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Legal Pathways to Deep Decarbonization: Lessons from California and Germany

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LESSONS FROM CALIFORNIA AND GERMANY

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INTRODUCTION

On December 12, 2015, in Paris, France, the parties to the U.N. Framework Convention on Climate Change[1]—a total of 196 countries[2]—unanimously agreed to a goal of net zero greenhouse gas emissions by the second half of this century.[3]

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[1] U.N. Framework Convention on Climate Change, *opened for signature* May 9, 1992, 1771 U.N.T.S. 107 (entered into force Mar. 21, 1994), https://unfccc.int/files/essential_background/background_publications_htmlpdf/application/pdf/conveng.pdf [https://perma.cc/YDT3-X4WZ] [hereinafter *Framework Convention*].

[2] *Status of Ratification of the Convention*, UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, http://unfccc.int/essential_background/convention/status_of_ratification/items/2631.php [https://perma.cc/BJ59-D495]. There are actually 197 parties—196 countries and an economic integration organization, the European Union. *Id.*

[3] "Parties aim to reach global peaking of greenhouse gas emissions as soon as possible . . . and to undertake rapid reductions thereafter . . . so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century." Conference of the Parties, United Nations Framework Convention on Climate Change, Paris Agreement, art. 4.1, in Decision 1/CP.21 (Adoption of the Paris Agreement) U.N. Doc. FCCC/CP/2015/L.9/Rev. 1 (Dec. 12, 2015), https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf [https://perma.cc/UL3P-FYE5]. The "balance" of emissions and removals means net zero emissions. Kelly Levin et al., *INSIDER: Understanding the Paris Agreement's Long-Term Goal to Limit Global Warming*, WORLD RES. INST. (Dec. 15, 2015), http://www.wri.org/blog/2015/12/insider-understanding-paris-agreement%E2%80%99s-long-term-goal-limit-global-warming [https://perma.cc/G9XY-EGDL]. Carbon dioxide, the most important climate change pollutant, can be removed from the atmosphere by a variety of natural and other processes. *See Framework Convention, supra* note 1, at art. 1.8 (defining a "sink" as "any process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere"). Decision 1/CP.21 has two parts, a decision by the parties about implementation and an annex. The annex contains the Paris Agreement itself. To avoid confusion with the Paris Agreement, citations to the decision will refer

The Paris Agreement, as it is called, marked the first time since the Framework Convention opened for signature in 1992 that all parties had agreed to such a goal. It was also the first time that all parties agreed to take actions to reduce their greenhouse gas emissions.[4] The only prior agreement even remotely comparable to the Paris Agreement—the Kyoto Protocol—did not contain an overall emissions reduction goal and only limited developed countries' emissions.[5]

For the United States, the challenge of achieving this goal is enormous. While greenhouse gas emissions in the United States are slightly lower than they were about a decade ago, the United States is the second largest emitter of greenhouse gases in the world (after China).[6] U.S. carbon dioxide emissions per capita are among the highest in the world.[7] The U.S. energy sector is now heavily dependent on coal, oil, and natural gas—which together are responsible for the bulk of U.S. greenhouse gas emissions, mostly in the form of carbon dioxide.[8] Any comprehensive effort to address climate pollutants must also address methane, nitrous oxide, and fluorinated gases.[9]

The United States has begun to address greenhouse gas emissions. In the run-up to the Paris climate conference, every country was asked to submit an Intended Nationally Determined Contribution (INDC) to reduce its greenhouse gas emissions.[10] In

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to Decision 1/CP.21, and citations to the Paris Agreement itself will refer to the Paris Agreement.

[4] Joby Warrick & Chris Mooney, *196 Countries Approve Historic Climate Agreement*, WASH. POST (Dec. 12, 2015), https://www.washingtonpost.com/news/energy-environment/wp/2015/12/12/proposed-historic-climate-pact-nears-final-vote/ [https://perma.cc/4PP6-7EWG].

[5] Kyoto Protocol to the United Nations Framework Convention on Climate Change, art. 3.1 & annex B, 10, 1998, U.N. Doc. FCCC/CP/197/L.7/Add, http://unfccc.int/resource/docs/convkp/kpeng.pdf [https://perma.cc/6AV5-ZUR7].

[6] *Global Greenhouse Gas Emissions Data*, EPA, https://www3.epa.gov/climatechange/ghgemissions/global.html [https://perma.cc/5XGD-XJBH].

[7] *CO2 Emissions (Metric Tons Per Capita)*, THE WORLD BANK, http://data.worldbank.org/indicator/EN.ATM.CO2E.PC [https://perma.cc/34RX-LXTU] (showing U.S. per capita emissions to be 17.0 tons in 2011, which is exceeded only by Aruba, Bahrain, Brunei Darussalam, Kuwait, Luxembourg, Oman, Qatar, Trinidad and Tobago, and United Arab Emirates).

[8] EPA, INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990–2014, at ES-5–ES-7 tbl.ES-2 (2016), https://www3.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2016-Main-Text.pdf [https://perma.cc/4G8W-ZZQQ] (showing carbon dioxide emissions from fossil fuel combustion to constitute the great majority of overall greenhouse gas emissions).

[9] *See id.* at ES-6–ES-7 tbl.ES-2 (showing U.S. emissions of those pollutants).

[10] *Intended Nationally Determined Contributions (INDCs)*, UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, http://unfccc.int/focus/indc_portal/items/8766.php[https://perma.cc/TZ5Y-B4CJ]. The INDCs would have had legal status if the subsequent Paris Agreement required them to be achieved or included measures for formally implementing them. DANIEL BODANSKY & LAVANYA RAJAMANI, CTR. FOR CLIMATE & ENERGY SOLS., KEY LEGAL ISSUES IN THE 2015 CLIMATE NEGOTIATIONS 3

its INDC, the U.S. State Department said that the United States' short-term objective is "to achieve an economy-wide target of reducing its greenhouse gas [GHG] emissions by 26–28 per cent below its 2005 level in 2025."[11] This objective, the United States said, "is consistent with a straight line emission reduction pathway from 2020 to deep, economy-wide emission reductions of 80% or more [from 2005 levels] by 2050."[12] The United States also explained that the short-term objective is based on actions that had already been taken, or were about to be finalized, including strengthened efficiency standards for motor vehicles, household appliances, and industrial equipment; methane emission standards for landfills as well as oil and gas facilities; and the EPA's Clean Power Plan.[13] After Paris, the Obama administration took additional steps that were consistent with the overall goal of the Paris Agreement, such as a moratorium on new coal leases on federal lands as part of a comprehensive review of that program.[14] Yet implementation of the Clean Power Plan, which would reduce greenhouse gases from electric generating facilities by 32% from 2005 levels by 2030,[15] has been enjoined by the U.S. Supreme Court until all legal challenges are resolved.[16] Even with the Clean Power Plan, however, the United States must double its pace in reducing carbon intensity to reach the 2025 goal.[17]

The political future of the Clean Power Plan and short-term U.S. decarbonization efforts are also in doubt as this article goes to press because of the election of President Donald Trump, who expressed skepticism about climate change science

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(2015), http://www.c2es.org/docUploads/legal-issues-brief-06-2015.pdf [https://perma.cc/86R5-UJGV]. The Paris Agreement did not do that.

[11] UNITED STATES, COVER NOTE INDC AND ACCOMPANYING INFORMATION (2015), http://www4.unfccc.int/submissions/INDC/Published%20Documents/United%20States%20of%20America/1/U.S.%20Cover%20Note%20INDC%20and%20Accompanying%20Information.pdf [https://perma.cc/ELE7-93JL] [hereinafter UNITED STATES, COVER NOTE INDC].

[12] *Id.*

[13] *Id.*

[14] Press Release, U.S. Dep't of the Interior, Secretary Jewell Launches Comprehensive Review of Federal Coal Program (Jan. 15, 2016), https://www.doi.gov/press releases/secretary-jewell-launches-comprehensive-review-federal-coal-program [https://perma.cc/N68F-Y23N].

[15] Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units; 80 Fed. Reg. 64,661, 64,736 n.384 (Oct. 23, 2015) (to be codified at 40 C.F.R. pt. 60).

[16] West Virginia v. EPA, 136 S. Ct. 1000, 1000 (2016).

[17] Cristina Maza, *Climate Deal to Be Signed Amid 'Faster' Global Progress, Moniz Says*, CHRISTIAN SCI. MONITOR (Apr. 20, 2016), http://www.csmonitor.com/Environment/2016/0420/Climate-deal-to-be-signed-amid-faster-global-progress-Moniz-says [https://perma.cc/QU4S-7CE5].

and campaigned against the Clean Power Plan.[18] On March 28, 2017, President Trump issued an executive order directing EPA to suspend, rescind, or revise the Clean Power Plan.[19] Still, while the momentum for clean energy in the United States—and thus decarbonization—might be slowed, it is likely to be irreversible.[20] This article is premised on the view that decarbonization is both necessary and inevitable.

Achieving the zero-emissions goal requires answering two questions. First, what technical and policy pathways or strategies exist for the United States to achieve that goal? Second, what laws are most likely to actually get the job done—both because they are likely to work and because they are likely to get enacted in the first place? These challenges are compounded by the fact that the United States has little legal or regulatory experience in conceiving and carrying out multigenerational projects of this scale, moving intentionally from one state of affairs to another.[21] Policy continuity over many decades is also a necessary ingredient to make the transition work,[22] and climate change has divided the major political parties in recent presidential elections, including the 2016 election.[23]

An important clue to the answer to both questions lies in the fact that some jurisdictions are further along in their

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[18] John Schwartz, *Trump's Climate Views: Combative, Conflicting and Confusing*, N.Y. TIMES (Mar. 10, 2017), https://www.nytimes.com/2017/03/10/climate/donald-trump-global-warming-views.html?_r=0 [https://perma.cc/3MD8-RJRC] (summarizing various Trump campaign statements about climate change and renewable energy); Chelsea Harvey, *Trump Has Vowed to Kill the Clean Power Plan. Here's How He Might—and Might Not—Succeed*, WASH. POST (Nov. 11, 2016), https://www.washingtonpost.com/news/energy-environment/wp/2016/11/11/trump-has-vowed-to-kill-the-clean-power-plan-heres-how-he-might-and-might-not-succeed/?utm_term=.96fccce87cd3 [https://perma.cc/2MVK-VKTX].

[19] Exec. Order No. 13,783, 82 Fed. Reg. 16,093, 16,095, § 4 (Mar. 31, 2017); *see also* Review of the Clean Power Plan, 82 Fed. Reg. 16,239 (Apr. 4, 2017) (explaining how EPA intends to review the Clean Power Plan in light of the Executive Order).

[20] Barack Obama, *The Irreversible Momentum of Clean Energy*, SCIENCE, Jan. 9, 2017, at 1, http://science.sciencemag.org/content/early/2017/01/06/science.aam6284.full [https://perma.cc/S6S3-ZRKJ] (explaining that momentum is irreversible because 1) its benefits are greater than the risks of climate change, 2) businesses have concluded that clean energy reduces costs and creates jobs, 3) the costs of renewable electricity are lower than those for electricity from coal, and 4) other countries and businesses are actively engaged in developing and using clean energy).

[21] John C. Dernbach, *Navigating the U.S. Transition to Sustainability: Matching National Governance Challenges with Appropriate Legal Tools*, 44 TULSA L. REV. 93, 99 (2008) (identifying civil rights, trade liberalization, and the transfer of federal lands to private landowners as possibly analogous).

[22] *Id.* at 100 (identifying the Monroe Doctrine and containment of Communism as examples of political continuity in foreign policy, and economic development and prevention and reduction of crime as examples in domestic policy).

[23] In 2008, however, both Democratic Party nominee Barack Obama and Republican Party nominee John McCain supported federal legislation to address climate change. *The Candidates on Climate*, 2 NATURE REP. CLIMATE CHANGE 126, 126–27 (2008), http://www.nature.com/climate/2008/0810/pdf/climate.2008.100.pdf [https://perma.cc/74QC-B3V7].

thinking and action on this issue than the United States as a whole. Two such jurisdictions are Germany, a separate country, and California, a prominent U.S. state. Both have economy-wide goals for substantial reductions in greenhouse gas emissions by 2050, and both have ample experience adopting and implementing laws to improve energy efficiency, foster renewable energy, and reduce greenhouse gas emissions. While neither has achieved anything like deep decarbonization (reductions of at least 42%–57% in 2050 energy-related carbon dioxide emissions, with an ultimate objective of having all net emissions of greenhouse gases "approach zero between 2050 and 2075"),[24] both are making a serious effort to do so. In the economic realm, too, each is significant in its own right. While the United States has the world's largest economy, as measured by gross domestic product (GDP), Germany ranks fourth and California sixth.[25] Because the economic impact of action on climate change is both a major obstacle and a major opportunity for the transition, it is no small thing that two of the world's leading economies are in leadership positions for that transition.

This article will thus attempt to answer this question: What can the United States learn from the experiences of California and Germany thus far?[26] California's long-time leadership on environmental and energy issues means that many California laws are eventually adopted in some form by Congress or otherwise strongly influence the direction of federal policymaking.[27] At the same time, the similarities between Germany and the United States—large industrial democracies with federal systems and relatively high levels of energy use—

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[24] DEEP DECARBONIZATION PATHWAYS PROJECT, PATHWAYS TO DEEP DECARBONIZATION 3 (2015), http://deepdecarbonization.org/wp-content/uploads/2016/03/DDPP_2015_REPORT.pdf [https://perma.cc/S44X-7748].

[25] Paul Ausick, *California Now World's Sixth-Largest Economy*, 24/7 WALL ST. (June 15, 2016), http://247wallst.com/economy/2016/06/15/california-now-worlds-sixth-largest-economy/ [https://perma.cc/D9DH-ZD6C].

[26] These are not the only jurisdictions that are farther along than the United States. For a comparison of the United States and the United Kingdom on climate change, see John C. Dernbach & Andrea Ross, *The Sustainable Relationship: What the United States and the United Kingdom Can Teach Each Other About Climate Change and Sustainable Development at the National Level, in Six Easy Lessons*, ENVTL. F., May–June 2013; *see also* DECARBONIZATION IN THE EUROPEAN UNION: INTERNAL POLICIES AND EXTERNAL STRATEGIES (Claire Dupont & Sebastian Oberthür eds., 2015). A comprehensive treatment and analysis of what the United States can learn from all other leading jurisdictions would require book-length treatment, and that is not possible in this article.

[27] *See, e.g.*, *California Leads the World: Pioneering Solutions to Environmental Problems*, NAT. RES. DEF. COUNCIL & ENVTL. DEF., https://members.e2.org/ext/doc/CALeadershipfactsheet.pdf [https://perma.cc/2FXG-RHA7].

have made comparative analysis of the two countries a fruitful topic for energy and environmental law scholarship.[28]

Part I of this article describes the challenge of finding appropriate legal pathways to achieve the zero-emissions goal. Using long-term modeling and analysis of the various physical and structural changes that are required, the Deep Decarbonization Pathways Project shows various technical and policy pathways to deep decarbonization in the United States, Germany, and fourteen other countries, which together represent 74% of the world's greenhouse gas emissions.[29] What this project does not do, however, is explain the legal pathways—the specific ways in which law could guide, direct, and enable this transition.

Part II provides an overview of energy and climate law in California, Germany, and the United States. Essentially, California and Germany have achieved greater reductions than the United States as a percentage of their overall emissions, they have established more aggressive long-term and sector-specific goals, and they have adopted laws that are directed toward achieving those goals.[30]

Finally, Part III describes the many lessons that the United States can learn from the experiences of California and Germany in choosing legal pathways. Perhaps most fundamentally, widespread public support and participation are needed, in no small part because of the magnitude of the decarbonization task. It is also essential to have a sustainable development perspective in drafting and implementing laws to address the social, environmental, economic, and security risks of climate change, and to maximize the social, environmental, economic, and security co-benefits of the actions taken.

To be sure, California and Germany are nowhere near the finish line for decarbonization, and each jurisdiction has experienced its own challenges and problems. Additional

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[28] *See, e.g.*, Felix Mormann et al., *A Tale of Three Markets: Comparing the Renewable Energy Experiences of California, Texas, and Germany*, 35 STAN. ENVTL. L.J. 55 (2016); Susan Rose-Ackerman, *Environmental Policy and Federal Structure: A Comparison of the United States and Germany*, 47 VAND. L. REV. 1587, 1588–89 (1994). Mainstream media sources also point to what the United States can learn about a clean energy future from California and Germany. *See, e.g.*, Kate Galbraith, *California May Be a Leader on Climate Change, But It Still Has Plenty of Work to Do*, GRIST (Nov. 28, 2015), http://grist.org/climate-energy/california-may-be-a-leader-on-climate-change-but-it-still-has-plenty-of-work-to-do/ [https://perma.cc/Z246-9AC3] ("California is often cited as an international example of what is possible on climate, alongside powerhouses like Germany."); Robert Kunzig, *Germany Could Be a Model for How We'll Get Power in the Future*, NAT'L GEOGRAPHIC (Oct. 15, 2015), http://ngm.nationalgeographic.com/2015/11/climate-change/germany-renewable-energy-revolution-text [https://perma.cc/KVH9-S8NU].

[29] DEEP DECARBONIZATION PATHWAYS PROJECT, *supra* note 24, at 3.

[30] *See infra* Part II.

problems no doubt await each. Still, given the magnitude of the climate change challenge confronting the United States (and other countries), as well as the obvious political challenges, it is essential to mine the experiences of those leading the effort.

I. FINDING APPROPRIATE LEGAL PATHWAYS TO ACHIEVE DEEP DECARBONIZATION

A. The Urgency of Climate Change and the Paris Agreement

The Paris Agreement, as already noted, is built on the INDCs that countries submitted in the run-up to the Paris conference. Just prior to the Paris conference, 178 out of the Framework Convention's 196 country-parties had submitted an INDC. These countries together emit 93% of the world's greenhouse gas emissions.[31] The U.S. commitment noted in the Introduction of this article was one of those.[32] The Paris Agreement is premised on a "bottom-up" approach to reducing global greenhouse gas emissions, based on the sum total of all INDCs and emissions reductions achieved under those INDCs. Unfolding climate science developments underscore the need for all countries, and particularly developed countries like the United States, to significantly increase the ambition of their commitments.

The Paris Agreement was designed to achieve the objective of the Framework Convention on Climate Change, which is the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."[33] The world's understanding of what that level means is evolving in the direction of lower concentrations of greenhouse gases and thus lower emissions. Prior to Paris, the most frequently stated goal was to hold the global increase in temperatures to 2°C (or 3.6°F) above preindustrial levels.[34] The Paris Agreement, however, aims to hold "the increase in the global average temperature to well below 2 °C above pre-industrial levels and

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[31] Gregor Erbach, European Parliamentary Research Service, Negotiating a New UN Climate Agreement: Challenges for the Paris Climate Change Conference, PE Doc. 572.794, at 16 (2015), http://www.europarl.europa.eu/RegData/etudes/IDAN/2015/572794/EPRS_IDA(2015)572794_EN.pdf [https://perma.cc/6YTP-PVXA].

[32] *See supra* notes 11–15 and accompanying text.

[33] *Framework Convention*, *supra* note 1, at art. 2.

[34] United Nations Framework Convention on Climate Change, *Report of the Conference of the Parties on Its Sixteenth Session, Held in Cancun from 29 November to 10 December 2010*, Decision 1/CP.16, ¶ 4, FCCC/CP/2010/7/Add.1 (Mar. 15, 2011), http://unfccc.int/resource/docs/2010/cop16/eng/07a01.pdf [https://perma.cc/U62Y-C7S8].

to pursue efforts to limit the temperature increase to 1.5 °C [2.7°F] above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change."[35]

The 2°C limit has been translated into a specific carbon "budget"—a numerical limit on all additional emissions, cumulatively, for the rest of the century.[36] The Intergovernmental Panel on Climate Change (IPCC) has concluded that this budget is between 630 and 1180 gigatons of carbon dioxide equivalent.[37] That range represents the cumulative total of all new emissions of carbon dioxide equivalent between 2011 and 2100.[38] A budget, of course, is finite; it cannot—or should not—be exceeded. In other words, living within a budget necessarily requires that all greenhouse gas emissions must sooner or later be net zero. To have a "likely" chance of staying within a budget defined by a 2°C increase, the IPCC says, global greenhouse gas emissions need to be 40%–70% lower by 2050 and "near zero" gigatons of carbon dioxide equivalent or "below" by 2100.[39]

It follows that net zero emissions must be achieved more quickly to keep warming under 1.5°C. Table 1 shows the global deadlines given by the United Nations Environment Program[40] in 2015 for achieving net zero emissions in order to hold temperatures below both 1.5°C and 2°C, respectively.

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[35] Paris Agreement, *supra* note 3, at art. 2.1(a).

[36] Fred Pearce, *What Is the Carbon Limit? That Depends Who You Ask*, YALE ENV'T 360 (Nov. 6, 2014), http://e360.yale.edu/feature/what_is_the_carbon_limit_that_depends_who_you_ask/2825/ [https://perma.cc/T24V-9M89].

[37] INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2014: MITIGATION OF CLIMATE CHANGE 431 tbl.6.3 (Ottmar Edenhofer et al. eds., 2014), https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_full.pdf [https://perma.cc/2DW7-7T82]. A gigaton is one billion tons. Carbon dioxide equivalent includes all greenhouses gases measured according to the warming potential of carbon dioxide.

[38] *Id.*

[39] *Id.* at 10–12. The term "likely" means that the chance of a particular outcome is greater than 66 percent, or two out of three. *Id.* at 4 n.2.

[40] The United Nations Environment Programme provides extensive scientific, technical, and policy analysis in support of global efforts to address climate change. *See generally Climate Change*, U.N. ENV'T PROGRAMME, http://www.unep.org/climatechange/ [https://perma.cc/K7YL-AVBK].

TABLE 1. Deadline for Achieving Net Zero Emissions with Greater than a 50% Probability of Success[41]

	1.5°C Increase	2°C Increase
Total carbon dioxide emissions[42]	2045–2050	2065–2070
Total greenhouse gas emissions covered under Kyoto Protocol[43]	2060–2080	2095

As Table 1 makes clear, the entire world must get to net zero carbon dioxide emissions in roughly three decades in order to hold the temperature increase below 1.5°C. Two extra decades are allowed to get to net zero if the goal is to hold temperatures below a 2°C increase. Under the 1.5°C scenario, all other greenhouse gas emissions must be zero well before century's end, while the 2°C scenario permits the achievement of zero greenhouse gas emissions shortly before 2100.

Three observations clarify both the daunting nature of this challenge and its urgency. First, growth in energy use and, consequently, carbon dioxide emissions, is projected to be very high in the coming decades, particularly in developing countries. Energy-related greenhouse gas emissions are responsible for the great majority of total greenhouse gas emissions.[44] In addition, 78% of the total global greenhouse gas emissions increase between 1970 and 2010 was due to carbon dioxide emissions from energy and industrial production.[45] As recently as 2000, developed countries consumed more energy overall than developing countries.[46] By 2040, however, developing country energy consumption is projected to be more than double that in developed countries.[47] More than 85% of the

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[41] U.N. ENV'T PROGRAMME, EMISSIONS GAP REPORT 2015: A UNEP SYNTHESIS REPORT 6, tbl.2.1 (2015), https://uneplive.unep.org/media/docs/theme/13/EGR_2015_301115_lores.pdf [https://perma.cc/P7TS-WK8P] (advance report).

[42] From energy and industry, as well as land use, land-use change, and forestry.

[43] Not only carbon dioxide but also methane, nitrous oxide, and fluorinated compounds.

[44] INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, *supra* note 37, at 354–55.

[45] *Id.* at 6.

[46] U.S. ENERGY INFO. ADMIN., INTERNATIONAL ENERGY OUTLOOK 2013, at 9 fig.12 (2013), http://www.eia.gov/forecasts/ieo/pdf/0484(2013).pdf [https://perma.cc/V4AB-YUX7].

[47] *Id.*

growth in energy consumption over that period will come from developing countries.[48] China and India alone are expected to account for half of the global increase in energy consumption,[49] and China's energy consumption is projected to be more than double that of the United States by 2040.[50] While the focus of this article is developed country jurisdictions, such as the United States that could serve as models for developing countries' decarbonization efforts, the growth of emissions from developing countries underscores the need for the United States and other developed countries to intensify their decarbonization efforts to become such models.

Second, the probability of success given in Table 1 for meeting either scenario is low for an event of this enormity. That probability—only more than 50%—is just the smallest fraction better than the odds in a coin flip, and the downside of an adverse coin flip is serious. To have a higher probability of success, net zero, or even negative emissions, would have to be achieved even earlier. A variety of projections based on business-as-usual emissions growth put the world on track for a temperature increase of at least 3.7° to 4.8°C [6.7° to 8.6°F].[51] A 2012 report for the World Bank by the Potsdam Institute for Climate Impact Research and Climate Analytics describes the impact of a 4°C temperature increase by 2100 as disastrous.[52] Such a world, the report said, "would be one of unprecedented heat waves, severe drought, and major floods in many regions, with serious impacts on ecosystems and associated services," and no certainty that adaptation would even be possible.[53]

Climate change is also occurring with growing speed and intensity. Atmospheric concentrations of greenhouse gases (including carbon dioxide) are higher now than they have been in more than 800,000 years.[54] Basic physics dictates that higher atmospheric concentrations of these gases lead to warmer

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[48] *Id.* at 9.

[49] *Id.* at 9–10.

[50] *Id.* at 10.

[51] SUSTAINABLE DEV. SOLS. NETWORK & INST. FOR SUSTAINABLE DEV. & INT'L RELATIONS, PATHWAYS TO DEEP DECARBONIZATION 4 (2014), http://unsdsn.org/wp-content/uploads/2014/09/DDPP_Digit_updated.pdf [https://perma.cc/FZ9C-K3ZV].

[52] THE WORLD BANK, TURN DOWN THE HEAT: WHY A 4°C WARMER WORLD MUST BE AVOIDED, at xiii–xviii (2012), http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2015/07/17/090224b0828c33e7/1_0/Rendered/PDF/Turn0down0the00orld0must0be0avoided.pdf [https://perma.cc/Y3ZF-H5G5].

[53] *Id.* at xiii–xiv, xviii.

[54] INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2013: THE PHYSICAL SCIENCE BASIS SUMMARY FOR POLICYMAKERS 9 (2013), https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WGIAR5_SPM_brochure_en.pdf [https://perma.cc/DT3D-79PX].

temperatures and higher sea levels.[55] We are already experiencing the effects of climate change all over the world. The year 2016 was the warmest year on record, eclipsing the previous record set in 2015.[56] According to the National Aeronautics and Space Administration (NASA), "the first six months of 2016" was the warmest six-month period in NASA's "modern temperature record, which dates to 1880."[57] All of this, of course, underscores the importance of reducing greenhouse gas emissions as rapidly as possible.

Third, it may not be enough to bring the level of emissions to zero. Carbon dioxide, the most prominent greenhouse gas, stays in the atmosphere for hundreds of years.[58] Given the magnitude of the risks involved, and the strong possibility—some would say the certainty—that some nations will not significantly reduce their emissions, it is likely that finding ways to remove carbon dioxide from the atmosphere, and thus getting net emissions below zero in other countries, will be necessary.[59] That will require significantly strengthening the INDCs.

A major problem known to the parties before Paris is that their INDCs, taken together, are not sufficient to put countries on a trajectory toward keeping the average temperature increase below 2°C. The INDCs submitted by all countries prior to Paris "present[ed] a real increase in the ambition level compared to a projection of current policies," according to the U.N. Environment Program in 2015.[60] As its report explains, however, the INDCs represent only about half of the reduction required by 2030 if the world is to have a likely chance (greater than 66%) of keeping the global temperature increase below

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[55] For an explanation in "five easy steps" of how greenhouse gas emissions by humans are causing climate change, see MICHAEL E. MANN, THE HOCKEY STICK AND THE CLIMATE WARS: DISPATCHES FROM THE FRONT LINES 12–18 (2012).

[56] *NASA, NOAA Data Show 2016 Warmest Year on Record Globally*, NASA (Jan. 18, 2017), https://www.nasa.gov/press-release/nasa-noaa-data-show-2016-warmest-year-on-record-globally [https://perma.cc/7WT6-82JH].

[57] *2016 Climate Trends Continue to Break Records*, NASA (July 19, 2016), http://www.nasa.gov/feature/goddard/2016/climate-trends-continue-to-break-records [https://perma.cc/8ATD-DRSY].

[58] *See Carbon Is Forever*, NATURE REPORTS CLIMATE CHANGE (Nov. 20, 2008), http://www.nature.com/climate/2008/0812/full/climate.2008.122.html [https://perma.cc/UNX6-AUJD].

[59] Bobby Magill, *Michigan Scientists See Urgency for Negative Emissions*, CLIMATE CENT. (Aug. 8, 2016), http://www.climatecentral.org/news/scientists-see-urgency-for-negative-emissions-20588 [https://perma.cc/UY9B-EZWN]. Still, there appear to be serious economic and technological limits to employing various carbon removal methods at scale. *See* Pete Smith et al., *Biophysical and Economic Limits to Negative CO_2 Emissions*, 6 NATURE CLIMATE CHANGE 42 (2015).

[60] U.N. ENV'T PROGRAMME, *supra* note 41, at xviii.

2°C.[61] Similarly, both the Organization for Economic Cooperation and Development and the International Energy Agency issued reports prior to the conference saying that the total emissions reductions from all countries that had thus far submitted would barely change the world's greenhouse gas emissions trajectory.[62] The Conference of the Parties in Paris noted this emissions gap—between what is needed and what was promised—"with concern."[63]

To meet the zero-emissions goal, the Paris Agreement established a process for ratcheting up national emissions reductions commitments over time. Beginning in 2020, and every five years afterwards, each country is to "prepare, communicate and maintain successive nationally determined contributions that it intends to achieve."[64] These, of course, are in addition to those that countries have already submitted. Each "successive nationally determined contribution" is to "represent a progression beyond the Party's then current nationally determined contribution and reflect its highest possible ambition."[65] Beginning in 2023, and every five years afterward, the Conference of the Parties is to "take stock of the implementation of this Agreement to assess the collective progress towards achieving [its] purpose."[66] "The outcome of th[is] global stocktake" is to "inform Parties in updating and enhancing, in a nationally determined manner, their actions," including "enhanc[ed] international cooperation for climate action."[67] The Paris Agreement also stated that "[a]ll Parties should strive to formulate and communicate long-term low greenhouse gas

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[61] *UNEP's Emissions Gas Report: INDCs Signal Unprecedented Momentum for Climate Agreement in Pairs, but Achieving 2 Degree Objective Contingent upon Enhanced Ambition in Future Years*, U.N. ENV'T (Nov. 6, 2015), http://web.unep.org/africa/news/unep's-emissions-gap-report-indcs-signal-unprecedented-momentum-climate-agreement-paris [https://perma.cc/3LKW-ERC3]; *see* U.N. ENV'T PROGRAMME, *supra* note 41, at xviii.

[62] ORG. FOR ECON. COOPERATION & DEV., CLIMATE CHANGE MITIGATION: POLICIES AND PROGRESS 16 (2015), http://www.oecd-ilibrary.org/docserver/download/9715061e.pdf?expires=1483564380&id=id&accname=ocid45121179&checksum=8D057A00C441F52D9CE97FC5C6C2A7F9 [https://perma.cc/UJF4-BHQ5] ("Even if the INDCs and national targets announced to date are fully achieved, the remaining global carbon budget (consistent with a below 2 °C world) will be exhausted by around 2040 unless stronger action is taken."); INT'L ENERGY AGENCY, ENERGY AND CLIMATE CHANGE: WORLD ENERGY OUTLOOK SPECIAL REPORT 12 (2015), https://www.iea.org/publications/freepublications/publication/WEO2015SpecialReportonEnergyandClimateChange.pdf [https://perma.cc/47AH-7T4S] ("With INDCs submitted so far, and the planned energy policies in countries that have yet to submit, the world's estimated remaining carbon budget consistent with a 50% chance of keeping the rise in temperature below 2 °C is consumed by around 2040—eight months later than is projected in the absence of INDCs.").

[63] Paris Agreement, *supra* note 3, para. 17.

[64] *Id.* arts. 4.2, 4.9; *see also* Decision 1/CP.21, *supra* note 3, paras. 23, 24.

[65] Paris Agreement, *supra* note 3, art. 4.3.

[66] *Id.* arts. 14.1, 14.2.

[67] *Id.* art. 14.3.

emission development strategies."[68] The parties to the agreement were also invited "to communicate, by 2020, to the secretariat mid-century, long-term low greenhouse gas emission development strategies" that would then be published on the secretariat's website.[69] Again, the overall objective is net zero greenhouse gas emissions by the second half of the century.[70]

Another significant challenge for the United States is the expectation stated in the Framework Convention that developed countries will take a leadership position in reducing their greenhouse gas emissions. As the preamble states, developed countries have contributed "the largest share of historical and current global emissions of greenhouse gases."[71] They also, by definition, have greater financial and technological resources. Thus, in ratifying the Framework Convention, developed countries agreed to adopt policies and measures that will demonstrate that they are "taking the lead" in addressing climate change.[72] That means that the United States, among other developed countries, should strive to reduce its greenhouse gas emissions as rapidly as possible. In other words, the emissions reductions curves for developed countries should be steeper than those for developing countries. Such a leadership position, for example, would require that the United States reduce the carbon dioxide emissions intensity of the economy (carbon dioxide emissions per dollar of GDP) by an annual rate of 8% between now and 2050.[73] By contrast, the currently projected *total* reduction in carbon dioxide emissions intensity between 2016 and 2040 is 10%.[74] A steeper glide path to decarbonization requires the United States to learn from jurisdictions that are further along.

B. Deep Decarbonization's Technical and Policy Pathways

A basic problem with long-term emissions reduction goals is that "there has been little physically realistic modeling of the energy and economic transformations required" to

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[68] *Id.* art. 4.19.

[69] Decision 1/CP.21, *supra* note 3, para. 36.

[70] Paris Agreement, *supra* note 3, art. 4.1.

[71] *Framework Convention*, *supra* note 1, pmbl.

[72] *Id.* art. 4.2(a).

[73] 2 JAMES H. WILLIAMS ET AL., DEEP DECARBONIZATION PATHWAYS PROJECT, POLICY IMPLICATIONS OF DEEP DECARBONIZATION IN THE UNITED STATES 10 (2015), http://deepdecarbonization.org/wp-content/uploads/2015/11/US_Deep_Decarbonization_Policy_Report.pdf [https://perma.cc/R2SZ-4E9E] [hereinafter DDPP U.S. POLICY REPORT].

[74] U.S. ENERGY INFO. ADMIN., ANNUAL ENERGY OUTLOOK 2017 WITH PROJECTIONS TO 2050, at 24 (2017), https://www.eia.gov/outlooks/aeo/pdf/0383(2017).pdf [https://perma.cc/Z9M5-ZLLT].

substantially reduce greenhouse gas emissions by that date.[75] Using California's goal of reducing greenhouse gas emissions by 90% from 1990 levels by 2050 as a focal point, Jim Williams and others concluded in a 2012 paper that technically feasible energy efficiency and renewable electricity by themselves are not sufficient to achieve California's goals.[76] It is also necessary, they concluded, that the transportation sector moves from liquid fossil fuels to decarbonized electricity.[77] This analysis, which shows the value of sophisticated long-term thinking and modeling on the necessary long-term changes, marks the beginning of the Deep Decarbonization Pathways Project (DDPP).[78] The modeling and analysis exemplified by the DDPP provide a way of envisioning the major technological and other changes that are needed, the basic policy options that exist, and the decisions that must be made.

The DDPP, which is led by the Sustainable Development Solutions Network[79] and the Institute for Sustainable Development and International Relations,[80] is the principal international effort to devise pathways to decarbonize the global economy.[81] Other reports look at decarbonization solely from a global perspective,[82] and individual nations have produced their own reports on pathways to decarbonization,[83] but the DDPP appears to be the

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[75] James H. Williams et al., *The Technology Path to Deep Greenhouse Gas Emissions Cuts by 2050: The Pivotal Role of Electricity*, 335 SCIENCE 53, 53 (2012). Jim Williams now directs the DDPP project. *About*, DEEP DECARBONIZATION PATHWAYS PROJECT, http://deepdecarbonization.org/about/ [https://perma.cc/7ZDG-2XCP].

[76] Williams et al., *supra* note 75, at 53.

[77] *Id.* at 53–54.

[78] *See* Jim Williams et al., Pathways to Deep Decarbonization in the United States slide 5 (May 10, 2016) (PowerPoint presentation) (on file with author).

[79] *Vision and Organization*, SUSTAINABLE DEV. SOLS. NETWORK, http://unsdsn.org/about-us/vision-and-organization/ [https://perma.cc/C3TF-53D5]; *see also About*, *supra* note 75 (explaining relationship between Sustainable Development Solutions Network and Deep Decarbonization Pathways Project).

[80] *Id.*; *see also IDDRI*, INST. FOR SUSTAINABLE DEV. & INT'L RELATIONS, http://www.iddri.org/Iddri/ [https://perma.cc/3YFX-2DAG].

[81] *See* SUSTAINABLE DEV. SOLS. NETWORK & INST. FOR SUSTAINABLE DEV. & INT'L RELATIONS, PATHWAYS TO DEEP DECARBONIZATION 4 (2014), http://unsdsn.org/wp-content/uploads/2014/09/DDPP_Digit_updated.pdf [https://perma.cc/GLE2-5WVG] [hereinafter DDPP 2014 REPORT].

[82] MARIANNE FAY ET AL., INT'L BANK FOR RECONSTRUCTION AND DEV./THE WORLD BANK, DECARBONIZING DEVELOPMENT: THREE STEPS TO A ZERO-CARBON FUTURE (2015), https://openknowledge.worldbank.org/handle/10986/21842 (following "English PDF Final" hyperlink).

[83] *See, e.g.*, U.K., HM GOVERNMENT, 2050 PATHWAYS ANALYSIS (2010), https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/42562/216-2050-pathways-analysis-report.pdf [hereinafter UK PATHWAYS ANALYSIS]. The European Union has also published several deep decarbonization roadmaps. Claire Dupont & Sebastian Oberthür, *Decarbonization in the EU: Setting the Scene, in* DECARBONIZATION IN THE EUROPEAN UNION: INTERNAL POLICIES AND EXTERNAL STRATEGIES, *supra* note 26, at 1, 7–8.

only effort to systematically and comprehensively analyze decarbonization pathways across the globe.

DDPP is based on the work of research teams in 16 countries that are responsible for 74% of the world's greenhouse gas emissions: Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, Mexico, Russia, South Africa, South Korea, the United Kingdom, and the United States.[84] The project was undertaken "to understand and show how individual countries can transition to a low-carbon economy" based on the limit of 2°C.[85] Prior to this project, most of these countries "had never developed pathways consistent with a global 2°C limit, nor were they actively considering this question."[86]

The overall objective of the project is to devise pathways that will "ensure a better-than-even chance of remaining below a 2°C temperature rise," based on the 2014 report of the Intergovernmental Panel on Climate Change (IPCC).[87] To ensure that result, the IPCC said, requires that global emissions must be reduced 42%–57% below 2010 levels by 2050, and 73%–107% below 2010 levels by 2100.[88] To have a greater possibility of success of keeping the temperature increase below 2°C, or to have any reasonable possibility of keeping the temperature increase below 1.5°C, would require even greater and more rapid reductions.[89] (Table 1 indicates the need for more rapid reductions for both temperature scenarios.) Effectively addressing climate change, DDPP says, will require, "more than any other factor, the profound transformation of energy systems through steeply reducing carbon intensity in all sectors of the economy."[90] The project also assumes a century-long effort divided into two parts, 2011–2050 and 2051–2100; most of the emissions reduction would occur prior to 2050, with the rest occurring afterward as emissions reach zero.[91]

DDPP concludes that it is technically feasible to limit warming to 2°C despite global growth in population of 17% between 2010 and 2050 and global GDP growth of 250% in the

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[84] SUSTAINABLE DEV. SOLS. NETWORK & INST. FOR SUSTAINABLE DEV. & INT'L RELATIONS, PATHWAYS TO DEEP DECARBONIZATION: 2015 REPORT 3 (2015), http://deepdecarbonization.org/wp-content/uploads/2016/03/DDPP_2015_REPORT.pdf [https://perma.cc/H58P-29FB] [hereinafter DDPP 2015 SYNTHESIS REPORT].

[85] DDPP 2014 REPORT, *supra* note 81, at III.

[86] DDPP 2015 SYNTHESIS REPORT, *supra* note 84, at 42.

[87] *Id.* at 3.

[88] INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, *supra* note 37, at 13, tbl.SPM.1.

[89] *Id.*

[90] DDPP 2015 SYNTHESIS REPORT, *supra* note 84, at 3. Some of the individual country reports, however, address other greenhouse gases. *Id.* at 18 n.10.

[91] DDPP 2014 REPORT, *supra* note 81, at 8.

same period.[92] Research teams in each of the sixteen countries used a "backcasting" approach that assumed the 2°C goal based on the IPCC carbon budget had been met and then described the changes that were needed to achieve that goal.[93] The research teams, which worked independently of their governments, were comprised primarily of technology, energy, and economic analysts.[94] The most ambitious pathways in these reports reduced emissions intensity per unit of GDP by 87% from 2010 levels by 2050 and emissions intensity per capita by 62%.[95] Nearly all of the reports showed pathways to reducing carbon dioxide emissions to 2 tons or less per capita by 2050,[96] which is much lower than the current global average of 5.2 tons per capita.[97] Because per capita emissions tend to be higher in developed countries than in developing countries, the needed emissions reductions in developed countries are greater.

All pathways are based on "three pillars of energy system transformation."[98] These are (1) energy efficiency and conservation across all sectors of the economy, including power generation, transportation, buildings, industry, and urban design; (2) low-carbon electricity from replacement of fossil fuel-based generation with renewable energy or the use of carbon capture and storage at fossil fuel based generating facilities; and (3) switching from more carbon intensive fuels to less carbon-intensive fuels in all economic sectors.[99] Deep decarbonization requires that all three be achieved at scale in all countries.[100] The first pillar, energy efficiency and conservation, plays the dominant role in the DDPP scenarios prior to 2030, while the

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[92] *Id.* at 5–6.

[93] *Id.* at X. Nearly all of the reports for the sixteen countries are available at *Country Reports*, DEEP DECARBONIZATION PATHWAYS PROJECT, http://deepdecarbonization.org/countries/ [https://perma.cc/HXR6-YRS9]. For an explanation of the use of backcasting in achieving sustainability, see Philip J. Vergragt & Jaco Quist, *Backcasting for Sustainability: Introduction to the Special Issue*, 78 TECHNOLOGICAL FORECASTING & SOC. CHANGE 747 (2011).

[94] The U.S. research team, for example, drew from a consulting firm and two U.S. government laboratories, 1 JAMES H. WILLIAMS ET AL., ENERGY & ENVTL. ECON. (E3), LAWRENCE BERKELEY NAT'L LAB. & PAC. NW. NAT'L LAB., PATHWAYS TO DEEP DECARBONIZATION IN THE UNITED STATES, at iii (2015), http://deepdecarbonization.org/wp-content/uploads/2015/11/US_Deep_Decarbonization_Technical_Report.pdf [https://perma.cc/W7FU-FUU2] [hereinafter DDPP U.S. TECHNICAL REPORT].

[95] DDPP 2015 SYNTHESIS REPORT, *supra* note 84, at 6.

[96] *Id.* at 6–7. The two exceptions are China and South Africa, which are reduced to about three tons per capita by 2050. *Id.* at 7, tbl.4a.

[97] DDPP 2014 REPORT, *supra* note 81, at VIII, 24–26.

[98] DDPP 2015 SYNTHESIS REPORT, *supra* note 84, at 8.

[99] *Id.*

[100] *Id.*

second and third pillars become the primary drivers of decarbonization after that.[101]

The tipping point to decarbonization occurs, according to DDPP, when "costs decline at a rate and speed sufficient to drive their global deployment based solely on their favorable economics."[102] Getting to that point requires enormous new investment in low-carbon technologies, though gross energy investment will be only modestly greater than it is at present.[103] That level of new and redirected investment requires "that policymakers establish investment market rules and institutions to direct investments towards low-carbon options."[104] One approach is for developed countries to "take the lead in developing, deploying, and buying down the cost of low-carbon technologies so they become affordable earlier in developing countries, relative to the cost of conventional technologies."[105]

According to DDPP, these pathways have enormous practical value for all stakeholders: "By describing the full extent of the transformation required over a longer time frame, DDPs provide a unique context for understanding the ambition of current INDCs, and what further measures deep decarbonization will entail."[106] These pathways allow decision makers to see how the next thing that ostensibly needs to be done, or how the climate-related issue now in front of them, fits into an overall effort to decarbonize a nation's entire economy. This is particularly true because, as noted earlier, most of the sixteen DDPP countries had not previously engaged in this effort.[107] And it is true, not only of governmental decision makers but also of private decision makers and their investors.[108]

C. Identifying Legal Pathways to Deep Decarbonization

While the DDPP illuminates key technical and policy approaches required for deep decarbonization, it does not identify in any detail the legal options or pathways that are required.

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[101] *Id.* at 10–11.

[102] *Id.* at 30.

[103] *Id.* at 32.

[104] *Id.* at 34.

[105] *Id.* at 30; *see* Felix Mormann, *Enhancing the Investor Appeal of Renewable Energy*, 42 ENVTL. L. 681 (2012) (recommending ways to design and implement policies to make renewable energy more appealing to investors and facilitate faster deployment of renewable energy at a lower cost).

[106] DDPP 2015 SYNTHESIS REPORT, *supra* note 84, at 35.

[107] *Id.* at 42.

[108] *Id.* at 36.

While the DDPP has prepared reports for the United States,[109] for instance, those reports do not explain what laws the United States would need to adopt to reduce its greenhouse gas emissions by 80% from 1990 levels by 2050.

Ultimately, deep decarbonization is not likely to occur unless specific policies are translated into draft laws, enacted, and then implemented. The identification and analysis of different laws or combinations of laws would make it possible for decision makers and the public to visualize what the legal choices are, enabling lawyers, policymakers, and the public to understand specifically how decarbonization could work. It would help close the gap between the emissions reduction goal and the specific legal actions that are needed to achieve it. Such an analysis would also provide a legal playbook or toolbox for policymakers, lawyers, and others.

Many possible legal and policy approaches to decarbonization are available, including government-supported research and development, carbon pricing, regulation, public information, and land use and transportation law changes. For any given policy option—say carbon pricing—a variety of approaches exist, including not only cap-and-trade and carbon taxation, but also a wide variety of designs for any law that would impose a carbon price.[110] Legal tools can be used independently or in combination, and they can be sequenced in different ways over time. An analysis of different legal pathways could illuminate tradeoffs among and between different approaches and identify ways in which various tools could be mutually reinforcing or mutually antagonistic. What laws are needed in individual sectors, such as industry, agriculture, forestry, and electricity generation—to produce negative emissions? What are the most cost-effective and equitable ways of drafting and implementing those laws, and with the most benefits? What legal obstacles exist, and what are the best ways of overcoming them? The development of different legal pathways—based on different tools and combinations of tools—could assist in answering those questions.

As anyone who has drafted a statute or regulation well knows, there is often a considerable initial difference between the policy preference of the client (be it a government agency, legislator, business, or nongovernmental organization) and what

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[109] *See* DDPP U.S. POLICY REPORT, *supra* note 73; DDPP U.S. TECHNICAL REPORT, *supra* note 94.

[110] *See, e.g.*, SHI-LING HSU, THE CASE FOR A CARBON TAX: GETTING PAST OUR HANG-UPS TO EFFECTIVE CLIMATE POLICY (2011).

is needed to translate that policy into an appropriate law. Only very rarely can a policy proposal be translated directly into a statute or regulation without the addition of considerable detail (e.g., definition of terms, and in particular who or what is covered; timing; what statute(s), if any, need to be amended or repealed; procedural requirements like permitting and public notice, etc.). The more legally precise a particular proposal is, the easier it is to translate that proposal into draft legislation. Legal pathways or options, as described here, still need to be translated into draft legislation or regulatory language. But they provide a much higher level of detail about what the relevant laws would require or prohibit, and they provide policy makers, lawyers, the public, and others with a clearer immediate understanding of what the ultimately enacted law would do. And a law that has been adopted and applied somewhere else, with many of the relevant details already resolved, is vastly easier to adapt to one's jurisdiction than starting from scratch.

There is, at present, no comprehensive analysis of legal pathways to deep decarbonization in the United States.[111] Another source of information about possible legal pathways exists in the jurisdictions that have already made significant progress toward deep decarbonization, including California and Germany. While these jurisdictions have not achieved deep decarbonization, they are significantly farther along than the United States, and there is much the country can learn from their legal experiences.

II. OVERVIEW OF CLIMATE CHANGE LAW AND POLICY IN CALIFORNIA, GERMANY, AND THE UNITED STATES

While California, Germany, and the United States are all addressing climate change, California and Germany have set longer-term and more specific goals for reducing emissions and have adopted more ambitious laws, in comparison to the United States. They have also achieved greater percentage reductions in emissions than the United States. The first part of this section describes and analyzes emissions as well as targets and timetables in each jurisdiction. The second part describes what each jurisdiction has done so far to reduce its greenhouse gas emissions and also describes analytical work done by others, particularly the Deep Decarbonization Pathways Project, to

[111] Such an analysis should be available in 2018. LEGAL PATHWAYS TO DEEP DECARBONIZATION IN THE UNITED STATES (Michael B. Gerrard & John C. Dernbach eds., forthcoming 2018).

explain how decarbonization can be achieved. Both Germany and California have a long way to go in achieving decarbonization, but the United States lags considerably behind them.

A. Emissions, Targets, and Timetables

Not surprisingly, the United States emits far more greenhouse gas emissions in millions of metric tons of carbon dioxide equivalent than either California or Germany, as Table 2 shows. It also had the greatest increase (7.3%) in overall greenhouse gas emissions between 1990 and 2014. California's increase was much smaller (2.7%), while Germany had a remarkable 27.6% reduction.

TABLE 2. Greenhouse Gas Emissions in California, Germany, and the United States in Million Metric Tons of Carbon Dioxide Equivalent (Excluding Land Use, Land-Use Change, and Forestry)

	1990	2014	Percentage Difference
California	431[112]	441.5[113]	2.4
Germany[114]	1248	902	(27.6)
United States[115]	6397.1	6870.5	7.4

California and Germany have set short-term as well as long-term economy-wide goals for reducing their emissions by 80% from 1990 levels by 2050. As already explained, their long-term goals can be criticized as insufficiently ambitious in light

[112] *California 1990 Greenhouse Gas Emissions Level and 2020 Limit*, CAL. AIR RES. BD., https://www.arb.ca.gov/cc/inventory/1990level/1990level.htm [https://perma.cc/8YSL-5EYU] (1990 figure as revised in 2014).

[113] *California Greenhouse Gas Emission Inventory—2016 Edition*, CAL. AIR RES. BD., https://www.arb.ca.gov/cc/inventory/data/data.htm [https://perma.cc/W4N6-QVJM].

[114] FED. ENV'T AGENCY (GERMANY), SUBMISSION UNDER THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE AND THE KYOTO PROTOCOL 2016: NATIONAL INVENTORY REPORT FOR THE GERMAN GREENHOUSE GAS INVENTORY 1990–2014, at 70 (2016), https://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/climate_change_24_2016_submission_under_the_united_nations_framework_nir_2016.pdf [https://perma.cc/9SNB-535B]; SUSTAINABLE DEV. SOLS. NETWORK & INST. FOR SUSTAINABLE DEV. & INT'L RELATIONS, PATHWAYS TO DEEP DECARBONIZATION IN GERMANY 3 (2015), http://deepdecarbonization.org/wp-content/uploads/2015/09/DDPP_DEU.pdf [https://perma.cc/3BEB-KF2X] [hereinafter PATHWAYS TO DEEP DECARBONIZATION IN GERMANY].

[115] EPA, *supra* note 8, at ES-24 tbl.ES-7.

of the developing science. Still, they are considerably more ambitious and longer term than that of the United States, which has only a short-term reduction goal. Table 3 provides a summary of these goals.

TABLE 3. Economy-Wide Greenhouse Gas Targets and Timetables: California, Germany, and United States

	Short-Term or Intermediate Emissions Reduction Goals(s)	Long-Term Emissions Reduction Goal(s)
California	Reduce emissions to 1990 levels by 2020[116] Reduce emissions to 40% below 1990 levels by 2030[117]	Reduce emissions to 80% below 1990 levels by 2050[118]
Germany	Reduce emissions to 40% below 1990 levels by 2020[119] Reduce emissions to at least 55% below 1990 levels by 2030[120]	Reduce emissions to 70% below 1990 levels by 2040[121] Reduce emissions to 80%–95% below 1990 levels by 2050[122]
United States	Reduce emissions to 26%–28% below 2005 levels by 2025[123]	None

[116] Exec. Order No. S-3-05 (Cal. 2005), https://www.gov.ca.gov/news.php?id=1861 [https://perma.cc/G5WA-6HZ4]. This goal for 2020 is reaffirmed in Global Warming Solutions Act of 2006, CAL. HEALTH & SAFETY CODE §§ 38505(n), 38551 (West 2010).

[117] CAL. HEALTH & SAFETY CODE § 38566 (West 2016); Cal. Exec. Order No. B-30-15 (2015), https://www.gov.ca.gov/news.php?id=18938 [https://perma.cc/Q8TG-HE77].

[118] Exec. Order No. S-3-05 (Cal. 2005).

[119] European Commission, Submission by Latvia and the European Commission on Behalf of the European Union and Its Member States 1 (Mar. 6, 2015), http://www4.unfccc.int/submissions/INDC/Published%20Documents/Latvia/1/LV-03-06-EU%20INDC.pdf [https://perma.cc/9498-F2DU].

[120] GERMAN FED. MINISTRY OF ECON. & TECH. & GERMAN FED. MINISTRY FOR THE ENV'T, NATURE CONSERVATION & NUCLEAR SAFETY, ENERGY CONCEPT FOR AN ENVIRONMENTALLY SOUND, RELIABLE AND AFFORDABLE ENERGY SUPPLY 5 (2010), http://www.bmwi.de/English/Redaktion/Pdf/energy-concept,property=pdf,bereich=bmwi,sprache=en,rwb=true.pdf [https://perma.cc/V6UM-7A8F].

[121] *Id.*

[122] *Id.*

[123] UNITED STATES, COVER NOTE INDC, *supra* note 11.

The short-term or intermediate targets and timetables set by the United States, as Table 3 indicates, are much less ambitious than the short-term or intermediate goals established by California and Germany. The United States' choice of a 2005 baseline affects the ambitiousness of its goals. Because U.S. greenhouse gas emissions in 2005 were 16.6% greater than those in 1990,[124] the U.S. short-term or intermediate objective translates roughly to a reduction of 14%–16% below 1990 levels. This is significantly lower than Germany's objective for achieving a 40% reduction below 1990 levels by 2020, and appears to be slightly lower than that in California, which plans to go from 1990 levels in 2020 to 40% below 1990 levels by 2030. If California achieves that reduction in equal annual percentages over that decade, its emissions would be 20% below 1990 levels by 2025.

While the United States did not commit to a long-term emissions reduction goal, its INDC stated: "This target is consistent with a straight line emission reduction pathway from 2020 to deep, economy-wide emission reductions of 80% or more by 2050."[125] Even if the United States had stated this endpoint as a goal, it would still be less ambitious than the goals set in California and Germany because it employs a 2005 baseline.

In addition to the overall targets and timetables stated in Table 3, California and Germany have sector-specific targets and timetables as well as targets for renewable energy and energy efficiency. In California, these include having renewable sources provide 33% of the state's electricity by 2020[126] and 50% of the state's electricity by 2030,[127] reducing petroleum use by half by 2030,[128] and doubling "the planned level of savings from energy efficiency improvements in existing buildings."[129]

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[124] U.S. greenhouse gas emissions in 2005 were 7350.2 million metric tons of carbon dioxide equivalent, compared to 6301.1 tons in 1990. EPA, INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990–2013, at ES-17 tbl.ES-4 (2015), http://www3.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2015-Main-Text.pdf [https://perma.cc/6M4X-QEQQ]. The 2005 baseline, in other words, is 16.6% higher than the 1990 baseline. Thus, emissions reductions from the 2005 baseline are not as great as those from the 1990 baseline.

[125] UNITED STATES, COVER NOTE INDC, *supra* note 11.

[126] CAL. PUB. RES. CODE § 25740 (West 2011).

[127] Clean Energy and Pollution Reduction Act of 2015, S.B. 350, 2015–16 Leg., Reg. Sess. (Cal. 2015).

[128] CAL. ENVTL. PROT. AGENCY, CALIFORNIA'S 2030 CLIMATE COMMITMENTS: CUTTING PETROLEUM USE IN HALF BY 2030, http://www.arb.ca.gov/newsrel/petroleum_reductions.pdf [https://perma.cc/XS4Z-SS9Z].

[129] CAL. ENERGY COMM'N, CALIFORNIA'S 2030 CLIMATE COMMITMENT: DOUBLE ENERGY SAVINGS IN EXISTING BUILDINGS & DEVELOP CLEANER HEATING FUELS BY

Germany's specific targets and timetables are intertwined with those of the European Union (EU), but in some ways are more ambitious. The EU aims to reduce greenhouse gas emissions by 20% by 2020, 40% by 2030, and 80%–95% below 1990 levels by 2050.[130] As part of the EU's overall effort to reduce greenhouse gas emissions, it has adopted both energy efficiency and renewable energy goals. Germany, in turn, has adopted specific goals for both energy efficiency and renewable energy.

For energy efficiency, the European Council has set a goal for 2020 of "saving 20% of the EU's energy consumption compared to projections,"[131] and a goal for 2030 of achieving a 27% improvement in energy efficiency "compared to projections of future energy consumption."[132] The European Parliament and Council have adopted directives[133] to implement the 2007 European Council's goals for energy efficiency.[134] The energy efficiency directive requires each of the EU's twenty-eight member states to establish "an indicative national energy efficiency target" for 2020, and to express that target in terms of overall primary and final energy consumption in that year.[135] In 2013, Germany submitted

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2030, http://www.energy.ca.gov/commission/fact_sheets/documents/Fact_Sheet_-_Energy_Efficiency.pdf [https://perma.cc/E6U4-BS86].

130 *EU Climate Action*, EUROPEAN COMM'N, http://ec.europa.eu/clima/citizens/eu/index_en.htm [https://perma.cc/QW92-YX4G]. Consistent with that, the EU INDC states: "The EU and its Member States [including Germany] are committed to a binding target of an at least 40% domestic reduction in greenhouse gas emissions by 2030 compared to 1990." European Commission, *supra* note 119, at 1.

131 Council of the European Union, Cover Note from Presidency to Delegations, *Brussels European Council 8/9 March 2007: Presidency Conclusions*, Council of the European Union (2007) annex 1, paras. 6, 7 (May 2, 2007), http://www.consilium.europa.eu/ueDocs/cms_Data/docs/pressData/en/ec/93135.pdf [https://perma.cc/HYK7-8H99].

132 European Council, Cover Note from General Secretariat of the Council to Delegations, European Council (23 and 24 October 2014) Conclusions, EUCO 169/14, CO EUR 13, CONCL 5, para. 3 (Oct. 24, 2014), http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/145397.pdf [https://perma.cc/4LDS-SGZT].

133 In EU parlance, a directive requires each Member State to adopt legislation in order to achieve formulated goals, but leaves discretion to the Member State as to how to achieve the goal. *What Is an EU Directive?*, EUROPEAN LAW MONITOR, http://www.europeanlawmonitor.org/what-is-guide-to-key-eu-terms/eu-legislation-what-is-an-eu-directive.html [https://perma.cc/UZ9J-X5DW].

134 Council Directive 2012/27, 2012 O.J. (L. 315) 1 (EC), https://biobs.jrc.ec.europa.eu/sites/default/files/generated/files/policy/Directive%202012-27-EU%20Energy%20Efficiency.pdf [https://perma.cc/NGS5-BDC3] [hereinafter EU Energy Efficiency Directive].

135 *Id.* art. 3(1). The directive translates the 20% goal for 2020 into two figures—1474 million tons of oil equivalent of "primary energy consumption," and 1078 million tons of oil equivalent of "final energy consumption." *Id.* arts. 2(2), 2(3), 3(1)(a). Final energy consumption is a lower figure because of, among other things, energy losses at the power plant in translating primary energy into electricity, and energy losses that occur in transmission of electricity in power lines. In addition, it required each Member State to submit, by 2014, a National Energy Efficiency Action Plan, which was to include "'significant energy efficiency improvement measures and expected and/or achieved energy savings . . . in view of achieving the national energy efficiency targets." *Id.* art. 24(2). This submission is to be repeated "every three years thereafter." *Id.* The plan also

its indicative national energy efficiency target, stating that it intended to "reduc[e] primary energy consumption by 20 % by 2020 and 50 % by 2050 compared to 2008."[136]

For renewable energy, the European Council has set a goal for 2020 of increasing to 20% the "share of renewable energies in overall EU energy consumption," and a goal for 2030 of increasing to 27% the share of renewable energy consumed in the European Union.[137] The European Council also has adopted a directive to implement the renewable energy goals.[138] The renewable energy directive requires each member state to "ensure that the share of energy from renewable sources . . . in gross final consumption of energy in 2020" meets a specified percentage.[139] Germany's required share is 18%.[140] The directive also requires each member state to "adopt a national renewable energy action plan" that includes, among other things, "national targets for the share of energy from renewable sources consumed in transport, electricity and heating and cooling in 2020."[141] In its national renewable energy action plan, the country says that it expects to slightly exceed the 2020 target by achieving 19.6% renewable energy.[142]

Germany has also established, independently of the EU, goals to increase the proportion of electricity consumption from renewable sources to 80% by 2050, with intermediate goals of 50% by 2030, and 65% by 2040.[143] In addition, after the

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is to include a "strategy for mobilizing investment" in the energy efficient upgrade and retrofit of existing commercial and residential building stock, *id.* art. 4, promote the market for energy services, *id.* art. 18, and identify measures that will be employed to remove "barriers to energy efficiency." *Id.* art. 19.

136 GERMAN FED. OFFICE OF ECON. & EXP. CONTROL, FED. AGENCY FOR ENERGY EFFICIENCY, 3RD NATIONAL ENERGY EFFICIENCY ACTION PLAN (NEEAP) 2014 FOR THE FEDERAL REPUBLIC OF GERMANY 5 (2014), https://ec.europa.eu/energy/sites/ener/files/documents/2014_neeap_en_germany.pdf [https://perma.cc/DA2C-U333] [hereinafter 3RD NATIONAL ENERGY EFFICIENCY ACTION PLAN].

137 Council of the European Union, *supra* note 131, at annex. I, paras. 6, 7; European Council, *supra* note 132.

138 Council Directive 2009/28/EC, 2009 O.J. (L. 140) 16, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0028&from=EN [https://perma.cc/5PH6-M6ET] [hereinafter EU Renewable Energy Directive].

139 *Id.* art. 3.1. This directive applies to both electricity and liquid fuels such as gasoline.

140 *Id.* at annex I(A).

141 *Id.* art. 4.1.

142 FED. REPUBLIC OF GER., NATIONAL RENEWABLE ENERGY ACTION PLAN IN ACCORDANCE WITH DIRECTIVE 2009/28/EC ON THE PROMOTION OF THE USE OF ENERGY FROM RENEWABLE SOURCES 5 (2010), https://ec.europa.eu/energy/en/topics/renewable-energy/national-action-plans (follow "Germany" hyperlink). "The share of renewable energies in the electricity sector will thereby amount to 38.6 %, the share in the heating/cooling sector will be 15.5 %, while in the transport sector it will amount to 13.2 %." *Id.*

143 GERMAN FED. MINISTRY OF ECON. & TECH. & GERMAN FED. MINISTRY FOR THE ENV'T, *supra* note 120, at 5. For an argument that Germany's 2050 goal for renewable electricity should be 100%, see GERMAN ADVISORY COUNCIL ON THE ENV'T, PATHWAYS

Fukushima nuclear disaster of 2011,[144] Germany set a goal for nuclear power of a different kind: zero nuclear energy by 2022.[145] Of the seventeen nuclear power plants then in operation, which provided about 25% of the country's electricity production, nine were already closed as of 2016. The remaining eight, which provide about 16% of the country's electricity, are to be closed by that date.[146]

The United States has also begun establishing more specific goals, but not through law. In 2015, President Obama announced two goals: (1) that 20% of the electricity generated in 2030 will come from renewable sources, and (2) that energy productivity will double by 2030.[147] In June 2016, the presidents of Mexico, Canada, and the United States agreed that 50% of North Americans' electricity in 2025 would come from "clean energy" sources, a term that includes hydroelectric and nuclear energy.[148] This is higher than the present figure of about 35% and the Energy Information Administration's previously projected figure of 43% for 2025.[149] The increased ambition of these recently stated goals moves the United States closer to those of Germany and California. As this article goes to press, the continued existence of these goals is in doubt.

TOWARDS A 100 % RENEWABLE ELECTRICITY SYSTEM (2011). Many cities and regions in Germany are already working toward a 100% renewable electricity goal. Anna Milena Jurca, Note, *The Energiewende: Germany's Transition to an Economy Fueled by Renewables*, 27 GEO. INT'L ENVTL. L. REV. 141, 172–76 (2014).

144 Mayumi Negishi & Eric Pfanner, *Fukushima Still Rattles Japan, Five Years After Nuclear Disaster*, WALL ST. J. (Mar. 9, 2016), http://www.wsj.com/articles/fukushima-still-rattles-japan-five-years-after-nuclear-disaster-1457482830 [https://perma.cc/R2HK-9KK5].

145 *Uranium and Nuclear Energy*, FED. MINISTRY FOR ECON. AFFAIRS & ENERGY, http://www.bmwi.de/Redaktion/EN/Textsammlungen/Energy/kernenergie.html;jsessionid=DD1062E21FA0EED341E9781373D38141 [https://perma.cc/7KAP-RQJK].

146 *Id.*; *German Cabinet Approves 2022 Nuclear Shutdown*, DEUTSCHE WELLE (June 7, 2011), http://www.dw.com/en/german-cabinet-approves-2022-nuclear-shutdown/a-15134028 [https://perma.cc/73LNSLLS]; *Nuclear Power in Germany*, WORLD NUCLEAR ASS'N, http://www.world-nuclear.org/information-library/country-profiles/countries-g-n/germany.aspx [https://perma.cc/WJ9Q-PG27] (last updated Feb. 8, 2017).

147 Press Release, White House, FACT SHEET: President Obama Announces New Actions to Bring Renewable Energy and Energy Efficiency to Households Across the Country (Aug. 24, 2015), https://www.whitehouse.gov/the-press-office/2015/08/24/fact-sheet-president-obama-announces-new-actions-bring-renewable-energy [https://perma.cc/GM5G-8C9Z]. Energy productivity measures how much energy is needed to produce a dollar of GDP, and is a measure of energy efficiency. GLOB. ALL. FOR ENERGY PRODUCTIVITY, ENERGY PRODUCTIVITY PLAYBOOK 3 (2016), https://www.ase.org/sites/ase.org/files/gaep_playbook-energy-productivity_alliance-to-save-energy.pdf [https://perma.cc/C8H7-RVSH].

148 Jason Furman & Brian Deese, *The Economic Benefits of a 50 Percent Target for Clean Energy Generation by 2025*, WHITE HOUSE (June 29, 2016, 8:00 AM), https://www.whitehouse.gov/blog/2016/06/29/economic-benefits-50-percent-target-clean-energy-generation-2025 [https://perma.cc/THB5-MJV2].

149 *Id.*

B. Legal and Policy Actions Toward Decarbonization

California and Germany have adopted more ambitious laws and have done much greater analytical work and public outreach in determining how to achieve deep decarbonization than the United States, even though both have a long way to go. While U.S. efforts have become more ambitious in recent years, California and Germany are much farther along. In all three, there is also at least one long-term deep decarbonization strategy.

1. California

a. Actions

California's greenhouse gas mitigation effort is based on energy efficiency, renewable energy, and direct regulation of greenhouse gases. The oldest of these efforts are directed at energy efficiency and predate the 1992 Framework Convention on Climate Change.

For four decades, "California has implemented cost-effective building codes and appliance standards that have saved consumers billions of dollars."[150] California has long been a leader in implementing statewide efficiency standards for appliances, such as refrigerators, influencing other states and national product suppliers to improve codes and performance.[151] California's standards, in fact, prompted the federal government to adopt energy efficiency standards for a wide range of household appliances as well as industrial equipment, such as pumps.[152] California has exercised similar leadership in building codes.[153] It has also adopted strategic plans for net zero energy in residential and commercial buildings.[154] Other energy efficiency measures include financial incentives; required disclosure of nonresidential building energy use to buyers, lenders, and lessees; energy savings requirements for public buildings and government vehicle fleets; energy savings performance contract

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[150] CAL. ENERGY COMM'N, TRACKING PROGRESS 1 (2015), http://www.energy.ca.gov/renewables/tracking_progress/documents/energy_efficiency.pdf [https://perma.cc/A3J3-DVBU].

[151] *See* Ann E. Carlson, Commentary, *Energy Efficiency and Federalism*, 107 MICH. L. REV. FIRST IMPRESSIONS 63, 65 (2008).

[152] ELIZABETH DORIS ET AL., NAT'L RENEWABLE ENERGY LAB., ENERGY EFFICIENCY POLICY IN THE UNITED STATES: OVERVIEW OF TRENDS AT DIFFERENT LEVELS OF GOVERNMENT 12–13 (2009), http://www.nrel.gov/docs/fy10osti/46532.pdf [https://perma.cc/U6YW-RRSX].

[153] *Id.* at 7–11.

[154] *Energy Efficiency Strategic Plan*, CAL. PUB. UTILS. COMM'N, http://www.cpuc.ca.gov/General.aspx?id=4125 [https://perma.cc/26V9-E5C2].

authorization for state agencies; and research and development.[155] California has also decoupled utility profits from sales of electricity, imposed a charge of 0.3 cents per kilowatt-hour to fund energy efficiency and other public benefit activities, and established energy efficiency goals along with incentives for utilities to achieve those goals.[156]

These and other measures have meant that, for about four decades, per capita electricity consumption in California has been relatively flat, even as per capita U.S. consumption has increased by about 50%. California has thus saved consumers billions of dollars, reduced air pollution from fossil fuels, created jobs, and helped low-income families.[157]

California also has an aggressive program for renewable energy. The centerpiece of the program is the state's renewable portfolio standard, which requires that the percentage of the state's retail electricity sales that come from renewable sources increase each year. That percentage is required to reach 33% by 2020[158] and 50% by 2030.[159] Other legal tools to support this effort include a feed-in tariff for smaller renewable electricity generators.[160] In addition, the state has a net-metering law that allows electricity customers who generate their own renewable energy to sell their extra electricity back to the grid.[161]

California also has the nation's most far-reaching climate change legislation. California's Global Warming Solutions Act of 2006 (known as AB 32, after its bill number in the legislature) requires the state to reduce its greenhouse gas emissions to 1990 levels by 2020.[162] AB 32 assigns to the California Air

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[155] *California*, AM. COUNCIL FOR AN ENERGY-EFFICIENT ECON., http://database.aceee.org/state/california [https://perma.cc/9DLW-G63A] (last updated Sept. 2016).

[156] NAT'L RESEARCH COUNCIL, REAL PROSPECTS FOR ENERGY EFFICIENCY IN THE UNITED STATES 282–83 (2010). *But see* Arik Levinson, *California Energy Efficiency: Lessons for the Rest of the World, or Not?*, 107 J. ECON. BEHAV. & ORG. 269 (2014) (arguing that the most important reasons for flattened electricity consumption are related to California's relatively mild climate and its demographics).

[157] NAT. RES. DEF. COUNCIL, FACT SHEET: CALIFORNIA'S ENERGY EFFICIENCY SUCCESS STORY: SAVING BILLIONS OF DOLLARS AND CURBING TONS OF POLLUTION 2 (2013), https://www.nrdc.org/sites/default/files/ca-success-story-FS.pdf [https://perma.cc/MXG5-JTRT].

[158] CAL. PUB. RES. CODE § 25740 (West 2011).

[159] Clean Energy and Pollution Reduction Act of 2015, S.B. 350, 2015–2016 Leg., Reg. Sess. (Cal. 2015).

[160] Mormann et al., *supra* note 28, at 79–80. A feed-in tariff guarantees renewable energy developers a price for the electricity they provide, ordinarily for a period of fifteen to twenty years, and guarantees access to the grid. *State and Local Governments*, NAT'L RENEWABLE ENERGY LAB., http://www.nrel.gov/tech_deployment/state_local_governments/basics_tariffs.html [https://perma.cc/4H6J-483F].

[161] *See* Mormann et al., *supra* note 28, at 79–80.

[162] California, Global Warming Solutions Act of 2006, CAL. HEALTH & SAFETY CODE §§ 38500–99 (West 2007).

Resources Board (CARB) the task of choosing legal and policy tools to meet that goal.[163] CARB has elected to proceed with an economy-wide cap-and-trade program.[164] The program caps overall greenhouse gas emissions and then reduces the overall emissions limit annually until the 2020 goal is met. Sources covered under the cap—which emit 85% of California's greenhouse gas emissions—are each subject to their own declining emissions caps.[165] In 2014, California linked its cap-and-trade program to Quebec's cap-and-trade program, creating a larger emissions trading market,[166] which expands economic opportunities for trading and should reduce costs. In 2016, California adopted legislation setting a goal of reducing greenhouse gas emissions by 40% from 1990 levels by 2030.[167] While the legislation does not specifically address cap-and-trade, it does require the adoption of regulations for "cost-effective greenhouse gas emissions reductions."[168] Because emissions trading is considered more cost-effective than many other approaches, there is a significant likelihood that the state will modify its existing emissions trading program to meet the more ambitious 2030 goal.

The cap-and-trade program is only part of California's comprehensive plan for achieving the "maximum technologically feasible" and "cost-effective" reductions in greenhouse gas emissions that AB 32 mandates.[169] California has adopted low-carbon fuel standards, which would cut greenhouse gas emissions by reducing the carbon intensity of transportation fuels used in the state by at least 10% by 2020.[170] California also limits the carbon intensity of new long-term electricity supply

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[163] *Id.* § 38501(f)–(h).

[164] *See* CAL. CODE REGS. tit. 17, §§ 95801–96022 (2017).

[165] *Id.*

[166] *Multi-State Climate Initiatives*, CTR. FOR CLIMATE & ENERGY SOLS., http://www.c2es.org/us-states-regions/regional-climate-initiatives#WCI [https://perma.cc/ZN9W-7T25]. This cooperative effort is facilitated by the Western Climate Initiative, Inc. (WCI), a nonprofit organization. *Id.* California is also working with British Columbia and Ontario on joint cap-and-trade efforts through WCI. *Id.*

[167] CAL. HEALTH & SAFETY CODE § 38566 (West 2017).

[168] *Id.*

[169] *See id.* § 38560.

[170] *See* CAL. CODE REGS. tit. 17, §§ 95480–95497 (2017). The low-carbon fuel standard rule has been challenged on the ground that it discriminates against out-of-state ethanol producers and crude oil sources. Rocky Mountain Farmers Union v. Corey, 730 F.3d 1070 (9th Cir. 2013) (holding that the standard is not facially discriminatory against interstate commerce but remanding to district court for determination whether ethanol provisions in standard discriminate against interstate commerce in purpose or effect and, if not, to apply a balancing test to those provisions). On remand, see Am. Fuels & Petrochemical Mfrs. Ass'n v. Corey, Nos. 1:09-cv-2234-LJO-BAM, 1:10-CV-163-LJO-BAM, 2015 WL 5096279, at *38–39 (E.D. Cal. Aug. 28, 2015) (granting and denying various motions by both sides relating to the pleadings, but not dismissing the case).

agreements so that the supplier cannot generate emissions greater than a combined-cycle natural gas-fired power plant, which generates approximately one-half the emissions of a coal-fired plant.[171]

b. Decarbonization Strategy

In 2014, several California agencies and California's Independent System Operator (which operates the state's electricity grid) asked E3 (Energy + Environmental Economics), a consulting firm, to analyze the technical and economic feasibility of various pathways to meet its 2030 and 2050 emissions reduction goals.[172] Decarbonizing California's economy, E3 concluded, requires four transitions.[173] First, energy efficiency for buildings, industry, and motor vehicles must be doubled and there must be a significant reduction in vehicle miles traveled.[174] Second, there must be "[g]reater reliance on electricity in buildings [and] zero emission vehicles."[175] Third, renewable sources must provide 50%–60% "of annual electricity use by 2030."[176] Fourth, liquid and gaseous fuels should be decarbonized because sustainable biomass is insufficient in quantity to replace those fuels.[177] A fifth requirement—unrelated to energy—is that other greenhouse gases (e.g., methane, fluorinated gases, etc.), as well as non-energy related carbon dioxide emissions (e.g. agriculture) must also be reduced.[178] As California proceeds to implement these recommendations and its 2016 legislation, its efforts to address climate change have been intensifying.

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171 *See* CAL. PUB. UTIL. CODE § 8340 (West 2009); CAL. PUB. UTIL. CODE § 8341 (West 2008).

172 *See* ENERGY + ENVTL. ECON., SUMMARY OF THE CALIFORNIA STATE AGENCIES' PATHWAYS PROJECT: LONG-TERM GREENHOUSE GAS REDUCTION SCENARIOS (2015), https://www.arb.ca.gov/html/fact_sheets/e3_2030scenarios.pdf [https://perma.cc/J8JE-PM4R]. This is the consulting firm where Jim Williams then worked.

173 Amber Mahone et al., E3, California PATHWAYS: GHG Scenario Results slide 9 (Apr. 6, 2015) (PowerPoint presentation), http://www.ethree.com/wp-content/uploads/2017/02/E3_PATHWAYS_GHG_Scenarios_Updated_April2015.pdf [https://perma.cc/9CGB-UJBU]. Further explanation and links to supporting data are available at ENERGY + ENVTL. ECON., *supra* note 172.

174 Mahone et al., *supra* note 173, at slide 10.

175 *Id.* at slide 11.

176 *Id.* at slide 12.

177 *Id.* at slides 9, 13.

178 *Id.* at slide 14.

2. Germany

a. Actions

The German energy strategy, known as *Energiewende* (or energy transition), is intended to reduce Germany's energy consumption and move the economy from nuclear and fossil fuels to renewable energy.[179] The *Energiewende*, in turn, is based on the same three basic building blocks as the California program—energy efficiency, renewable energy, and direct regulation of greenhouse gases.

Germany's 2014 Energy Efficiency Action Plan, described above, sets out a variety of laws, market mechanisms, and programs that are intended to achieve the national goals of reducing energy consumption from 2008 levels by 20% by 2020 and 50% by 2050. These include laws fostering the market for energy efficiency services;[180] laws directing the greater use of distributed power, which increases efficiency by reducing transmission line energy losses; programs to fund the construction and renovation of buildings for greater efficiency; and various energy efficiency informational programs.[181] The government achieved a 9% reduction in primary energy consumption from 2008 levels by 2014[182]—which is no small thing. Still, the government's target of reducing primary energy consumption in 2020 to 20% below 2008 levels[183] appears unlikely to be met.

The primary driver for increased renewable energy in Germany is a feed-in tariff. While Germany has used feed-in tariffs to promote renewable energy since the early 1990s, the feed-in tariff in the Renewable Energy Sources Law of 2000 (*Erneuerbare-Energien-Gesetz* or EEG*)*, which has been revised or amended four times since then, is recognized as the principle

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[179] *Ready for the Next Phase of the Energy Transition*, GER. FED. MINISTRY FOR ECON. AFFAIRS & ENERGY, http://www.bmwi.de/Redaktion/EN/Dossier/energy-transition.html [https://perma.cc/SH4K-G48B]. For a useful overview, see Jurca, *supra* note 143. The origin of the term has been traced to opponents of nuclear power in the 1970s and 1980s who wanted to show that there was an alternative way to provide electricity. CRAIG MORRIS & MARTIN PEHNT, HEINRICH BÖLL FOUND., ENERGY TRANSITION: THE GERMAN ENERGIEWENDE 58 (2012), https://book.energytransition.org/sites/default/files/downloads-2016/book/German-Energy-Transition_en.pdf [https://perma.cc/R4F6-Y47X]. The framework for this transition, which is oriented toward 2050, is set out in a paper, *Energy Concept for an Environmentally Sound, Reliable and Affordable Energy Supply*, which was published by the German government in 2010. GERMAN FED. MINISTRY OF ECON. & TECH. & GERMAN FED. MINISTRY FOR THE ENV'T, *supra* note 120.

[180] PATHWAYS TO DEEP DECARBONIZATION IN GERMANY, *supra* note 114, at 56.

[181] 3RD NATIONAL ENERGY EFFICIENCY ACTION PLAN, *supra* note 136, at 11–14.

[182] PATHWAYS TO DEEP DECARBONIZATION IN GERMANY, *supra* note 114, at 56.

[183] *Id.*

driver for Germany's increased use of renewable energy.[184] The feed-in tariff in the EEG required grid operators to purchase renewable electricity at cost-based rates for a twenty-year period; the rates were based on the cost of renewable technologies plus an "adder" to allow a profit, not on market rates.[185] The EEG has an undeniable effect on renewable electricity in Germany. Between 1990 and 2000, renewable sources grew from 3.4%–6.2% of the country's gross electric consumption[186] but soared to 31% in 2015.[187] Germany supplements the EEG with other measures. According to the National Renewable Energy Action Plan, these include various tax incentives as well as state and municipal funding programs.[188] Additional measures promote offshore wind energy and create regulatory and market incentives to foster the use of renewable energy for heating.[189] Yet the rapid growth in renewable energy in Germany, and the challenges of managing the rapidity of that growth, have led the government to agree to a 45% cap on the fraction of electricity from renewable sources for 2025.[190]

A principle part of the German effort to directly regulate greenhouse gases is the EU Emissions Trading System, which was launched in 2005.[191] The system covers about 45% of the EU's greenhouse gas emissions.[192] Between 1990 and 2014, German greenhouse gas emissions covered by the emissions trading system declined 23%.[193] For all covered EU emissions in that period, the reduction was 22.9%.[194] Although the emissions trading system is directed at greenhouse gas emissions, the

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[184] Mormann et al., *supra* note 28, at 81; Jurca, *supra* note 143, at 145–46.

[185] Lincoln L. Davies & Kirsten Allen, *Feed-In Tariffs in Turmoil*, 116 W. VA. L. REV. 937, 948–49 (2014).

[186] *Id.* at 960.

[187] *Germany's Renewables Electricity Generation Grows in 2015, but Coal Still Dominant*, U.S. ENERGY INFO. ADMIN. (May 24, 2016), http://www.eia.gov/todayinenergy/detail.cfm?id=26372 [https://perma.cc/LZ3Q-K3K6].

[188] FED. REPUBLIC OF GER., *supra* note 142, at 5–6; *see also* GERMAN FED. MINISTRY OF ECON. & TECH. & GERMAN FED. MINISTRY FOR THE ENV'T, *supra* note 120, 7–10.

[189] 3RD NATIONAL ENERGY EFFICIENCY ACTION PLAN, *supra* note 136, at 12.

[190] *Energy Hit: Germany's Decision to Slow the Expansion of Green-Energy Production Is a Reasonable Move*, 534 NATURE 152, 152 (2016), http://www.nature.com/polopoly_fs/1.20041!/menu/main/topColumns/topLeftColumn/pdf/534152a.pdf [https://perma.cc/CQ62-B238].

[191] *See generally* CLIMATE CHANGE AND EUROPEAN EMISSIONS TRADING: LESSONS FOR THEORY AND PRACTICE (Michael G. Faure & Marjan Peeters eds., 2008).

[192] *Greenhouse Gas Emission Statistics*, EUROSTAT, http://ec.europa.eu/eurostat/statistics-explained/index.php/Greenhouse_gas_emission_statistics [https://perma.cc/LV8E-XVDH].

[193] *Id.* (calculation based on reduction from 1258.2 to 969.1 million metric tons of carbon dioxide equivalent in that time period).

[194] *Id.* (calculation based on reduction from 5735.1 to 4419.2 million metric tons of carbon dioxide equivalent in that time period).

increased price of fossil fuel energy caused by the cost of allowances encourages, to a modest degree, the use of both energy efficiency and renewable energy.

The German government has also been working toward its 2020 and 2050 targets in other ways. In 2014, it issued its strategy for reducing greenhouse gas emissions to 40% below 1990 levels by 2020.[195] Because greenhouse gas emissions were already 27.6% below 1990 levels in 2014, a further reduction of 12.4% is needed to meet this objective.[196] The plan identifies "key policy measures" for a wide variety of sectors and activities, including electricity generation; building and housing; transportation; industry, commerce, trade, and services; waste and recycling management; agriculture; land use, land-use change, and forestry; research and development; and public education.[197]

b. Decarbonization Strategy

The German government has also been developing a strategy for reducing greenhouse gas emissions by 80%–95% below 1990 levels by 2050.[198] The German government held an extensive stakeholder outreach and input process in 2015 on this strategy.[199] The government says this reduction is achievable and can be made affordable and publicly acceptable.[200] The strategy is to be based on four pillars: "paving the way" for renewable energy and energy efficiency, "[d]esigning the exit game for the high-carbon assets," developing the necessary infrastructure, and making a great many innovations that are now in the design-and-demonstration phase "work in time."[201] Pursuant to the Paris Agreement, the German government in late

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[195] GERMAN FED. MINISTRY FOR THE ENV'T, NATURE CONSERVATION, BUILDING & NUCLEAR SAFETY, THE GERMAN GOVERNMENT'S CLIMATE ACTION PROGRAMME 2020 (2014), http://www.bmub.bund.de/fileadmin/Daten_BMU/Pools/Broschueren/aktionsprogramm_klimaschutz_2020_broschuere_en_bf.pdf [https://perma.cc/Z7W2-4GNK] [hereinafter CLIMATE ACTION PROGRAMME 2020].

[196] *See supra* Table 2.

[197] CLIMATE ACTION PROGRAMME 2020, *supra* note 195, at 24–71. They also include emissions trading and cooperation with the EU. *Id.*

[198] Felix C. Matthes, Recent Greenhouse Gas Emission and Energy Trends, Prospects and Lessons from Long-Term Modeling for Germany (Dec. 9, 2015) (PowerPoint Presentation given at side event at U.N. Conference on Climate Change, Paris, France) (on file with author).

[199] *See* Megan Darby, *Germany Mulls 'Mammoth' 95% Cut in Emissions by 2050*, CLIMATE HOME (Mar. 18, 2016), http://www.climatechangenews.com/2016/03/18/germany-mulls-minimal-carbon-emissions-in-a-generation/ [https://perma.cc/N8B5-66AZ].

[200] Matthes, *supra* note 198, at slide 6.

[201] *Id.*

2016 submitted its decarbonization strategy for 2050—just as this article was going to press.[202]

The DDPP has also developed a decarbonization strategy for Germany, which concludes that "deep decarbonization can be achieved in Germany by 2050."[203] It explains that "a huge amount of theoretical and practical knowledge on transformation processes" exists because of "about 30 years of critical engagement with climate and energy policies in Germany."[204] Still, challenges remain. While there has been significant progress in reducing greenhouse gas emissions since 1990, reducing greenhouse gas emissions by 80%–95% by 2050 will require annual reductions of 3.5%, which is equal to the greatest annual reductions ever achieved in the country.[205]

The German DDPP team analyzed three already-developed decarbonization scenarios for Germany out of dozens that have been released in recent years.[206] Significantly, one of the scenarios shows that "most of the government's climate and energy targets are missed," and indicates how the country's energy system needs to change to meet those targets.[207] Three strategies are significant in all three scenarios: increased energy efficiency in all sectors, but particularly in buildings; greater use of renewable sources for electricity generation; and greater use of electricity (including electricity for heat) as well as electricity-based hydrogen and synthetic fuels.[208] None of these scenarios consider nuclear energy or carbon capture and sequestration (CCS) because there is "little acceptance" of these technologies within Germany.[209] The report, nonetheless, acknowledged that certain, "more controversial" mitigation strategies could also be employed, including behavioral change that brings about lower

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[202] FED. MINISTRY FOR ENV'T, NATURE CONSERVATION, BUILDING & NUCLEAR SAFETY, CLIMATE ACTION PLAN 2050: PRINCIPLES AND GOALS OF THE GERMAN GOVERNMENT'S CLIMATE POLICY (2016), http://unfccc.int/files/focus/long-term_strategies/application/pdf/161114_climate_action_plan_2050_en_bf.pdf [https://perma.cc/66MM-96K7]. The text of the entire plan is available in German. KLIMASCHUTZPLAN: KLIMASCHUTZPOLITISCHE GRUNDSÄTZE UND ZIELE DER BUNDESREGIERUNG 2050 (2016), http://www.bmub.bund.de/fileadmin/Daten_BMU/Download_PDF/Klimaschutz/klimaschutzplan_2050_bf.pdf [https://perma.cc/4SJ9-XYYT].

[203] PATHWAYS TO DEEP DECARBONIZATION IN GERMANY, *supra* note 114, at 64.

[204] *Id.* at 6.

[205] *Id.* at 3.

[206] *Id.* at 12–16. These scenarios were chosen because, among other reasons, they were issued recently (2014) and because they achieve the German target of at least an 80% reduction in greenhouse gas emissions by 2050, "at least with regard to energy-related emissions." *Id.* at 14.

[207] *Id.* at 16.

[208] *Id.* at 30–41.

[209] *Id.* at 4.

energy demand, "[n]et imports of electricity or bioenergy," and the use of CCS for industrial emissions.[210]

While the report summarizes a variety of German laws and policies relating to energy and climate change, it also concludes that changes in those laws and policies are needed for each of the three key strategies if deep decarbonization is to be achieved.[211] A key problem affecting all three strategies

> lies in the fact that the German "Energiewende" is not centrally organized but influenced and regulated by different levels of governance (EU, national level, federal states, regions and municipalities). While different tasks need to be carried out on each of these levels, successfully managing climate and energy policy from a multi-level perspective constitutes a challenge in itself.[212]

The report identified additional policy measures that are needed to achieve Germany's goals for each of the three strategies. For energy efficiency, many different barriers to greater energy efficiency exist, and each must be overcome by different approaches.[213] Strengthened EU vehicle efficiency standards would also help, as would municipal government and public utility outreach to the general public on ways to improve energy efficiency.[214] To increase public support for the second strategy—greater use of renewable energy—the report says that feed-in tariffs "should be gradually replaced by market-based feed-in premiums."[215] Because market-based premiums involve a lower cost than feed-in tariffs, they should have the effect of lowering the cost of renewable energy and making it more publicly acceptable. Again, both EU policies and municipal actions can foster renewable energy—the former by increasing financial support and the latter by, among other things, using public energy utilities to install their own renewable energy facilities.[216] Finally, the third strategy—greater electrification—requires "a consistent and stable policy framework . . . to be established," as well as greater research and development on technologically difficult problems such as storage.[217] Germany has already made substantial progress toward decarbonization by a variety of different actions,

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[210] *Id.* at 42–46. Another option is to reduce agricultural emissions of greenhouse gases, which are not related to the production of energy. *Id.* at 46–48.

[211] *Id.* at 55–63.

[212] *Id.* at 55.

[213] *Id.*

[214] *Id.* at 57–58.

[215] *Id.* at 59.

[216] *Id.*

[217] *Id.* at 63. Stronger EU support is also needed. *Id.*

through considerable analytical work and an extensive stakeholder process.

3. The United States

a. Actions

U.S. climate change efforts have also focused on energy efficiency, renewable energy, and direct regulation of greenhouse gases. In many ways, however, states—including, but not limited to California—as well as local governments and regional organizations have been more ambitious than the federal government.

Federal energy efficiency laws for motor vehicles and appliances that date back to the 1970s are now being employed more aggressively not only for energy efficiency but also to reduce greenhouse gas emissions.[218] In 2010, EPA and the Department of Transportation (DOT) adopted a final regulation increasing Corporate Average Fuel Economy (CAFE) standards for light-duty motor vehicles to a combined average emissions level of 250 grams of carbon dioxide per mile, or 35.5 miles per gallon, by 2016, if manufacturers meet them entirely with fuel efficiency improvements.[219] Then, in 2012, EPA and DOT issued further rules for passenger cars, light-duty trucks, and medium-duty passenger vehicles for model years 2017–2025.[220] The final standards are projected to result in even lower emissions—an average industry fleet-wide level of 163 grams per mile of carbon dioxide in model year 2025, which is equivalent to 54.5 miles per gallon if achieved exclusively through fuel economy improvements.[221] EPA and DOT have also adopted the first-ever regulations to reduce greenhouse gas emissions and improve fuel efficiency of medium- and heavy-duty trucks.[222]

The Department of Energy has adopted and strengthened energy efficiency standards for a wide variety of products,

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[218] John C. Dernbach & Marianne Tyrrell, *Federal Energy Efficiency and Conservation Laws*, *in* THE LAW OF CLEAN ENERGY: EFFICIENCY AND RENEWABLES 25, 27–34 (Michael B. Gerrard ed., 2011).

[219] Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards, 75 Fed. Reg. 25,324, 25,329–30 (May 7, 2010) (codified at 40 C.F.R. pts. 85, 86, 600; 49 C.F.R. pts. 531, 533, 536).

[220] 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, 77 Fed. Reg. 62,624, 62,624 (Oct. 15, 2012) (codified at 40 C.F.R. pts. 85, 86, 600).

[221] *Id.* at 62,627.

[222] Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles, 76 Fed. Reg. 57,106, 57,106 (Sept. 15, 2011) (codified at 40 C.F.R. pts. 85, 86, 600,1033, 1036, 1037, 1039, 1065, 1066, 1068).

including new refrigerators, air conditioners, clothes washers, and furnaces.[223] The Department of Energy has also adopted efficiency standards for electric motors and a variety of other equipment.[224] Taken together, these standards cover "more than 60 products, representing about 90% of home energy use, 60% of commercial building energy use, and approximately 30% of industrial energy use."[225] State and local governments have also supported greater energy efficiency through tax incentives, purchasing requirements, and more stringent standards than those of the federal government.[226]

The federal government has played a fairly aggressive, if controversial, role in requiring the increased use of renewable energy in gasoline and other liquid fuels,[227] but has played a less direct role concerning renewable electricity. Renewable electricity in the United States has grown largely as a result of state renewable portfolio standards, net-metering laws, feed-in tariffs, and other state laws,[228] supported by, among other things, federal tax incentives.[229]

The United States has also begun to venture into direct regulation of greenhouse gases. Some 8000 facilities are now required to report their greenhouse gas emissions.[230] EPA has also begun to use its authority under the Clean Air Act to regulate greenhouse gas emissions from new and existing stationary sources. The most prominent example, already

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[223] *See* 10 C.F.R. § 430.32 (2013).

[224] *See id.* pt. 431.

[225] U.S. DEP'T OF ENERGY, SAVING ENERGY AND MONEY WITH APPLIANCE AND EQUIPMENT STANDARDS IN THE UNITED STATES (2015), http://energy.gov/sites/prod/files/2015/07/f24/Appliance%20and%20Equipment%20Standards%20Fact%20Sheet%207-21-15.pdf [https://perma.cc/CZJ3-WETX].

[226] Alexandra B. Klass & John K. Harting, *State and Municipal Energy Efficiency Laws, in* THE LAW OF CLEAN ENERGY: EFFICIENCY AND RENEWABLES, *supra* note 218, at 57.

[227] *See* Timothy A. Slating & Jay P. Kesan, *The Renewable Fuel Standard 3.0? Moving Forward with the Federal Biofuel Mandate*, 20 N.Y.U. ENVTL. L.J. 374 (2014).

[228] *See, e.g.*, Felix Mormann, *Clean Energy Federalism*, 67 FLA. L. REV. 1621 (2015); Joshua P. Fershee, *Renewables Mandates and Goals*, *in* THE LAW OF CLEAN ENERGY: EFFICIENCY AND RENEWABLES, *supra* note 218, at 77. Renewable portfolio standards, like the one in California, require a specified percentage of a state's electricity to come from renewable sources. *See supra* text accompanying notes 155–156. Feed-in tariffs, like the one in Germany, require the payment of a specified fee for new renewable energy for a particular period. *See supra* text accompanying note 184. A net-metering law allows homeowners and residents that generate more electricity than they can use to sell the excess to the grid. Valerie J. Faden, *Net Metering of Renewable Energy: How Traditional Electricity Suppliers Fight to Keep You in the Dark*, 10 WIDENER J. PUB. L. 109, 109 (2000).

[229] Roberta F. Mann & E. Margaret Rowe, *Taxation*, *in* THE LAW OF CLEAN ENERGY: EFFICIENCY AND RENEWABLES, *supra* note 218, at 145, 146–49.

[230] *See* 40 C.F.R. § 98 (2010); EPA, FACT SHEET: GREENHOUSE GASES REPORTING PROGRAM IMPLEMENTATION (2013), https://www.epa.gov/sites/production/files/2014-09/documents/ghgfactsheet.pdf [https://perma.cc/328P-R9QR].

noted, is the Clean Power Plan, which would reduce greenhouse gases from existing electric generating facilities to 32% below 2005 levels by 2030.[231] A variety of other actions are contained in a Climate Change Action Plan issued by the White House in 2013.[232] In many ways, however, regional, state, and local actions have been more aggressive than those of the federal government.[233]

b. Decarbonization Strategy

The DDPP has prepared two deep decarbonization reports for the United States.[234] In addition, in November 2016, just as this article was going to press, the U.S. government submitted its deep decarbonization strategy for 2050.[235] At about the same time, the Risky Business Project, which was founded by former New York City Mayor Michael Bloomberg, former U.S. Secretary of the Treasury Hank Paulson, and businessman and philanthropist Tom Steyer,[236] issued its own decarbonization strategy for the United States, entitled *From Risk to Return, Investing in a Clean Energy Economy*.[237] The two more recent reports draw substantially the same conclusions on major issues as the DDPP reports because they share many of the same methodologies and authors.[238]

The two DDPP reports, taken together, make remarkably clear the gap between current law and the laws

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[231] Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units, 80 Fed. Reg. 64,662, 64,736 n.384 (Oct. 23, 2015) (to be codified at 40 C.F.R. pt. 60).

[232] EXEC. OFFICE OF THE PRESIDENT, THE PRESIDENT'S CLIMATE ACTION PLAN 10–11 (2013), https://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf [https://perma.cc/MR27-MCFL]. President Trump's Executive Order also rescinded the Climate Action Plan. Exec. Order No. 13,783, 82 Fed. Reg. 16,093, 16,094, § 3(b) (Mar. 31, 2017).

[233] *See* GLOBAL CLIMATE CHANGE AND U.S. LAW chs. 9–12 (Michael B. Gerrard & Jody Freeman eds., 2d ed. 2014).

[234] *See* DDPP U.S. TECHNICAL REPORT, *supra* note 94; DDPP U.S. POLICY REPORT, *supra* note 73.

[235] *See* THE WHITE HOUSE, UNITED STATES MID-CENTURY STRATEGY FOR DEEP DECARBONIZATION (John Carey et al. eds., 2016), http://unfccc.int/files/focus/long-term_strategies/application/pdf/mid_century_strategy_report-final_red.pdf [https://perma.cc/3RKK-6GAQ].

[236] *About Us*, RISKY BUS., https://riskybusiness.org/about/ [https://perma.cc/7XUP-Y3QJ].

[237] TIM DUANE ET AL., RISKY BUS., FROM RISK TO RETURN: INVESTING IN A CLEAN ENERGY ECONOMY (2016), https://riskybusiness.org/fromrisktoreturn/ (links to report, four appendices, and case study).

[238] *Id.* at 70 (acknowledging substantial research assistance from DDPP and DDPP authors); Ben Haley, *DDPP Informs US Climate Strategy*, EVOLVED ENERGY RESEARCH (Nov. 16, 2016), http://www.evolved.energy/single-post/2016/11/16/Deep-Decarboniation-Pathways-Project-Informs-US-Climate-Strategy [https://perma.cc/W6DC-EPW7].

that are needed to achieve deep decarbonization. Perhaps the DDPP's "most important finding is that it is technically feasible for the U.S. to reduce [carbon dioxide] emissions from fossil fuel combustion" to 85% below 1990 levels by 2050, which is "an order of magnitude decrease in per capita emissions compared to 2010."[239] If the United States did that, it could reduce its overall greenhouse gas emissions to 80% below 1990 levels by 2050.[240]

Enormous changes would be required in the U.S. energy system to make those reductions happen. Because it is difficult to decarbonize gas and liquid fuels, the researchers said, meeting the 2050 objective would require almost complete decarbonization of electricity and, among other things, switching a "large share" of end uses that require gasoline and liquid fuels over to electricity (such as electric cars).[241] It would also be necessary to produce fuel from electricity itself, they said, citing the production of hydrogen from electrolysis as an example.[242] That would double electricity generation but reduce carbon intensity to between 3% and 10% of current levels, requiring a vast increase in either renewable energy (as much as "2,500 gigawatts (GW) of wind and solar generation (30 times present capacity)") or carbon capture and sequestration.[243] The average fuel economy for light-duty vehicles, such as cars, would need to be over 100 miles per gallon, and these vehicles would need to be fueled almost entirely by electricity and hydrogen.[244]

According to the report, the future of the U.S. energy system depends on at least "five critical elements."[245] These are (1) the commercial availability of carbon capture and storage (CCS), (2) the supply and allocation of biomass energy feedstock that can displace fossil fuel, (3) the sources of energy used for electricity production, (4) the "balancing" strategies that are employed to keep the electricity grid reliable, and (5) the uptake of energy efficiency and switching to low-carbon fuels.[246] Decisions on these five elements open or close pathways to decarbonization. For example, if CCS is not

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[239] DDPP 2014 REPORT, *supra* note 81, at 204. "Technical feasibility is defined here as a robust analytical demonstration that multiple technology pathways exist for achieving the 2050 emissions target that satisfy a broad set of reasonableness criteria, including reliance on commercial or near-commercial technologies, natural infrastructure turnover, power system operability, and sustainability limits on natural resources." DDPP U.S. TECHNICAL REPORT, *supra* note 94, at 2.

[240] DDPP U.S. TECHNICAL REPORT, *supra* note 94, at xii.

[241] *Id.* at xiv.

[242] *Id.*

[243] *Id.*

[244] *Id.*

[245] *Id.* at 14.

[246] *Id.* at 14–15.

commercially available, there is no future for fossil fuels for electricity, and the only remaining sources for electricity are renewable and nuclear power.[247]

The DDP researchers developed four different decarbonization scenarios for the United States, which highlight the role of some of these critical elements and also illustrate the variety of potential approaches. Because electricity is at the center of a decarbonized energy system, the scenarios highlight contrasting ways of providing it. These four scenarios are High Nuclear, High Renewables, High CCS (fossil fuels with CCS), and Mixed Case (based on "a balanced mix of all three primary energy resources").[248]

The DDPP researchers concluded that certain key policy objectives for this energy transition must be met. These are:

- Anticipate investment needs and build a suitable investment environment
- Incorporate future carbon consequences in current purchasing decisions
- Create stable drivers for sustained long-term transitions
- Develop institutional structures for coordination across sectors
- Integrate supply and demand-side planning and procurement
- Create the right kinds of competition
- Enable the required rates of consumer adoption
- Catalyze the needed cost reductions in key technologies
- Limit cost increases faced by consumers
- Minimize inequitable distributional effects[249]

These objectives make plain the basic policy structure for redirecting the entire energy system. For example: "The annual investment requirement for low-carbon and efficient technologies rises from under $100 billion today to over $1 trillion in a span of about 20 years."[250] The policy and legal signals necessary to sustain this transition, moreover, must be consistent enough over time to create a "predictable investment environment."[251]

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[247] *Id.* at 15.
[248] *Id.* at 16.
[249] DDPP U.S. POLICY REPORT, *supra* note 73, at 61.
[250] *Id.* at 12.
[251] *Id.*

Across all four scenarios, the overall cost to the U.S. economy in 2050, the report says, is about $320 billion (or 0.8% of the expected GDP for 2050 of $40 trillion).[252] Average monthly household spending on energy goods and services would be only $35 higher in 2050 than it would otherwise be; somewhat higher electricity prices are mostly offset by lower costs for gasoline and natural gas.[253] DDPP assumes very little change in personal lifestyles, and suggests that the "seeming paradox" of decarbonization is that, while the required changes are enormous, "the day to day interaction of most people with using energy goods and services will change very little."[254]

DDPP makes clear that the scale of required changes from existing law is considerable, though these changes are not set out in any detail. The following illustrate the magnitude of the differences. To begin with, because the Clean Power Plan does not begin to get to the necessary scale of changes needed (e.g., deep decarbonization, redesign of wholesale electricity markets), it must be modified or augmented by other state and federal laws.[255] In addition, the federal renewable fuel standard for liquid fuels should be changed so that, among other things, it is based on "near zero lifecycle carbon" and is used for diesel fuel, jet fuel, or natural gas, where it "has much greater carbon benefit."[256] Moreover, CAFE standards for motor vehicles "must become more aggressive in transforming the vehicle fleet" so that virtually the entire fleet is made up of "electric, fuel cell, or plug-in hybrid vehicles" by 2040.[257] Finally, energy efficiency standards for buildings, as well as buildings themselves, need to be refocused on carbon emissions, not primary energy use; less efficiency in use of energy from a renewable source is probably better from a carbon perspective than greater efficiency in use of energy from a fossil fuel source.[258]

The United States has made growing progress in addressing greenhouse gas emissions in recent years and the DDPP describes various decarbonization scenarios. Still, while California's and Germany's decarbonization efforts have a long way to go, they are considerably ahead of the United States'.

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[252] *Id.* at 30.

[253] *Id.* at 28.

[254] *Id.* at 24. The report adds: "Lifestyle changes, such as use of bicycles in lieu of cars, vegetarian diets, and wearing sweaters to reduce home heating loads, are not required, though by lowering energy service demand these measures could reduce the amount of low-carbon technology that must be deployed, and potentially lower costs." *Id.*

[255] *Id.* at 85–86.

[256] *Id.* at 87–88.

[257] *Id.* at 89–90.

[258] *Id.* at 91–92.

IV. LESSONS FROM CALIFORNIA AND GERMANY

California and Germany offer considerable insight into what legal pathways the United States should employ in seeking decarbonization and what overall approaches should guide the choice of specific legal pathways. Some of these concern enabling conditions and frames for those legal pathways—particularly, widespread public support, the use of sustainable development to address climate change, and the use of long-term and sector-specific targets and timetables with accompanying strategies. Others involve law and governance issues about legal pathways—laws as building blocks, sequencing, learning from experience about the efficacy of various laws, and coordinated governance. These lessons can help guide U.S. efforts to accelerate the reduction of its greenhouse gas emissions.

A. Enabling Conditions and Frames

1. Public Support and Participation

In democracies, of course, public support and participation are essential for the adoption or modification of laws and policies. This public support, as suggested earlier, also needs to continue over decades if governments are to maintain consistent and relatively unchanged policies necessary to support the long-term investments and actions essential for decarbonization.[259] Moreover, it is increasingly clear that human behavioral change can be a significant component of any national strategy to address climate change, affecting the uptake of new technologies and the adoption of new approaches.[260] Widespread public support makes these behavioral changes more likely. Finally, public support is needed because decarbonization efforts necessarily involve trial and error; there are bound to be reversals and failures in an

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[259] UK PATHWAYS ANALYSIS, *supra* note 83, at 4 ("Creating a low carbon economy will require the consent and participation of citizens given the scale and pace of change required. Government can play a leadership role, but transforming our economy will require a coalition of citizens, business, and the energy industry.").

[260] Michael P. Vandenbergh et al., *Implementing the Behavioral Wedge: Designing and Adopting Effective Carbon Emissions Reduction Programs*, 40 ENVTL. L. REP. 10547 (2010) (identifying six principles for the design of policies to induce changes in household technology adoption and use and evaluating recent federal household energy initiatives in light of those six principles); Thomas Dietz et al., *Household Actions Can Provide a Behavioral Wedge to Rapidly Reduce US Carbon Emissions*, 106 PROC. NAT'L ACAD. SCI. 18452 (2009) (concluding that national implementation of seventeen different household actions could reduce overall US carbon dioxide emissions by 7.4%, with little or no reduction in household well-being).

unprecedented effort of this magnitude, and public support needs to be unwavering even when inevitable problems occur.

Such public support exists in California and Germany. California's efforts to address climate change have been supported and furthered by both Republican and Democratic governors, and California adults are more likely to think climate change is a serious problem than adults in the rest of the United States.[261] Indeed, a referendum to delay implementation of AB 32 was defeated in 2010.[262] Remarkably, polling data consistently indicate that more than 90% of the German public support the *Energiewende*.[263] Public support in Germany continues notwithstanding continued criticism that the feed-in tariff has contributed to an increase in electricity costs.[264]

In the United States, by contrast, the national Republican Party appears virtually united in its opposition to serious action on climate change (at least in public), and partisan division has made it impossible for the U.S. Congress to adopt significant legislation on climate change.[265] While climate change was not a major issue in Donald Trump's 2016 presidential campaign, he was openly skeptical of climate change science and claimed that regulation of fossil fuels weakens the economy.[266] His March 2017 executive order is unquestionably intended to roll back or weaken the climate change efforts of the Obama administration.[267] There are, nonetheless, signs that the partisan division may be abating—but they are only signs. In a March 2016 Gallup poll,

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[261] Chris Megerian, *In Paris, Schwarzenegger and Brown Unite to Seek Climate Action*, L.A. TIMES (Dec. 7, 2015), http://www.latimes.com/politics/la-pol-ca-paris-climate-talks-schwarzenegger-brown-story.html [https://perma.cc/C8NU-7EY3]; David Kordus, *Californians' Views on Climate Change*, PUB. POLICY INST. OF CAL. (Jan. 2017), http://www.ppic.org/main/publication_show.asp?i=1172 [https://perma.cc/BPD8-TUPG].

[262] Colin Sullivan & Debra Kahn, *Voters Reject 2-Sided Assault on Climate Law*, N.Y. TIMES (Nov. 3, 2010), http://www.nytimes.com/cwire/2010/11/03/03climatewire-voters-reject-2-sided-assault-on-climate-law-13439.html?pagewanted=all [https://perma.cc/N66H-XBV8].

[263] *Do Germans Support the Energiewende?,* HENIRICH BÖLL STIFTUNG FOUND., https://book.energytransition.org/do-germans-support-energiewende/ [https://perma.cc/82KX-Z6B4]; AGORA ENERGIEWENDE ET AL., UNDERSTANDING THE ENERGIEWENDE 10 (2015), https://www.agora-energiewende.de/fileadmin/Projekte/2015/Understanding_the_EW/Agora_Understanding_the_Energiewende.pdf [https://perma.cc/7T8C-MKD6].

[264] *See* AGORA ENERGIEWENDE ET AL., *supra* note 263, at 31–32; *see also* Bentham Paulos, *Are the Legacy Costs of Germany's Solar Feed-In Tariff Fixable?*, GREENTECH MEDIA (June 4, 2014), https://www.greentechmedia.com/articles/read/germany-moves-to-reform-its-renewable-energy-law [https://perma.cc/6ZRD-8M35] (explaining German policy response to high electricity costs from feed-in tariff).

[265] Riley E. Dunlap et al., *The Political Divide on Climate Change: Partisan Polarization Widens in the U.S.,* 58 ENV'T.: SCI. & POL'Y FOR SUSTAINABLE DEV. 4, 5 (2016).

[266] Clare Foran, *Donald Trump and the Triumph of Climate-Change Denial*, ATLANTIC (Dec. 25, 2016), https://www.theatlantic.com/politics/archive/2016/12/donald-trump-climate-change-skeptic-denial/510359/ [https://perma.cc/JYJ5-4WAS].

[267] Exec. Order No. 13,783, 82 Fed. Reg. 16,093 (Mar. 31, 2017).

a record number (65%) of "Americans [are] now saying increases in the Earth's temperature over the last century are primarily attributable to human activities rather than natural causes," and a significantly increased, but lower, number of Republicans (40%) feel the same way.[268] It is likely that the economic development and job creation opportunities provided by renewable energy and energy efficiency[269] will eventually lead to greater future Republican support for action on climate change, including Republican presidential support. It is likely, in other words, that they will see climate change action through the lens of sustainable development.

2. Sustainable Development

Sustainable development is a decision-making framework for reconciling and furthering economic development, social well-being, and security with environmental protection.[270] The term grew out of the realization that conventional development—which includes both economic and social development, and is based on security—was causing widespread and growing environmental degradation and also causing or contributing to poverty and social inequality.[271] Sustainable development is an effort to transform the way in which development is conducted.[272] The basic idea is that development should have not only social, economic, and security goals but should also have environmental goals.[273] This transformation—from conventional development to sustainable development—requires the integration of development and environment in decision making.[274]

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[268] Lydia Saad & Jeffrey M. Jones, *U.S. Concern About Global Warming at Eight-Year High*, GALLUP (Mar. 16, 2016), http://www.gallup.com/poll/190010/concern-global-warming-eight-year-high.aspx [https://perma.cc/Z2KX-UCE5]. *But see* Dunlap et al., *supra* note 265.

[269] Jim Marston, *What Trump And Pence Don't Get About Clean Energy Jobs,* FORBES (Dec. 2, 2016), http://www.forbes.com/sites/edfenergyexchange/2016/12/02/what-trump-and-pence-dont-get-about-clean-energy-jobs/2/#6433094d3db8 [https://perma.cc/DT5Y-6AYT].

[270] John C. Dernbach & Federico Cheever, *Sustainable Development and Its Discontents*, 4 TRANSNAT'L ENVTL. L. 247 (2015); John C. Dernbach, *Sustainable Development as a Framework for National Governance*, 49 CASE W. RES. L. REV. 1 (1998) [hereinafter Dernbach, *Sustainable Development as a Framework for National Governance*]. The pathways described in the sixteen DDPP country reports are all based on the use sustainable development to create economic, social, environmental, and other benefits. DDPP 2015 SYNTHESIS REPORT, *supra* note 84, at 21–28.

[271] Dernbach, *Sustainable Development as a Framework for National Governance*, *supra* note 270, at 8–24.

[272] *See* Dernbach & Cheever, *supra* note 270, at 273.

[273] *Id.* at 252–76.

[274] Dernbach, *Sustainable Development as a Framework for National Governance*, *supra* note 270, at 50–58.

Sustainable development is a central idea of the Framework Convention on Climate Change: "The Parties have a right to, and should, promote sustainable development."[275] If decarbonization achieves an environmental goal—protection of the climate—then designing legal decarbonization pathways for sustainable development means designing them for economic, security, social, and other environmental co-benefits. Achieving multiple benefits through a single policy can increase public support for that policy and make it more cost effective.[276] This is particularly important for climate change because reductions in greenhouse gas emissions do not produce local benefits; the co-benefits of those measures do. Designing legal measures that maximize these co-benefits is a key element in getting these measures adopted.

National laws that allow subnational governments such as states and municipalities to particularize implementation to local circumstances, for example, may lead to greater co-benefits than more uniform laws.[277] Deep decarbonization legal pathways that rely more on a properly motivated public, and individual efforts to reduce greenhouse gas emissions, are likely to be less expensive than the cost of other measures.[278] It is also essential to draft measures in ways that protect the poor and manage the impact of the transition on the fossil fuel industry. Thus, legal pathways based on sustainable development could identify the most attractive and politically achievable legal pathways for keeping the temperature increase well below 2°C.

The executive orders and laws that are at the foundation of California's climate change effort all set out the threats that climate change poses to the state and the economic development, job creation, and other benefits of action to address climate change.[279] Germany's energy transition is expressly framed in terms of sustainability and is premised on the country becoming one "of the most energy-efficient and greenest economies in the world while enjoying competitive energy prices and a high level of prosperity."[280] There is significant evidence of

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[275] *Framework Convention*, *supra* note 1, art. 3.4.

[276] PATHWAYS TO DEEP DECARBONIZATION IN GERMANY, *supra* note 114, at 48.

[277] John C. Dernbach et al., *Making the States Full Partners in a National Climate Change Effort: A Necessary Element for Sustainable Economic Development*, 40 ENVTL. L. REP. 10,597 (2010).

[278] *See* Dietz et al., *supra* note 260, at 18453.

[279] Exec. Order No. S-3-05 (Cal. 2005); CAL. HEALTH & SAFETY CODE §§ 38501(a)–(e) (West 2007).

[280] GERMAN FED. MINISTRY OF ECON. & TECH. & GERMAN FED. MINISTRY FOR THE ENV'T, *supra* note 120, at 3. For Germany, co-benefits include energy security. "In 2013, Germany imported 98% of oil consumed domestically, 88% of gas, and 87% of coal . . . ." PATHWAYS TO DEEP DECARBONIZATION IN GERMANY, *supra* note 114, at 49.

job creation in the solar and wind industries in California and Germany.[281] California is also framing its effort in terms of reducing vulnerabilities to climate change, including the vulnerability of water supplies to drought.[282] The old frame—that people must forfeit their well-being to address climate change—is being refuted not simply with arguments, but with evidence. In fact, an effort to repeal California's AB 32 by public referendum in 2010 was defeated largely on the strength of the economic development and public health benefits of AB 32. California relied on similar arguments in adopting legislation in 2016 to strengthen its ability to reduce greenhouse gas emissions.[283]

Indeed, the DDPP report for the United States identifies four broad categories of co-benefits that could be used to guide the development of possible legal pathways. These include, of course, a stable climate and clean environment, not only because of its obvious climate protection benefits, but also because a "deeply decarbonized energy system lowers air pollution, improves public health, reduces fossil fuel related disasters, and promotes environmental justice."[284] A decarbonized energy system also has "much more predictable energy costs and a more stable investment environment" than the existing system with continuing oil-price fluctuations and resource availability issues.[285] In addition, a "deeply decarbonized energy system has many more potential economic winners than the current system, due to dramatically increased and widely distributed investment across regions, technologies, energy types, and industries."[286] Finally, decarbonization will have significant benefits for economic modernization, U.S. competitiveness, and job creation—particularly in the electricity sector—because decarbonization is based on U.S. strengths in science and technology.[287] The United States can enhance the likelihood of making greater progress by framing the climate change issue in sustainability

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Other co-benefits include "higher competitiveness of and global business opportunities for companies, job creation, stronger GDP growth, smaller energy bills for households and less air pollution." *Id.* at 5, 50–54.

[281] Mormann et al., *supra* note 28, at 74–75.

[282] RUTH LANGRIDGE ET AL., UNIV. OF CAL., SANTA CRUZ, CLIMATE CHANGE AND WATER SUPPLY SECURITY: RECONFIGURING GROUNDWATER MANAGEMENT TO REDUCE DROUGHT VULNERABILITY 1–2 (2012), http://www.energy.ca.gov/2012publications/CEC-500-2012-017/CEC-500-2012-017.pdf [https://perma.cc/GS75-FWAM].

[283] Chris Megerian & Liam Dillon, *Gov. Brown Signs Sweeping Legislation to Combat Climate Change,* L.A. TIMES (Sept. 8, 2016), http://www.latimes.com/politics/la-pol-ca-jerry-brown-signs-climate-laws-20160908-snap-story.html [https://perma.cc/44LY-HRSF].

[284] DDPP U.S. POLICY REPORT, *supra* note 73, at 34.

[285] *Id.*

[286] *Id.*

[287] *Id.* at 34, 47.

terms—creating economic, social, and environment benefits; reducing costs; and enhancing human quality of life in the present and over the long term. The United States may or may not take this approach, but the benefits of doing so cannot reasonably be denied.

3. Long-Term and Sector-Specific Targets and Timetables with Accompanying Strategies

Targets and timetables based on decarbonization are essential to any jurisdiction's effort to reduce greenhouse gas emissions.[288] Targets and timetables are the only way to match the required effort, including law, policy, funding, and technological development and deployment, to the reductions needed. They provide an organizing framework around which many actions from different sectors can be conducted.[289] Targets and timetables also serve as a measure of the effectiveness of the laws and policies that are adopted and implemented to achieve them. When long-term goals are involved, these short-term targets and timetables can provide milestones or benchmarks for progress toward such goals. Although the United States does not have a long-term goal, all three jurisdictions have short-term economy-wide goals to guide progress and assess what additional actions, if any, need to be undertaken.

The more specific short-term goals in California and Germany also have considerable value. Because California's renewable portfolio standard both sets goals and provides a legal requirement for achieving them, it is particularly likely to be effective. In Germany, even the probability that some specific goals for 2020 will be met (energy efficiency) or not met (renewable energy and perhaps greenhouse gas emissions) influences whether additional measures are undertaken.[290]

The absence of a firm, long-term economy-wide goal for the United States, however, is problematic. U.S. law tends to be oriented toward the next technologically or economically feasible step (e.g., CAFE standards), which does not take into

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[288] *See generally* John C. Dernbach, *Targets, Timetables and Effective Implementing Mechanisms: Necessary Building Blocks for Sustainable Development*, 27 WM. & MARY ENVTL. L. & POL'Y REV. 79 (2002) (explaining the value of targets and timetables in environmental protection).

[289] "Goals, even if imperfect, may be necessary as a focal point around which support can be mobilized and the fairness of each country's mitigation commitments can be judged." Michael P. Vandenbergh & Jonathan A. Gilligan, *Beyond Gridlock*, 40 COLUM. J. ENVTL. L. 217, 227–28 (2015).

[290] The goals announced by the Obama administration in 2015 and 2016 for renewable energy, energy productivity, and clean energy will have the same value if they are treated seriously by subsequent administrations and by Congress.

consideration what is actually required by 2050. It can thus easily have the effect of reducing the level of ambition required to achieve a long-term goal. Assuming that the United States can achieve 54.5 miles per gallon as a fleet-wide average for *new* vehicles by 2025, for example, how does it achieve a fleet-wide average of more than 100 miles per gallon for *all* vehicles by 2050? As the deep decarbonization report for the United States explained, "[t]his would require the deployment of roughly 300 million alternative fuel vehicles by 2050."[291] Long-term goals would oblige policy makers to consider that question and develop credible and workable laws and policies that answer it, at the same time as they develop shorter-term laws and policies. It seems likely that the United States will require a much higher level of ambition regarding motor vehicles' fuel efficiency between 2025 and 2050 to achieve the outcome described in the deep decarbonization report. It also seems possible that a more ambitious 2025 standard or goal would have better positioned the United States to achieve the required reductions.[292]

In the decarbonization context, a long-term goal also is necessary to avoid dead ends—legal approaches that seem to reduce emissions for a while but ultimately cannot deliver the scale or pace of reductions needed.[293] Without CCS, shale gas represents such a dead end. The use of shale gas for electricity emits about half as much carbon dioxide as the use of coal and is given some of the credit for somewhat lower U.S. greenhouse gas emissions in recent years.[294] Still, an emissions reduction of 50% is not enough for deep decarbonization. This conclusion does not even consider the leakage of methane (a more potent greenhouse gas than carbon dioxide) from shale gas wells, compressor stations, and other facilities.[295] Reliance on shale gas without CCS to reduce greenhouse gas emissions is highly unlikely to meet any credible long-term reduction goal.

Long-term thinking is also necessary to anticipate forks in the road with long-term consequences. Zero-emission vehicles provide an example. If those vehicles are powered by electricity, then an electricity-charging infrastructure needs to

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[291] DDPP U.S. TECHNICAL REPORT, *supra* note 94, at xiv.

[292] *Cf.* Howard A. Latin, *Climate Change Mitigation and Decarbonization*, 25 VILL. ENVTL. L.J. 1, 82 (2014) ("[T]he fundamental climate change policy choice for America is between a decarbonization strategy that will be 'difficult to accomplish' and the conventional multi-decade emissions-reduction approaches that are 'certain to fail.'").

[293] *See* Williams et al., *supra* note 78, at slide 9.

[294] EPA, *supra* note 124, at ES-23 tbl.ES-7, ES-24.

[295] Donald A. Brown, *Is Shale Gas Part of a Sustainable Solution to Climate Change? A Factual and Ethical Analysis, in* SHALE GAS AND THE FUTURE OF ENERGY: LAW AND POLICY FOR SUSTAINABILITY 271 (John C. Dernbach & James R. May eds., 2016).

be developed and located where people live, work, or go to school. If those vehicles are powered by hydrogen fuel cells, then hydrogen production must occur at a much greater scale.[296]

Finally, long-term goals and thinking are needed because some of the hardest issues (e.g., availability of specific technologies and costs) involve goods and services that are marketed globally.[297] Improvements over time are highly likely to reduce costs, leading to tipping points for adoption of new low-carbon or zero-carbon goods and services that quickly become deployed at scale. The German feed-in tariff, for example, has led to reductions in the cost of solar photovoltaic technology.[298] Similarly, a deep decarbonization goal for 2050 would put financial markets, investors, and fossil fuel companies on notice of long-term changes and would provide for a more orderly transition.[299]

B. Law and Governance

1. Laws as Building Blocks

Many laws are needed to make decarbonization work. While there continue to be advocates for silver bullets, such as carbon taxes and technological breakthroughs, the reality is that a variety of legal and policy tools (silver buckshot) are required to make decarbonization work.[300] Because greenhouse gases are emitted by a variety of different economic sectors—including transportation, industry, residential dwellings, commercial establishments, and agriculture—laws that are specifically targeted to one of those sectors are more likely to effectively address the specific conditions, technologies, and behaviors that occur in that sector. Greenhouse gas emissions from motor vehicles, for instance, raise a different set of legal and policy issues than greenhouse gas emissions from residential dwellings. Pollutants other than carbon dioxide (nitrous oxide, methane, fluorinated gases, black carbon, etc.) require

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296 *See* Williams et al., *supra* note 78, at slide 10.

297 *See id.* at slide 11.

298 *See infra* note 320 and accompanying text.

299 *Id.*

300 ELINOR OSTROM, GOVERNING THE COMMONS: THE EVOLUTION OF INSTITUTIONS FOR COLLECTIVE ACTION 21–22 (1990) ("Policy analysts who would recommend a single prescription for commons problems have paid little attention to how diverse institutional arrangements operate in practice."); Thomas D. Peterson, Robert B. McKinstry, Jr. & John C. Dernbach, *Developing a Comprehensive Approach to Climate Change Policy in the United States That Fully Integrates Levels of Government and Economic Sectors*, 26 VA. ENVTL. L.J. 227, 240 (2008) ("The combination of different actions and mechanisms across all of the relevant sectors is critical to meeting strong new emissions targets.").

specifically tailored laws. Finally, there is also abundant evidence that higher charges for energy or carbon by themselves cannot effectively address a variety of behavioral and other issues that require context-specific laws. Even though Germany has high energy prices, which have fostered greater energy efficiency, the absence of more specific efficiency laws is one of the reasons that country is not on course to meet its energy efficiency target for 2020.[301]

Germany and California have been able to increase the share of their electricity provided by renewable sources because of a diverse range of legal and policy instruments that are directed at what is required for both solar and wind energy.[302] Although the United States is farther from decarbonization, it too has used a variety of legal instruments to address energy efficiency, renewable energy, and climate change. In the wake of the U.S. Supreme Court's stay of the Clean Power Plan,[303] a key feature of the Obama administration's climate strategy, some of the nation's leading legal scholars published a paper arguing that EPA should consider using another tool, Section 115 of the Clean Air Act, to regulate greenhouse gases through that Act's state implementation plan process.[304] That approach is consistent with a strategy built on multiple legal building blocks.

2. Sequencing

While a variety of legal building blocks can yield an outcome that is more tailored to the specific sectors or problems at issue, a variety of legal building blocks also enable sequencing of measures over time. In the carbon tax example given above, one could argue that such a tax could have the effect of reducing emissions from both motor vehicles and residential dwellings. But Republican opposition means that a carbon tax at the U.S. federal level is not likely to be enacted in the near future.[305] Another problem with waiting for the right political

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[301] PATHWAYS TO DEEP DECARBONIZATION IN GERMANY, *supra* note 114, at 55–56.

[302] Mormann et al., *supra* note 28, at 90–92. Because Texas law has focused on wind rather than solar power, by contrast, the use of wind for electricity has grown much more than the use of solar. *Id.* at 91–92.

[303] *See supra* text accompanying note 17.

[304] MICHAEL BURGER ET AL., SABIN CTR. FOR CLIMATE CHANGE LAW, COLUMBIA LAW SCHOOL, LEGAL PATHWAYS TO REDUCING GREENHOUSE GAS EMISSIONS UNDER SECTION 115 OF THE CLEAN AIR ACT (2016), https://web.law.columbia.edu/sites/default/files/microsites/climate-change/legal_pathways_to_reducing_ghg_emissions_under_section_115_of_the_caa.pdf [https://perma.cc/9RQ7-ZMXX].

[305] *See* William Gale, *A Tax Even Conservatives Can Love*, U.S. NEWS & WORLD REP. (Feb. 22, 2016), http://www.usnews.com/news/the-report/articles/2016-02-22/the-next-president-should-implement-the-carbon-tax [https://perma.cc/776U-MWM6].

circumstances and timing for adoption of an optimal instrument, moreover, is that these circumstances are almost impossible to know in advance.[306] Because waiting for a "best" solution to climate change before acting will almost certainly have serious and irreversible economic, human, and environmental costs, a series of partial measures enacted now can, if nothing else, slow down the rate at which greenhouse gases accumulate in the atmosphere.[307] Moreover, there is significant empirical evidence that the employment of other legal tools that foster energy efficiency and renewable energy can create a political environment more amenable to a carbon tax by building industries that operate as a counterweight to fossil fuel interests. Nearly two-thirds of the countries and subnational jurisdictions that had adopted a carbon pricing scheme by 2013, for example, had previously adopted renewable energy portfolio standards or feed-in tariffs for renewable energy.[308]

Climate change efforts in California, Germany, and the United States all began with significant energy efficiency laws that had nothing to do with climate change. The effect of these laws was to reduce the amount of energy that needs to be used in the first place. These laws have proven foundational for subsequent climate change efforts because of their avoided carbon dioxide emissions. They also suggest that energy efficiency and conservation efforts should continue, albeit toward more ambitious zero-carbon outcomes. These measures are, for the most part, politically feasible now, and there is no need for additional information.

Building on this insight, the DDPP recommends that the policies and measures that should be prioritized in time are those (1) "that are common to all pathways (e.g. electrification using decarbonized electricity)"; (2) "for which near-term action is required to make gradual deployment at scale possible over the course of the transition (e.g. efficiency)"; and (3) "which

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[306] Jonathan M. Gilligan & Michael P. Vandenbergh, *Accounting for Political Feasibility in Climate Instrument Choice,* 32 VA. ENVTL. L.J. 1, 19–20 (2014).

[307] *Id.* at 15 ("Rather than looking for a single unified policy to address a difficult problem, such as climate change, it may be more efficient to pursue a battery of 'good enough' measures whose collective impact would meaningfully address the problem.").

[308] Jonas Meckling et al., *Winning Coalitions for Climate Policy*, 349 SCIENCE 1170 (2015). Another approach to sequencing is based on the value of taking partial measures now and making adjustments over time rather than adopting a complete approach to a problem right away. In climate change adaptation, the former approach can be appropriate if future outcomes are uncertain; uncertainty is likely to decrease over time, and flexibility exists to take future action based on new information. Peter Linquiti & Nicholas Vonortas, *The Value of Flexibility in Adapting to Climate Change: A Real Options Analysis of Investments in Coastal Defense*, 3 CLIMATE CHANGE ECON. 1250008, 1250008-2–1250008-3 (2012).

preserve future freedom of choice by encouraging the extended use of existing facilities and/or systems (e.g. re-use of natural gas networks to transmit renewable syngas [synthetic gas] or a portion of hydrogen)."[309] This kind of sequencing is an essential part of any legal approach to deep decarbonization.[310]

3. Learning from Experience About the Efficacy of Various Laws

One of the most basic things that can be learned from leaders is what works and what does not work. This is how states and the federal government learn from other states in the United States,[311] and it also reflects a basic lesson of the study of comparative law at the global level.[312] Laws that work in one jurisdiction can be considered for adoption in another jurisdiction with due regard for differences in legal and political culture.[313] Laws in one jurisdiction that do not work, are too costly, or create too many unintended consequences, need to be substantially rewritten or not used at all. Learning from experience saves time and reduces reliance on behavioral models or hypotheses that may not fully or accurately reflect the gritty reality to which they apply. Learning from experience also lets later-acting jurisdictions improve on the laws employed by the leaders.

For example, a critical issue in ramping up the use of renewable sources for electricity is maintaining reliability of the grid. Base-load generating facilities that run all the time are simply more reliable—the argument goes—than wind and solar, because the wind is not always blowing nor is the sun always shining. Yet Germany and California have, remarkably, "both managed to lower average service interruption times in their electricity grids while tripling the amount of electricity

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[309] DDPP 2015 SYNTHESIS REPORT, *supra* note 84, at 36.

[310] Sequencing also requires a good measure of adaptive management in the development and implementation of climate change laws. Jan McDonald & Megan C. Styles, *Legal Strategies for Adaptive Management Under Climate Change*, 26 J. ENVTL. L. 25 (2014). Although the DDPP is directed toward a goal of keeping global temperatures below 2°C, it is appearing likely that more ambitious goals will be needed. If particular legal or technical pathways to decarbonization do not work out, then alternative approaches will be required.

[311] *See, e.g.*, John C. Dernbach, *Pennsylvania's Implementation of the Surface Mining Control and Reclamation Act: An Assessment of How "Cooperative Federalism" Can Make State Regulatory Programs More Effective*, 19 U. MICH. J.L. REFORM 903, 904–07 (1986).

[312] *See, e.g.*, *supra* note 28 and accompanying text.

[313] John C. Dernbach, *Reflections on Comparative Law, Environmental Law, and Sustainability*, 3 WIDENER L. SYMP. J. 279, 280, 282 (1998).

generated from solar and wind."[314] The grid works, not because intermittency is an easy problem to address, but because of "targeted measures, ranging from regulatory mandates to market-based incentives."[315] Government decision makers, grid operators, and entrepreneurs in those jurisdictions have found a variety of ways to manage the intermittent nature of solar and wind energy, including storage and new services for balancing supply and demand on the grid.[316]

Another example of an experience that could inform lawmaking in other jurisdictions is provided by Germany's ability to facilitate solar energy development despite its northern latitude; the region gets about as much sunlight as Alaska and half that of California.[317] Germany nonetheless is able to make up for that by making it easier for developers to finance, install, and get governmental approval for renewable facilities, and easier to supply their electricity to the grid.[318]

Finally, Germany's feed-in tariff is widely regarded as the cause of the admittedly high prices that German residential customers pay for their electricity.[319] Yet an analysis of those prices indicates that the tariff is responsible for only 21% of residential rates; that Germany's strong legal support for renewable energy led to a buildup of Chinese solar photovoltaic manufacturing capability, which in turn has driven down the price of renewable energy; and that German households consume about half as much electricity as their Californian counterparts.[320] As a result, German and Californian households pay about the same on an average monthly basis for electricity.[321] Because it appears that the original feed-in tariffs failed to anticipate and adjust to tumbling prices for solar panels and other hardware, Germany has steadily reduced the amount of subsequent tariffs.[322] Still, the original tariffs are locked in for twenty years.[323] Germany's experience thus provides a variety of lessons to U.S. lawmakers about the design and implementation of laws encouraging the use of renewable energy.

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314 Mormann et al., *supra* note 28, at 98.
315 *Id.*
316 *Id.* at 88–90.
317 *Id.* at 59.
318 *Id.* at 59, 84–86.
319 *See id.* at 92.
320 *Id.* at 92–97.
321 *Id.* at 95–96.
322 *Id.* at 93.
323 *Id.*

4. Coordinated Governance

A challenge faced by California and, perhaps to a greater degree, Germany, is how to get a variety of different levels of government working together in a coordinated way for the same objective. A basic problem in achieving decarbonization occurs when different levels of governance—international, national, state, regional, or local—give inconsistent or conflicting signals about what is desired or sought.[324] The basic idea of coordinated governance is an organizational framework in which all levels of government are working toward the same decarbonization objectives.[325] Without such coordinated governance, it will be much more difficult to accelerate the pace of decarbonization.

As their experiences indicate, California, Germany, and the United States all face challenges of coordinated governance. California has been able to address many of these issues through its national leadership position among states. In many cases, California's approaches have simply been adopted at the national level, or California has been allowed by federal law to adopt and implement more ambitious approaches.[326] For Germany, as its DDPP report indicates, the acceleration of its deep decarbonization effort depends on much closer levels of cooperation among all levels of government, including the EU.[327] In the United States, these issues are even more severe. There are wide disparities among states in their support for climate change; while many states are working to implement the Clean Power Plan, many others sued to invalidate it.[328] As the Trump administration begins an effort to roll back greenhouse gas mitigation regulations adopted during the Obama administration, states such as California and New York are threatening to stand in the way of that effort.[329]

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[324] *See, e.g.*, Jonathan D. Weiss, *Local Governance and Sustainability: Major Progress, Significant Challenges*, *in* AGENDA FOR A SUSTAINABLE AMERICA 43, 50–53 (John C. Dernbach ed., 2009).

[325] Coordinated governance can include hierarchical relationships among different levels of governance, shared or collaborative governance, or other forms of coordination or cooperation. *See* Jody Freeman & Daniel A. Farber, *Modular Environmental Regulation*, 54 DUKE L.J. 795 (2005).

[326] *See supra* note 27 and accompanying text.

[327] *See* text accompanying *supra* notes 209–215.

[328] Bobby Magill, *The Suit Against the Clean Power Plan, Explained*, CLIMATE CENT. (Apr. 12, 2016), http://www.climatecentral.org/news/the-suit-against-the-clean-power-plan-explained-20234 [https://perma.cc/K6BK-PQVM].

[329] Chelsea Harvey, *New York, California Lead State Efforts on Climate Change as Trump Retreats*, NEWSWEEK (Apr. 9, 2017), http://www.newsweek.com/new-york-california-state-efforts-climate-change-trump-retreats-580704 [https://perma.cc/2TFR-2S2Z].

These coordination issues suggest an allocation of decision-making and implementation responsibility that corresponds to the strengths of each level of government. For example, U.S. environmental protection laws are built on a model of cooperative federalism by which the federal government sets minimum standards and provides financial support for enforcement and administration of those standards, and states have the right to run programs in accordance with those standards.[330]

These lessons from California and Germany are just a starting point in capturing what the United States can learn from their decarbonization experience thus far. But, they are enough to demonstrate the considerable value of that experience. While it is essential to have all levels of government working for decarbonization, subnational governments may help backstop decarbonization efforts when there is a policy reversal at the national level.

CONCLUSION

The technical, economic, legal, and political challenges of deep decarbonization in the United States seems less daunting when one realizes that others are farther along than the United States and are still thriving. Both Germany and California have set, and are working toward, more ambitious and specific goals for reducing greenhouse gas emissions than those in place in the United States. Their laws are also more far-reaching than those in the United States. Lessons from the actual experiences of California and Germany provide a sound starting point for the further development of U.S. laws. If the United States wants to take an international lead in decarbonizing its economy, and reap the considerable benefits that would bring, it should build on what has already been learned.

These lessons fall into two groups. The first concerns enabling conditions and frames. Perhaps the most key enabling condition is widespread public support. Both California and Germany have significantly higher levels of public support for action on climate change than the United States. Because decarbonization requires not only public laws but also private actions, a high level of public support is needed for decarbonization.

Another enabling condition or frame is a sustainable development approach. Essentially, sustainable development provides a framework for addressing climate change that is

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[330] *See, e.g.*, Dernbach, *supra* note 311, at 904.

based on maximizing the economic, security, social, and environmental co-benefits of laws to address climate change. In so doing, it provides a basis for increasing public support for laws and proposed laws, and for finding opportunity at a time of significant risk. A final enabling condition, or frame, is long-term and sector-specific targets and timetables as well as implementation strategies. These targets and timetables provide a focal point for action as well as a way of measuring success and failure; they, too, can be used to mobilize public support.

The second group of lessons concerns law and governance. These include the value of laws as building blocks, which means that multiple laws are needed to achieve decarbonization; stand-alone silver bullets like a carbon tax are unlikely to succeed by themselves. Sequencing of laws over time is also an essential lesson; each of these jurisdictions, including the United States, has built its existing system of laws over decades, making changes as circumstances and apparent public need dictate. Another lesson is simply a reflection of domestic and international comparative law; the experience of individual jurisdictions provides a useful source of information for what works and what does not work. And a final lesson is the value of coordinated governance—making sure that all levels of governance in a jurisdiction are working toward the same decarbonization objectives with mutually reinforcing laws.

These lessons are not exhaustive. A more detailed examination of particular aspects of Germany's and California's experiences, respectively, would no doubt yield other lessons. Still, at a time of enormous risk and potentially enormous opportunity, these lessons shed some light on the legal pathways that are needed to decarbonize the U.S. economy. Whether the U.S. government is willing to heed these lessons, of course, remains to be seen.