BYU Law Review

Volume 2011 | Issue 6 Article 8

12-18-2011

Adaptive Mitigation in the Electric Power Sector

Lesley K. McAllister

Adaptive Mitigation in the Electric Power Sector

Lesley K. McAllister[*]

TABLE OF CONTENTS

* Professor of Law, University of San Diego School of Law; Associate Adjunct Professor, School of International Relations and Pacific Studies, University of California San Diego. For their helpful comments, the author thanks Dan Farber, Robin Craig, Lisa Grow Sun, Brigham Daniels, Michael Wara, Meg Caldwell, Debbie Sivas, and others who participated in presentations at Brigham Young University School of Law and Stanford Law School.

I. INTRODUCTION

The electric power sector and other sectors that are the primary producers of greenhouse gases are in a unique position with respect to climate change. Over the next several decades, these sectors are likely to face increasing pressure to adopt mitigation measures that reduce their greenhouse gas emissions.[1] In this process of transformation, an opportunity exists to adopt technologies and practices that not only further climate change mitigation but also climate change adaptation.

Climate change policy has given little attention to potential interactions between mitigation and adaptation. Both are now recognized as important types of responses to climate change, but discussions of mitigation and adaptation policy almost always occur separately. This Article suggests that, as a result, we are at risk of failing to adaptively mitigate. Adaptive mitigation involves evaluating mitigation options according to how they serve the needs of adaptation and adopting policy instruments that promote mitigation options that have adaptation benefits.

The electric power sector has been a primary focus of attention in discussions of climate change mitigation but not in discussions of climate change adaptation.[2] The sector is responsible for approximately one-third of the country's greenhouse gas emissions, and a wide variety of mitigation alternatives exist.[3] These mitigation alternatives vary widely in terms of attributes that are relevant to adaptation, namely, their reliance on water resources that are likely to become scarcer with climate change, their vulnerability to climate-

1. The major economic sectors responsible for greenhouse gas emissions in the United States are electric power, transportation, industry, agriculture, commercial, and residential. ENVTL. PROT. AGENCY, INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990–2009 ES-14–ES-15 (2011), *available at* http://epa.gov/climatechange/emissions/downloads11/US-GHG-Inventory-2011-Complete_Report.pdf.

2. *See, e.g.*, JANE EBINGER & WALTER VERGARA, THE WORLD BANK, CLIMATE IMPACTS ON ENERGY SYSTEMS: KEY ISSUES FOR ENERGY SECTOR ADAPTATION, at xv (2011), *available at* http://tinyurl.com/cfsu6ne (stating that mitigation has been a "key focus of the energy sector" and that the "energy sector is under-represented in both peer-reviewed literature on adaptation and in related investment and action").

3. *Id.*; *see also* GRANGER MORGAN ET AL., THE U.S. ELECTRIC POWER SECTOR AND CLIMATE CHANGE MITIGATION 23 (2005), *available at* http://www.pewclimate.org/docUploads/Electricity_Final.pdf (explaining the variety of mitigation measures available in the sector).

change related disasters, and their environmental impacts aside from climate change.

Part II explains the disjuncture between mitigation and adaptation policy and the need for greater integration. Part III analyzes the possibilities for synergies between mitigation and adaptation in the electric power sector. The analysis shows that several mitigation options, particularly energy efficiency and some renewable energy technologies, have a wide variety of adaptation benefits. Part IV recommends policies to promote adaptive mitigation. Such policies would ensure that information about climate change impacts is disseminated, that project review considers adaptation, and that planning integrates mitigation and adaptation.

II. MITIGATION AND ADAPTATION

Mitigation and adaptation are both types of responses to climate change. Mitigation focuses on how to decrease the emissions of greenhouse gases and lower their concentrations in the atmosphere.[4] Adaptation focuses on how human and natural systems can adjust to a climate-changed world.[5] Both seek to moderate the severity of climate change—mitigation by reducing how much the climate changes, and adaptation by reducing how much harm is suffered because of climate change. Even though there are many important linkages between mitigation and adaptation, climate change policy has often treated them separately.[6] The first section below explains this disjuncture, and the second argues for greater integration.

4. Robin Kundis Craig, "*Stationarity Is Dead"—Long Live Transformation: Five Principles for Climate Change Adaptation Law*, 34 HARV. ENVTL. L. REV. 9, 18–19 (2010); *see also* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: IMPACTS, ADAPTATION, AND VULNERABILITY: CONTRIBUTION OF WORKING GROUP II TO THE FOURTH ASSESSMENT REPORT OF THE IPCC app. 1, at 878 (2007) [hereinafter IPCC] (defining mitigation as "[a]n *anthropogenic* intervention to reduce the anthropogenic forcing of the *climate system*; it includes strategies to reduce *greenhouse gas sources* and emissions and enhancing *greenhouse gas sinks*").

5. IPCC, *supra* note 4, app. 1, at 869 (defining adaptation as the "[a]djustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities").

6. Richard J.T. Klein et al., *Inter-Relationships Between Adaptation and Mitigation*, *in* IPCC, *supra* note 4, at 745, 748 (Research on adaptation and mitigation has been rather unconnected to date, involving largely different communities of scholars who take different approaches to analyse [sic] the two responses."); Darryn McEvoy et al., *Adaptation and Mitigation in Urban Areas: Synergies and Conflicts*, 159 MUN. ENGINEER 185–90 (2006) (Issue ME4).

A. The Disjuncture Between Mitigation and Adaptation

For a wide variety of reasons, mitigation and adaptation have often occupied different policy spaces and proceeded along different policy paths. Overall, mitigation has received much more attention than adaptation. In early policy discussions, climate change policy advocates viewed mitigation as a superior response to adaptation and hoped that adaptation could be avoided with proper attention to mitigation.[7] More recently, with the understanding that climate change is occurring and will continue regardless of mitigation activities, adaptation has been acknowledged as a critical area for policy development.[8] Yet mitigation has remained the priority.[9] When political jurisdictions have acted in response to climate change, they have most often developed policies to mitigate.[10]

Even as adaptation has garnered more attention, adaptation policy has remained disjointed from mitigation policy. One source of separate treatment is that policy communities that are focused on different areas of the world tend to emphasize either mitigation or adaptation. Mitigation has been viewed as the primary concern of developed countries given their high levels of emissions.[11] Adaptation, in turn, has often been viewed as an issue of primary interest to developing countries.[12] Predictions of climate change

7. J.B. Ruhl, *Climate Change Adaptation and the Structural Transformation of Environmental Law*, 40 ENVTL. L. 363, 365–68 (2010); *see also* Stephane Hallegatte et al., *Designing Climate Change Adaptation Policies: An Economic Framework* 3 (The World Bank, Working Paper No. 5568, 2011) ("[Adaptation] is perceived by some stakeholders as a less valid solution because it focuses on the consequences of climate change and not on its causes, and even as a dangerous solution since it could stand in the way of the discussion on mitigation.").

8. *See, e.g.*, Craig, *supra* note 4, at 24 ("[T]he world is probably already committed to a 2°C increase in average global temperature."); Ruhl, *supra* note 7, at 370–71.

9. McEvoy et al., *supra* note 6, at 185 ("Although mitigation continues to be the prime focus of policymakers . . . , the mid to late 1990s witnessed a shift in emphasis, with the international scientific community becoming increasingly concerned about the risks associated with a changing climate . . . .").

10. Craig, *supra* note 4, at 19–20 ("Almost all of the climate change legislation and programs that the states, regional organizations, and Congress have been considering or implementing are mitigation measures . . . .").

11. *E.g.*, Jessica M. Ayers & Saleemul Huq, *The Value of Linking Mitigation and Adaptation: A Case Study of Bangladesh*, 43 ENVTL. MGMT. 753, 757 (2008).

12. *Id.*; *see, e.g.*, Daniel Cole, *Climate Change, Adaptation, and Development*, 26 UCLA J. ENVTL. L. & POL'Y 1–2 (2008); *see also* Orr Karassin, *Mind the Gap: Knowledge and Need in Regulating Adaptation to Climate Change*, 22 GEO. INT'L ENVTL. L. REV. 383, 386 ("[G]lobal attention has focused on adaptation needs in developing countries . . . .").

impacts suggest that some of the most extreme changes will be felt in the tropical latitudes where many developing countries lie, and the vulnerability of developing countries may be heightened by their lack of political and economic resources.[13]

Another source of disjuncture is that the benefits of mitigation policy are considered to be global and long-term while the benefits of adaptation are often viewed as more localized and immediate.[14] Reducing emissions has the global benefit of limiting the buildup of greenhouse gases in the atmosphere. The benefit is long-term because of the long time lags between emissions and their climate forcing effects. The benefits of adaptation, in contrast, seem to remain to a greater degree where the adaptation occurs and may even reduce risk immediately.[15] For example, a community that builds seawalls is less likely to be damaged by a storm surge, and a fire-prone region that improves its communication system can evacuate residents more quickly. Due to these differences, many view mitigation as an issue of national and international interest while viewing adaptation as an issue for localities and other subnational regions.[16]

Scientific uncertainty may be a greater problem for adaptation policy than mitigation policy. Many jurisdictions have made substantial progress in mitigation policy despite claims of scientific uncertainty. Policymakers are aided by the fact that sources of greenhouse gases are well characterized and emissions reductions associated with policy actions are relatively easy to predict. Scientific uncertainty may endure as a problem for adaptation, however, because climate change impacts will remain difficult to predict, particularly at the local and regional levels that may be most directly

13. UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC), CLIMATE CHANGE: IMPACTS, VULNERABILITIES AND ADAPTATION IN DEVELOPING COUNTRIES 5 (2007), *available at* http://unfccc.int/resource/docs/publications/impacts.pdf.

14. FEDERICA CIMATO & MICHAEL MULLAN, DEP'T FOR ENV'T FOOD & RURAL AFFAIRS, ADAPTING TO CLIMATE CHANGE: ANALYSING THE ROLE OF GOVERNMENT 7 (2010), *available at* http://tinyurl.com/3gwyq3u; Klein et al., *supra* note 6, at 747 (explaining that mitigation has been considered most from a global perspective and adaptation has been considered most from a local or regional perspective).

15. McEvoy et al., *supra* note 6, at 187 (describing a mismatch in spatial scale).

16. Klein et al., *supra* note 6, at 747 (explaining that mitigation is driven by international agreements and national law, while adaptation involves private actions of affected entities).

relevant to adaptation.[17] As Professor Craig stated, "Climate change impacts operate on complex ecosystems and set in motion feedback loops and nonlinear changes, neither of which are entirely (or even mostly) predictable through existing knowledge and modeling."[18]

Differences are also evident in the overall goals of mitigation and adaptation policy. The goal of mitigation policy is easily quantified.[19] Mitigation policy seeks to reduce greenhouse gas emissions, generally measured in tons of CO2-equivalent. Its ultimate goal is to stabilize the concentration of greenhouse gases in the atmosphere, which is also readily measurable. In contrast, the metrics for measuring success in adaptation are not as clear. Indeed, success in adaptation will be hard to measure because it manifests itself as avoided harm—avoided deaths, avoided species extinctions, and avoided property damage.[20]

Finally, mitigation and adaptation policies have traditionally targeted different actors. Mitigation policy targets the sectors that produce greenhouse gas emissions such as the electric power sector, the transportation sector, and forestry operations.[21] The targets of adaptation policy, in contrast, have been the actors and environments that are perceived to be most sensitive to climate impacts and responsible for managing them, such as coastal property owners, public lands managers, and regional planners.[22]

B. Integrating Mitigation and Adaptation

Many of the motivations and rationales for separating mitigation and adaptation break down under closer inspection.[23] It is now clear that both adaptation and mitigation will have to take place at a large scale, and serious policy debate about adaptation seems likely to spur

17. Hallegatte et al., *supra* note 7, at 5–6 (explaining that adapting to a 4°C change in average global temperature is much different from a 2°C change and that climate models diverge in their predictions about local impacts).

18. Craig, *supra* note 4, at 26.

19. *See* Cimato & Mullan, *supra* note 14, at 7.

20. Matthias Ruth, *Managing Regional Climate Mitigation and Adaptation Co-benefits and Co-costs*, *in* RESILIENT CITIES: CITIES AND ADAPTATION TO CLIMATE CHANGE—PROCEEDINGS OF THE GLOBAL FORUM 2010, at 207 (2011) ("[M]itigation measures have clearly measureable outcomes . . . , while it is considerably more difficult to assess the value of damages avoided by adaptation.").

21. *See* McEvoy et al., *supra* note 6, at 188.

22. *See id.*

23. *Cf.* Ayers & Huq, *supra* note 11.

rather than hinder mitigation policy. As stated by one commentator, "Many communities have concluded that rather than discouraging a commitment to mitigation, calling attention to adaptation can actually inspire a greater commitment to mitigation as the specter of future consequences is highlighted."[24]

Also, adaptation will require significant policy initiatives in developed as well as developing countries. In many respects, the effects of climate change on temperate zones may be as significant and disruptive as effects in tropical zones.[25] In the United States, agricultural lands that are currently very productive are vulnerable to drought, and the extensive built environment on the coasts is subject to sea-level rise. Moreover, to the extent that adaptation planning occurs in developed countries with greater political and economic resources, important lessons may be learned about adaptation that can be transferred to countries with fewer resources.[26]

The assertion that mitigation is a global issue while adaptation is a local issue is also problematic. Adaptation has many dimensions that will require international and national governance, and mitigation has many dimensions that will require local and subnational governance. Adaptation is not just about building sea walls and improving local communication systems but is also about providing for climate refugees and dealing with changes in agricultural production and trade.[27] Many mitigation policy decisions, in turn, will be local and regional as changes in land use, transportation, and energy infrastructure are required.[28] Both mitigation and adaptation policy are necessarily multi-scalar and cannot be committed to a single level of government. The critical

24. Edna Sussman, *Case Study: Climate Change Adaptation Planning Guidance for Local Governments in the United States*, SUSTAINABLE DEV. L. & POL'Y, Winter 2009, at 31 (Winter 2009) (citing A.K. SNOVER ET AL., CTR. FOR SCI. IN THE EARTH SYS., PREPARING FOR CLIMATE CHANGE: GUIDEBOOK FOR LOCAL REGIONAL AND STATE GOVERNMENT (2007)).

25. FRÉDÉRIC GAGNON-LEBRUN & SHARDUL AGRAWALA, ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD), PROGRESS ON ADAPTATION TO CLIMATE CHANGE IN DEVELOPED COUNTRIES: AN ANALYSIS OF BROAD TRENDS 11 (May 2006), *available at* http://www.oecd.org/dataoecd/49/18/37178873.pdf.

26. *Id.*

27. *Cf.* Ayers & Huq, *supra* note 11, at 5. (stating that adaptation may also have global benefits where it reduces threats to biodiversity and natural systems).

28. *Cf.* Katherine A. Trisolini, *All Hands on Deck: Local Governments and the Potential for Bidirectional Climate Change Regulation*, 62 STAN. L. REV. 669 (2010) (explaining that federal legislation will not eliminate the need for regulation at the local level).

questions involve how to divide the authority of various levels of government and how to coordinate their actions.[29]

Uncertainty will be a serious problem in both mitigation and adaptation policy. But the most intractable uncertainty is not likely to regard whether climate change is anthropogenic or even how it will manifest at the local and regional levels. Rather it may regard the sufficiency of mitigation and adaptation efforts in light of the risk of nonlinear changes in climate. There are clear risks of tipping points, feedback loops, and other nonlinear change, but significant uncertainty exists about the magnitude of these risks.[30] Because greenhouse gas emissions have long-term, climate-forcing effects and because ecosystems are complex, it will be difficult to know how effective even substantial emissions reductions will be in restoring climate stability. This type of uncertainty seems likely to ultimately overshadow the uncertainties that are currently considered most problematic for mitigation and adaptation policy.

While the goals of mitigation and adaptation policy and the sectors they target are different in some ways, the ultimate concern of both is the same: how should society respond to climate change? Mitigation and adaptation have often been viewed as substitutes that compete for the same climate change response resources.[31] However, there are limits to trading off mitigation for adaptation. As the Intergovernmental Panel on Climate Change (IPCC) has stated, "[W]ithout mitigation, a magnitude of climate change is likely to be reached that makes adaptation impossible for some natural systems, while for most human systems it would involve very high social and economic costs."[32] Mitigation and adaptation should be viewed as complementary rather than competing strategies: mitigation efforts are necessary to keep climate change impacts to a moderate level, which in turn enables adaptation efforts to handle a larger share of the impacts.[33]

29. *See, e.g.*, Daniel A. Farber, *Climate Adaptation and Federalism: Mapping the Issues*, 1 SAN DIEGO J. CLIMATE & ENERGY L. 259, 260 (2009); Robert L. Glicksman, *Climate Change Adaptation: A Collective Action Perspective on Federalism Considerations*, 40 ENVTL. L. 1159, 1163 (2010).

30. Martin L. Weitzman, *Fat-Tailed Uncertainty in the Economics of Catastrophic Climate Change,* 5 REVIEW OF ENVTL. ECON. & POL'Y 275 (2011).

31. *See* Ayers & Huq, *supra* note 11, at 6.

32. Klein et al., *supra* note 6, at 747.

33. *See* Thomas J. Wilbanks et al., *Possible Responses to Climate Change: Integrating Mitigation and Adaptation*, 45 ENV'T 29, 34 (2003).

This call for integration of mitigation policy and adaptation policy is not intended to deny that there are situations in which it is best to consider mitigation and adaptation separately. Instead, it is meant to suggest that there are many situations in which mitigation and adaptation should be considered together. Because of the separation between mitigation and adaptation policy, relatively little attention has been given to possible synergies and conflicts.[34] In its 2007 report, the IPCC, for the first time, included a chapter dedicated to the relationship between mitigation and adaptation.[35] The report identified a need for "well-documented studies at the regional and sectoral level[s]" and urged the development of "[a]n analytical and institutional framework for monitoring the inter-relationships."[36]

One important way that mitigation and adaptation relate is that mitigation actions have consequences for adaptation.[37] As Professor Farber has recognized, "[T]he same action can both mitigate future climate change and assist adaptation to impending climate change."[38] In this case, there would be a synergy between mitigation and adaptation: an adaptation benefit would be provided by the mitigation. Alternatively, an action that mitigates climate change might work against, or conflict with, adaptation, and an adaptation cost may ultimately be incurred because of the mitigation action. An approach of adaptive mitigation recognizes the possibility of adaptation benefits and costs and seeks to design policy to ensure that they are identified and considered in mitigation policy decisions.[39]

III. ADAPTIVE MITIGATION: EXAMPLES FROM THE ELECTRIC POWER SECTOR

Not all mitigation alternatives are equal in terms of adapting to climate change. If a particular mitigation approach also contributes

34. *See* McEvoy et al., *supra* note 6, at 186.

35. Klein et al., *supra* note 6.

36. *Id*. at 770; *see also* Ruth, *supra* note 20, at 205.

37. Klein et al., *supra* note 6, at 747 (identifying four types of inter-relationships).

38. Farber, *supra* note 29, at 260.

39. This Article analyzes adaptive (and maladaptive) mitigation, with a focus on the adaptation benefits and costs of mitigation actions. Another approach to understanding the synergies between mitigation and adaptation would be to analyze mitigative (and malmitigative) adaptation, focusing on the mitigation benefits and costs of adaptation actions.

to adaptation, it can be considered adaptive mitigation. Adaptive mitigation not only reduces greenhouse gas emissions but also reduces vulnerability and enhances resilience, which are key terms in adaptation policy.[40] Vulnerability has been defined as the "degree to which a system is susceptible, or unable to cope with, adverse effects of climate change, including climate variability and extremes."[41] Resilience, in contrast, refers to "a system's ability to absorb impacts and continue to function."[42] Resilience is often used synonymously with adaptive capacity, which has been defined as the "[a]bility of a . . . system to adjust to climate change . . . moderate potential damages; take advantage of opportunities; or cope with the consequences."[43] Mitigation that is maladaptive, in contrast, achieves emissions reductions, but also "constrain[s] the options or ability of other decision makers now or in the future to manage the impacts of climate change." Maladaptive mitigation, in other words, increases vulnerability and reduces resilience.[44]

There is a unique opportunity to combine considerations of mitigation and adaptation in the sectors that are most important for mitigation. This section of the Article focuses on the electric power sector, but similar opportunities for adaptive mitigation may exist in the transportation, agricultural, and forestry sectors. The first part below shows how the electric power sector both causes and is

40. COUNCIL ON ENVTL. QUALITY (CEQ), PROGRESS REPORT OF THE INTERAGENCY CLIMATE CHANGE ADAPTATION TASK FORCE: RECOMMENDED ACTIONS IN SUPPORT OF A NATIONAL CLIMATE CHANGE ADAPTATION STRATEGY 15 (2010) [hereinafter CEQ] (defining key terms in text box); Craig, *supra* note 4, at 21–22.

41. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, THIRD ASSESSMENT REPORT, CLIMATE CHANGE 2001: IMPACTS, ADAPTATION & VULNERABILITY 881 (2001); *see also* Ira R. Feldman & Joshua H. Kahan, *Preparing for the Day After Tomorrow: Frameworks for Climate Change Adaptation*, 8 SUSTAINABLE DEV. L. & POL'Y 61, 62 (2007) ("Vulnerability is a central concept for climate change adaptation policy and planning, and can be seen as the connecting thread . . . .").

42. Craig, *supra* note 4, at 22; *see also* CEQ, *supra* note 40, at 15; NAT'L RESEARCH COUNCIL, AMERICA'S CLIMATE CHOICES: PANEL ON ADAPTING TO THE IMPACTS OF CLIMATE CHANGE 19 (2011) (defining resilience as "[a] capability to anticipate, prepare for, respond to, and recover from significant multi-hazard threats with minimum damage to social well-being, the economy, and the environment").

43. CEQ, *supra* note 40, at 869; *see also Adaptation Guidance Notes—Key Words and Definitions*, WORLD BANK, http://climatechange.worldbank.org/climatechange/content/adaptation-guidance-notes-key-words-and-definitions (stating that resilience is a synonym of adaptive capacity when talking about human systems) (last visited Oct. 13, 2011).

44. EBINGER & VERGARA, *supra* note 2, at 90 (providing a definition of maladaptation); *see also* Karassin, *supra* note 12, at 389 n.31 (stating that maladaptation "describes the extent to which adaptation fails or has been conducted in an unsustainable manner").

affected by climate change. The second part analyzes the potential for adaptive mitigation in the electric power sector by identifying three types of adaptation benefits that mitigation alternatives provide to different degrees, namely, water conservation, resistance to extreme events, and low environmental impact.[45]

A. Electric Power and Climate Change

Responsible for a large amount of greenhouse gas emissions, the U.S. electric power sector has been at the center of attention in climate change mitigation policy. Less emphasized is the extent to which the sector is vulnerable to the impacts of climate change.[46] Given the importance of electricity in the economy, the sector's vulnerabilities should be recognized and reduced even as its greenhouse gas emissions are mitigated.

Electricity generation by the electric power sector accounted for 33% of U.S. greenhouse gas emissions in 2009, more than the transportation sector (27%) and the industrial sector (20%).[47] About 71% of electricity in the United States is generated from fossil-fuel based energy sources, primarily coal and natural gas. Another 20% comes from nuclear energy, 6% from hydroelectric, and 3% from renewable energy sources including wind, solar, and biomass.[48] The residential and commercial sectors each consume a bit more than a third of electricity produced, while the industrial sector consumes just over a quarter.[49]

Technological alternatives for mitigating emissions from the electric power sector fall into three categories. One category involves switching away from fuels that produce more greenhouse gases toward fuels that produce fewer or none. Coal-fired power plants emit about twice the amount of greenhouse gases as natural gas-fired

45. An extreme weather event has been defined by the IPCC as "[a]n event that is rare at a particular place and time of year." IPCC, CLIMATE CHANGE 2007: SYNTHESIS REPORT, ANNEXES GLOSSARY E-I (2007), *available at* http://www.ipcc.ch/publications_and_data/ar4/syr/en/annexessglossary-e-i.html.

46. THOMAS J. WILBANKS ET AL., EFFECTS OF CLIMATE CHANGE ON ENERGY PRODUCTION AND USE IN THE UNITED STATES, at iv (2008) (stating that the impacts on the energy sector from climate change have been understudied).

47. ENVTL. PROT. AGENCY, *supra* note 1, at ES-15.

48. NAT'L RESEARCH COUNCIL (NRC), HIDDEN COSTS OF ENERGY: UNPRICED CONSEQUENCES OF ENERGY PRODUCTION AND USE 65 (2010), *available at* http://www.nap.edu/catalog.php?record_id=12794.

49. *Id.* at 64.

power plants.[50] Facilities that generate electricity from nuclear, solar, and wind energy produce no greenhouse gas emissions. Electricity generation from biomass is carbon-neutral if new biomass is grown to replace the combusted biomass.[51]

A second category includes energy efficiency and conservation measures. Energy efficiency involves the use of technology to prevent the waste of energy, while energy conservation involves behavioral change that reduces the unnecessary use of energy.[52] The efficiency of electricity production can be increased, for example, by employing a combined cycle in thermal electricity generation in which the exhaust of one heat engine is used as the heat source for another.[53] Efficiency in electricity consumption may be improved through the use of more efficient appliances and better insulation. Conservation is achieved when building occupants turn off lights or use appliances less frequently.

A final mitigation option in the sector is to capture and store carbon from electricity generation facilities. However, unlike the approaches mentioned above, this is an end-of-the-pipe solution that does not actually reduce emissions, but rather collects and disposes them underground instead of in the atmosphere. The feasibility of large-scale carbon capture and storage has not been demonstrated.[54]

Although mitigation has received most attention, the electric power sector is also an extremely important sector to consider for adaptation. Importantly, the electricity sector is significantly vulnerable to climate variability. Adaptation policy for the electricity sector should ensure that the sector can reliably supply electricity under conditions of climate change.

In its report on how climate change will affect the energy sector, the U.S. Climate Change Science Program identified three types of

50. MORGAN ET AL., *supra* note 3, at 36.

51. *Id.* at 36–37.

52. KAREN EHRHARDT-MARTINEZ & JOHN A. "SKIP" LAITNER, AM. COUNCIL FOR AN ENERGY-EFFICIENT ECONOMY, THE SIZE OF THE U.S. ENERGY EFFICIENCY MARKET: GENERATING A MORE COMPLETE PICTURE 2–3 (2008).

53. U.S. DEP'T OF ENERGY (DOE), ENERGY DEMANDS ON WATER RESOURCES 66 (2006) ("The highest-efficiency, fossil-based electricity-generating technologies employ combined-cycle technology.").

54. *See, e.g.*, U.S. GOV'T ACCOUNTABILITY OFFICE, GAO-08-1080, CLIMATE CHANGE: FEDERAL ACTIONS WILL GREATLY AFFECT THE VIABILITY OF CARBON CAPTURE AND STORAGE AS A KEY MITIGATION OPTION 2–3 (2008), *available at* http://www.gao.gov/new.items/d081080.pdf.

impacts: impacts on energy consumption, impacts on energy production and supply, and indirect impacts on consumption and production.[55] With respect to energy consumption, the report found that climate warming will lead to greater demand for electricity, which is used in providing almost all cooling services.[56] Increased demand would come not just from more cooling of buildings, but also from greater industrial cooling, such as that related to food production and storage.[57]

Energy production and supply may be affected by climate change in a wide variety of ways.[58] Extreme weather events, which may increase in frequency or intensity, could affect generating facilities and transmission lines.[59] Generating facilities that rely on water supplies may be impacted by drought or other changes in precipitation patterns. Temperature increases would decrease the efficiency of electricity production and distribution. Also, a "significant fraction" of the U.S. energy infrastructure is coastal and would be threatened by sea-level rise and coastal erosion.[60]

Moreover, climate change could have an impact on the supply of fuel for electricity generation. In the case of hydropower, wind power, and solar power, particular climate conditions essentially serve as the necessary fuel.[61] While nuclear and fossil fuel power plants do not depend on climate so directly, the mining and transportation of their fuels could be affected by extreme weather events and water

55. WILBANKS ET AL., *supra* note 46, at 1–2.

56. *Id.* at 1. *See also* GLOBAL CLIMATE CHANGE IMPACTS IN THE UNITED STATES 53 (Thomas R. Karl et al. eds., 2009) (stating that increases in demand for cooling energy "will result in significant increases in electricity use and higher peak demand in most regions").

57. *See* EBINGER & VERGARA, *supra* note 2, at 41.

58. WILBANKS ET AL., *supra* note 46, at 1.

59. *See id.* at 38; *see also* Chris Baltimore, *Texas Weathers Rolling Blackouts as Mercury Drops*, REUTERS, Feb. 2, 2011, http://www.reuters.com/article/2011/02/02/us-ercot-rollingblackots-idUSTRE7116ZH20110202 (describing how extreme cold weather in Texas led to blackouts in the winter of 2011).

60. GLOBAL CLIMATE CHANGE IMPACTS IN THE UNITED STATES, *supra* note 56, at 57; EBINGER & VERGARA, *supra* note 2, at 41.

61. EBINGER & VERGARA, *supra* note 2, at 30–33.

scarcity.[62] Offshore oil and gas infrastructure is particularly vulnerable to extreme events such as hurricanes.[63]

Finally, the report recognized that climate change may indirectly shape energy consumption and production. First, policies created to mitigate greenhouse gas emissions from the electricity sector, such as those suggested above, would lead to changes in energy prices, energy planning, energy technology development and deployment, and the institutional structure of energy production.[64] Also, climate change may affect regional economic development, international trade, and energy security in ways that impact energy supply and demand.[65]

A significant consideration in both mitigation and adaptation in the energy sector is the "long-lived infrastructure [of energy] and associated consumption patterns."[66] Many types of energy infrastructure change over a timescale of decades. Fossil-fuel power plants constructed today have expected lifetimes of fifteen to forty years, and transmission lines are replaced on average every forty to seventy-five years.[67] In terms of mitigation, these long lifetimes present barriers in transitioning to low-carbon energy sources. In terms of adaptation, long-lifespan energy infrastructure may be especially vulnerable to climate change, particularly if climate change impacts were not considered in its design.

B. Mitigation that Reduces Vulnerability and Enhances Resilience

Some mitigation alternatives in the electric power sector are likely to have synergies with adaptation in the sense that they reduce the vulnerability of the sector and enhance its resilience. Stated

62. *Id.* at 35–36; *see, e.g.*, Alexander Wilson, *Argentine Water in Demand Amid Gold, Oil, Gas Rush*, CHRON.COM, Sept. 30, 2011, http://www.chron.com/business/article/Argentine-water-in-demand-amid-gold-oil-gas-rush-2197682.php (reporting that freshwater scarcity may limit the exploitation of shale oil resources in Argentina).

63. EBINGER & VERGARA, *supra* note 2, at 41; GLOBAL CLIMATE CHANGE IMPACTS IN THE UNITED STATES, *supra* note 56, at 53.

64. WILBANKS ET AL., *supra* note 46, at 49–56.

65. *Id.* at 53–55; *see also* EBINGER & VERGARA, *supra* note 2, at xxxi (explaining that energy demand is influenced by factors such as economic growth, which "are or will be themselves influenced by climate and climate change . . . independent of any immediate concerns of the energy sector").

66. EBINGER & VERGARA, *supra* note 2, at xvi.

67. *Id.* at xxi.

differently, some mitigation alternatives have adaptation benefits. [68] They provide benefits not only through reducing greenhouse gas emissions but also through contributing to adaptation. This section identifies three types of adaptation benefits and analyzes the extent to which certain mitigation strategies in the electric power sector are likely to provide them.

1. Conservation of water resources

An adaptation benefit is provided when chosen mitigation alternatives do not rely on resources that are likely to become less available with climate change. Most notably, in several areas of the United States, water resources are likely to become scarcer and more stressed. Mitigation alternatives that avoid relying on water resources in these areas have the potential to decrease the vulnerability of the electric power sector and enhance its resilience.

As explained in a 2009 report by the U.S. Global Change Research Program, climate change is expected to affect "where, when and how much water is available."[69] Dry areas such as the Southwest are expected to become drier, while wet areas like the Northeast are expected to become wetter.[70] Floods and droughts are likely to become more common and more intense as precipitation patterns change.[71] Particularly in the West, water resources are expected to become more stressed. Many areas in the West "are already at risk for serious conflict over water, even in the absence of climate change."[72]

In the past several years, the extensive linkages between energy and water have been recognized and referred to as the energy-water nexus.[73] The Energy Policy Act of 2005 directed the Department of Energy (DOE) to carry out a research program to "address water-related issues associated with the provision of adequate supplies,

68. Ruth, *supra* note 20, at 205.

69. GLOBAL CLIMATE CHANGE IMPACTS IN THE UNITED STATES, *supra* note 56, at 41.

70. *Id.* at 42.

71. *Id.* at 44.

72. *Id.* at 47.

73. *See*, *e.g.*, Brent Barker, *Running Dry at the Power Plant,* EPRI J., Summer 2007, at 26–35; H. David Gold & Jason Bass, *The Energy-Water Nexus: Socioeconomic Considerations and Suggested Legal Reforms in the Southwest*, 50 NAT. RESOURCES J. 563, 564 (2010); Benjamin K. Sovacool, *Running on Empty: The Electricity-Water Nexus and the U.S. Electric Utility Sector*, 30 ENERGY L. J. 11 (2009).

optimal management, and efficient use of energy."[74] The resulting report about energy demands on water resources found that the "lack of integrated energy and water planning and management has already impacted energy production in many basins and regions across the country."[75]

The U.S. electric power sector is deeply reliant on the availability of water. Most obviously, hydroelectric facilities depend on a suitable water supply. Hydropower has been said to be the energy source likely to be most directly affected by climate change because of its sensitivity to "the amount, timing and geographical pattern of precipitation and temperature."[76] During Europe's 2003 heat wave and drought, for example, hydropower generation capacity in France was reduced by about 20%.[77] Although running water through turbines to produce electricity does not technically consume water, large amounts of water may be consumed through evaporation from the surface of a dam.[78] For example, Arizona's Lake Powell has been calculated to lose an average of 590,000 acre-feet of water to evaporation annually, just shy of the annual water use of the city of Los Angeles.[79]

Thermal power plants, which produce about 90% of electricity in the United States, also often depend on the availability of large quantities of water for cooling.[80] Presently, many of these thermal power plants are coal-fired and emit large amount of greenhouse

74. *See* Pub. L. No. 109-58, § 979(a)(2), 119 Stat. 905 (2005) (codified at 42 U.S.C. § 16319(a)(2) (2000)).

75. DOE, *supra* note 53, at 11.

76. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, *supra* note 41, at 399.

77. ELEC. POWER RESEARCH INST. (EPRI), PROGRAM ON TECHNOLOGY INNOVATION: AN ENERGY/WATER SUSTAINABILITY RESEARCH PROGRAM FOR THE ELECTRIC POWER INDUSTRY 2–7 (2007); *see also* CAL. NATURAL RES. AGENCY, 2009 CALIFORNIA CLIMATE ADAPTATION STRATEGY 122 (2009) ("Potential reductions on precipitation levels could significantly reduce hydropower production which currently accounts for up to 20 percent of the state's electricity supply.").

78. P. TORCELLINI ET AL., NAT'L RENEWABLE ENERGY LAB., NREL/TP-550-33905, CONSUMPTIVE WATER USE FOR U.S. POWER PRODUCTION 1 (2003), *available at* http://www.nrel.gov/docs/fy04osti/33905.pdf.

79. *See* Dave Wegner, *A Report on Evaporation and Groundwater Seepage*, GLEN CANYON INST., http://www.glencanyon.org/publications/hiddenpassage/hp4evaprept.php (stating that annual losses due to evaporation are 590,000 acre-feet per year) (last visited Oct. 27, 2011); MAYOR ANTONIO R. VILLARAIGOSA, L.A. DEP'T OF WATER AND POWER, SECURING L.A.'S WATER SUPPLY 4, fig.1 (May 2008), *available at* http://tinyurl.com/8xdcors (showing water use in 2005 to be just over 600,000 acre-feet).

80. VILLARAIGOSA, *supra* note 79, at 1–2.

gases.[81] Several mitigation alternatives, including natural gas power plants, nuclear energy power plants, concentrated solar power plants, and biomass power plants would also utilize thermal power generation technology. While these types of power plants would emit fewer greenhouse gases, they may require as much or more water for cooling.

The water required for cooling in thermal power plants depends on whether the cooling system uses once-through cooling, wet-recirculating cooling, or dry cooling. Many older power plants have once-through cooling systems, in which very large amounts of water are withdrawn from the environment and then returned at a warmer temperature. In 2005, thermoelectric power plants in the United States accounted for about 40% of all freshwater withdrawals.[82] Most of this water is returned to the environment after it is used for cooling, but harm to aquatic organisms may occur both when water is taken in by the plant and when it is discharged at higher temperatures.[83] Many newer thermal power plants use wet-recirculating cooling, which requires the withdrawal of only one-tenth to one-hundredth the amount of water, but actually consumes about twice as much per unit of electricity produced.[84] Dry cooling systems use air rather than water for cooling. Currently, about 43% of thermoelectric plants in the United States use once-through cooling, 56% use wet recirculating cooling, and 1% use dry cooling.[85] The adoption of dry cooling systems has been limited because they have the highest capital costs and are the least efficient of the three.[86]

81. *Id.* at 3.

82. JOAN F. KENNY ET AL., U.S. GEOLOGICAL SURVEY, ESTIMATED USE OF WATER IN THE UNITED STATES IN 2005, at 1 (2009), *available at* http://pubs.usgs.gov/circ/1344/; EPRI, *supra* note 77, at 2-2, tbl. 2-1.

83. See EPRI, *supra* note 77, at 1-1 (noting that thermal power plants only account for about 3% of freshwater consumption, as compared to about 40% of freshwater withdrawals).

84. JORDAN MACKNICK ET AL., NAT'L RENEWABLE ENERGY LAB., A REVIEW OF OPERATIONAL WATER CONSUMPTION AND WITHDRAWAL FACTORS FOR ELECTRICITY GENERATING TECHNOLOGIES iv (March 2011), *available at* http://www.nrel.gov/docs/fy11osti/50900.pdf.

85. U.S. DEP'T OF ENERGY (DOE), NAT'L ENERGY TECH. LAB. (NETL), ESTIMATING FRESHWATER NEEDS TO MEET FUTURE THERMOELECTRIC GENERATION REQUIREMENTS 13 (2008), *available at* http://www.netl.doe.gov/technologies/coalpower/ewr/pubs/2008_Water_Needs_Analysis-Final_10-2-2008.pdf (explaining in the text above that cooling ponds are a type of wet-recirculating cooling).

86. Thomas J. Feeley & Barbara Carney, *Innovative Approaches and Technologies for Improved Power Plant Water Management*, NETL PROGRAM FACTS (2005), *available at* http://www.netl.doe.gov/publications/factsheets/program/Prog055.pdf; *see also* Barker,

The cooling needs of thermal power plants become greater and more difficult to satisfy when air and water temperatures are higher. Dry cooling has a "hot weather penalty" because cooling efficiency is reduced when air temperatures are higher.[87] Dry cooling has been used most often in colder climates and in arid climates where water scarcity is already a major consideration.[88] The functionality of wet cooling systems may also be compromised in situations of heat waves and droughts, which are expected to increase in frequency and intensity.[89] The European heat wave in 2003 led to low river flows and increased water temperatures, which required some power plants to reduce their production of electricity and others to shut down completely.[90] It has been suggested that if the heat wave had continued, as much as 30% of France's power production would have been at risk.[91]

These considerations suggest that thermal electricity generation will face greater challenges as the climate changes. Climate change will bring warmer air and water temperatures and growing water scarcity in some regions of the country, all of which present problems for thermal power plants. When temperatures are highest—as in a heat wave—high demand for cooling services coincides with a reduced ability of thermal power plants to reliably produce electricity, potentially resulting in power outages.[92] Also,

supra note 73, at 32 (quantifying the cost of a dry cooling system as three to four times as much as a wet system and the average efficiency penalty at 2%, except on the hottest days of the year when it can reach 20%).

87. EPRI, *supra* note 77, at 4–6 (discussing the "hot weather penalty" due to reduced cooling efficiency).

88. Sovacool, *supra* note 73, at 17.

89. GLOBAL CLIMATE CHANGE IMPACTS IN THE UNITED STATES, *supra* note 56, at 32.

90. EBINGER & VERGARA, *supra* note 2, at 8; Laurent Dubus, *Practices, Needs and Impediments in the Use of Weather/Climate Information in the Electricity Sector, in* MANAGEMENT OF WEATHER AND CLIMATE RISK IN THE ENERGY INDUSTRY 182-83 (2010); CROSS-CHAPTER CASE STUDY IN CLIMATE CHANGE 2007: IMPACTS, ADAPTATION AND VULNERABILITY. CONTRIBUTION OF WORKING GROUP II TO THE FOURTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, 846 (M.L. Parry et al. eds., 2007) [hereinafter CROSS-CHAPTER CASE STUDY], *available at* http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-xccc.pdf.

91. CROSS-CHAPTER CASE STUDY, *supra* note 90.

92. EBINGER & VERGARA, *supra* note 2, at 34 (stating that, at the same time that more electricity was needed to cool homes and workplaces, less was available); *see also* CAL. NATURAL RES. AGENCY, *supra* note 77, at 122 (explaining that high demand for cooling services increases the risk of outages, particularly in the hot summer months).

during heat waves, transformers may not be able to cool off sufficiently at night and may fail.[93]

Using carbon capture and storage as a mitigation strategy increases the water requirements of a fossil-fueled power plant. The equipment used to capture the carbon reduces plant efficiency and also requires additional cooling water.[94] Depending on whether the plant burns coal or natural gas and other specifications of the plant, carbon capture increases water consumption by 46% to 90% per unit of energy produced.[95] In addition, when carbon is stored underground, aquifers that supply drinking water may be contaminated.[96]

Several mitigation options in the energy sector are much less reliant on water. Energy efficiency and energy conservation are mitigation approaches that require no water. Also, wind turbines require almost no water for energy production.[97] While concentrating solar thermal technology is like other thermal electric technologies in its cooling needs, solar photovoltaic requires almost no water.[98] By not relying on water, these mitigation technologies provide an important adaptation benefit. To the extent that they replace existing electricity generation, there is an opportunity to reduce water usage in the energy sector. If they are used in the future instead of more water-consumptive mitigation alternatives such as thermal electric power generation with wet cooling, additional stress on water supplies can be avoided. In contrast, biomass technologies may place pressure on water resources during both the cultivation of biomass fuel and its combustion.[99]

93. Lisa M. Beard et al., *Key Technical Challenges for the Electric Power Industry and Climate Change*, 25 IEEE TRANSACTIONS ON ENERGY CONVERSION, no. 2, June 2010, at 468; GLOBAL CLIMATE CHANGE IMPACTS IN THE UNITED STATES, *supra* note 56, at 59 (noting that electric power transformers failed in the 2006 summer heat wave in the United States).

94. U.S. DEP'T OF ENERGY NAT'L ENERGY TECH. LAB., DOE/NETL-402/080108, WATER REQUIREMENTS FOR EXISTING AND EMERGING THERMOELECTRIC PLANT TECHNOLOGIES 11, (2009), *available at* http://www.netl.doe.gov/energy-analyses/pubs/WaterRequirements.pdf.

95. *Id.* at 13.

96. Mark G. Little & Robert B. Jackson, *Potential Impacts of Leakage from Deep CO_2 Geosequestration on Overlying Freshwater Aquifers*, 44 ENVTL. SCI. TECH., no. 23, 2010 at 9225–32.

97. Gold & Bass, *supra* note 73, at 579.

98. *Id.* at 579–80.

99. *See* Göran Berndes, *Bioenergy and Water—The Implications of Large-Scale Bioenergy*

While generally less dependent than fossil-fuel-based energy technologies on water resources, solar and wind technologies are in other ways more dependent on the presence of particular climate conditions.[100] Solar energy depends on the availability of sunlight, while wind energy depends on the availability of wind.[101] These sources are often referred to as "variable" or "intermittent," in contrast to "dispatchable" fossil-fuel based sources that can produce power in a steady and controllable way.[102] They are thus considered ill-suited for providing base-load power without the addition of back-up power sources or energy storage technologies.[103] Also, like thermal electric generation, solar and wind power production is less efficient at higher ambient air temperatures.[104]

2. Resistance to extreme events

An adaptation benefit is also provided when a mitigation approach is chosen that increases the electric power system's ability to cope with climate-related extreme events. In addition to heat waves and droughts, there is evidence that climate change will bring increasing forest fires, floods, heavy downpours, and hurricanes.[105] Some mitigation options in the energy sector are likely to increase the energy system's vulnerability to extreme events while others might increase the system's resilience.

The electric power system is routinely disrupted by extreme events, with power outages often caused by damage to transmission lines. Greater incidence of fires, floods, and storms can be expected

Production for Water Use and Supply, 12 GLOBAL ENVTL. CHANGE 253–71(2002).

100. *Cf.* EBINGER & VERGARA, *supra* note 2, at *xxi*.

101. *Id.* at xxi (explaining that in this way, solar and wind are more, not less, weather-dependent); *see also id.* at xxiii (explaining that the impact of climate change on solar and wind potential could be positive or negative).

102. Paul L. Joskow, *Comparing the Costs of Intermittent and Dispatchable Electricity Generating Technologies*, 100 AM. ECON. REVIEW: PAPERS & PROCEEDINGS, no.3, 2011 at 238–41.

103. *But see* AM. WIND ENERGY ASSOC., WIND POWER AND RELIABILITY: THE ROLES OF BASELOAD AND VARIABLE RESOURCES, http://www.awea.org/learnabout/publications/upload/Baseload_Factsheet.pdf ("[B]aseload power is only one of many ways to meet the power system's need for energy and capacity . . . .").

104. EBINGER & VERGARA, *supra* note 2, at xxii (discussing climate effects on renewable generation).

105. GLOBAL CLIMATE CHANGE IMPACTS IN THE UNITED STATES, *supra* note 56, at 32–34, 82.

to lead to more frequent outages.[106] Indeed, the number of major weather-related power outages in the U.S. increased from about five to twenty each year in the mid-1990s to about fifty to one hundred each year in the late 2000s.[107] Also, coastal infrastructure will be at greater risk from storm surges, erosion, and sea-level rise.[108] As discussed in the 2009 California Adaptation Strategy, heavy precipitation in the winter months is likely to cause flooding that damages energy infrastructure, and "the largest projected damages will come from sea-level rise threatening large portions of California's coastal transportation, housing, and energy-related infrastructure."[109]

Mitigation options in the electric power sector differ in their susceptibility to extreme events. Location of infrastructure matters greatly. Electricity plants that require water are generally located near water bodies, and thus more vulnerable to flooding events and coastal changes. Transmission lines may run through areas prone to fire or storm damage. Also, the location of fuel supplies may affect the reliability of electricity generation. In the United States, the Gulf region contains much of the country's oil and gas infrastructure. With the intensification of hurricanes, many off-shore oil and gas rigs, pipelines, and on-shore refineries are put at risk.[110] Six months after Hurricane Katrina, for example, almost half of all affected facilities were still shut down.[111] Increased flooding in the Midwest could threaten the transportation of coal as rail lines often cross and are often located along rivers.[112]

106. Cimato & Mullan, *supra* note 14, at 44 (explaining that damage to power lines, transmission grids, and offshore infrastructure can lead to power disruptions).

107. NAT'L WILDLIFE FED'N, MORE EXTREME WEATHER AND THE U.S. ENERGY INFRASTRUCTURE 4 (2011), *available at* http://www.nwf.org/~/media/PDFs/Global-Warming/Extreme-Weather/Final_NWF_EnergyInfrastructureReport_4-8-11.ashx ("[M]ajor weather-related outages are almost always caused by an interruption in electricity distribution rather than electricity generation.").

108. *See* OFFICE OF ELEC. DELIVERY AND ENERGY RELIABILITY, U.S. DEPT. OF ENERGY (DOE), COMPARING THE IMPACTS OF THE 2005 AND 2008 HURRICANES ON U.S. ENERGY INFRASTRUCTURE (2009), http://www.oe.netl.doe.gov/docs/HurricaneComp0508r2.pdf.

109. CAL. NATURAL RES. AGENCY, *supra* note 77, at 122.

110. NATIONAL WILDLIFE FED'N, MORE EXTREME WEATHER AND THE U.S. ENERGY INFRASTRUCTURE 6-7 (2011), http://blzorig.www.nwf.org/~/media/PDFs/Global-Warming/Extreme-Weather/Final_NWF_EnergyInfrastructureReport_4-8-11.ashx.

111. *Id.*

112. *Id.* at 8–9.

The electric power sector's vulnerability to extreme events could be reduced by mitigation approaches that decentralize the sector. Traditionally, the electric power sector has utilized large, centralized infrastructure, such as coal-fired power plants, that provide electricity to an entire city via an extensive network of transmission lines.[113] Mitigation strategies that involve thermal power generation, such as nuclear and concentrated solar power plants, continue in this tradition of centralized energy production.[114] Other electricity generation technologies offer the possibility of a more decentralized electric power system in which large-scale service disruptions could be less frequent.[115]

Decentralization of electricity production could also enhance the reliability of the sector in other ways. Regional and local congestion of transmission lines can lead to higher electricity prices and less reliable service.[116] The development of more decentralized power sources could potentially reduce such congestion. Also, where electricity is consumed close to where it is produced, electricity losses during transmission could be avoided. About 7% of electricity is routinely lost during transmission in the U.S. electric power system.[117]

Solar photovoltaic ("solar PV") technology is particularly promising in terms of decentralizing the power sector. Panels can be installed on building rooftops to create a decentralized, "distributed" energy system.[118] Wind energy and geothermal energy may also be deployed on a small scale in or near population centers.[119] Distributed generation may occur at the individual level, as in the case of solar PV panels that provide power to a single residence, or at

113. Garrick B. Pursley & Hannah J. Wiseman, *Local Energy*, 60 EMORY L.J. 877, 886 (2011) (discussing the dominant "centralized model" of electricity provision).

114. EBINGER & VERGARA, *supra* note 2, at xxviii, 64 (discussing how some energy production approaches are more centralized and others are more decentralized).

115. Sara C. Bronin, *Curbing Energy Sprawl with Microgrids*, 43 CONN. L. REV. 547, 563 (2010) ("Decentralization of power sources provides greater reliability, because if one power source goes down, other power sources can remain fully functional.").

116. *Id.*; Gold & Bass, *supra* note 73, at 582.

117. *See* U.S. Energy Info. Admin. (EIA), *How Much Electricity Is Lost in Transmission and Distribution in the United States?*, EIA.GOV, http://www.eia.gov/tools/faqs/faq.cfm?id=105&t=3 (last updated June 15, 2011).

118. Pursley & Wiseman, *supra* note 113, at 897–98 (explaining that renewable energy exists at two scales: the farm scale, which involves "large concentrated arrays of generating units," and the garden scale, which involves "smaller, distributed systems").

119. *Id.* at 897.

the neighborhood level, with a variety of energy generation technologies linked through "microgrids" that serve multiple users.[120] "Smart grid" technologies would facilitate the integration of distributed energy sources into the grid while also assisting in adaptation by giving utilities faced with a climate-change-related electricity system failure greater ability "to identify the location of a failure and quickly re-route electricity to locations where demand is more critical."[121] Also, these renewable technologies have the advantage of not having to rely on the transportation of fuel to the site of electricity generation and therefore not being vulnerable to extreme events that could affect such transportation.

The incorporation of solar PV, geothermal, and other generation technologies that do not presently constitute a large part of the electric power system would also bring diversity to the sector. Diversity is a means both to help prevent disruptions to energy supply and to reduce their effects if they occur. Unlike more targeted efforts to prevent disruptions, diversity remains an effective strategy "even if the sources or modalities of the prospective disruptions are effectively unknown."[122] Currently, the electric power sector is highly dependent on a relatively small number of generating technologies and fuels. Increased diversity of energy supply options can be expected to enhance the sector's resilience.[123] As explained in a World Bank report, a more decentralized energy structure based on locally available renewable sources might "prove more flexible and adaptive" and "more able to cope with the increasing variability and unpredictability caused by environmental change."[124] Energy efficiency and conservation also enhance the electric power system's ability to cope with extreme events by reducing the chance of grid overload and failure.[125] With load reductions from efficiency or

120. Bronin, *supra* note 115, at 563.

121. Rosemary Lyster, *Smart Grids: Opportunities for Climate Change Mitigation and Adaptation*, 36 MONASH U. L. REV. 173, 175 (2010). On smart grid technology generally, see LITOS STRATEGIC COMMC'N, U.S. DEP'T OF ENERGY, THE SMART GRID: AN INTRODUCTION (2008), *available at* http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/DOE_SG_Book_Single_Pages%281%29.pdf.

122. Andy Stirling, *The Diversification Dimension of Energy Security*, *in* ROUTLEDGE HANDBOOK OF ENERGY SECURITY 147 (Benjamin K. Sovacool ed., 2011).

123. EBINGER & VERGARA, *supra* note 2, at 4.

124. *Id.* at xxviii.

125. Relatedly, "demand response" measures have been used by utilities to cope with potential grid overload. *See. e.g.,* FED. ENERGY REGULATORY COMM., 2010 ASSESSMENT OF DEMAND RESPONSE AND ADVANCED METERING: STAFF REPORT 21 (2011), *available at*

conservation, the system is better equipped to accommodate increases in electricity demand for building cooling that are expected to accompany climate change. When peak demand can be met without great strain, the system is less vulnerable to service disruptions. Also, the system is more able to reliably supply power when severe weather affects electricity generation or distribution. Some efficiency improvements, such as constructing buildings to maximize use of natural light, may also serve adaptation needs by making buildings more useful and comfortable during power outages.

3. Low environmental impact

An adaptation benefit is also provided when chosen mitigation strategies have low environmental impacts aside from their low greenhouse gas emissions. Mitigation strategies in the electric power sector vary greatly in the extent to which they cause significant environmental impacts such as air and water pollution and habitat destruction. The possibility of reducing environmental impact by replacing more harmful electricity generation with less harmful electricity generation is an important benefit even in the absence of climate change. With climate change, reducing such environmental impacts is likely to become even more valuable.

Natural systems will experience greater stress with climate change. As Professor Craig has discussed, eliminating or reducing non-climate-change stresses promotes resilience and adaptive capacity.[126] Eliminating non-climate stress helps because "ecosystems that are already coping with other problems such as pollution, habitat destruction, and loss of biodiversity, are more vulnerable to climate change impacts than systems not already suffering from such stresses."[127] Mitigation alternatives that reduce pollution and promote habitat conservation have the potential to moderate or counteract some of the impact of climate change and thus assist in adaptation. In contrast, mitigation alternatives that cause pollution

http://www.ferc.gov/legal/staff-reports/2010-dr-report.pdf (defining demand response as "[c]hanges in electric use by demand-side resources from their normal consumption patterns in response to changes in the price of electricity, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized").

126. Craig, *supra* note 4, at 43; Glicksman, *supra* note 29, at 1171–72.

127. Craig, *supra* note 4, at 43.

or habitat destruction may find themselves subject to new regulatory requirements and other costs as environmental problems grow worse.

For example, rising temperatures due to climate change are expected to increase the formation of smog.[128] The state of California has stated that this "climate penalty" could offset many of the gains that have been made through air pollution control measures.[129] Additional air pollution measures may be deemed necessary to safeguard human health. Providing habitat for threatened and endangered species is also expected to become more important with climate change. As climate change occurs, species that are able to shift their ranges will require habitat corridors in which they can move to more favorable conditions. In its adaptation plan, California states that "[p]lanning to maintain natural corridors in anticipation of predicted climate changes should be factored into future local and regional habitat conservation planning efforts."[130]

The electric power sector in the United States causes many serious environmental impacts. Coal mining, which fuels about half of the country's electricity generation,[131] harms the environment in a variety of ways depending on how it is performed. Traditional underground mining can cause land subsidence that affects surface and subsurface water flows.[132] The surface disposal of mine wastes causes mine-acid drainage and other water pollution problems.[133] In the western United States, a prevalent form of shallow-surface mining has led to large areas of land disturbance and mine-waste pollution.[134] In the eastern United States, mountaintop-removal mining—in which steep terrain is surface mined and large quantities of rock and soil are typically placed in adjacent valleys—has become common.[135] In addition to land disturbance and mining waste problems, mountaintop mining harms streams and watersheds.[136]

128. CAL. NATURAL RES. AGENCY, *supra* note 77, at 33.
129. *Id.*
130. *Id.* at 45–46.
131. NRC, *supra* note 48, at 71.
132. *Id.* at 79.
133. *Id.* at 79–80.
134. *Id.* at 78–80.
135. *Id.*
136. *Id.* at 80–81.

Also, the transportation of coal, which is often mined at considerable distance from where it is burned, contributes to air pollution.[137]

Coal-fired power plants are among the nation's largest sources of air and water pollution. Fossil fuel fired power plants are responsible for two-thirds of sulfur dioxide emissions and almost a quarter of nitrogen oxide emissions, and coal-fired power plants contribute the large majority of this pollution.[138] A recent study by the National Research Council (NRC) calculated aggregate health and environmental damages associated with conventional air pollution emissions from coal-fired power plants in 2005 at "approximately $62 billion (2007 USD), or $156 million per plant on average."[139] In addition, coal-fired power plants emit over eighty-four types of hazardous air pollutants, including 40% of the nation's mercury emissions.[140] Fly-ash and other combustion byproducts must be stored and disposed of, which is often accomplished through on-site retention ponds and landfills that can contaminate nearby water sources.[141] Also, as power plants have increasingly installed scrubbers to prevent pollutants from being released to the air, they may be sending the pollution instead to local waterways.[142]

Mitigation options vary greatly in the environmental impacts they cause. Electricity generation from natural gas, like that from coal, has impacts throughout its life cycle. Exploratory activities for natural gas can pollute water with "oils, heavy metals and dissolved solids," and offshore exploratory activities "can adversely affect fish and marine mammals."[143] Once extraction begins, gas wells produce

137. DANIEL A. LASHOF ET AL., NATURAL RES. DEF. COUNCIL, COAL IN A CHANGING CLIMATE 10 (2007), *available at* http://www.nrdc.org/globalwarming/coal/coalclimate.pdf.

138. *Air Emissions*, EPA.GOV, http://www.epa.gov/cleanenergy/energy-and-you/affect/air-emissions.html (last updated Dec. 28, 2007); Pace Univ., *Electricity from: Coal*, POWER SCORECARD, http://www.powerscorecard.org/tech_detail.cfm?resource_id=2 (last visited Oct. 15, 2011) ("[C]oal power plants are responsible for 93 percent of the sulfur dioxide and 80 percent of the nitrogen oxide emissions . . . .").

139. NRC, *supra* note 48, at 149 (quantifying the aggregate damages associated with emissions of sulfur dioxide, nitrogen oxides, and particulate matter).

140. AM. LUNG ASS'N, TOXIC AIR: THE CASE FOR CLEANING UP COAL-FIRED POWER PLANTS 2 (2011), *available at* http://www.lungusa.org/assets/documents/healthy-air/toxic-air-report.pdf.

141. NRC, *supra* note 48, at 104–05.

142. Charles Duhigg, *Cleansing the Air at the Expense of Waterways*, N.Y. TIMES, Oct. 12, 2009, http://www.nytimes.com/2009/10/13/us/13water.html?pagewanted=all.

143. NRC, *supra* note 48, at 111.

not only dry gas but also a waste liquid referred to as "produced water."[144] When hydraulic fracturing is used for extraction, contamination of groundwater can occur.[145] Offshore and nearshore extraction operations can cause impacts in coastal areas including saltwater encroachment and land subsidence.[146] The average aggregate health and environmental damages from natural gas power plants in 2005 were monetized at just under $1.5 million per plant, much lower than coal-fired power plants, but still significant.[147]

Nuclear power plants produce relatively little air and water pollution aside from the thermal water pollution associated with once-through cooling.[148] However, environmental impacts can occur in uranium mining and radioactive wastes disposal. Uranium mining can cause worker exposure to radiation through inhalation, ingestion, and direct irradiation of the body.[149] The mining process can also contaminate surface waters or groundwater, leading to broader public exposure.[150] After nuclear power is produced, questions of nuclear-waste disposal arise. Efforts to develop a geologic repository for high-level radioactive wastes in the United States have failed, and disposal generally occurs in less secure locations on-site at nuclear power plants.[151] The risk of a low-frequency, high-impact event that releases radiation into the environment cannot be ignored. Indeed, the likelihood of such events may be expected to increase with the incidence of more wildfires, floods, and hurricanes.

Several renewable energy technologies have much lower pollution impacts than fossil fuel and nuclear energy. Wind, solar, geothermal, and tidal energy technologies require no production, refinement, or transportation of fuels. All the attendant environmental impacts of fuel supply are thus eliminated. The manufacture of solar PV panels can cause pollution as certain materials used in the process are toxic and others may need to be

144. *Id*. at 112.
145. *Id*. at 113.
146. *Id*. at 113–14.
147. *Id*. at 117.
148. *Id*. at 130–31.
149. *Id*. at 128.
150. *Id*.
151. *Id*. at 132–33.

mined.[152] Also, solar PV panels may cause pollution if disposed of improperly.[153] Yet, even considering its whole life cycle, solar PV's conventional and toxic pollution impacts are much lower than those of fossil fuels.[154] As for biomass power technologies, the use of fertilizers and pesticides in biomass cultivation may cause some pollution, but it is likely to be less than the pollution caused by mining.[155] Biomass power, unlike most other renewable sources, also involves combustion-related pollution.[156]

Renewable energy sources vary in their impacts on habitat and other ecological processes. Wind energy causes bird and bat deaths, but generally not to a degree that threatens populations.[157] Both wind and solar energy may involve land-use change that affects habitat. In addition to lands needed for the installation of turbines and panels, roads and transmission lines may need to be constructed.[158] Biomass cultivation requires land, which may directly or indirectly lead to deforestation and related habitat destruction.[159] Indeed, a shift from conventional energy sources to renewable energy sources could lead to "energy sprawl" as the latter may require greater land resources.[160] One study projected that by 2030, an additional area larger that the state of Nebraska could be impacted by new energy development, either directly through clearing or indirectly through fragmentation of habitat and adverse effects on species.[161]

152. *Id.* at 143.

153. *Id.* at 144.

154. *Id.* at 143.

155. *See* MORGAN ET. AL., *supra* note 3, at 36–37.

156. *Id.*

157. *See* NRC, *supra* note 48, at 139–40. *But see* Bronin, *supra* note 115, at 555–56 (discussing a wind farm in California that killed tens of thousands of birds, including a thousand protected golden eagles).

158. *See* NRC, *supra* note 48, at 140.

159. For example, ethanol subsidies in the United States led indirectly to deforestation in Brazil. *See, e.g.*, Michael Grunwald, *The Clean Energy Scam*, TIME, Apr. 7, 2008, at 40, *available at* http://www.time.com/time/magazine/article/0,9171,1725975,00.html. As U.S. farmers switched from food crops to ethanol, the price of food rose, spurring more forest-to-agriculture land-use conversion in Brazil. *Id.*

160. Robert I. McDonald et al., *Energy Sprawl or Energy Efficiency: Climate Policy Impacts on Natural Habitat for the United States of America*, PLOS ONE, at 1 (Aug. 26, 2009), http://www.plosone.org/article/info:doi/10.1371/journal.pone.0006802; *see also id.* at 4 fig.3 (presenting calculations of land-use intensities for various energy technologies).

161. *Id.* at 4.

Importantly, however, renewable energy technologies can be deployed through distributed generation approaches that largely avoid the consumption of land for new energy infrastructure. The installation of solar PV panels on rooftops and parking lots, for example, presents the opportunity for greatly expanded solar generation with few land conversion impacts. Professor Bronin argues that much future energy development could occur through neighborhood-scale microgrids, in which various distributed energy technologies are organized into "closed, low-voltage system[s]" that provide electricity to nearby neighborhoods without the need for new land-intensive, large-scale facilities and transmission lines.[162]

Energy efficiency and conservation are the mitigation alternatives with the lowest environmental impacts. To the extent that energy efficiency replaces high impact electricity generation, such as fossil-fuel combustion, it can prevent significant pollution and habitat destruction.[163] In addition, many forms of energy efficiency are cheaper than other mitigation options in the electric power sector, and even have negative costs. A 2009 report produced by McKinsey found that the United States could save $1.2 trillion by 2020 if it invested $520 billion in building and appliance efficiency improvements.[164]

IV. POLICY FOR ADAPTIVE MITIGATION

Energy policies in the United States are likely to be increasingly driven by the need to mitigate greenhouse gases. At the same time, energy policies should take into account the need to adapt to climate change. This section makes three broad policy recommendations to spur adaptive mitigation: public policy should (1) enable relevant information dissemination, (2) provide for project review that is attentive to adaptation, and (3) require planning processes that integrate consideration of mitigation and adaptation. While these policy proposals might also promote adaptive mitigation in other sectors, the discussion below is tailored to the electric power sector.

162. Bronin, *supra* note 115, at 559–61.

163. *See, e.g.*, McDonald et al., *supra* note 160, at 4 fig.3 (showing that the land-use intensity of efficiency gains in electricity production is negative).

164. MCKINSEY & CO., UNLOCKING ENERGY EFFICIENCY IN THE U.S. ECONOMY, at iii (2009), *available at* http://tinyurl.com/3cmovt9.

A. Information Dissemination

An important policy task for adaptive mitigation is to further develop and disseminate information about projected climate impacts on sectors that are the focus of mitigation. This information provides private and public actors with information that they can use to make adaptation-related decisions.[165] Study of the effects of climate change on the energy sector has begun, but more should be undertaken both by governmental entities and interested private actors such as the insurance industry.

Adaptation measures can be considered as either private or public.[166] Private adaptation measures are "market-driven" measures taken by private actors.[167] Private entities that generate electricity may engage in private adaptation by, for example, deciding to invest in generating technologies that are less water intensive based on increasing water costs. Similarly, to the extent that liability or regulatory costs are projected, private entities may shift toward electricity generation that is more disaster tolerant or lower in environmental impact. Public adaptation measures, in contrast, are instituted by a public agency and are "policy-driven" measures.[168]

Many decision makers in the electric power sector are private actors who can be expected to seek ways to lessen climate-change impacts and their associated costs. Yet, as a public good, information about projected climate impacts on the energy system may be under-produced. Policymakers can assist by ensuring that it is produced and made accessible.[169] As explained by Professor Glicksman, government has "an appropriate federal role in gathering and distributing

165. *Cf.* Council on Envtl. Quality, *Climate Change Adaptation Task Force*, WHITEHOUSE.GOV, http://tinyurl.com/2vll8xm (last visited Oct. 27, 2011) (recommending that the federal government "[e]nsure scientific information about the impacts of climate change is easily accessible so public and private sector decision-makers can build adaptive capacity into their plans and activities").

166. *See Adaptation Guidance Notes—Key Words and Definitions*, *supra* note 43 (defining private adaptation as "[a]daptation that is initiated and implemented by individuals, households or private companies" that "is usually in the actor's rational self-interest," and public adaptation as "[a]daptation that is initiated and implemented by governments at all levels" that "is usually directed at collective needs").

167. EBINGER & VERGARA, *supra* note 2, at 54.

168. *Id.*

169. *See id.* at 71.

information needed to make informed climate change adaptation policy choices."[170]

With the many effects that even normal weather can have on electricity production and transmission, the electric power sector uses weather forecasts extensively to manage risks.[171] As climate variability increases with climate change, the sector will need increasingly sophisticated and accurate forecast information.[172] Also, improved forecasting will be critical to integrating renewables in a cost-effective manner. At present, however, it is not clear that the sector considers climate change to be a major risk.[173] Making information available about climate change impacts will provide a basis for private actors to understand the magnitude of the risk and make private decisions that are more adaptive.[174]

The U.S. Climate Change Science Program made an important first step in providing the type of information needed with its 2008 report about the effects of climate change on energy supply and demand.[175] Also, the California Climate Adaptation Strategy, prepared in 2009, contains a chapter that addresses energy infrastructure.[176] Further studies should provide information tailored to particular regions and generation technologies, focused not just on the likely climate impacts but also on how particular measures can enhance system reliability and otherwise protect from climate risks.

Insurance companies can play important roles in both provisioning information about climate change risks and providing incentives for risk reduction. A 2008 survey of insurance industry analysts showed that they consider climate change to be the largest risk facing the industry.[177] According to one commentator, "insurers

170. Glicksman, *supra* note 29, at 1181–82.

171. *See* EBINGER & VERGARA, *supra* note 2, at 8 (stating that the electric power sector "makes varied use of available climate information to plan for peak load management and extreme event response"); Dubus, *supra* note 90, at 181-82.

172. Dubus, *supra* note 90, at 184–85.

173. EBINGER & VERGARA, *supra* note 2, at xxviii (observing that climate change risks may be falling under the radar).

174. *See id.* at xvii.

175. *See* WILBANKS ET AL., *supra* note 46; *see also* KOEN RADEMAEKERS ET AL., INVESTMENT NEEDS FOR FUTURE ADAPTATION MEASURES IN EU NUCLEAR POWER PLANTS AND OTHER ELECTRICITY GENERATION TECHNOLOGIES DUE TO EFFECTS OF CLIMATE CHANGE (2011).

176. CAL. NATURAL RES. AGENCY, *supra* note 77, at 122–34.

177. EVAN MILLS, FROM RISK TO OPPORTUNITY: INSURER RESPONSES TO CLIMATE CHANGE 8 (2009), *available at* http://www.ceres.org/resources/reports/insurer-responses-

are beginning to apply their expertise in data collection, catastrophe modelling and risk analysis to better track trends and define the problems posed by climate change and point towards solutions for both the industry and society at large."[178] Insurers can also craft their insurance products in ways that reward adaptive behavior. They can, for example, refuse to insure energy infrastructure that is vulnerable to climate change, require that insured parties take certain adaptation measures, or offer lower premiums to those that that do.[179]

B. Project Review

Even when information about the impact of climate change is available, private actors may not act on it. Because climate change impacts are uncertain and occur over the long term, private actors may seek to avoid the present cost of taking adaptation measures and discount the future cost of not doing so.[180] Governmental review of proposed energy development projects should focus attention on how they could be adversely affected by climate change and ensure that such development will serve adaptation as well as mitigation goals. Effective project review of this type would help prevent reliance on mitigation alternatives that increase vulnerability.

Project reviews that incorporate adaptation could occur as part of environmental impact assessments prepared by federal agencies under the National Environmental Policy Act (NEPA) and state agencies under little-NEPA statutes, such as the New York State Environmental Quality Review Act and the California Environmental Quality Act (CEQA).[181] Such review can also occur under review processes that are specific to energy projects at the federal or state level.

to-climate-change-2009.

178. Evan Mills, *A Global Review of Insurance Industry Responses to Climate Change,* 34 GENEVA PAPERS 323, 338 (2009). *See generally* Evan Mills, *The Role of U.S. Insurance Regulators in Responding to Climate Change*, 26 UCLA J. ENVTL. L. & POL'Y 129 (2008).

179. *See* Anastasia M. Telesetsky, Insuring Against Future Climate Change: The Use of Mandatory Catastrophe Risk Insurance and Microinsurance to Promote Mitigation and Adaptation 44 (Aug. 2009) (unpublished LL.M. thesis, University of British Columbia).

180. *See* Cimato & Mullan, *supra* note 14.

181. *Cf.* Edna Sussman et al., *Climate Change Adaptation: Fostering Progress Through Law and Regulation*, 18 N.Y.U. ENVTL. L.J. 55, 77 (2010); Katherine M. Baldwin, Note, *NEPA and CEQA: Effective Legal Frameworks for Compelling Consideration of Adaptation to Climate Change*, 82 S. CAL. L. REV. 769, 800–01 (2009).

With regard to NEPA, the federal government issued draft guidance in 2010 suggesting that federal agencies should consider both an action's impact on greenhouse gas emissions (relevant to mitigation) and climate change's impact on the action (relevant to adaptation) in preparing an Environmental Impact Statement ("EIS").[182] With respect to assessing the impact of climate change on the action, the draft guidance states that agencies should "focus on aspects of climate change that may lead to changes in the impacts, sustainability, vulnerability and design of the proposed action and alternative courses of action."[183] Under the draft guidance, energy infrastructure projects would generally require review of such impacts given that they have long life spans, in which climate change impacts would be expected, and that they are frequently proposed for locations that might be vulnerable to climate change impacts.[184] Finally, the draft guidance instructs federal agencies to refer to the U.S. Climate Change Science Program's reports—which include the above-mentioned report about the effects of climate change on energy production and use—for the best available scientific information.[185]

Professor Farber has proposed that a new instrument be established to facilitate adaptation assessment.[186] Modeled after the EIS, a Climate Impact Statement would be prepared by federal agencies when climate change would have a significant impact on a proposed project and would analyze both the impacts of climate change and the options for reducing or eliminating the resulting harm.[187] While Farber also endorses the idea of incorporating the analysis of climate change impacts into presently required EISs, he argues that creating a new instrument would enable Climate Impact

182. Memorandum from Nancy H. Sutley, Council on Envtl. Quality, to Heads of Fed. Dep'ts and Agencies, Draft NEPA Guidance on Consideration of the Effects of Climate Change and Greenhouse Gas Emissions (Feb. 18, 2010), *available at* http://tinyurl.com/ct48pyy.

183. *Id*. at 2.

184. *See id*. at 7.

185. *Id*. at 7–8.

186. Daniel A. Farber, *A Legal Framework for Climate Adaptation Assessment*, RESOURCES FOR THE FUTURE 1 (Dec. 2009), http://www.rff.org/rff/documents/RFF-IB-09-14.pdf [hereinafter Farber, *Legal Framework*]; *see also* Daniel A. Farber, *Adaptation Planning and Climate Impact Assessments: Learning from NEPA's Flaws*, 39 ENVTL. L. REP. 10605, 10605 (2009) [hereinafter Farber, *Adaptation Planning*].

187. *See* Farber, *Legal Framework*, *supra* note 186, at 1.

Statements to avoid some of the shortcomings of EISs. Climate Impact Assessments could be incorporated into earlier stages of decision making, involve more monitoring and follow-up, be more widely publicized, more adequately deal with uncertainty, and could be triggered not just by a proposal of federal action but also by a determination that an existing agency action implicates adaptation concerns.[188]

With regard to CEQA, California adopted amendments to its CEQA Guidelines in 2010 that provide guidance to state agencies on how to address an action's impact on greenhouse gas emissions.[189] California declined, however, to broadly require that environmental impact reports (EIRs) prepared under CEQA address the impact of climate change on the proposed project.[190] Where a certain hazard will occur with reasonable certainty, whether due to climate change or not, the guidelines require that the EIR evaluate the impacts that would occur upon the occurrence of that hazard.[191] However, if long-term uncertainties are present, detailed consideration of possible impacts of temperature change, habitat modification, changes in agriculture and forestry, or water supply variability is not required.[192] Further, agencies are not required to generate their own original research on potential future changes as part of CEQA review. In limiting the extent to which adaptation concerns need to be considered under CEQA, California determined that "CEQA should not be viewed as the tool to implement the [California] Adaptation Strategy."[193]

California's Adaptation Strategy suggests that the impact of climate change on energy projects should occur through other assessment processes specific to the energy sector. It recommends that the California Energy Commission consider the effects of sea-level rise, temperature increases, precipitation changes, and extreme

188. *See* Farber, *Adaptation Planning*, *supra* note 186, at 10,605.

189. *CEQA Guidelines*, CAL. NAT. RES. AGENCY, http://ceres.ca.gov/ceqa/guidelines/ (last visited Oct. 27, 2011).

190. CAL. NATURAL RES. AGENCY, FINAL STATEMENT OF REASONS FOR REGULATORY ACTION: AMENDMENTS TO THE STATE CEQA GUIDELINES ADDRESSING ANALYSIS AND MITIGATION OF GREENHOUSE GAS EMISSIONS PURSUANT TO SB97, at 10 (2009), *available at* http://ceres.ca.gov/ceqa/docs/Final_Statement_of_Reasons.pdf.

191. *Id.* at 102.

192. *Id.* at 102–03.

193. *Id.* at 101.

events when siting and relicensing energy facilities.[194] It also suggests that the Energy Commission conduct studies to broadly assess the impacts of climate change on energy infrastructure, and then use this information to inform its siting and planning programs.[195] An important related policy question is whether to exempt certain types of energy projects from project review in order to facilitate their development. Consistent with other state policies to encourage renewable energy, California recently amended CEQA to exempt solar energy installations on the rooftops of existing buildings or parking lots.[196]

C. Planning

Project review has the potential to identify and force change in project proposals that increase vulnerability, but it does little to promote projects that enhance resilience. A proposal for a water-intensive energy installation in a drought-prone area, for example, is likely to be scrutinized in project review processes that consider adaptation issues. However, such a review process will have little effect in promoting energy efficiency which uses no water. Rather, planning processes are needed to identify and provide policy incentives for mitigation alternatives that have valuable adaptation benefits.

Planning is the primary policy tool that is being used for adaptation.[197] Eleven states have completed climate change adaptation plans, and plans are in progress in four others.[198] Many cities plan for adaptation by following a five-step program of conducting a resiliency study, setting preparedness goals, creating a preparedness plan, implementing a preparedness plan, and monitoring and evaluating results.[199] The U.S. federal government has also embarked on a process of adaptation planning. In 2009, an

194. CAL. NATURAL RES. AGENCY, *supra* note 77, at 131.

195. *Id.*

196. S.B. 226, 2011 Leg., 2011-2012 Sess. (Ca. 2011).

197. *See, e.g.*, Elizabeth C. Black, *Climate Change Adaptation: Local Solutions for a Global Problem*, 22 GEO. INT'L ENVTL. L. REV. 359 (2010); Sussman, *supra* note 24.

198. *State Adaptation Plans*, CENTER FOR CLIMATE CHANGE & ENERGY SOLUTIONS, http://www.pewclimate.org/what_s_being_done/in_the_states/adaptation_map.cfm (last updated May 31, 2011).

199. *See, e.g.*, *Climate Resilient Communities Program*, INT'L COUNCIL FOR LOCAL ENVTL. INITIATIVES USA, http://www.icleiusa.org/programs/climate/Climate_Adaptation/climate-resilient-communities-program (last visited Nov. 10, 2011).

executive order tasked the Council on Environmental Quality with writing a progress report on federal agency actions supporting a national climate change adaptation strategy and making recommendations "for any further such measures as the CEQ Chair may deem necessary."[200] In 2010, CEQ released a report emphasizing the "vital" role of federal leadership in "planning for and implementing adaptive actions."[201] The report recommended that federal agencies develop and implement coordinated climate change adaptation plans in which each agency identifies aspects of climate change likely to impact its ability to achieve its mission.[202]

These planning processes have generally occurred separately from discussions of mitigation policy and they may not have focused on the sectors most relevant to mitigation. Notably, planning approaches have not been commonly advocated in mitigation policy. The regulatory instrument of choice in mitigation policy has instead been cap and trade regulation, which seeks to "put a price" on greenhouse gas emissions by establishing a market in which emissions allowances can be bought and sold. Cap-and-trade programs have been part of most major congressional proposals to address climate change, including the American Clean Energy and Security Act (Waxman-Markey bill) passed by the U.S. House of Representatives in 2009.[203] The Regional Greenhouse Gas Initiative and the Western Climate Initiative have also utilized a cap-and-trade regulatory approach.[204]

Cap-and-trade regulation implicitly eschews the idea of governmental planning. Cap-and-trade is premised on the idea that the market is the best locus of decision making for which mitigation alternatives should be pursued.[205] In a functioning cap-and-trade program, emitters that can reduce their emissions for a cost lower

200. Exec. Order No. 13,514, § 1, 74 Fed. Reg. 52,117and 52,125 (Oct. 8, 2009).

201. CEQ, *supra* note 40, at 7.

202. *Id.* at 26–27.

203. American Clean Energy and Security Act of 2009, H.R. Res. 2454, 111th Cong. (2009) (enacted) (authored by Reps. Henry A. Waxman (D-Cal.) and Edward J. Markey (D-Mass.)).

204. *See* Lesley K. McAllister, *Regional Climate Regulation: From State Competition to State Collaboration*, 1 SAN DIEGO J. CLIMATE & ENERGY L. 81 (2009).

205. NEIL GUNNINGHAM & PETER GRABOWSKY, SMART REGULATION: DESIGNING ENVIRONMENTAL POLICY 72 (stating that the assumption of tradable emissions programs is "that firms are in a better position than regulatory authorities to identify and specify appropriate action").

than the price of a pollution allowance will choose to do so, while emitters that face higher costs will buy allowances in the market.[206] In choosing cap and trade, the government essentially relinquishes control to the market over which pollution reduction approaches get adopted and in what order.

In the market, moreover, the only relevant consideration is the cost of the emissions reduction. If market actors would pay less to reduce emissions by switching from coal to natural gas than from coal to solar power, market incentives would favor the switch to natural gas. Additional costs or benefits of a mitigation approach, such as adaptation benefits, may not be incorporated into the price that market actors pay and therefore not be valued in the market. As a result, the least-cost mitigation alternative for market actors may not be the least-cost alternative for society.

Planning processes for key mitigation sectors such as the electric power sector should integrate mitigation and adaptation. In the electric power sector, traditional planning processes such as integrated resource planning (IRP) can be modified and expanded to take adaptation into account. Used since the 1980s, IRP is "a planning and selection process for new energy resources that evaluates the full range of alternatives . . . in order to provide adequate and reliable service to its electric customers at the lowest system cost."[207] Older approaches to electric resource planning had focused on "supply-side" projects—the development of new generation, transmission and distribution facilities.[208] The key innovation of IRP was that both supply-side measures and demand-side measures such as energy efficiency and conservation would be evaluated and incorporated in decisions about how to meet forecasted electricity demand.[209]

206. *Id.* ("Rational behavior by participating firms would mean that low marginal cost firms continue to reduce emissions . . . whilst high marginal cost firms will continue to pollute . . . .").

207. Energy Policy Act of 1992, 42 U.S.C. §§ 13201–13574 (2006); *see also* RACHEL WILSON & PAUL PETERSON, SYNAPSE ENERGY ECON., INC., A BRIEF SURVEY OF STATE INTEGRATED RESOURCE PLANNING RULES AND REQUIREMENTS 1, (Apr. 28, 2011), *available at* http://tinyurl.com/d9k5dxk.

208. THE TELLUS INST., BEST PRACTICES GUIDE: INTEGRATED RESOURCE PLANNING FOR ELECTRICITY 3 (undated, circa 2009), *available at* http://pdf.usaid.gov/pdf_docs/PNACQ960.pdf.

209. Scott F. Bertschi, *Integrated Resource Planning and Demand-Side Management in Electric Utility Regulation: Public Utility Panacea or a Waste of Energy?*, 43 EMORY L.J. 815, 830 (1994).

By the early 1990s, more than half of state utility regulatory commissions required some type of IRP.[210] A first step in IRP is generally to set the objectives of the planning process. These may include, for example, providing reliable electric service, minimizing costs, minimizing environmental impacts, diversifying and localizing supply, increasing efficiency, providing local employment, and retaining flexibility.[211] The remaining steps include forecasting demand, investigating supply-side options and preparing potential supply plans, investigating demand-side options and preparing potential demand-side management plans, constructing and assessing alternative plans that integrate supply- and demand-side options, and selecting a single preferred integrated resource plan to guide activities over the planning horizon.[212] The selection of the preferred plan is generally based on a set of assessment criteria that reflect the objectives determined at the outset.[213]

Plans are typically prepared by utilities under rules and guidance from the state public utilities commission.[214] The wave of electric sector restructuring (or deregulation) that occurred in many states in the 1990s affected the practice of integrated resource planning.[215] IRP rules were repealed in some states and replaced by "long-term procurement planning" rules in other states.[216] In 2011, twenty-seven states required the filing of integrated resource plans and eleven states required the filing of procurement plans.[217] Although procurement plans differ from resource plans based on the different role of utilities in a restructured sector, they have tended to embrace a similar objective of requiring the utility to evaluate both supply- and demand-side procurement strategies.[218]

210. *Id.* at 829; WILSON & PETERSON, *supra* note 207, at 2 (stating that 14 states had "full-featured" IRP requirements, while 18 other states had IRP processes that were less complete).

211. THE TELLUS INST., *supra* note 208, at 6–7.

212. *Id.* at 37.

213. *Id.* at 33–35.

214. WILSON & PETERSON, *supra* note 207, at 4.

215. *Cf.* Marc B. Mihaly, *Recovery of a Lost Decade (Or Is It Three?): Developing the Capacity in Government Necessary to Reduce Carbon Emissions and Administer Energy Markets*, 88 OR. L. REV. 405, 476 (2009) (describing deregulation as a politically charged term for restructuring).

216. WILSON & PETERSON, *supra* note 207, at 13.

217. *Id.* at 14.

218. *Id.* at 13–14.

IRP and similar planning processes can be modified to incorporate adaptation and value the adaptation benefits of different energy resources. Many risks to the sector are commonly analyzed in integrated resource plans, including changes in fuel prices, load growth, and new regulatory requirements.[219] The risks of climate change impacts on various supply- and demand-side resources can similarly be assessed. Several of the traditional objectives of IRP, such as diversifying supply and retaining flexibility, dovetail naturally with adaptation. In addition, providing adaptation benefits could be explicitly identified as an IRP objective. To fully consider adaptation in the planning process, it may be helpful to expand the planning horizon from the typical ten or twenty years to thirty or forty years.[220] In many ways, the uncertainty around how climate change will affect the electric power sector creates an even greater need for IRP and other comprehensive and systematic planning mechanisms.[221]

State rules may require not just that all supply- and demand-side resources be identified and evaluated in planning processes, but also that some types of resources be prioritized. California's "loading order" policy, for example, prioritizes cost-effective and reliable energy efficiency and conservation.[222] When new generation is still deemed necessary, agencies should seek to meet needs "first by renewable energy resources and distributed generation" and only afterwards "by additional clean, fossil fuel, central-station generation."[223] In 2005, the policy was codified by statute.[224] While

219. *Id.* at 3.

220. *Id.* at 6–7 (showing that planning horizons are generally ten to twenty years).

221. *Cf.* Marc Chupka et al., *Reviving Integrated Resource Planning for Electric Utilities: New Challenges and Innovative Approaches*, ENERGY (The Brattle Grp.), 2008, at 1, *available at* http://www.brattle.com/_documents/UploadLibrary/Upload685.pdf; *see also* TENN. VALLEY AUTH., TVA STATEMENT ON CLIMATE CHANGE ADAPTATION (Jun. 1, 2011), *available at* http://www.tva.gov/environment/sustainability/climate_change_statement.pdf (stating that the TVA will incorporate climate change adaptation into its integrated resource plan).

222. STATE OF CAL., ENERGY ACTION PLAN 4 (2003), *available at* http://www.energy.ca.gov/energy_action_plan/2003-05-08_ACTION_PLAN.PDF; CAL. PUB. UTIL. CODE § 454.5(b)(9)(C) (West 2008) (codifying the loading order policy).

223. STATE OF CAL., *supra* note 222, at 4.

224. CAL. PUB. UTIL. CODE § 454.5(b)(9)(C) (requiring utilities' procurement plans to include a showing that "[t]he electrical corporation will first meet its unmet resource needs through all available energy efficiency and demand reduction resources that are cost effective, reliable, and feasible").

California's loading order policy was based on costs and environmental considerations,[225] a similar guiding policy could have resulted based on adaptation considerations.

California's loading order policy has been implemented in a myriad of ways that exemplify the potential effect of an overarching policy determination that orients and organizes public and private action in a sector.[226] A 2005 Implementation Roadmap for the Energy Action Plan set forth fifteen key actions to ensure the prioritization of energy efficiency in meeting the state's energy needs spanning from raising public awareness to setting new standards for buildings and appliances.[227] According to a recent study, California's adoption of long-term energy efficiency goals for its utilities has a strong, direct impact on the extent to which they rely on improved efficiency to meet expected demand growth.[228]

V. CONCLUSION

The electric power sector is poised to undergo major changes in the next several decades. As a major source of greenhouse gases, the sector is likely to experience regulatory pressure to mitigate. At the same time, the significant impacts of climate change will become increasingly apparent, spurring a range of adaptation measures.

While mitigation and adaptation have been treated primarily as separate policy domains, there are contexts in which they should be considered in an integrated way. In the electric power sector, and other sectors that will be the focus of mitigation policy, there is a special opportunity to take an approach of adaptive mitigation that recognizes and takes advantages of potential synergies between mitigation and adaptation.

225. STATE OF CAL., *supra* note 222, at 2 (stating the goal in terms of cost-effectiveness and environmental soundness).

226. *See, e.g.,* CAL. ENERGY COMM'N (CEC), CEC-400-2005-043, STAFF REPORT: IMPLEMENTING CALIFORNIA'S LOADING ORDER FOR ELECTRICITY RESOURCES, (July 2005), *available at* http://www.energy.ca.gov/2005publications/CEC-400-2005-043/CEC-400-2005-043.PDF.

227. STATE OF CAL., ENERGY ACTION PLAN II: IMPLEMENTATION ROADMAP FOR ENERGY POLICIES 4–7 (Oct. 2005), *available at* http://docs.cpuc.ca.gov/word_pdf/REPORT/51604.pdf.

228. Nicole Hopper et al., *Energy Efficiency as a Preferred Resource: Evidence from Utility Resource Plans in the Western United States and Canada*, 2 ENERGY EFFICIENCY 1, 7 (2009).

In the case of the electric power sector, mitigation alternatives vary widely in the extent to which they provide adaptation benefits. In their ability to conserve water resources, mitigation technologies vary from being more water intensive than current technologies to requiring virtually no water. In their tolerance of extreme events, mitigation alternatives vary from being as or more vulnerable than traditional plants to furnishing greater resilience through distributed generation and diversification. In their environmental impacts, some mitigation technologies pollute as much or more than present technologies while others produce practically no pollution or habitat disturbance.

These adaptation benefits should be valued in mitigation policy. Improving the dissemination of information on climate change impacts is an important first step. Government agencies should also review mitigation projects with adaptation in mind. Such review would be likely to identify proposals that are maladaptive, such as the installation of a highly water-intensive facility in an area expected to become prone to drought. To identify and promote mitigation alternatives that furnish adaptation benefits, more proactive planning processes are called for. Together, such policies could usher in an electric power sector that is viewed much less as part of the climate change problem and much more as part of its solution.