector*, ENERGIES, Jan. 28, 2021, at 1, 2.

in small-scale regions and identify strategies to support this transition.[155]

Ultimately, by promoting access to funding, developing innovative business models, and fostering partnerships with government agencies and community organizations, start-ups and communities seeking to enter the renewable energy market can drive the launch and deployment of renewables for a more sustainable and equitable energy system. Finance mechanisms and start-up strategies can ensure that the energy transition is just and equitable.

CONCLUSION

In synthesizing and reflecting on the literature review, we see points of emphasis as well as gaps that can inform law and policy reform in the following key ways:

Integrate rather than simply incorporate equity and justice in energy transitions reform. Even as equity and justice considerations have become increasingly common themes in energy transition discourse and policy spheres, the literature still reflects an enduring gap to bridge between technical and social aspects of transition.[156] Equity and justice considerations should be and can be integrated from the outset of energy policy reform efforts and transition policy development rather than assumed to be incorporated in response to public participation, which typically takes place at a later stage of public dialogue. Without this integration, reform efforts create a structural risk of re-enacting inequality in new patterns of development.

Anticipate and avoid potential for misalignment between just transition policy for declining fossil energy industries and new clean energy economic development for restorative justice. The just transition literature centered on alleviating economic hardship in

155. Jannika Mattes, Andreas Huber & Jens Koehrsen, *Energy Transitions in Small-Scale Regions – What We Can Learn from a Regional Innovation Systems Perspective*, 78 ENERGY POL'Y 255, 255–56 (2015).

156. *See* Roemer & Haggerty, *supra* note 74, at 2.

communities dependent on the coal industry finds commonality, but not complete alignment with, current efforts to focus clean energy jobs and other benefits in "disadvantaged communities." The Justice40 Initiative, which President Biden created by executive order to direct 40% of climate-related investments in this way, is one such effort.[157] The tendency toward a divided focus in the literature on communities facing loss of longstanding energy industries on the one hand and possibilities for addressing historical environmental injustice with clean energy on the other hand suggests there is more work to do to integrate these two critical dimensions within energy transition reform rather than disaggregate them in ways that could create counter-productive competition for funds or policy attention.

Engage at state and federal levels with the role of local land use in the energy transition. Local land use is central to every new energy infrastructure project, yet it remains sidelined in the national conversation due largely to political and regulatory mismatch despite its prominent acknowledgement within the literature.[158] This is not new—land use impact tends not to be at the forefront of policymaking—yet it is an avoidance worth rethinking when it leaves a distinct gap where the potential for landscape and regional planning could guide a more rapid clean energy transition. Land use literature suggests that land use intensity must be contemplated, but it has not deeply engaged with how to meet capacity needs.[159] The literature also raises new questions about procedural and distributive justice during the transition: How will benefits and burdens be allocated? Will there be new winners and losers, or will renewable energy develop similarly to fossil fuels? How will renewable energy project decommissioning impact future land uses? How will battery storage needs impact resource extraction and new forms of land disturbance?

More closely examine the policy implications of international linkages undergirding clean energy transitions. There is growing attention to the importance of place-based and contextualized analysis

157. Exec. Order No. 14,008, 86 Fed. Reg. 7619, 7631–32 (Feb. 1, 2021).
158. Mattes et al., *supra* note 155, at 255; Pursley & Wiseman, *supra* note 41, at 882–84.
159. Mattes et al., *supra* note 155, at 255; Pursley & Wiseman, *supra* note 41, at 882–84.

of energy transitions.[160] The focus on individual communities and discrete populations, however, sometimes misses comprehensive supply-chain or "cradle-to-grave" approaches to the energy transition. For example, the minerals used in batteries in electric cars—a key facet of energy transitions in many developed countries—are primarily sourced in developing countries and processed in China.[161] Although a small subset of the literature has begun to integrate transition approaches, many energy transition pieces remain siloed within sociotechnical or justice literature. Further integration of these approaches could better address a central question of the transition: the extent to which social and justice-based questions frame and define the types of rate of technology implementation and the extent to which technological projections and assumptions drive sociological and justice-based impacts.

Pair focus on local contexts for infrastructure with equal attention to other vital equity and justice dimensions of energy reform and transition policy that are not based on proximity. Energy justice has expansive relevance for more aspects of energy transition than those that might immediately come to mind in connection with a specific community or landscape. Importantly, energy justice offers guidance for policymakers in new instrument design to facilitate clean energy transitions as well as a critical framing for reform of existing legal regimes. Such framing reflects meaning that extends beyond proximity to include issues like energy burden, clean energy financing, or technology accessibility and affordability where the equity dimensions may be less obvious but may have highly dispersed effects.[162]

Increase attention to and foster co-benefits of energy transitions. Another facet of the transition literature that remains underexplored—

160. Ping Huang & Vanesa Castán Broto, *Interdependence between Urban Processes and Energy Transitions: The Dimensions of Urban Energy Transitions (DUET) Framework*, 28 ENV'T INNOVATION & SOCIETAL TRANSITIONS 35, 40 (2018).

161. *Fact Sheet: Securing a Made in America Supply Chain for Critical Minerals*, WHITE HOUSE (Feb. 22, 2022), https://www.whitehouse.gov/briefing-room/statements-releases/2022/02/22/fact-sheet-securing-a-made-in-america-supply-chain-for-critical-minerals/ [https://perma.cc/5Q5K-BNHT].

162. Kirsten Jenkins, Darren McCauley & Alister Forman, Editorial, *Energy Justice: A Policy Approach*, 105 ENERGY POL'Y 631, 632 (2017).

and that could substantially improve transition policy—is the recognition and harnessing of the "co-benefits" of energy transitions. The implementation of low-carbon energy technologies can expand individuals' access to electricity, improve health by reducing co-pollutants (from power plants and dung and wood-fueled cook stoves, for example), and reduce energy poverty.