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LEGAL TOOLS FOR CLIMATE ADAPTATION ADVOCACY:

THE ELECTRIC GRID AND ITS REGULATORS—FERC AND STATE PUBLIC UTILITY COMMISSIONS

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1. INTRODUCTION

The electric grid connects electricity generators to consumers. State and federal regulators are tasked with ensuring that consumers have access to safe and reliable electricity at just and reasonable rates. The requirements of this task have and will continue to transform as technologies change and as the impacts of climate change alter the context in which the electric grid operates. Thus, regulators who make adapting to climate change a priority will better fulfill their mandate to ensure that utilities provide consumers with safe and reliable electricity at just and reasonable rates.[1] Yet some regulators do not recognize how closely adaptation aligns with their basic mandate. This chapter is written for advocates seeking a more thorough integration of adaptation considerations into regulation of the electric grid. Part 1 describes the grid, its regulators, and their functions. Part 2 highlights impacts of climate change that are expected to impair grid operations: increased temperatures and heat waves, changes in precipitation, storms, and sea-level rise. Part 3 discusses substantive proposals to adapt to climate change impacts. Part 4 summarizes the basic regulatory proceedings and identifies opportunities for an advocate to present evidence and arguments during such proceedings.

1.1. Electric Grid Overview

The electric grid is comprised of three segments—generation, transmission, and distribution. Generation converts primary energy into electrical power.[2] Transmission carries high-voltage electricity from generation facilities over long distances, often across state lines, to lower-voltage distribution systems.[3] Once high-voltage electricity reaches a substation and there is "stepped down" to a lower voltage for distribution, it flows to homes and businesses. At each

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[1] Adaptation refers to "actions to prepare for and adjust to new conditions, thereby reducing harm or taking advantage of new opportunities." U.S. GLOBAL CHANGE RESEARCH PROGRAM, CLIMATE CHANGE IMPACTS IN THE UNITED STATES: THE THIRD NATIONAL CLIMATE ASSESSMENT 13 (Jerry M. Melillo et al. eds., 2014), http://nca2014.globalchange.gov/downloads.

[2] MASS. INST. OF TECH., THE FUTURE OF THE ELECTRIC GRID app. at 247 (2011) [hereinafter "MIT 2011"], http://mitei.mit.edu/publications/reports-studies/future-electric-grid.

[3] *Id.*

stage of this process, electricity travels at the speed of light.[4] The maximum capacities of transmission and distribution lines and facilities cannot be exceeded by the electricity flowing through them, or failures will result.[5] Therefore, electricity supply (generation) must be balanced continuously and precisely against demand. Grid operators manage this minute-to-minute balancing by anticipating levels of demand, matching them with supply, and adjusting to accommodate unpredicted mismatches.[6] While utilization of energy storage resources (e.g. large batteries and pumped-storage hydropower) could theoretically simplify this balancing effort, the construction and maintenance of storage resources is currently too expensive to be adopted widely.[7]

The electricity industry was once dominated by vertically integrated utilities that provided generation, transmission, and distribution services and charged "bundled" rates, which were reviewed and authorized by state public utility commissions.[8] Starting in the 1990s, the industry went through a period of partial "restructuring" characterized by deregulation at both the wholesale and retail levels.[9]

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[4] 186,000 miles per second or 297,600 km/sec. U.S.-CAN. POWER SYS. OUTAGE TASK FORCE, FINAL REPORT ON THE AUGUST 14, 2003 BLACKOUT IN THE UNITED STATES AND CANADA 6 (2004), http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/BlackoutFinal-Web.pdf.

[5] *See* Massoud Amin & Phillip F. Schewe, *Preventing Blackouts*, SCI. AM. (Aug. 13, 2008), http://www.scientificamerican.com/article/preventing-blackouts-power-grid/.

[6] REGULATORY ASSISTANCE PROJECT, ELECTRICITY REGULATION IN THE US 17 (2011) [hereinafter "RAP 2011"], http://www.raponline.org/docs/RAP_Lazar_ElectricityRegulationInTheUS_Guide_2011_03.pdf.

[7] *Id.*; *See* FED. ENERGY REGULATORY COMM'N, ENERGY PRIMER: A HANDBOOK OF ENERGY MARKET BASICS 2 (2012), http://www.ferc.gov/market-oversight/guide/energy-primer.pdf; *see also* INT'L ENERGY AGENCY, ENERGY STORAGE TECHNOLOGY ROADMAP: TECHNOLOGY ANNEX (2014), https://www.iea.org/media/freepublications/technologyroadmaps/AnnexA_TechnologyAnnexforweb.pdf (listing commercially available electricity storage technologies, as well as developing technologies); *but see* Anne C. Mulkern, *Tesla Is Close to Unveiling a Home Storage Battery, Reports $108M 4Q Loss*, CLIMATEWIRE (Feb. 12, 2015), http://www.eenews.net/climatewire/stories/1060013352/; Herman K. Trabish, *Why Utility Execs Say Storage Is the Top Emerging Energy Technology*, UTIL. DIVE (Feb. 4, 2015), http://www.utilitydive.com/news/why-utility-execs-say-storage-is-the-top-emerging-energy-technology/358615/.

[8] MIT 2011, *supra* note 2, at 176.

[9] W.M. WARWICK, A PRIMER ON ELECTRIC UTILITIES, DEREGULATION, AND RESTRUCTURING OF U.S. ELECTRICITY MARKETS 13 (version 2 2002), http://www.pnl.gov/main/publications/external/technical_reports/PNNL-13906.pdf.

At the wholesale level, this restructuring involved establishing independent transmission system operators (ISOs) and regional transmission organizations (RTOs) to manage transmission facilities and to ensure non-discriminatory access to those facilities for generators and distribution utilities.[10] Currently, about two-thirds of Americans live in regions served by ISO/RTOs (see Figure 1, below).[11] Utilities in the Southeast and much of the West did not reorganize management of their transmission segments into ISO/RTOs, and so continue to manage the grid's generation, transmission, and distribution components as integrated monopolies, regulated by state utility commissions.[12]

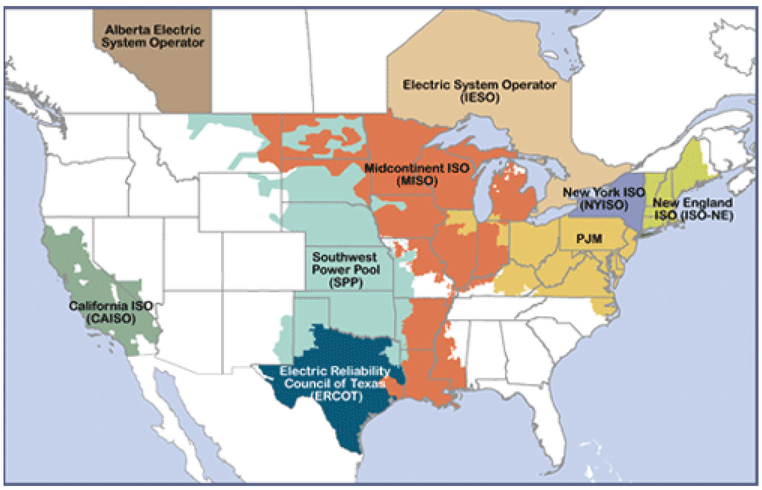

Figure 1. Map showing ISO/RTO regions.[13]

Retail-level restructuring has involved some states "unbundling" the generation and distribution services that regulated utilities previously sold to consumers as an integrated

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[10] MIT 2011, *supra* note 2, at 239.

[11] *See* MIT 2011, *supra* note 2, at 4; ISO/RTO COUNCIL, THE VALUE OF INDEPENDENT REGIONAL GRID OPERATORS 9 (2005), http://www.nyiso.com/public/webdocs/media_room/press_releases/2005/isortowhitepaper_final11112005.pdf.

[12] WARWICK, *supra* note 9, at 60.

[13] *Regional Transmission Organizations (RTO)/Independent System Operators (ISO)*. FED. ENERGY REGULATORY COMM'N (Jan. 21, 2016), http://www.ferc.gov/industries/electric/indus-act/rto.asp.

package.[14] In the 16 states where such services have been unbundled,[15] consumers can choose among competing generators for generation services and among distribution service providers and other energy service companies for distribution services.[16]

In states that have not restructured their retail electricity market but where the transmission grid is operated by an ISO/RTO, distribution utilities operate as a regulated monopoly and purchase wholesale electricity on the ISO/RTO-managed wholesale market.[17]

In addition to these changes to the regulatory and financial aspects of the grid, we are also in the midst of changes to its physical operation. Historically, information has not flowed alongside electricity through transmission and distribution systems. Consequently, if a tree fell and cut a distribution line, the grid operator might see that an imbalance was occurring, but would not be able to pinpoint and repair it until someone could lay eyes on the site of the break. Now, however, information technology can make the grid "smart," or amenable to more sensitive and responsive monitoring and from afar. More specifically, a "smart grid" can optimize the balancing of supply and demand even amid disruptions with little or no human guidance, can provide grid operators with more precise controls over various functions, and can inform consumers about how much electricity they are using and how much it is costing them to do so.[18] A smarter grid can also support the integration of energy storage and distributed generation resources,[19] both of which promise more flexible and cost-effective grid balancing as well as smoother integration of variable renewable generation resources that rely on the sun shining or the wind blowing. Finally, a smart grid is better able to operate in the midst of a destructive storm or other form of disruption. This resilience owes in large part to the option to disaggregate grid operations into "microgrids." A microgrid is a segment of the

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[14] MIT 2011, *supra* note 2, at 176; RAP 2011, *supra* note 6, at 8.

[15] U.S. Energy Info. Admin., *Status of Electricity Restructuring by State*, http://1.usa.gov/1Ljw7Ai (updated Sept. 2010).

[16] RAP 2011, *supra* note 6, at 8 (indicating that large volume customers, e.g. big commercial and industrial users, were allowed to negotiate directly with wholesale power suppliers that competed with the services provided by the utility at regulated price); MIT 2011, *supra* note 2, at 176.

[17] MIT 2011, *supra* note 2, at 176.

[18] PETER FOX-PENNER, SMART POWER 35–37 (2010).

[19] *Id.* at 37.

distribution grid that can operate independently by drawing on local generation resources and modulating local demand to ensure full or partial grid functionality for some duration.[20]

While many of the technologies required to support a smart grid exist, their incorporation into the existing electric grid will necessarily entail careful integration with respect to engineering, financial, and regulatory requirements—steps that are likely to be taken slowly.[21]

1.2. Regulation by PUCs and FERC

All 50 states plus the District of Columbia have established commissions, called either public utility commissions, public service commissions, corporation commissions, or commerce commissions ("PUCs" or "commissions"), to oversee the operation and finances of the electric utility or utilities in their jurisdiction.[22] Similarly, Congress has charged FERC, through the Federal Power Act of 1935, with oversight of electricity transmitted in interstate commerce. Practically speaking, this means that—with some exceptions—whereas state commissions have oversight over utility-owned generation facilities and distribution grids, FERC has oversight over the transmission grid.

The statutes that create state commissions and FERC also specify procedures, principles, and requirements for how they shall regulate their respective segments of the electric grid. These interventions in electricity markets reflect recognition by legislators that safe and reliable access to electricity is essential for the wellbeing of society and its individual members. They also respond to the fact that electricity services have historically been most efficiently provided by an entity that holds a monopoly in a given region—this is why electric utilities have long been called "natural" monopolies.[23] As regulation can do a better job than markets at pushing natural monopolies to provide high quality service and charge reasonable prices,[24] legislatures

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[20] MIT 2011, *supra* note 2, at 115.
[21] NAT'L SCI. & TECH. COUNCIL, A POLICY FRAMEWORK FOR THE 21ST CENTURY GRID 1 (2012), https://www.whitehouse.gov/sites/default/files/microsites/ostp/nstc-smart-grid-june2011.pdf.
[22] *Id.* at 236 (App. B).
[23] RAP 2011, *supra* note 6, at 3.
[24] *See* ALFRED E. KAHN, THE ECONOMICS OF REGULATION: PRINCIPLES AND INSTITUTIONS 119–23 (1988).

have stepped in to make sure that electricity service providers do not charge consumers more than is necessary to provide safe and reliable service.[25] As noted above, restructuring efforts at the wholesale and retail levels depart somewhat from this rubric of regulated natural monopoly. However, that departure is in all cases only partial: PUCs and FERC continue to monitor and police electricity markets in order to ensure that those markets provide safe and reliable electricity to consumers at just and reasonable rates.

1.2.1. Regulators' Central Task

While statutory language varies somewhat across jurisdictions, all regulators' central task is to ensure that capital investments in the electric grid and its day-to-day operations provide consumers with "safe and reliable electricity at just and reasonable rates."[26] Practically speaking, this means regulators must ensure that participants in the electricity sector perform their part in achieving that goal amid changes in population, technology, and electricity demand and supply. This means nearly continuous decision-making about prices, budgets, plans for maintenance and construction, and programs relating to complex functions like the compensation of energy efficiency investments.[27] As commissions make or authorize these decisions, they consider—based on the legislation that guides them—some factors but not others. Thus, commissions act primarily as an economic regulator, leaving environmental or other concerns to other agencies,[28] but they are also generally charged with serving the "public interest," which is susceptible to a range of interpretations.[29]

Commissions generally engage in a careful analysis to plan for the future of the electricity system, relying on long-term demand forecasts of 10 to 20 years that in turn take into account estimates of population growth, historic individual consumption patterns, projected

[25] *Id.*
[26] *See, e.g.*, National Association of State Utility Consumer Advocates, Resolution 2014-04, at 1 (2014), http://nasuca.org/nasuca-electricity-resolution-2014-04/.
[27] *Id.*
[28] *Id.* at 3, 28.
[29] *See* Erik Filipink, NAT'L REGULATORY RESEARCH INST., SERVING THE "PUBLIC INTEREST" – TRADITIONAL VS EXPANSIVE UTILITY REGULATION, NRRI REP. NO. 10-02 (2010), http://bit.ly/1OEeIbp.

economic growth, and impacts of new energy conservation and demand response programs.[30] New infrastructure projects often include construction of new generation units and transmission lines, requiring significant capital investments.[31] Some state commissions are required by statute to develop integrated resource plans (IRPs)—sometimes called "least-cost planning"—which takes a comprehensive approach to planning for the best way to match consumer preferences to resource availability.[32] Whether the IRP is required by statute, or conducted because the PUC has decided to do so on its own, the IRP process allows commissions to compare options for how best to meet changes in the location, size, and nature of consumer demand. Such options might include developing new generation and transmission facilities or reconfiguring existing resources and making greater use of "non-transmission alternatives," such as energy efficiency and distributed generation.[33] In the absence of an IRP process, PUCs consider proposed investments in electricity infrastructure on more of an ad hoc basis, but still with an understanding that new facilities' lifespans could extend several decades into the future.

Beyond instructing commissions to provide safe and reliable electricity at just and reasonable rates, legislatures also sometimes specify how commissions should exercise certain aspects of their authority. For example, while FERC has the broad authority to monitor and regulate national energy infrastructure, it must also comply with federal statutes concerning

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30 MIT 2011, *supra* note 2, at 259 (App. B).
31 *Id.* (noting that planning often takes up to a decade to complete).
32 RAP 2011, *supra* note 6, at 63.
33 RACHEL WILSON & BRUCE BIEWALD, SYNAPSE ENERGY ECONOMICS, INC., BEST PRACTICES IN ELECTRIC UTILITY INTEGRATED RESOURCE PLANNING 9-11 (2013), http://www.synapse-energy.com/sites/default/files/SynapseReport.2013-06.RAP_.Best-Practices-in-IRP.13-038.pdf; *see also* Shelley Welton, *Non-transmission Alternatives*, 39 HARV. ENVTL. L. REV. 457 (2015).

specific pipelines[34] and energy sources,[35] environmental reviews,[36] financial reporting, information technology reporting, and historic preservation.[37]

Commissions generally have substantial discretion to interpret the laws that guide their decisions—discretion they can employ to a variety of ends when deciding about costs utilities ask to incur or about how those costs should be apportioned to groups of ratepayers. Thus commission decisions can reflect a desire to encourage economic development by offering lower rates to new or growing industrial customers, to limit rate increases to vulnerable residential consumers, to maintain gradualism in price-setting, or to achieve some other aim.[38] Ideally, however, commissions should (1) align risk (costs) with reward (benefits), (2) base all determinations on facts rather than hopes, (3) prioritize customer service over cost recovery, and (4) remain objective despite political pressure.[39]

The ultimate check on commissions' discretion is that their decisions may be reviewed by courts. While commissions therefore generally seek to act within the bounds of their authority to avoid judicial review and possible reversal, courts will defer to commissioners' expertise, unless the evidence shows that the commission exceeded its statutory authority, misinterpreted the law, or conducted an unfair process.[40] Certain types of agency action may increase the risk of judicial reversal, including pursuing goals without a clear statutory basis, playing a new role without clearly delegated authority, making decisions based on criteria that are not aligned with explicit goals, or considering different priorities in relation to each other even though the relevant law does not prescribe a balancing test.[41]

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[34] *E.g.*, Alaska Natural Gas Pipeline Act of 2004, 15D U.S.C. §§ 720-720n (2012).
[35] *E.g.*, Natural Gas Act, 15B U.S.C. §§ 717-717z (2012).
[36] *E.g.*, Federal Deepwater Ports Act of 1974, 33 U.S.C. §§ 1501-24 (2012); Clean Air Act, 42 U.S.C. §§ 7401-31; Clean Water Act, 33 U.S.C. §§ 1251-1388; Coastal Zone Management Act, 16 U.S.C. §§ 1451-66.
[37] *See Federal Statutes*, FED. ENERGY REGULATORY COMM'N (February 10, 2016) http://www.ferc.gov/legal/fed-sta.asp.
[38] RAP 2011, *supra* note 6, at 51.
[39] SCOTT HEMPLING, PRESIDE OR LEAD? THE ATTRIBUTES AND ACTIONS OF EFFECTIVE REGULATORS 69 (2nd ed. 2010).
[40] RAP 2011, *supra* note 6, at 22.
[41] SCOTT HEMPLING, REGULATING PUBLIC UTILITY PERFORMANCE 405 (2013).

1.2.2. Federal and State Jurisdiction

Electric power was entirely under states' jurisdiction until 1935 when Congress, through the Federal Power Act, authorized the Federal Power Commission (now the Federal Energy Regulatory Commission, or FERC) to regulate the wholesale transmission and sale of electric power in interstate commerce.[42] This system of dual authority has yielded a complex and somewhat blurry allocation of jurisdiction between state commissions and FERC.[43] (See Table 1, below.)

Activity	***Jurisdictional Authority***		
	Federal (FERC)	**State (PUCs)**	**Local**
Interstate transmission of electricity and natural gas	X		
Hydropower licensing	X		
Off-shore wind facility licensing	X	X	
Sale of electricity at wholesale	X		
On-land facility siting	X	X	X
Environmental impact review	X	X	X
Sale of electricity at retail		X	
Electricity distribution service oversight		X	
Consumer-owned distribution utility oversight		X	X

Table 1. *Regulatory authority over grid facilities.*[44]

The principal basis for the Federal Power Act's intervention in the electricity sector is that the U.S. Constitution allows federal regulation of interstate commerce.[45] The transportation and sale

[42] JOSEPH P. TOMAIN & RICHARD D. CUDAHY, ENERGY LAW IN A NUTSHELL 153 (2nd ed. 2011). New York v. FERC, 535 U.S. 1, 21 (2002) ("The FPA authorized federal regulation not only of wholesale sales that had been beyond the reach of state power, but also the regulation of wholesale sales that had been previously subject to state regulation").
[43] RAP 2011, *supra* note 6, at 1, 24, 25. *See* FERC v. Elec. Power Supply Ass'n v. FERC, 577 U. S. ____ (2016); Hughes v. Talen Energy Marketing, LLC, 136 S. Ct. 993 (2016).
[44] RAP 2011, *supra* note 6, at 11. For a more thorough depiction of actors, activities, and jurisdiction, see Scott Hempling, *Electricity Jurisdiction: Actions by Market Participants*, http://bit.ly/1RGqyCz (updated Feb. 2016).
[45] RAP 2011, *supra* note 6, at 11.

of electricity is economic activity—"commerce"—that crosses state lines. The Supreme Court recognized early on in the life of the electric grid that the locus of flowing electricity rather than the ownership of electric grid facilities was the relevant analysis when considering jurisdictional questions—"an engineering and scientific, rather than a legalistic or governmental, test."[46] In subsequent decisions, the Court elaborated on the Constitutional and statutory bases for jurisdiction over components of the electric grid, and has settled on a basic understanding that intrastate facilities cannot escape federal jurisdiction merely because their assets to do not reach across state lines.[47]

1.2.3. The Core Function of Commissions: Rate-Setting

State commissions' functions generally include determining a utility's revenue requirement, establishing rates for each class of customers, determining general rules and procedures for resource acquisition and managing supply, and adopting performance standards for distribution system services.[48] Commissions also oversee a utility's affiliated but unregulated interests to prevent self-dealing or risky actions, like issuing unreasonably-termed securities that could impair future access to capital.[49] In most states, as depicted in Table 1 above, commissions and other state agencies also have responsibility for issuing the permits necessary to build and operate generation, transmission, and distribution facilities.[50]

Commissions generally establish and amend the rates utilities charge consumers through proceedings called "rate cases", explained further in Part 4. Most U.S. retail electricity rates are determined by cost-of-service pricing, which involves (1) establishing a fair rate of

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[46] Connecticut Light & Power Co. v. FPC, 324 U. S. 515, 529 (1945); *see also* FPC v. Southern California Edison Co., 376 U. S. 205, 376 U. S. 209 n. 5 (1964).

[47] Florida Power & Light Co. v. Federal Power Commission, 404 U.S. 453 (1972) (rejecting argument that movement of electricity demand merely rose and fell in parallel to—rather than in interaction with—interstate supply and demand); *see also* FERC v. Mississippi, 456 U.S. 742, 757 (1982) ("it is difficult to conceive of a more basic element of interstate commerce than electric energy, a product that is used in virtually every home and every commercial or manufacturing facility. No state relies solely on its own resources in this respect").

[48] MIT 2011, *supra* note 2, at 177.

[49] RAP 2011, *supra* note 6, at 27.

[50] *Id.* at 24.

return on prudent capital investments, called the utility's "revenue requirement," and (2) determining the rates that will suffice to ensure that the utility recovers its revenue requirement from ratepayers.[51] Importantly, the revenue requirement excludes "imprudent" capital investments, meaning that a utility is not guaranteed recovery for such investments. A commission conducting a rate case evaluates proposed capital investments in electric facilities and explains its reasons for concluding that they are (or are not) "prudent."[52] In restructured regions, commissions still have oversight over utilities' cost recovery for distribution services, but they rely on the prices arrived at through market mechanisms to determine how much the costs of generation, wholesale power purchases, and transmission should be reflected in ratepayers' bills, and do so in diverse ways.[53]

2. THE GRID'S CLIMATE-RELATED VULNERABILITIES

The electricity system is vulnerable to weather and natural disasters and that vulnerability will likely grow amid the growing impacts of climate change.[54] Commissions can be slow to absorb this fact, however, and may continue to rely on certain assumptions about the future that may not hold true as the effects of climate change materialize. The four climate change impacts most likely to affect electricity consumption and production are (1) a rise in average and peak temperatures and humidity and increasingly long and severe heat waves, (2) changes in the timing and amount of precipitation events, (3) changes in the frequency and intensity of extreme weather events, and (4) sea-level rise and coastal flooding.[55] Because predictions about how climate change will manifest in weather patterns are necessarily

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[51] MIT 2011, *supra* note 2, at 176. See discussion, *infra*, at Part 4.2.

[52] *See, e.g.*, Kristi E. Swartz, *Georgia Power Faces Prudency Test as Reactor Costs Rise by $1.7B*, E&E News, Feb. 29, 2016, http://bit.ly/1XV5Y1L.

[53] MIT 2011, *supra* note 2, at 176.

[54] Vulnerability, in the adaptation context, has been defined as "[t]he degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes." Rosina Bierbaum et al., *Adaptation*, *in* U.S. GLOBAL CHANGE RESEARCH PROGRAM, CLIMATE CHANGE IMPACTS IN THE UNITED STATES: THE THIRD NATIONAL CLIMATE ASSESSMENT 670, 671 (Jerry M. Melillo et al. eds., 2014), http://nca2014.globalchange.gov/downloads.

[55] Robin Kundis Craig, *Energy System Impacts*, *in* AM. BAR ASS'N, THE LAW OF ADAPTATION TO CLIMATE CHANGE 133, 134 (Michael B. Gerrard & Katrina Fischer Kuh eds., 2012).

imprecise, commissions face particular challenges when attempting to make well-supported planning decisions that provide for robustness to climate change impacts.[56] An understanding of the vulnerabilities of the electricity system and possible regulatory responses to these vulnerabilities is essential for an advocate seeking to provide input for commission decision-making processes.

While the precise timing and nature of climate change impacts on the electricity sector are uncertain, experts agree that storms and floods, increased temperatures, and decreased access to water will affect both electricity supply and demand. No mode of electricity generation is impervious to climate change impacts, whether it is fueled by fossil, nuclear, or renewable sources.[57] As for demand, more frequent and dramatic temperature swings and weather events are expected to alter the pattern of electricity use.[58] Although the specific character of extreme precipitation events, sustained summer heat, droughts, and winter storms will vary by region and cannot be predicted with precision in general,[59] FERC and state commissions should take these impacts into account as they consider plans intended to provide safe and reliable electricity at just and reasonable rates decades into the future.[60]

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[56] Bierbaum, *supra* note 54, at 671.

[57] *See* Craig, *supra* note 55, at 155 (describing how relying on ambient natural resources like water, wind, and solar radiation makes renewable energy more likely to be more sensitive to climate variability than fossil or nuclear energy systems); Stanley R. Bull et al., *Effects of Climate Change on Energy Production and Distribution in the United States*, *in* U.S. CLIMATE CHANGE SCI. PGM., EFFECTS OF CLIMATE CHANGE ON ENERGY PRODUCTION AND USE IN THE UNITED STATES 29 (Thomas J. Wilbanks et al. eds., 2008), http://science.energy.gov/~/media/ber/pdf/Sap_4_5_final_all.pdf (explaining the changes in climate adversely effecting both fossil fuel and nuclear generation); Douglas J. Arent et al., *Key Economic Sectors and Services*, *in* CLIMATE CHANGE 2014: IMPACTS, ADAPTATION AND VULNERABILITY 659, 666 (Christopher B. Field et al. eds., 2014), http://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap10_FINAL.pdf.

[58] *See* A. Kavousian et al., *Determinants of Residential Electricity Consumption: Using Smart Meter Data to Examine the Effect of Climate, Building Characteristics, Appliance Stock, and Occupants' Behavior*, 55 Energy 184, 187 (2013) ("the daily minimum consumption is influenced the most by weather, location, and physical characteristics of the building").

[59] John Walsh et al., *Our Changing Climate*, *in* U.S. GLOBAL CHANGE RES. PGM., CLIMATE CHANGE IMPACTS IN THE UNITED STATES: THE THIRD NATIONAL CLIMATE ASSESSMENT 19 (Jerry M. Melillo et al. eds., 2014), http://nca2014.globalchange.gov/downloads.

[60] For detailed reports about various impacts of climate change on the electricity sector *see* AM. BAR ASS'N, THE LAW OF ADAPTATION TO CLIMATE CHANGE 133, 134 (Michael B. Gerrard & Katrina Fischer Kuh eds.,

2.1. Increased Temperatures

As average global temperatures rise, the United States will experience a general warming trend, with hotter summers and milder winters[61]—a change with implications not just for comfort but also for public health.[62] Increased temperatures will impact energy demand for heating and cooling in homes and offices, industrial processes, transportation, construction, and agriculture. It will likely also shift the form of energy demanded in the northern parts of the U.S. from heating oil and natural gas to electricity.[63]

The energy implications of a nationwide increase in demand for cooling will not be balanced out by a coinciding decrease in demand for heating.[64] Rather, since electricity is the source for most cooling and only a portion of heating services, increased cooling requirements and decreased heating requirements will likely result in an overall *increase* in electricity demand.[65] This increase has significant implications for electricity capacity requirements due to its effect on "peak" demand—the periods of the year and the day when aggregate demand reaches its highest level. That is, as demand for electricity for cooling increases, higher peaks may well reach and exceed the grid's existing capacity.[66] Furthermore, because heat waves have

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2012); MICHELLE DAVIS & STEVE CLEMMER, POWER FAILURE (2014), http://www.ucsusa.org/global_warming/science_and_impacts/impacts/effects-of-climate-change-risks-on-our-electricity-system.html; U.S. CLIMATE CHANGE SCI. PGM., EFFECTS OF CLIMATE CHANGE ON ENERGY PRODUCTION AND USE IN THE UNITED STATES (Thomas J. Wilbanks et al. eds., 2008), http://science.energy.gov/~/media/ber/pdf/Sap_4_5_final_all.pdf; ASIAN DEV. BANK, CLIMATE RISK AND ADAPTATION IN THE ELECTRIC POWER SECTOR (2012), http://www10.iadb.org/intal/intalcdi/PE/2012/12152.pdf; U.S. GOV'T ACCOUNTABILITY OFFICE (GAO), CLIMATE CHANGE: ENERGY INFRASTRUCTURE RISKS AND ADAPTATION EFFORTS, GAO-14-74 (2014), http://www.gao.gov/assets/670/660558.pdf; U.S. DEP'T OF ENERGY, U.S. ENERGY SECTOR VULNERABILITIES TO CLIMATE CHANGE AND EXTREME WEATHER (2013), http://energy.gov/sites/prod/files/2013/07/f2/20130716-Energy%20Sector%20Vulnerabilities%20Report.pdf.

[61] Craig, *supra* note 55, at 135.

[62] McGeehin Luber, *Climate Change and Extreme Heat Events*, 35 AM. J. PREVENTATIVE MED. 429, 429 (2008) (describing the increased risk of heat-related illnesses including heat exhaustion and heat stroke related to increased summer daytime highs in temperature).

[63] Craig, *supra* note 55, at 135–37.

[64] *Id.* at 135.

[65] *Id.*; GAO-14-74, *supra* note 60, at 31.

[66] *Id.*

severe, adverse public health effects—they account for more deaths annually than hurricanes, lightening, tornadoes, floods, and earthquakes combined[67]—they will be the source of a powerful imperative to provide artificial cooling as needed, even if doing so is costly.

Along with increasing customers' cooling demands, increases in air temperature will reduce generation and transmission efficiency, meaning that the same facilities will require more inputs to generate and deliver the same outputs.[68] This owes to the design of existing facilities, many of which rely on proximate sources of water for cooling,[69] and embody design specifications that do not anticipate extreme heat or cold for long durations.[70] In other words, extreme temperatures will likely lead to lower capacity rates at nuclear, coal- and gas-fired power plants,[71] lower transmission and distribution line carrying capacity,[72], increased stresses on the distribution system, and decreased substation efficiency and lifespan.[73] High soil temperatures and soil dryness may also lead to less-than-optimal operating conditions for buried ("undergrounded") cables, with predictably adverse effects on grid reliability.[74]

Heat waves, characterized by stagnant, warm air masses and consecutive nights with high minimum temperatures,[75] promise particular challenges for the grid and its operators.[76] Because grid components are generally not designed to operate at sustained high temperatures, and because heat waves will also prompt higher rates of electricity demand for cooling, grid

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[67] Luber, *supra* note 62, at 429; Sharon L. Harlan & Darren M. Ruddell, *Climate Change and Health in Cities*, 3 CURRENT OP. IN ENVTL. SUSTAINABILITY 126, 127 (2011), http://www.sciencedirect.com/science/article/pii/S1877343511000029.
[68] ASIAN DEV. BANK, *supra* note 60, at xiii.
[69] Craig, *supra* note 55, at 148; ASIAN DEV. BANK, *supra* note 60, at xiii.
[70] Craig, *supra* note 55, at 153; Bull et al., *supra* note 57, at 34.
[71] Sofia Aivalioti, *Electricity Sector Adaptation to Heat Waves*, SABIN CTR. CLIMATE CHANGE LAW (Jan. 2015), http://web.law.columbia.edu/sites/default/files/microsites/climate-change/white_paper_-_electricity_sector_adaptation_to_heat_waves.pdf.
[72] Arent et al. *supra* note 57, at 669.
[73] U.S. DEP'T OF ENERGY, *supra* note 60, at 12.
[74] Bull et al., *supra* note 57, at 45 (citing to IPCC Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change found at http://www.grida.no/publications/other/ipcc_tar/?src=/climate/ipcc_tar/wg2/).
[75] Luber, *supra* note 62, at 429.
[76] U.S. DEP'T OF ENERGY, *supra* note 60, at 10.

operators will need to manage ever-higher demand peaks with impaired tools. Such circumstances could put reliability at risk,[77] with costly consequences.[78]

2.2. Changes in Precipitation and Seasonal Patterns

As a result of climate change, northern parts of the U.S. are expected to continue to become wetter, and southern and western parts to become drier.[79] In the western U.S. in particular, decreases in summer rains and winter snowpack will mean lower levels in rivers and reservoirs.[80] In general, most US areas will likely experience more frequent and intense extreme precipitation events.[81] Such changes are expected to lead to episodic and long-lasting water shortages in some areas, and to flooding in others.[82]

The supply side of the electricity sector is already feeling these effects. Extreme weather events impact nearly all forms of generation.[83] Hydroelectric generation is extremely sensitive to changes in both precipitation and river discharge.[84] One recent example is the 2007 drought in northern Georgia that reduced the volume of the Chattahoochee River by nearly 80 percent, leading to a 45 percent reduction in hydroelectric power generation in the region.[85] Another similar example occurred in the opposite corner of the country, where the Bonneville Power Authority failed to meet it contractual obligations to generate hydroelectric power in 2010 as a result of unexpectedly low snowpack and stream volume.[86]

Most fossil fuel and nuclear plants—both called "thermoelectric" plants because they generate electricity by first generating heat—require significant amounts of water to generate,

[77] Arent et al., *supra* note 57, at 669; Aivalioti, *supra* note 71, at 2.
[78] KRISTINA HAMACHI LACOMMARE & JOSEPH H. ETO, ERNEST ORLANDO LAWRENCE BERKELEY NAT'L LAB., UNDERSTANDING THE COST OF POWER INTERRUPTIONS TO US ELECTRICITY CONSUMERS, at xii (2004), https://emp.lbl.gov/sites/all/files/REPORT%20lbnl%20-%2055718.pdf.
[79] GAO-14-74, *supra* note 60, at 7.
[80] U.S. DEP'T OF ENERGY, *supra* note 60, at 17.
[81] GAO-14-74, *supra* note 60, at 7.
[82] Walsh et al. , *supra* note 59, at 66.
[83] Arent et al., *supra* note 57, at 666–68 (noting that wind turbines may constitute an exception to this rule).
[84] U.S. CLIMATE CHANGE SCI. PGM., *supra* note 57, at 41.
[85] GAO14-74, *supra* note 60, at 30.
[86] *Id.*

cool, and condense steam.[87] To serve those needs, thermoelectric plants nationwide make larger withdrawals of freshwater than either the agricultural, residential, or industrial sectors: over 200 billion gallons per day and approximately 40 percent of all sectors combined.[88] Decreased water availability and increased water temperatures reduce the effectiveness of thermoelectric plants' water-reliant cooling systems.[89] In response to insufficient amounts of water, warm outgoing water, or warm intake cooling water, thermoelectric plants sometimes reduce or suspend operation.[90] Utility-scale solar installations also require substantial volumes of water to keep their photovoltaic panels (or, in the case of concentrated solar power facilities, mirrors) clean.[91] Just as too little water can disrupt thermoelectric plant operations, so can too much water in the form of riverine and coastal flooding.[92]

Changes in precipitation and temperature affect the transmission and distribution segments of the grid as well as generation facilities. Increased precipitation, alone or in combination with high winds, can damage power lines and substations, causing outages.[93] On the other hand, reduced rainfall along with increasing temperatures can increase the risk of wildfires, which present distinct but no less significant dangers to grid facilities.[94]

There is good reason to expect that these changing patterns will also affect electricity demand. For instance, there is some evidence that increased precipitation may have a "humidity effect" on electricity demand: a one-inch increase in monthly precipitation was found to result in increased consumption by residential users of both electricity (7%) and of natural gas (2%).[95]

2.3. Extreme Weather Events

[87] GAO-14-74, *supra* note 60, at 19; Bull et al., *supra* note 57, at 34.
[88] U.S. DEP'T OF ENERGY, *supra* note 60, at 22.
[89] Walsh et al., *supra* note 59, at 259, 260; GAO-14-74, *supra* note 60, at 19.
[90] *Id.* at 20 (citing a DOE study with examples of plant shutdowns.)
[91] MASS. INST. TECH., THE FUTURE OF SOLAR ENERGY 49 (2015).
[92] *Id.* at 21.
[93] GAO-14-74, *supra* note 60, at 24.
[94] *Id.* at 25.
[95] U.S. CLIMATE CHANGE SCI. PGM., *supra* note 57, at 18.

Stronger and more frequent storms, which cause damage directly through wind, waves, snow and ice and indirectly through incidental flooding, can impair electricity supplies by reducing the availability of energy inputs (including renewable resources as well as fuels for thermoelectric plants), damaging facilities, and forcing reductions in output.[96] Climate change will continue to affect storms' frequency, intensity, and duration on an average basis,[97] but it will also make specific events' timing and character harder to predict.[98]

Most generation facilities, power lines, and substations and transformers, are exposed to the weather.[99] Hurricanes and tornadoes, along with other high wind events that topple trees, have historically been the most frequent cause of grid disruptions.[100] Disruptions also follow from flooding associated with storm surges.[101] For instance, safe operation and shutdown of a nuclear reactor require reliable interconnection of intact key components, which can be damaged by extreme weather events.[102] Even solar-powered electricity generation technologies, which rely on mounted structures, photovoltaic panels, and other sensitive components, can suffer damage from windstorms, hurricanes, and hail.[103]

Several recent events provide vivid examples of this point, including Hurricane Katrina in the Gulf of Mexico,[104] and Hurricane Sandy in the Northeast.[105] But even riverine floods

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[96] ASIAN DEV. BANK, *supra* note 60, at xiii; Arent et al., *supra* note 57, at 669.
[97] Kenneth E. Kunkel et al., *Climate of the Contiguous United States*, *in* U.S. DEP'T OF COMMERCE, REGIONAL CLIMATE TRENDS AND SCENARIOS FOR THE U.S. NATIONAL CLIMATE ASSESSMENT 69–71 (2013), http://www.nesdis.noaa.gov/technical_reports/NOAA_NESDIS_Tech_Report_142-9-Climate_of_the_Contiguous_United_States.pdf.
[98] U.S. CLIMATE CHANGE SCI. PGM., *supra* note 57, at 35.
[99] Arent et al., *supra* note 57, at 669.
[100] *Id.*; GAO-14-74, *supra* note 60, at 25.
[101] Storm surges are defined as when seawater presses far inland sometimes at heights of 10 to 20 feet or more above typical high tide due to strong winds. JULIE MCNAMARA ET AL., LIGHTS OUT? 1 (2015), http://www.ucsusa.org/sites/default/files/attach/2015/10/lights-out-full-report.pdf.
[102] Arent et al., *supra* note 57, at 667.
[103] Arent et al., *supra* note 57, at 667.
[104] GAO-14-74, *supra* note 60, at 37 (noting that a southeast energy corporation experienced unprecedented damage to transmission and distribution systems, flooded substations, and power plants resulting in shutdowns leading to power outages for roughly 800,000 customers in Louisiana following Hurricane Katrina and Rita).

involving no storm surge or wave action can submerge equipment, causing partial or total failure and requiring costly repair or replacement, as demonstrated by a less windy but still damaging recent flood in South Carolina.[106] In each case, local and regional electric facilities were not built to withstand what hit them.[107]

Of these examples, Hurricane Sandy is especially notable for its impact on the electric grid. That massive storm made landfall in New Jersey in October 2012.[108] It caused power outages affecting 8.66 million people across 20 states and the District of Columbia by damaging electric power transmission and distribution infrastructure, including substations, power lines, and utility poles.[109] State and federal recovery efforts were extremely costly.[110] Climate change impacts such as sea-level rise and increased sea surface temperatures guarantee that future storms will be, on average, bigger, more intense, and will deliver more precipitation.[111] The example of Sandy suggests that utilities and PUCs should look beyond historical weather patterns when deciding whether a given investment will achieve resiliency or storm-hardening.[112]

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[105] U.S. DEP'T OF ENERGY, COMPARING THE IMPACTS OF NORTHEAST HURRICANES ON ENERGY INFRASTRUCTURE 8 (2013), http://www.oe.netl.doe.gov/docs/Northeast%20Storm%20Comparison_FINAL_041513c.pdf.

[106] Polly Mosendz, *South Carolina Flooding Kills Nine, Leaves Thousands Without Power*, NEWSWEEK (Oct 5, 201515, 9:40 AM), http://www.newsweek.com/south-carolina-flooding-kills-least-seven-leaves-thousands-without-power-379830 (explaining that 21,150 power outages were reported from the South Carolina flooding).

[107] *See, e.g.*, U.S. DEP'T OF ENERGY, *supra* note 60, at v. EDISON ELEC. INST., BEFORE AND AFTER THE STORM 37 (2014), http://www.eei.org/issuesandpolicy/electricreliability/mutualassistance/Documents/BeforeandAftertheStorm.pdf (describing that in the aftermath of devastating hurricanes in the preceding years, Florida's legislature required the PSC to determine what should be done to increase the reliability of the state's transmission and distribution systems during extreme weather events).

[108] Eric S. Blake et al., National Hurricane Center, Tropical Cyclone Report: Hurricane Sandy (AL182012) 22–29 October 2012, Feb. 12, 2013, http://1.usa.gov/1oErBr3.

[109] GAO-14-74, *supra* note 60, at 2, 21. U.S. DEP'T OF ENERGY, *supra* note 60, at 8.

[110] *See* Sandy Recovery Office. FEMA. http://www.fema.gov/sandy-recovery-office; GAO-14-74, *supra* note 60, at 2, 21. U.S. DEP'T OF ENERGY, *supra* note 60, at 8.

[111] Kevin E. Trenberth et al., *Attribution of Climate Extreme Events* 5 NATURE CLIMATE CHANGE 725 (2015).

[112] Christine A. Fazio & Ethan I. Strell, *New York State Leading on Utility Climate Change Adaptation*, N.Y. L.J.(Feb. 27, 2014), http://www.clm.com/publication.cfm?ID=484.

2.4. Sea-level Rise

Seas are rising, both because glaciers around the world and the polar ice caps are melting, and because warmer oceans take up a larger volume than colder ones. In some parts of the U.S., such as the Mid-Atlantic, land subsidence exacerbates the effects of rising seas by bringing still more structures and facilities into closer contact with the ocean.[113] A large percentage of the nation's energy infrastructure (including operational power plants, nuclear facilities, and natural gas import/export facilities) sits along the coasts, where it has access to cooling water and shipping.[114] One 2010 study estimated potential losses of $350 billion along the Coast of the Gulf of Mexico in the next 20 years due to rising sea-level and loss of coastline.[115] Some of the specific mechanisms of damage anticipated in the report include downing of vegetation and of wooden poles that support power lines and the inundation of substations.[116] Although it was the result of an off-shore earthquake rather than a weather event, the devastating impact of a tsunami on Japanese nuclear facilities in March 2011 illustrates an extreme version of the risks that coastal facilities face, and the acute dangers arising from facilities not being designed to handle possible or probable extreme events.[117] As climate change-related risks increasingly come into focus, the utilities and commissions responsible for generation facilities built on coastlines should recognize that incurring costs to reduce those facilities' vulnerability can yield net *savings* and thus lower future electricity rates, notwithstanding the expense of adapting. Similarly, any plans for new coastal facilities—

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[113] *See* JACK EGGLESTON & JASON POPE, U.S. GEOLOGICAL SURVEY & HAMPTON ROADS PLANNING DIST. COMM'N, LAND SUBSIDENCE AND RELATIVE SEA-LEVEL RISE IN THE SOUTHERN CHESAPEAKE BAY REGION, CIRCULAR 1392 (2013), http://bit.ly/1S4aZBY.
[114] Bull et al., *supra* note 57, at 48.
[115] GAO-14-74, *supra* note 60, at 39.
[116] *Id.*
[117] *See* CHARLES MILLER ET AL., U.S. NUCLEAR REGULATORY COMM'N, RECOMMENDATIONS FOR ENHANCING REACTOR SAFETY IN THE 21ST CENTURY 7-14 (2011), http://pbadupws.nrc.gov/docs/ML1118/ML111861807.pdf.

whether they serve the grid's generation, transmission, or distribution segment—should receive scrutiny in light of expectations for sea-level rise and the risks known to accompany it.[118]

3. GOALS FOR ADAPTATION ADVOCACY

While advocates can also promote adaptation through legislative change, the focus of this chapter is the regulatory process that takes place before federal and state commissions. In general, advocacy efforts undertaken without legal representation before these commissions are more likely to be effective if directed at state PUCs than at FERC, as state PUCs are more accessible to members of the public and are charged with considering a broader range of issues.[119] Furthermore, as the Government Accountability Office noted recently, the federal role in directly adapting energy infrastructure is limited.[120]

Effective advocacy for climate change adaptation involves explaining how adaptation efforts can promote the central responsibility of the commission, namely providing safe and reliable electricity to consumers at just and reasonable rates. Advocates, knowing that the price and reliability of electricity in the future will be affected by climate-related drivers as well as factors traditionally weighed by commissions as costs or benefits, should seek to bring novel climate-related considerations to the fore.[121] This sort of emphasis can help promote substantive proposals for adaptation as well as procedural changes to commissions' decision-making processes.

3.1. Basic Premises to Convey to Commissions

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118 Jessica Wentz, *City of Miami Opposes Nuclear Plant Expansion, Citing Climate Change Risks*, CLIMATE LAW BLOG, (July 27, 2015) http://bit.ly/1QMUDPD.
119 *See* Part 1.2.3, *supra*.
120 GAO-14-74, *supra* note 60, at 45.
121 RAP 2011, *supra* note 6, at 28.

Commissions, in accordance with the statutes that guide them, frame their decisions in economic terms,[122] and are wary of committing ratepayers to paying more for a facility or service than those ratepayers stand to recoup in the form of measurable benefits. Specifically, commissioners must determine whether investment in a new facility or in improved resilience will be "prudent." This term's legal meaning is explained more fully in Part 4.3.1 below; for now, it is enough to understand that commissions police against any investment that is not expected either to pay for itself or to perform its intended function in a cost-effective manner. Thus, proposals like those described in Part 3.2 could strike commissioners as risky instead of prudent because they could entail sinking "ratepayer money into large, unfamiliar investments with the promise of enormous but hard to measure benefits."[123] Advocates should, therefore, understand that commissions may not be accustomed to accounting for "non-economic" factors like climate change-related impacts, and should be prepared to demonstrate in specific ways how greater climate resilience can reduce the costs of operation while increasing service reliability.

Advocates should also understand the scope of and limits on commissions' discretionary authority. Commissions are instructed by the statutes that establish and guide them to use their expertise when making decisions, and courts will generally defer to a commission's findings when facts are in dispute. For example, a projection of future demand for electricity services is a factual point that, once determined by a commission, an inexpert court will generally be loath to overturn. But commissions must also give reasons for resolving factual questions in a particular way. Thus, if it appears that a proposal before a commission relies heavily on a questionable estimate of future electricity demand, an advocate who favors revising that proposal should present arguments and evidence to the commission in support of a more reasonable electricity demand projection. In general, an advocate should understand that a commission can only ground its decisions in evidence, and so will be unable to agree with

[122] *Id.* at 3, 28.
[123] FOX-PENNER, *supra* note 18, at 52.

arguments, no matter how compelling, unless they are backed up by credible evidentiary support.

3.2. Substantive Adaptation Proposals to Address Grid Vulnerability

More and more, climate change will force elements of the electric grid to operate in conditions materially different from those for which they were designed.[124] While technologies and components capable of adapting the grid to higher temperatures, reduced water access, and more severe storms are largely available for deployment,[125] such deployment would be expensive and would present engineering and regulatory challenges.[126] As the U.S. Department of Energy has noted, addressing climate change-related vulnerabilities entails investments not only in new technologies and approaches, but also in enhanced information, stakeholder engagement, and enabling frameworks.[127] Such investments require commissions to have access to "improved data, models, and vulnerability assessments; greater outreach and collaboration to facilitate communication and education; and forward-looking innovation and deployment policies and strategies, which may be federal or non-federal." [128]

Thus, climate change confronts commissions with challenging and consequential analytic tasks, all focused on interpreting the value of novel components and approaches, and doing so in environmental circumstances that are departing from historical patterns. Beset by these uncertainties, commissions must nonetheless decide whether hardening existing components and procuring and deploying uprated or smart ones will cause ratepayers to pay more over the next 5, 10, or 20 years than just maintaining or reproducing the status quo. The basic role of advocates seeking to push commissions to consider and approve more and better grid adaptation efforts is to help demonstrate how incurring—or forgoing—additional expenses

[124] U.S. DEP'T OF ENERGY, *supra* note 60, at 1.
[125] *See* ELEC. POWER RES. INST., ESTIMATING THE COSTS AND BENEFITS OF THE SMART GRID A PRELIMINARY ESTIMATE OF THE INVESTMENT REQUIREMENTS AND THE RESULTANT BENEFITS OF A FULLY FUNCTIONING SMART GRID 5-1 – 6-20 (2011), http://1.usa.gov/1Qjo1z5 (describing in detail functions of smart components for transmission and distribution grid segments, as well as those components' costs).
[126] U.S. CLIMATE CHANGE SCI. PGM., *supra* note 57, at 48.
[127] U.S. DEP'T OF ENERGY, *supra* note 60, at 6.
[128] *Id*.

now can yield a more cost-effective system in the ensuing years.[129] Particular categories of capital and programmatic investment are discussed below.

3.2.1. Adopting Smart Grid Technology

Many of the adaptation strategies described in the following Parts would benefit from one or more smart grid components. By supplying utilities, consumers, and third parties with more and better information about electricity needs and options, smart grid technologies can facilitate integration of distributed generation, time-based pricing, demand response, and renewables, all of which promote grid flexibility and resiliency. Thus, while making the grid smarter is not the same as adapting it to climate change, a smarter grid is, generally, a better adapted one.[130]

3.2.2. Investing in Conservation and Demand-Side Management

Advocates seeking to push utilities to cost-effectively maintain electricity reliability should argue for investments in energy efficiency and conservation as well as demand-side management (DSM) to the extent permitted by the relevant statutory authority.[131]

Energy efficiency and conservation measures like building insulation and highly efficient lighting reduce the level of demand for which matching supply must be built,[132] and can thereby play a significant role in the balancing of electricity load and generation over the medium- to long-term.[133] In many instances, improving efficiency is a more cost effective

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[129] *See* EXECUTIVE OFFICE OF THE PRESIDENT, ECONOMIC BENEFITS OF INCREASING ELECTRIC GRID RESILIENCE TO WEATHER OUTAGES 3 (2013), http://bit.ly/1OQugZL (concluding that continued investment in grid modernization and resilience will mitigate costs of outages and save the economy billions of dollars).
[130] *See* Kalee Thompson, *How to Save the Electric Grid*, POPULAR SCI., Jan. 28, 2013, http://bit.ly/1Qdqwh1 (discussing several examples of adaptation efforts that build upon smart technologies).
[131] Craig, *supra* note 55, at 136.
[132] *See* Tamaryn Napp, Nilay Shah & David Fisk, *What's energy efficiency and how much can it help cut emissions?*, THE GUARDIAN (June 8, 2012, 4:32PM), http://www.theguardian.com/environment/2012/jun/08/energy-efficiency-carbon-savings.
[133] Craig, *supra* note 55, at 140.

strategy than adding generation or transmission capacity,[134] and can keep rates low by deferring or wholly obviating the need to pay for new facilities.[135]

States have diverse approaches to engaging utilities in energy efficiency and conservation efforts—whereas commissions in one state might have several ways to encourage utilities to invest in efficiency, commissions in another state might have little or no authority to do so.[136] Similarly, utilities face very different incentives in relation to the construction of new capacity depending on the jurisdiction where they operate. The legislatures in 17 states have "decoupled" their utilities' electricity sales from their profit margins, meaning that those utilities receive compensation based on a set of performance measures and *not* simply for the volume of electricity they produce and sell.[137] By contrast, utilities in other states continue to be compensated based on how much electricity their customers buy,[138] an arrangement that gives utilities strong incentives to build additional facilities and little reason to support—indeed good reason to stymie—efforts by consumers to consume less.[139] Consequently, while advocates should not shy away from presenting arguments to a commission in favor of energy efficiency

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[134] *See* ELECTRIC POWER RESEARCH INSTITUTE, U.S. ENERGY EFFICIENCY POTENTIAL THROUGH 2035, at 6-1 through 6-6 (2014), http://bit.ly/1OfjUj1; Am. Council for Energy-Efficient Econ., *New Report Finds Energy Efficiency is America's Cheapest Energy Resource*, ACEEE (March 25, 2014), http://aceee.org/press/2014/03/new-report-finds-energy-efficiency-a; Toshi Arimura et al., *Cost-Effectiveness of Electricity Energy Efficiency Programs*, RESOURCES FOR THE FUTURE (April 2011), http://www.rff.org/files/sharepoint/WorkImages/Download/RFF-DP-09-48-REV.pdf.

[135] DAVIS & CLEMMER, *supra* note 60, at 10.

[136] *See Energy Efficiency Resources Standards or Goals,* DATABASE OF STATE INCENTIVES FOR RENEWABLES & EFFICIENCY (Mar. 2015), http://bit.ly/1l6xhIl; EDISON FOUNDATION INSTITUTE FOR ELECTRIC INNOVATION, STATE ELECTRIC EFFICIENCY FRAMEWORKS (2014), http://bit.ly/1HYOUPA; SHELLEY WELTON, ET AL., PUBLIC UTILITY COMMISSIONS AND ENERGY EFFICIENCY A HANDBOOK OF LEGAL & REGULATORY TOOLS FOR COMMISSIONERS AND ADVOCATES (Aug. 2012).

[137] *Decoupling Policies*, CENTER FOR CLIMATE AND ENERGY SOLUTIONS, http://bit.ly/1OaS0ER (last visited Jan. 13, 2016); *see also* Joel Berg, *Utility Regulators Weigh Alternative Payment Methods*, CENTRAL PENNSYLVANIA BUS. J., Jan. 19, 2016, http://bit.ly/1VCssmJ (discussing upcoming hearing on decoupling proposal). For a description of different approaches to "decoupling," *see* REGULATORY ASSISTANCE PROJECT, REVENUE REGULATION AND DECOUPLING (2011), http://bit.ly/1O3bcpP.

[138] National Renewable Energy Laboratory, *Decoupling Policies: Options to Encourage Energy Efficiency Policies for Utilities*, U.S. DEP'T OF ENERGY, 1 (Dec. 2009), http://bit.ly/1LmqIqr ("decoupling . . . removes the incentive for utilities to increase sales as a means of increasing revenue and profits").

[139] *Id.*; *see also* Kahn, *supra* note 24, at 49–58.

and conservation in any case, advocates should be aware of how their jurisdiction approaches the topic before formulating such an argument.

DSM is a category of electricity pricing approaches that depart from the traditional paradigm of electricity consumers being blind and indifferent to the real-time costs of electricity system balancing. By incorporating consumer preferences and decisions into the process of balancing, DSM can lower the cost of balancing to individual consumers and to the system as a whole.[140] Consumers' DSM options depend on what the state legislature has authorized—or required—of commissions and utilities. How utilities may reward ratepayer participation in DSM programs in California[141] differs from what they may do in Indiana,[142] which differs again from what is required and allowed in Pennsylvania,[143] and elsewhere. Whatever the particulars of a given state's approach, many commissions are in a position to encourage electricity consumers to alter the amount and/or pattern of their consumption in ways that reduce the need to supply electricity—and thus the need to maintain or build electricity generation and transmission facilities.[144] Longstanding DSM programs have involved consumers receiving discounts on their electric bills by giving utilities direct control over a particular device—say, the motor of a swimming pool water filter—at times when the utility can reduce its costs by cycling that motor (and dozens or hundreds of others in its service territory) off for an hour instead of ramping up an additional power plant.[145] More recent additions to the DSM menu

[140] U.S. ENERGY INFO. ADMIN., ANNUAL ENERGY REVIEW, TABLE 8.13 ELECTRIC UTILITY DEMAND-SIDE MANAGEMENT PROGRAMS, 1989-2010 (Sept. 2012), http://1.usa.gov/1L9KfBg (listing energy and cost savings from DSM programs).

[141] *See Integrated Demand Side Management*, CAL. PUBLIC UTILITIES COMMISSION, http://www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=5417 (last visited Nov. 18, 2015) (providing links to materials summarizing California's longstanding and diverse DSM programs).

[142] *See* Letter from Indiana Utility Regulatory Commission to Michael Pence, Governor (Oct. 9, 2014), http://bit.ly/1O3iQAp (listing existing DSM programs and recommending changes).

[143] *See Energy Efficiency and Conservation (EE&C) Program*, PA. PUBLIC UTILITY COMMISSION, http://bit.ly/1X8cuQY (last updated Aug. 2015) (listing PUC orders that instruct utilities regarding amount and nature of required energy efficiency and DSM spending).

[144] *See generally* WORLD BANK, PRIMER ON DEMAND-SIDE MANAGEMENT (Feb. 2005), bit.ly/1SUox77.

[145] *See, e.g.*, Ellis Gardner, Scientific-Atlanta, *Load Management DSM: Past, Present & Future*, Proceedings of the Ninth Symposium on Improving Building Systems in Hot and Humid Climates (May 19–20, 1994), http://bit.ly/1HXZefT.

include varieties of "dynamic pricing,"[146] which unmoor the price of retail electricity from its averaged monthly rate and allow it instead to move up or down depending on the costs of supplying load at a particular window of time. Consumers, thus informed of when their electricity use will cost more or less, can optimize usage for themselves, and thereby reduce the costs that utilities incur (and pass through) by building, operating, and maintaining additional electricity supply capacity. Another form of DSM is called "economic demand response," "wholesale demand response," or just "demand response."[147] This involves a consumer agreeing to curtail usage for some duration and receiving payment in the wholesale marketplace for "supplying" a reduction that functions much as would an equivalent volume of generation.[148] Currently, the consumers that make heaviest use of the DSM programs mentioned above tend to be large industrial and commercial entities that consume large volumes of electricity, pay close attention to opportunities for cost savings, and can devise optimal ways to coordinate usage reductions that do not disrupt operations.[149]

Because transparent, real-time pricing information is helpful for DSM generally and prerequisite for several types of dynamic pricing, many DSM programs' success turns substantially on whether "smart meters," also called advanced metering infrastructure ("AMI"), have been installed in a given service territory.[150] Whereas traditional meters simply count the kilowatt hours attributable to a consumer in a given month, AMI tracks usage in real time, allowing the distribution utility to monitor the grid for shifts and outages, and allowing

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[146] RAP 2011, *supra* note 6, at 52. Types of dynamic pricing programs include time-of-use pricing, critical peak pricing, variable peak pricing, real time pricing, and critical peak rebates. These vary in their particulars but all require consumers to pay more for electricity when load moves closer to a peak, and to pay less when it moves away from a peak. *See Time Based Rate Programs*, SMARTGRID.GOV, https://www.smartgrid.gov/recovery_act/time_based_rate_programs.html (last visited Jan. 2, 2016).
[147] *See generally* U.S. Department of Energy, *Demand Response*, http://1.usa.gov/1ePEzKe (visited Feb. 18, 2016).
[148] This form of DSM, promoted by FERC with a 2011 order, has been controversial, and recently survived review by the Supreme Court. *See* FERC v. Elec. Power Supply Ass'n v. FERC, 577 U. S. ____ (2016).
[149] *See* Merrian Borgeson, Lawrence Berkeley Nat'l Lab., *Review of Self-direct Demand Side Management (DSM) Programs* (Nov. 2012), http://bit.ly/1lveA1E (cheapest DSM resources are from [commercial/industrial] customers).
[150] *Tips: Time-Based Electricity Rates*, ENERGY.GOV, http://www.energy.gov/energysaver/tips-time-based-electricity-rates (last visited Jan. 12, 2016).

consumers to know—if they participate in a form of dynamic pricing program—how much they can expect to be charged for electricity usage from minute to minute or hour to hour.[151] Consequently, creating or expanding DSM programs likely means first making large investments in AMI.[152]

3.2.3. Distributed Generation

Historically, supplying electricity has meant building large power plants and transmission and distribution systems to carry electricity from those plants to consumers.[153] Today, while this strategy still works, alternatives are also available in the form of distributed generation ("DG"), a category that includes rooftop and community-scale solar panels, small-scale wind generation, methane from landfills, backup generators, and cogeneration facilities that supply both heat and electricity to the buildings that house them.[154] Denmark's experience illustrates what it means to decentralize or "distribute" generation (see Figure 2, at right).[155] Because DG uses distribution networks rather than transmission networks to connect to consumers,[156] it avoids the efficiency losses resulting from connections to generation facilities intermediated by multiple substations and long transmission lines.[157] DG is also a critical component of microgrids, described in Parts 1.1 above and 3.2.4 below.

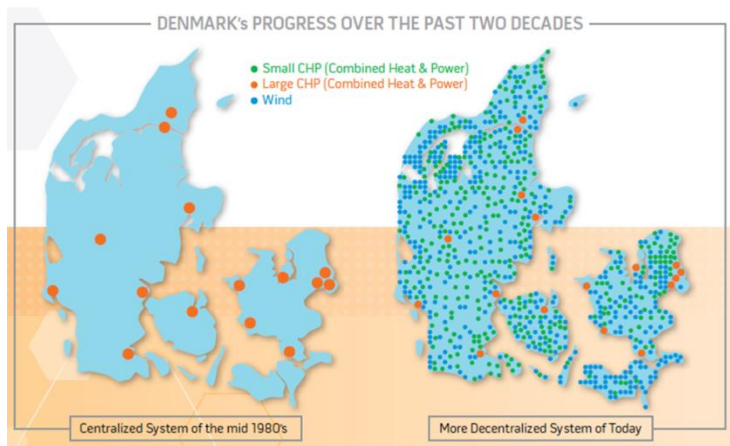

Figure 2. Danish transition to DG.

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[151] *See* RAP 2011, *supra* note 6, at 100–101.
[152] *See* PECO Energy Co., *Smart Meter Universal Deployment Plan*, PECO.COM 7 (2013), http://bit.ly/1QK0hSw ("The costs of Phase One, including the installation of 600,000 meters, were preliminarily estimated at $250 -$300 million.").
[153] Craig *supra* note 55, at 141.
[154] *Id.*
[155] U.S. DEP'T OF ENERGY, THE SMART GRID 9 (2008), http://1.usa.gov/1LmHtC0.
[156] Thomas Ackermann et al., *Distributed generation*, 57 ELEC. POWER SYS. RES. 195, 195 (2001).
[157] Craig *supra* note 55, at 141.

DG has great potential for adapting the electric grid to a changing climate. DG assets' geographic dispersal means that storm damage to particular linkages or nodes in the electric grid will be less likely to cause a widespread outage than might follow from damage to a distribution system that relies on one or two linkages to far-flung generation resources.[158] Notably, DG resources do not preclude connection to farther-flung generation resources and interconnections, but rather alleviate exclusive reliance on those resources. This greater stability is useful not only for resilience to storms and other events, but also for maintenance of power quality more generally.[159]

Converting the grid's physical, operational, regulatory, and financial architecture to allow for DG to supply a significant fraction of what consumers demand is no small task. At a minimum, it would entail a restructuring of rate plans and coordinated, multi-stakeholder infrastructure planning of the sort currently being pioneered in New York's multi-year Reforming the Energy Vision proceeding.[160] Furthermore, wholesale reliance on DG without a carefully phased transition could sacrifice economies of scale and the reliability provided by the existing system without creating a functional replacement.[161]

3.2.4. Grid Hardening

"Hardening" means making "physical changes to infrastructure to make it less susceptible to storm damage, such as high winds, flooding, or flying debris."[162] Practically speaking, hardening means ensuring that the equipment in the path of probable extreme

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[158] MIT 2011, *supra* note 2, at 111; AMORY B. LOVINS ET AL., SMALL IS PROFITABLE: THE HIDDEN ECONOMIC BENEFITS OF MAKING ELECTRICAL RESOURCES THE RIGHT SIZE 240 (2012).

[159] *See* Pew Charitable Trusts, *Distributed Generation: Cleaner, Cheaper, Stronger* (Oct. 2015), http://bit.ly/1Ualqae.

[160] *See* Tom Stanton, National Regulatory Research Institute, *Distributed Energy Resources: Status Report on Evaluating Proposals and Practices for Electric Utility Rate Design* (Sept. 2015) http://nrri.org/wp-content/uploads/2015/09/20150924-Stanton-Presentation.pdf; *About the Initiative*, NY DEP'T OF PUB. SERV. (01/28/2016 03:52:16 PM) http://www3.dps.ny.gov/W/PSCWeb.nsf/All/CC4F2EFA3A23551585257DEA007DCFE2?OpenDocument (summarizing the REV initiative); NY DEP'T OF PUB. SERV., STAFF WHITE PAPER ON BENEFIT COST ANALYSIS IN THE REFORMING ENERGY VISION PROCEEDING (2015).

[161] Craig *supra* note 55, at 141.

[162] GAO-14-74, *supra* note 60, at 11; EDISON ELECTRIC INST., *supra* note 107, at 1.

weather is appropriately situated and "uprated" (i.e., capable of withstanding impacts, inundation, etc.). Hardening measures can include burying power lines ("undergrounding"), paring back vegetation,[163] imposing revised design and construction standards on procured equipment, deploying smart components, and establishing microgrids. Because system hardening is expensive, and a hardening of the entirety of a distribution grid all at once is nearly always cost-prohibitive, utilities generally undertake hardening partially and incrementally, focusing first on the most critical and vulnerable system components.[164]

The problems presented by more and increasingly intense storms can be addressed at least in part by undergrounding and vegetation management. Undergrounding of transmission and distribution lines removes them from the path of storms, albeit five to 10 times the cost of maintaining overhead equipment[165] Thus any undergrounding effort must target problem areas carefully; such efforts are often not the most cost-effective method to reduce system vulnerability in particular locations.[166] Undergrounding is also not appropriate for high-risk flooding areas like coastal areas prone to storm surge.[167] Vegetation management can also be targeted at problematic or precarious trees and branches.[168] Advocates can press local officials to implement these measures by (1) establishing and enforcing ordinances that require the removal of dead/dying trees from private property near power lines and (2) planting, or communicating directly with private owners to plant, appropriate vegetation with shorter heights and longer lifecycles under power lines.[169] Programs to trim or cut down trees are often unpopular with local residents (until the trees take down power lines).

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[163] DEP'T OF ENERGY, QUADRENNIAL ENERGY REVIEW at 2-14 (2015) [hereinafter DEP'T OF ENERGY, QUAD. REV.], http://energy.gov/sites/prod/files/2015/07/f24/QER%20Full%20Report_TS%26D%20April%202015_0.pdf, ("While it might be considered low-tech, vegetation management is an essential activity; both the 1996 West Coast and 2003 East Coast-Midwest power outages started from trees along transmission lines.").
[164] EDISON ELECTRIC INST., *supra* note 107, at 7.
[165] DAVIS & CLEMMER, *supra* note 60, at 1–2.
[166] *Id.*
[167] *Id.*
[168] *Id.* at 4–5.
[169] *See id.*

Hardening also includes implementing design and construction standards that make facilities capable of withstanding severe weather events.[170] For example, in coastal areas, this might mean ensuring that the transformers, circuit breakers, and switches located at distribution substations are elevated, relocated or replaced with equipment capable of operating while submersed in fresh or saltwater.[171] Moats, floodwalls, or restored or enhanced natural protections like dunes and wetlands might also feature in a plan for hardening segments of an electricity distribution system in a coastal community.[172]

Installing smart components does not harden the grid to extreme weather—portions of the distribution system must remain intact for even a smart grid to be effective[173]—but smart technologies can improve system resilience, complementing hardening efforts by enabling grid operators to map outages in real time, isolate faults, and remotely reroute electricity through undamaged circuits and feeders so that no part of the grid stays down for long.[174] Smart technology also enables "islanding" of distribution grid sub-segments, microgrids that can continue operating independently for some duration without relying on generation sources beyond the microgrid's locality.[175]

3.2.5. Adapting Generation Through Careful Siting Decisions

When commissions consider new generation facility siting proposals, advocates should encourage the thorough consideration of the facility's need for and access to water, accessibility of key inputs (such as fuel), options for transportation and disposal of wastes, and the need for new transmission lines. Each of these features is likely to be affected in some way by the changing climate. Given that many generation facilities are built to operate for 50 years or more,

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[170] *Id.* at 6–7.
[171] DAVIS & CLEMMER, *supra* note 60, at 9; EDISON ELECTRIC INST., *supra* note 107, at 6–7.
[172] DAVIS & CLEMMER, *supra* note 60, at 9.
[173] EDISON ELECTRIC INST., *supra* note 107, at 9.
[174] *Id.*
[175] *Id.* at 11; Maryland—Resiliency Through Microgrids Task Force Report 11 (June 2014) http://bit.ly/1T0XJid ("distributed generation is a critical component of any microgrid").

advocates should push the utilities and commissions responsible for proposing and approving such facilities to consider longer-term climatic changes when tallying their costs and benefits.[176]

Atop the list of changes to anticipate is a facility's need for access to water relative to the cost of accessing water. Most existing thermoelectric generation is water-intensive, requiring an average of 25 gallons per kWh of electricity generated for cooling alone.[177] Thus, for facilities sited inland, particularly in western states where the value of water is sure to rise as its availability falls and becomes less predictable,[178] advocates should push utilities and commissions to explore thoroughly the operational and financial implications of potential futures for proximate water bodies and cooling needs.[179] For facilities sited on a coastline, advocates should demand that attention be paid to the implications of sea-level rise and attendant risks like erosion and storm surges.[180]

One potential answer to these concerns is plant designs that use less water. Examples include dry and wet-dry hybrid cooling systems, and thermoelectric facility designs that incorporate water reuse or heat rejection, or draw on alternative water sources—or, of course, renewables the do not require substantial amounts of water.[181] Although these technologies may appear more expensive when viewed through a traditional lens, the cost implications of relying unduly on water access will likely make novel approaches that reduce the need for such access more cost-effective.

In addition to concerns about the effects of climate change on what a generation facility must take in to operate, advocates should also attend to concerns about the wastes that facilities generate. Perhaps the most notable example is coal ash, which is often stored in settling ponds

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[176] Bull et al., *supra* note 57, at 47 (noting that coal-fired plants operate for 50–75 years); Paul Voosen, *How Long can a Nuclear Reactor Last*, SCI. AM. (Nov. 20, 2009), http://www.scientificamerican.com/article/nuclear-power-plant-aging-reactor-replacement-/ (explaining that nuclear power plants are predicted to operate much longer than their planned 40 year life span).
[177] Bull et al., *supra* note 57, at 32 (noting that the figure is "a weighted average that captures total thermoelectric water withdrawals and generation for both once-through and recirculating cooling systems.")
[178] U.S. CLIMATE CHANGE SCI. PGM., *supra* note 57, at 48.
[179] Arent et al., *supra* note 57, at 666; Aivalioti, *supra* note 71, at 30–31.
[180] Wentz, *supra* note 118.
[181] Craig, *supra* note 55, at 148.

near a facility.[182] More extreme storms, heavier precipitation, and attendant flooding raises the risk of a breach or overflow of such ponds—an event that could disperse millions of gallons of toxic sludge into the area around the plant and nearby waterways.[183]

3.2.6. Increasing Resiliency by Diversifying Energy Sources

Resiliency, the "ability to recover quickly from damage to facilities' components or to any of the external systems of which they depend,"[184] is advanced through utilities' efforts to diversify energy sources, invest in standby response equipment, maintain adequate back-up restoration supplies, plan for post-outage communication and coordination, and use advanced technologies.[185] More concretely, for a seasonally cold region like the northeast, this might mean having secure access to generation other than regional natural gas plants, in case the pipelines that feed them are overburdened by a sustained and severe cold snap.[186] Such efforts would be undertaken by utilities and supported by commissions through rate recovery—but such efforts might not occur without pressure from advocates. Importantly, resiliency measures do not necessarily prevent damage; but they can mitigate it substantially, enable electric facilities to continue operating amid impairments, and promote a rapid return to normal operations.[187]

Jurisdictions with diverse energy sources reduce their reliance on supply from any one energy source or region that may be particularly susceptible to climate change impacts.[188] Such diversification reduces the risk of interruption that attends reliance on a single generation facility, or on generation facilities powered by just one type of fuel by ensuring that any given

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[182] *See generally* .EPA, *Coal Ash (Coal Combustion Residuals, or CCR)*, http://1.usa.gov/1Qf8A9h (last updated Oct. 21, 2015).

[183] *See* Shaila Dewan, *Coal Ash Spill Revives Issue of Its Hazards*, N.Y. Times, Dec. 24, 2008, at A1, *available at* http://www.nytimes.com/2008/12/25/us/25sludge.html; Catherine E. Shoichet, *Spill Spews Tons of Coal Ash into North Carolina River*, CNN (Feb. 9, 2014), http://www.cnn.com/2014/02/09/us/north-carolina-coal-ash-spill/.

[184] GAO-14-74, *supra* note 60, at 11.

[185] EDISON ELEC. INST., *supra* note 107, at 13–16.

[186] *See* DEP'T OF ENERGY, QUAD. REV., *supra* note 180 at 2-13 ("dual-fueled (natural gas and petroleum) plants in the Northeast increased electricity reliability in the winter of 2013-2014 when the extreme cold of the polar vortex threatened to constrain natural gas supplies.").

[187] EDISON ELEC. INST., *supra* note 107, at 1.

[188] DAVIS & CLEMMER, *supra* note 60, at 11.

disruption—whether arising from an extreme weather event or a sudden spike in fuel prices—does not interrupt all proximate generation facilities.[189]

Renewables have the potential to contribute significantly to the resilience of the electricity sector, as evidenced by their performance during recent extreme weather events.[190] Compared to large thermoelectric plants, renewable generation resources are more spatially dispersed and generally less susceptible to shut down amid severe weather (See Part 3.2.3).[191] Some solar facilities and all wind farms are less dependent on water than thermoelectric plants,[192] and are much cheaper to repair or replace.

3.2.7. Increasing Resiliency by Utilizing Storage

Energy storage can improve grid stability and resilience in several ways. It can support greater integration of renewables by offsetting unexpected drops in generation when the wind stops blowing or the sun disappears behind clouds (as well as expected drops when the sun goes down).[193] It can reduce the height of demand "peaks" by providing substitutes for generation at times when all other generation facilities are already being tapped.[194] And, by

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[189] Aivalioti, *supra* note 71, at 2; DAVIS & CLEMMER, *supra* note 60, at 12.

[190] In Texas' 2011 heat wave, when thermoelectric power plants shut down, wind power helped prevent rolling blackouts. DAVIS & CLEMMER, *supra* note 60, at 12. Solar and wind energy sources survived Hurricane Sandy and began producing power soon after it passed. *Id.*

[191] Aivalioti, *supra* note 71, at 32.

[192] CAL. CLIMATE CHANGE CENTER, OUR CHANGING CLIMATE 2012 14 (2012) http://www.energy.ca.gov/2012publications/CEC-500-2012-007/CEC-500-2012-007.pdf.

[193] *See* U.S. DEP'T OF ENERGY, ENERGY STORAGE SAFETY STRATEGIC PLAN 10 (2014), http://energy.gov/sites/prod/files/2014/12/f19/OE%20Safety%20Strategic%20Plan%20December%202014.pdf; David Fridley, *Nine Challenges of Alternative Energy*, in THE POST CARBON READER 6 (Richard Heinberg & Daniel Lerch, eds., 2010) ("The key to evening out the impact of intermittency is storage; that is, the development of technologies and approaches that can store energy generated during periods of good wind and sun for use at other times"); *Energy Storage*, ENERGY.GOV, http://energy.gov/oe/services/technology-development/energy-storage.

[194] P. Denholm et al., *Energy Storage Technologies*, *in* NAT'L RENEWABLE ENERGY LAB., RENEWABLE ELECTRICITY FUTURES STUDY, at 12-1, 12-1 (M.M. Hand et al. eds., vol. 2, 2012), http://www.nrel.gov/analysis/re_futures/.

facilitating balancing without requiring additional generation, it can facilitate efficient balancing—a capability that is especially important for the operation of microgrids.[195]

The menu of commercially available energy storage options is currently dominated by pumped-storage hydropower, compressed air energy storage, and high-energy batteries,[196] though other technologies show promise as well.[197] It is difficult to predict which new technologies will be suitable for commercialization in even the next several years.[198] Existing storage technologies, commercial and experimental alike, are currently costly to construct and operate, and generally lose between 6 and 40% of the energy stored.[199] It is nonetheless possible that the benefits of deploying storage could outweigh its costs in some circumstances, particularly as higher levels of renewable penetration make it increasingly advantageous to balance out small intermittencies as storage is uniquely capable of doing.

4. BEING HEARD

To advocate for implementation of adaptation policies before a regulatory commission one must have at least some familiarity with several key features of commission proceedings, including particular types of proceeding and procedural requirements imposed on participants. Most commissions generally welcome public involvement if it is relevant and broadly conforms

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[195] *See, e.g.*, Mike Breslin, *Unique Microgrid To Provide Vermont Town With Resilient Power*, Electrical Contractor, Oct. 2014, http://bit.ly/1lwEaDn ("The Rutland project is one of the first exclusively solar-powered microgrids in the United States, the first to provide full backup to an emergency shelter on the distribution network . . . . It incorporates 7,722 solar panels, capable of generating 2.5 megawatts (MW) of electricity with 4 MW of battery storage, using both lithium-ion and lead-acid batteries to integrate the solar generation into the local grid, and provide backup power in case of an outage.").

[196] Denholm et al., *supra* note 194, at 303.

[197] *See* Xing Luo et al., *Overview of Current Development in Electrical Energy Storage Technologies and the Application Potential in Power System Operation*, 137 APPLIED ENERGY 511 (2015).

[198] Denholm et al., *supra* note 194, at 303 (explaining that a combination of low natural gas prices, availability of high-efficiency and flexible gas turbines, limited cost reductions in storage technologies, regulatory treatment of storage, costly licensing and permitting, challenges with storage valuation, utility risk aversion have limited storage development).

[199] RACHEL CARNEGIE ET AL., UTILITY SCALE ENERGY STORAGE SYSTEMS 3 (2013) https://www.purdue.edu/discoverypark/energy/assets/pdfs/SUFG/publications/SUFG%20Energy%20Storage%20Report.pdf. Fridley, *supra* note 193, at 430 (explaining that the major drawbacks of compressed-air storage, batteries, and molten salts include the losses involved in energy storage and release and the limited energy density achievable).

to the rules of procedure,[200] and they tolerate the limited experience of new participants, so long as they demonstrate respect for "regulatory principles and the dignity of the process."[201] For example, even an inexperienced advocate should not present arguments regarding approval for *construction* of a new power plant during the hearing dedicated to the *siting* of that power plant if the commission has made clear that it is dealing exclusively with the latter.

Commission procedures vary in minor ways across states. For instance, in some states, commissioners attend hearings, listen to evidence, ask questions, and rule on motions. In other states, hearings are conducted before a hearing officer/examiner (usually an attorney presiding as a judge) who writes a proposed order to the commissioners.[202] Notwithstanding such small differences, commissions in all states generally operate in two modes: quasi-judicial hearings and rulemakings of the sort conducted by other federal and state agencies.

Commissions conduct quasi-judicial proceedings, much as a court conducts litigation, in accordance with rules of procedure and evidence. They address the issues in a given proceeding by inviting or requesting various forms of participation, such as written comments or filings; document requests (to be submitted by participants to the utility itself, with copies sent to the commission or hearing officer and other docket participants); formal testimony, elicited by direct examination (often in written form) and cross-examination; and informal testimony offered at public hearings.[203] As explained below, some parties have more responsibilities than others with respect to their participation, but also more opportunities to make arguments to the commission. Commissions use this quasi-judicial procedural approach to decide the rate cases that examine utility revenues, rates of return, permissible capital expenditures, and the charges sought from each customer class to cover utility costs.[204]

When commissions promulgate a regulation, they typically do so through a rulemaking proceeding, which involves issuing a draft regulation, inviting written and oral comments on

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[200] *See, E.g.*, *Public Involvement, Intervenor Status and Compensation*, PUB. SERV. COMM'N OF WIS., https://psc.wi.gov/consumerinfo/intervenor.htm (last visited Jan. 12, 2016).
[201] RAP, *supra* note 6, at 104.
[202] *Id.* at 21.
[203] *See id.* at 29–31.
[204] *Id.* at 31.

that draft, responding to those comments, and issuing a final version that either adopts the suggestions contained in comments or explains why those suggestions have not been adopted.[205]

Commissions also generally hold "informal" public hearings before making decisions via either of the procedures mentioned above. Public hearings provide an opportunity for interested members of the public to submit written and oral testimony on issues of concern and do not require adherence to the more elaborate rules that govern quasi-judicial or rulemaking proceedings.[206]

The rest of this Part describes in more detail the players and opportunities for advocacy in the various proceedings conducted by commissions.

4.1. Participants: Statutory Parties, Consumer Advocates, Intervenors, and the Public

State law generally provides certain parties with a guaranteed right to participate in certain proceedings—so, for instance, the affected utility and commission staff have seats at the table in rate cases and generic proceedings.[207] Such parties are called "statutory parties" and are subject to particular procedural rules.[208] Most states have also established a consumer advocate's office to represent the interests of the public (either all customers, or just those not likely to be represented otherwise) in proceedings before the commission.[209] Consumer advocates tend to focus in particular on the total revenue requirement, its allocation among customer classes, and other aspects of rate design.[210] Consumer advocates typically do not focus solely on environmental concerns, but they do sometimes address such concerns, especially if they relate to the costs of providing services.[211] As the discussion in Part 2 above makes clear,

[205] *Id.*
[206] *Id.*
[207] *Id.* at 32.
[208] *Id.*
[209] *Id.*; *See* National Association of State Utility Consumer Advocates, *About NASUCA*, http://nasuca.org/about-us/ (last visited Nov. 20, 2015) ("NASUCA is an association of 44 consumer advocates in 40 states and the District of Columbia.").
[210] RAP, *supra* note 6, at 23.
[211] *Id.* at 22.

climate change has already and will increasingly add to the list of environmental concerns with direct cost implications.

As noted above, most commissions permit and encourage public testimony in rate cases. That testimony generally enters the record for the case at issue and can help inform a commission's decisions about what information to require of utilities as well as a commission's ultimate decision on the issues of a case.[212]

If an advocate can establish that the commission's decision in a particular case has the potential to significantly affect her substantial interests, she can file a motion with the commission requesting intervenor status.[213] Such motions' success varies by state: in some, they are rarely refused, in others commissions often reject them. In general, a commission will not grant intervenor status without a showing that no other party to the case adequately represents the would-be intervenor's interest.[214] Industrial or commercial customers, consumer groups, environmental groups, and other parties with interests in the outcome of a given case often participate as intervenors.[215] The Regulatory Assistance Project has cautioned public advocates about seeking intervenor status, which entails all the burdens of full and formal participation, including hearing attendance, discovery responses, and timely filings:

> Intervention in a formal regulatory proceeding is probably the most demanding form of citizen participation. Utility hearings are normally held under state administrative law rules, and function very much like a courtroom. While an individual may usually participate without an attorney, requirements of the rules of procedure and evidence must nonetheless be met.[216]

4.2. Generic Proceedings and Rulemakings

While rate cases are important settings for challenging commission decisions specific to a particular utility or investment, rulemaking and generic proceedings may also present an opportunity for advocate participation. Generic proceedings address any one of a host of issues,

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212 *Id.* at 30, 34.
213 *See, e.g.*, *Guide to Public Hearings*, PUB. SERV. COMM'N OF WIS., http://psc.wi.gov/thelibrary/publications/general/general01.pdf (last visited Jan. 12, 2016).
214 RAP, *supra* note 6, at 32.
215 *Id.*
216 *Id.*

such as rate design approaches, the launch or modification of energy efficiency programs, or consideration of decoupling or incentive regulation.[217] Rulemaking proceedings are initiated by the commission or other parties to create or revise generally-applicable rules and regulations.[218] For instance, a commission may issue a notice of proposed rulemaking regarding how community solar installations in the jurisdiction should be compensated and integrated into grid operations.[219]

An advocate must choose the appropriate proceeding for proposing adaptation strategies. If one wants a commission to insist that a utility add more flooding countermeasures to its plans for a new substation, one must participate in the rate case dealing with the proposed substation (typically a larger case in which the substation is but one element). Or, if the commission is drafting a rule about how utilities should factor flood risk into their estimation of costs and benefits for *all* future equipment installations, one must be sure to file comments timely in that rulemaking proceeding.

When a commission initiates a generic proceeding or rulemaking to which adaptation is relevant, advocates should look for announcements about opportunities for the public to comment, and, before drafting and submitting comments, should also review submissions filed by the utility and other participants in the proceeding. Comments should explain the evidence that supports their arguments in favor of or in opposition to a given proposal—the commission is more likely to make use of the evidence cited than to quote the arguments made by an advocate. Of course, decisions made through such proceedings are limited to issues within the authority delegated to the commission, which does not normally include significant policy

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[217] David Flanagan, *New York Public Service Commission Regulatory Decision Making Procedures*, NARUC, http://www.naruc.org/international/Documents/TypesofProceduresNYPSCUndertakes.pdf (last visited Jan. 12, 2016).
[218] *Id.*
[219] *See, e.g.*, Maryland Public Service Commission, Admin Docket RM56, Notice Initiating Rule Making and Notice of Rule Making Session: Revisions to COMAR 20.62 – Community Solar Energy Generation Systems (Nov. 25, 2015), http://bit.ly/1RTlWJe.

changes, like industry restructuring.[220] For issues beyond the scope of the commission's authority, advocates must focus on electing legislators and passing new legislation.

4.3. Rate Cases

Rate cases embody the "first and best established" function of commissions: determining a utility's revenue requirement and setting prices for consumers.[221] Rate cases generally involve review of all aspects of utility service[222] and are the mechanism by which commissions evaluate utilities' new investments, determine the revenue utilities should receive from ratepayers, and allocate the resulting costs among different groups of ratepayers. However, rate cases deal with more than just setting revenue requirements and rates: they can also deal with utilities' policies and standards if such issues are raised by the utility or the intervenors and are sufficiently related to a proposed rate change.[223] Some states require rate cases to commence on a set schedule, and most allow utilities to initiate a rate case by filing for a rate change every few years. Commissions or individuals can theoretically initiate a rate review, but, in practice, it is quite rare for a party other than the utility itself to do so.[224]

However it is initiated, commissions use rate cases to examine expenses a utility seeks to incur and charge to ratepayers and to determine if those expenses are prudent and necessary to provide safe and reliable electricity at just and reasonable rates.[225] Prudent expenses might relate to new facility, to a new marketing initiative that would inform consumers about a rebate program, or to any number of other measures that appear on the utility's balance sheet. For the reasons discussed in the foregoing Parts, the task of determining what expenses are prudent

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[220] The choice to restructure the energy industry is usually made by the legislature of the state through passing legislation. *See Status of Electricity Restructuring by State*, U.S. ENERGY INFO. ADMIN. (Sept. 2010) http://www.eia.gov/electricity/policies/restructuring/restructure_elect.html.
[221] RAP, *supra* note 6, at 25.
[222] *Id.* at 104.
[223] *Id.* at 56.
[224] *Id.* at 31.
[225] EDISON ELECTRIC INST., *supra* note 107, at 117; RAP 2011, *supra* note 6, at 31.

and how much utilities can recover for them is complicated by the predicted impacts of climate change.[226]

An advocate can take advantage of the opportunity to comment at a public hearing in a rate case to highlight flaws in the justification provided to support a utility's request for a rate increase if it is contrary to adaptation goals. For example, a utility may propose construction of a new inland thermoelectric power plant in order to meet 20-year demand forecasts. An advocate could challenge this proposal on several grounds. For one, does the forecasted demand consider the possibility of climate-related increases or decreases in consumers' demand for electricity?[227] Second, if the plant will rely on large volumes of water for cooling, has the utility taken into account likely changes in the availability and cost of accessing that water? What about expected changes in that water's average temperature and thus its cost-effectiveness for the stated purpose?[228] Third, what alternatives has the utility considered? Could it implement new efficiency measures or facilitate investments in new distributed generation capacity instead of building the power plant? And if it would cost a significant amount to harden the plant against storm or flood damage, would it be cheaper to plan to buy more power from an adjacent region for another few years instead of committing to owning and operating a billion-dollar power plant for 40 years or more?[229]

4.3.1. The Revenue Requirement

The focus of the rate case is the "revenue requirement," the total amount of revenue a utility needs in order to earn a fair rate of return on its investment.[230] Once determined, the revenue requirement is translated into the rates the utility will charge to different customer

[226] *See* discussion *supra* Part 1.2.1.
[227] *See* discussion *supra* Part 2.2.
[228] *See* discussion *supra* Parts 2.3 and 3.1.5.
[229] *See* discussion *supra* Parts 3.1.2 and 3.1.3.
[230] RAP 2011, *supra* note 6, at 38.

classes.[231] Generally, the utility is granted its cost-of-service plus a rate of return on its capital investments.

Utilities tend to base their revenue requests on a "test year" that illustrates expected annual capital costs, operating expenses, and sales revenues.[232] A test year is usually a recent year that ends before the rate case, although some commissions are moving toward using current or future years as test years.[233] Whether the test year is past or hypothetical, commissions review the costs in the test year and generally approve or disapprove a requested rate increase based in large part on whether the utility's revenues in that year exceeded or fell short of reasonably incurred costs.[234] When presenting plans for a major new investment, such as a power plant, a utility will generally frame the test year in a way that assumes the new plant will both relied upon ("used") and that its addition will mean lower costs and/or better service to ratepayers ("useful").[235]

Several key terms are useful to understanding how a commission determines the revenue requirement in a rate case. **"**Rate base" refers to the investment in long-lived assets used to provide service, adjusted for working capital, regulatory assets, and deferred taxes.[236] Investments included in the rate base must be both "used and useful" in providing service and "prudently" incurred. In the absence of evidence refuting use-and-usefulness of an investment, the utility enjoys a presumption that it will be both used and useful. The "rate of return" granted to a utility must to be sufficient to allow it to attract adequate investment, assuming prudent management and in light of the level of risk attributable to the utility's business model and proposed investments.[237] A utility's "capital structure," meaning the amount and mix of debt and equity issued by the utility, is also subject to commission approval. The utility's

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[231] For more information about the allocation of costs to customer classes, see RAP 2011, *supra* note 6, at 47–54.
[232] RAP 2011, *supra* note 6, at 38.
[233] EDISON ELECTRIC INST., *supra* note 107, at 19. RAP 2011, *supra* note 6, at 38.
[234] EDISON ELECTRIC INST., *supra* note 107, at 19.
[235] RAP 2011, *supra* note 6, at 39.
[236] TOMAIN & CUDAHY, *supra* note 42, at 184.
[237] *See* Bluefield Water Works & Improvement Co. v. Pub. Serv. Comm'n, 262 U.S. 679 (1923); Fed. Power Comm'n v. Hope Natural Gas Co. 320 U.S. 591 (1944).

overall rate of return reflects the assets and liabilities accruing to the utility as a result of that capital structure.[238] Operating expenses are those that recur regularly, including labor, power purchases, outside consultants and attorneys, maintenance services, fuel, taxes, depreciation and insurance.[239] Expenses are presumed necessary and prudent unless demonstrated to be inappropriate.[240] Other less predictable costs, like storm damage repairs, are often accounted for not as on annual basis but as a feature of a multi-year average.[241] Other adjustment mechanisms allow for utilities to respond to unexpected shifts in the costs of inputs like fuel or backup power purchases.[242]

4.3.2. Procedure

Rate cases generally proceed in largely the same way, although their timing can vary state by state. Typically, a major rate case takes 11 months from the filing of the petition to the commission's decision and follows the steps enumerated here:[243]

(1) Once a commission schedules a hearing for a rate change, it may employ a team of lawyers, accountants, engineers, economics and consumer specialists to represent the public interest by investigating the utility's proposals.[244]

(2) The commission sets deadlines for submitting information requests and interrogatories.

(3) All parties to a rate proceeding may submit evidence. Evidence usually includes written testimony and exhibits meant to provide factual support in the form of technical analysis, numerical tables, or worksheets. Several rounds of evidence may be allowed by the commission if factual points are disputed.

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238 RAP 2011, *supra* note 6, at 42–43.
239 *Id.* at 45.
240 *Id.*
241 *Id.*
242 *Id.*
243 Timeline below is adopted from section 9 of RAP 2011, *supra* note 6, at 32–35.
244 *Major Rate Case Process Review*, NY DEP'T OF PUB. SERV. (09/23/2011 03:55:53 PM), http://www3.dps.ny.gov/W/PSCWeb.nsf/0/364D0704BEEC5B7D85257856006C56B3?OpenDocument.

(4) During the hearing process, attorneys and other representatives conduct direct and cross-examinations of expert witnesses (though often the direct examination is conducted in advance through written pre-filed testimony).

(5) Almost all commissions allow time during cases over major rate increases for testimony from the general public. Public testimony is often invited either shortly before or after the expert testimony. Some argue that hearing public testimony after all of the parties' witnesses have testified brings the issues into focus—a boon to advocates and intervenors who want their members and supporters to address key issues and not to take aim at points unlikely to receive much attention from the commission. Although members of the public are generally not required to be experts or to testify under oath, courtroom demeanor is important.

(6) Parties can enter into settlement negotiations at any time before or after testimony is filed—but before the commission reaches a decision and issues an order—by presenting an agreement on all (or most) of the issues at hand to the commission.[245] Intervenors can sometimes play an outsized role in settlement negotiations since an all-party settlement increases the likelihood of the commission approving the settlement and thereby ending the formal hearing process. Since rate cases can take six to 12 months or longer, settlement is an important option.

(7) After all testimony is filed, parties file final briefs and make their closing oral arguments.

(8) After reviewing the record, the commission deliberates and issues a final order. Sometimes the commission's deliberation is open to the public.[246]

(9) When a hearing is held before an administrative law judge or hearing examiner, they release a proposed order detailing a recommended resolution of the contested issues. The parties then file written exceptions of the proposed order, indicating where they believe the record supports a different conclusion. The commission reviews the proposed order and the exceptions before issuing a final order that specifies the effective date of the change.

[245] *Id.*

[246] *See id.*

4.4. Appeals

Commission orders, whether they are the product of a quasi-judicial proceeding or a rulemaking, can be appealed for various reasons. However, parties that did not participate in the process that yielded the commission's decision generally cannot appeal it.[247] This requirement is termed the "exhaustion requirement," because a would-be appellant cannot file for relief in court before first "exhausting" all remedies available from the agency with jurisdiction over whatever that would-be appellant wishes to challenge. Practically, this means that one cannot challenge a commission decision in court without first timely raising concerns to the commission, i.e., *before* it issued its order. In many states, before appealing to a court, a would-be appellant must first seek reconsideration from the commission that issued the initial decision. A successful motion for reconsideration can create an opportunity to persuade a commission that it erred and should adjust some feature of its earlier decision. Arguments on reconsideration of an order issued in a rate case might proceed after the commission allows the challenged rates to take effect—should the challenger succeed, the commission would order refunds commensurate with changes to the new rates.

Courts are constrained in their review of commission decisions by the relevant "standard of review." That is, courts defer to commissions to varying degrees depending on the issue being appealed. If the appeal turns on a factual determination, a court will generally defer to the commission's decision—unless that decision reflects a clear error. If the appeal turns on an interpretation of the law, a court might not defer at all, instead conducting a "de novo" review.[248] This is an important point to recognize for advocates seeking more aggressive adaptation measures. Once a commission adopts factual premises about the likelihood or cost implications of a changed and changing climate, it can be extremely difficult if not impossible to persuade a court that those premises must be revised. At a minimum, any appellate challenge to a factual premise must be built on showing that solid evidence and sound argument were

[247] REGULATORY ASSISTANCE PROJECT, *supra* note 6 at 35. *See also* Me. Rev. Stat. tit. 35-A, § 1320 (1987); Ohio Rev. Code Ann. § 4903.13 (West 1953).
[248] RAP 2011, *supra* note 6, at 35.

presented to the commission, and that the commission's ultimate decision did not respond appropriately.

5. CONCLUSION

Climate change matters to the future of the electricity system in myriad ways. State regulatory commissions, tasked by statute with ensuring the provision of safe and reliable electricity at just and reasonable rates, oversee the operations of generation and distribution facilities. Commissions should, therefore, respond to climate change impacts in carrying out their central task. Advocates can help inform commissions about the implications of climate change for electricity infrastructure as well as push commissions to act on available information. This chapter has focused on state commissions, not because FERC has no role to play in fostering adaptation in the transmission portion of the bulk power system, or because FERC is deaf to adaptation advocacy, but because state commission proceedings are generally more accessible to members of the public and provide a greater variety of opportunities for the public to push for a better adapted grid.

When arguing for climate change adaptation, advocates should point out that failing to take climate change impacts into account will most likely hurt utilities' ability to perform cost-effectively. There is no question that the cost and reliability of electricity in the future will be affected by climate change impacts, and commissions should therefore factor those impacts into the cost-benefit analysis they use to decide whether proposed investments are prudent. To do otherwise would risk asking consumers to pay more for less reliable electricity.