UCLA LAW REVIEW

Socio-Political Evaluation of Energy Deployment (SPEED): A Framework Applied to Smart Grid

Jennie C. Stephens
Tarla Rai Peterson
Elizabeth J. Wilson

ABSTRACT

Despite a growing sense of urgency to improve energy systems so as to reduce fossil-fuel dependency, energy system change has been slow, uncertain, and geographically diverse. Interestingly, this regionally heterogeneous evolution of energy system change is not merely a consequence of technological limitations but also and importantly a product of complex socio-political factors influencing the deployment of new energy technologies. The socio-political context for energy deployment differs on national, state, and even local levels, making cross-jurisdictional analysis of energy systems challenging. At the same time, understanding how social, legal, cultural, and political factors influence energy deployment across multiple jurisdictions is critical to developing effective policies for reducing fossil-fuel dependency.

In response to such challenges, in 2008 we developed the Socio-Political Evaluation of Energy Deployment (SPEED) framework. SPEED is an interdisciplinary framework for analyzing how technological, social, and political conditions influence the development and deployment of specific energy technologies. SPEED has been applied to compare regional disparities in the deployment of multiple specific technologies. This Article illustrates how an enhanced version of the original SPEED framework can be used to characterize the socio-political factors influencing the development of energy systems across multiple regions. First, we describe the value of SPEED analysis in characterizing interactions among multiple factors—including cultural, political, environmental, legal, technical, and economic influences—that shape energy technology deployment and drive system change. Then, using smart grid development as an example of a system-wide energy initiative, we describe how the application of SPEED analysis could improve policy and regulatory effectiveness.

AUTHOR

Jennie C. Stephens is an Associate Professor of Environmental Science and Policy at Clark University in Worcester, Massachusetts. Tarla Rai Peterson is a Professor and Boone and Crockett Chair at Texas A&M University; adjunct Professor of Communication at University of Utah; Guest Professor of Environmental Communication at the Swedish University of Agricultural Sciences. Elizabeth J. Wilson is an Associate Professor of Energy and Environmental Policy and Law at the Humphrey School of Public Affairs

61 UCLA L. Rev. 1930 (2014)

at the University of Minnesota. This work has been supported by the National Science Foundation's Science, Technology and Society Program.

TABLE OF CONTENTS

"There is no one-size-fits-all option. It's up to states to mix and match to meet their goals."[1]

INTRODUCTION

Growing environmental, economic, and geopolitical concerns about fossil-fuel dependency have led to widespread acknowledgement of the need for change in society's energy systems.[2] As climate change risks become more pervasive and reliable access to energy becomes increasingly critical to basic societal functioning, a transition in energy systems has begun.[3] Despite recognition of the need for energy system change, deployment of alternative emerging energy technologies has been slow, uncertain, and geographically heterogeneous.[4] The slow pace of energy system change results from institutional and infrastructural lock-in involving societal preferences, expectations and routines that perpetuate and support the established system.[5] And the inconsistent patterns of deployment result from a myriad of entangled factors extending beyond the technological details, economic costs, and legal frameworks for any particular technology.[6] These complex and interwoven factors are often context-specific at local or regional scales, posing challenges for systematic analysis. And yet, such analysis is immensely valuable to advancing the societal priority of improving energy systems. As Obama stated in remarks on climate change at Georgetown University in June 2013: "Using less dirty energy,

---

[1] Gina McCarthy, Administrator, Envtl. Protection Agency, Announcement of Clean Power Plan (June 2, 2014), *available at* http://yosemite.epa.gov/opa/admpress.nsf/d0cf6618525a9efb85257359003fb69d/0a8e7164bb15185985257ceb0050c967!OpenDocument.

[2] *See, e.g.*, Barry D. Solomon & Karthik Krishna, *The Coming Sustainable Energy Transition: History, Strategies, and Outlook*, 39 ENERGY POL'Y 7422, 7422 (2011); *see also* Frank N. Laird, *Against Transitions? Uncovering Conflicts in Changing Energy Systems*, 22 SCI. AS CULTURE 149, 149 (2013).

[3] *See* VIJAY V. VAITHEESWARAN, POWER TO THE PEOPLE: HOW THE COMING ENERGY REVOLUTION WILL TRANSFORM INDUSTRY, CHANGE OUR LIVES, AND MAYBE EVEN SAVE THE PLANET 295–96 (2003); Lars Coenen et al., *Local Niche Experimentation in Energy Transitions: A Theoretical and Empirical Exploration of Proximity Advantages and Disadvantages*, 32 TECH. IN SOC. 295, 295–296 (2010).

[4] *See* Gregory C. Unruh, *Understanding Carbon Lock-In*, 28 ENERGY POL'Y 817–830 (2002); *see also* Kelly Sims Gallagher et al., *The Energy Technology Innovation System*, 37 ANN. REV. OF ENV. & RESOURCES 137, 149 (2012).

[5] Gregory C. Unruh, *Escaping Carbon Lock-In*, 30 ENERGY POL'Y 317, 317 (2002).

[6] *See* Daniel Breslau, *Studying and Doing Energy Transition*, 8 NATURE & CULTURE 324, 328–29 (2013).

transitioning to cleaner sources of energy, wasting less energy through our economy is where we need to go."[7]

Energy system change encompasses the simultaneous deployment of interconnected emerging energy technologies, the policy, legal, and regulatory changes necessitated by such deployment, and related shifts in consumer behavior, culture, and practice.[8] Analyzing energy system change, therefore, goes beyond assessment of any individual technology such as wind turbines or solar panels. Analyzing energy system change also necessitates the integration of social theory and cultural practices to move beyond simplistic assumptions of how individuals make choices related to energy-use.[9]

Deployment of energy technologies occurs at local and regional levels in energy systems that are embedded within larger national and global contexts.[10] Energy systems are socio-technical systems in which technological change is intricately linked to social change, and social change is intricately linked to technological change.[11] Energy system change is influenced at every level by more than mere technological capacity and resource availability, but rather is also guided by complex and dynamic institutional, regulatory, legal, political, economic, and cultural factors.[12] For example, technological advancements, shifting economics, and growing cultural acceptance of the potential for distributed generation and renewable energy has allowed households, businesses, and communities to be more involved in their energy management and production, and is changing societal norms. And large utility companies, dominant institutions in the electricity sector, are being economically impacted by these system changes, and mounting a political campaign to contain the threat of rapidly developing roof-top solar by lobbying for limits to net-metering regulations.[13] As a consequence of

---

[7] *See* President Barack Obama, Remarks by the President on Climate Change (June 25, 2013), http://www.whitehouse.gov/the-press-office/2013/06/25/remarks-president-climate-change.

[8] Frans Berkhout et al., *Understanding Energy Transitions*, 7 SUSTAINABILITY SCI. 109, 109 (2012); *see also* Elizabeth Shove, *Beyond the ABC: Climate Change Policy and Theories of Social Change*, 42 ENV. AND PLANNING 1273, 1273 (2010).

[9] *See* Shove, *supra* note 8, at 1273–74.

[10] *See* Hari M. Osofsky & Hannah J. Wiseman, *Dynamic Energy Federalism,* 72 MD. L. REV. 773, 780 (2012).

[11] F. W. Geels, *The Dynamics of Transitions in Socio-technical Systems: A Multi-level Analysis of the Transition Pathway from Horse-drawn Carriages to Automobiles (1860–1930)*, 17 TECH. ANALYSIS AND STRATEGIC MGMT. 445, 445–476.

[12] *See* Jennie C. Stephens et al., *Socio-Political Evaluation of Energy Deployment (SPEED): An Integrated Research Framework Analyzing Energy Technology Deployment*, 75 TECHNOLOGICAL FORECASTING AND SOC. CHANGE 1224, 1232 (2008).

[13] *See* PETER KIND, ENERGY INFRASTRUCTURE ADVOCATES, DISRUPTIVE CHALLENGES: FINANCIAL IMPLICATIONS AND STRATEGIC RESPONSES TO A CHANGING RETAIL

this complexity, a major challenge to developing sound policies for energy system change is to effectively characterize the dynamic social, technical, and political context within which new technologies are deployed. The complexity and heterogeneity of the socio-political context within which energy technology change occurs is not generally characterized in a systematic way during energy policy development, which often results in unanticipated challenges in energy policy implementation.

While research on technological change has focused primarily on evaluation and assessment of specific technologies,[14] far less attention and funding has been given to social science research on energy systems.[15] This research gap is due in part to the challenges of assessing, measuring, and quantifying social and cultural factors influencing energy system change. Much current energy research focuses primarily on economic and technical aspects of individual technologies, such as cost-benefit analyses of specific renewable energy technologies,[16] and offers explanations of energy change at mostly the national and global levels.[17] Although such a high-level focus may be helpful for some purposes, analysis at this level often misses more nuanced aspects of energy system change and the pathways toward technology deployment, such as how regionally-specific economic, cultural,

---

ELECTRIC BUSINESS 19 (2013); The Editorial Board, *The Koch Attack on Solar Energy*, N.Y. TIMES, Apr. 26, 2014, http://www.nytimes.com/2014/04/27/opinion/sunday/the-koch-attack-on-solar-energy.html?_r=0.

[14] *See, e.g.*, Michael Rodemeyer et al., Woodrow Wilson International Center for Scholars, *The Future of Technology Assessment* (2005), *available at* http://www.wilsoncenter.org/sites/default/files/techassessment.pdf (showing how the closing of the Office of Technology Assessment and demonstrating the focus on evaluation and assessment of specific technologies); Hans Mohr, *Technology Assessment in Theory and Practice*, 4 SOC. FOR PHIL. & TECH. 233, 233 (1999).

[15] *See generally* Thomas Webler & Seth P. Tuler, *Getting the Engineering Right Is Not Always Enough: Researching the Human Dimensions of the New Energy Technologies*, 38 ENERGY POL'Y 2690, 2690–91 (2010).

[16] *See, e.g.*, C. GELLINGS, ELEC. POWER RESEARCH 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 3-1 to 3-8 (2011), *available at* http://www.rmi.org/Content/Files/EstimatingCostsSmartGRid.pdf; Stéphane Isoard & Antonio Soria, *Technical Change Dynamics: Evidence From the Emerging Renewable Energy Technologies*, 23 ENERGY ECON. 619, 620–21 (2001); K. Usha Rao & V.V.N. Kishore, *A Review of Technology Diffusion Models With Special Reference to Renewable Energy Technologies*, 14 RENEWABLE AND SUSTAINABLE ENERGY REVS. 1070, 1073–74 (2010).

[17] *See, e.g.*, Gallagher et al., *supra* note 4, at 149.

political, and environmental factors that influence change.[18] How different communities in different regions perceive the risks and benefits of energy system changes relates to economic factors including existing businesses and infrastructure, cultural factors including aesthetic preferences and social practices, political factors including priorities of local political leaders, and environmental factors including local environmental concerns and impacts.[19]

Recognizing this gap in energy research, we developed the Socio-Political Evaluation of Energy Deployment (SPEED) framework in 2008.[20] The SPEED framework is an interdisciplinary, systematic approach to analyze factors influencing development and deployment of specific energy technologies. During the past six years, SPEED has been used to analyze the deployment of particular energy technologies across a variety of states and regions within the United States. Examples include comparative assessment of deployment of wind power,[21] carbon capture and storage,[22] and high voltage transmission energy systems.[23] This research demonstrated distinct variation of energy technology discourse in different states, highlighting both the value of and the need for integrated analysis that includes consideration of a variety of different socio-political factors across multiple jurisdictions.

---

[18] *See, e.g.*, Jennie C. Stephens & Scott Jiusto, *Assessing Innovation in Emerging Energy Technologies: Socio-Technical Dynamics of Carbon Capture and Storage (CCS) and Enhanced Geothermal Systems (EGS) in the USA*, 38 ENERGY POL'Y 2020, 2029 (2010).

[19] *See, e.g.*, F.W. Geels, *The Dynamics of Transitions in Socio-Technical Systems: A Multi-Level Analysis of the Transition Pathway From Horse-Drawn Carriages to Automobiles (1860–1930)*, 17 TECH. ANALYSIS & STRATEGIC MGMT. 445, 446 (2005); Frank N. Laird, *A Full-Court Press for Renewable Energy*, 25 ISSUES IN SCI. AND TECH. 53, 53–54 (2009); Daphne Ngar-yin Mah et al., *Governing the Transition of Socio-Technical Systems: A Case Study of the Development of Smart Grids in Korea*, 45 ENERGY POL'Y 133, 139 (2012).

[20] Stephens et al., *supra* note 116, at 1233.

[21] Elizabeth J. Wilson & Jennie C. Stephens, *Wind Deployment in the United States: States, Resources, Policy, and Discourse*, 43 ENVTL. SCI. & TECH. 9063. 9063 (2009) (applying the Socio-Political Evaluation of Energy Deployment (SPEED) framework to wind power using policy analysis and media analyis in four U.S. states, Massachusetts, Minnesota, Montana, and Texas); M. Fischlein, et. al., *Policy Stakeholders and Deployment of Wind Power in the Sub-National Context: A Comparison of Four U.S. States*, 38 ENERGY POL'Y 4429; M. Fischlein, et. al., *Which Way Does the Wind Blow? Analyzing the Sub-National Context for Renewable Energy Deployment in the United States*, ENVTL. POL'Y AND GOVERNANCE (forthcoming).

[22] *See, e.g.*, Andrea M. Feldpausch-Parker et al., *Spreading the News on Carbon Capture and Storage: A State-Level Comparison of US Media*, 7 ENVTL. COMM. 336, 338–39 (2013) (application of SPEED to media analysis of carbon capture and storage technology in four states: Massachusetts, Minnesota, Montana, and Texas).

[23] Miriam Fischlein et al., *States of Transmission: Moving Towards Large-Scale Wind Power*, 56 ENERGY POL'Y 101, 101–03 (2013).

This Article builds on this body of knowledge by presenting an enhanced version of the SPEED framework that can be applied not only to individual energy technologies, but also to broader energy-system-wide changes. In Part I, we explain how the SPEED framework provides a valuable tool for analyzing the interactions of multiple factors that shape energy system change, including cultural, political, legal, environmental, technical and economic influences. In Part II, we describe smart grid, the range of technologies included in smart grid initiatives, and the multiple actors and jurisdictional complexity of smart grid to explain why SPEED is a valuable approach to considering energy system change. Finally, in Part III, we apply the SPEED framework to smart grid to demonstrate the types of valuable policy-relevant insights on factors influencing electricity system change that can be gained from this type of socio-political assessment. The SPEED framework facilitates systematic analysis of economic, cultural, political, and environmental factors which are shaping energy system change to improve energy policy design, to inform implementation strategies and to establish effective metrics of evaluation.

I. THE SPEED FRAMEWORK

Both technological and economic assessments of energy deployment frequently influence policy and regulation, yet this type of analysis is limited in focus and scope.[24] Technological analysis typically focuses only on providing insights about the technical feasibility of deployment, and the utility of economic analysis is often limited by large uncertainties of future costs and availability of fuels and technologies. In response to these limits, we developed the first SPEED framework in 2008.[25] SPEED was designed to improve energy technology research by providing researchers with a framework to assess the specific contexts within which technology deployment occurs. SPEED facilitates characterization of the social and political aspects shaping energy technology deployment that are so often critical in determining deployment patterns. As such, SPEED provides an important linking of both technology analysis and policy analysis revealing context-specific characterization relevant to questions of policy implementation.[26]

---

[24] *See* Rodemeyer et al., *supra* note 14 (critiquing the integrating of technology assessment in federal-level policy).

[25] *See* Stephens et al., *supra* note 12, at 1232.

[26] *See* P. Sabatier & D. Mazmanian, *The Implementation of Public Policy: A Framework of Analysis*, 8 POLICY STUD. J. 530, 538–560 (1980); Milbrey Wallin McLaughlin, *Learning*

We have since applied SPEED to assess the socio-political contexts within which energy technologies are deployed, in order to better understand the perceived risks and benefits of deploying emerging technologies, such as wind power,[27] carbon capture and storage,[28] and geothermal,[29] using multiple methods including interviews,[30] media analysis,[31] and policy analysis.[32]

A. The Original SPEED Framework

The original SPEED framework included six categories of factors that can influence the deployment of specific energy technologies at the sub-national level: (1) technical, (2) economic, (3) regulatory and legal, (4) political, (5) institutional, and (6) social. We recognized that factors from within each category could have both negative and positive influences on energy technology deployment.[33] The strong environmental ambitions of the Governor of Massachusetts is an example of a positive political influence on wind power, while the Kennedy family's opposition to the offshore Cape Wind project is an example of a negative influence in both the political and social categories.

The categories within the SPEED framework were adapted from Niklas Luhmann's social theory. According to Luhmann, society functions systemically and internal communications enable survival of the social system.[34] Luhmann

---

From Experience: Lessons From Policy Implementation, 9 EDUCATIONAL EVALUATION AND POL'Y ANALYSIS 160, 171–178 (1987) (These lessons frame the conceptual and instrumental challenge for a third generation of implementation analysts—integrating the macro world of policymakers with the micro world of individual implementors.").

[27] *See, e.g.*, Fischlein et al., *supra* note 23, at 101–02; Miriam Fischlein et al., *Which Way Does the Wind Blow? Analyzing the Sub-National Context for Renewable Energy Deployment in the United States*, ENVTL. POL'Y & GOVERNANCE (forthcoming 2014) (on file with authors); Jennie C. Stephens et al., *Wind Energy in U.S. Media: A Comparative State-Level Analysis of a Critical Climate Change Mitigation Technology,* 3 ENVTL. COMM. 168, 169 (2009); Wilson & Stephens, *supra* note 21, at 9063–64.

[28] *See, e.g.*, Feldpausch-Parker et al., *supra* note 22, at 338–39; Andrea M. Feldpausch-Parker et al., *A Comparative State-Level Analysis of Carbon Capture and Storage (CCS) Discourse Among U.S. Energy Stakeholders and the Public*, 4 ENERGY PROCEDIA 6368, 6368–6370 (2011); Elizabeth J. Wilson et al., *Carbon Capture and Storage in Context: The Importance of State Policy and Discourse in Deploying Emerging Energy Technologies*, 1 ENERGY PROCEDIA, 4519, 4519–21 (2009); Elizabeth Wilson et al., *The Socio-Political Context for Deploying Carbon Capture and Storage in China and the U.S.*, 21 GLOBAL ENVTL. CHANGE 324, 324 (2011).

[29] *See* Stephens & Jiusto, *supra* note 18, at 2020–21.

[30] *See* Fischlein et al., *supra* note 23, at 102.

[31] *See* Feldpausch-Parker et al., *supra* note 22, at 336–37.

[32] *See* Wilson & Stephens, *supra* note 21, at 9063.

[33] *See* Stephens et al., *supra* note12, at 1231.

[34] NIKLAS LUHMANN, ECOLOGICAL COMMUNICATION (John Bednarz, Jr. trans., Polity Press 1989). Our use of Luhmann is synthetic; we draw from numerous different writings by Niklas

theorized modern, industrialized society as a loosely coupled set of subsystems that represent society's primary functions, such as economic, legal, and political functions.[35] We considered and adapted Luhmann's conception of society's primary functions into categories for classifying factors influencing energy system change. Luhmann's interpretation presumes that social relations are internally driven responses to, rather than interactions with, a social system's environment. Because the world is not constituted so that events fit neatly within the framework of one social function alone, system-level change requires that multiple function systems communicate with each other. In short, society's ability to change depends on the resonance and relations that develop through communication among its function systems. In the SPEED framework we also assume resonance, relationships, and communication among the different categories. For example, significant change to the energy system requires much more than technological feasibility. The new technologies must also provide economic advantages for some group or individual, usually those who wield significant political influence. Further, cultural norms, such as concerns for privacy and expectations of electricity use influence change. Energy system change also requires support for changes to legal requirements (often referred to as standards), which means cycling back through the same sets of relations.

When we applied the SPEED framework to understanding the socio-political context of deployment of individual energy technologies we realized limitations in effectively integrating the interpretation of our findings into the larger energy system. We recognized that any specific energy technology is associated with system-wide changes. Analysis of individual technologies in isolation of the larger system, therefore, provides insights with limited applicability. For example, we found that, regardless of state policies or existing laws, wind turbine deployment depends on the ability and the capacity to build transmission lines to move the electricity from where the wind turbines are (good wind resources) to concentrated centers of electricity demand.[36] In addition, wind power must be integrated into electricity system operation which depends on enhanced meteorological software that predicts wind availability and connects wind data to energy

---

Luhmann. We cite this particular book because the statements we make are most specifically discussed in it; but to understand our synthetic use of Luhmann's work one would have to read more than just a few pages of this book. For a more concise explanation of how we synthesize this work, see Tarla Rai Peterson, *Ecological Communication*, Q. J. OF SPEECH 256, 256–58 (1992) (Book Review).

[35] LUHMANN, *supra* note 34; Tarla Rai Peterson et al., *Social Practice and Biophysical Process*, *in* 1 THE ENVIRONMENTAL COMMUNICATION YEARBOOK 15 (Susan L. Senecah ed., 2004).

[36] *See* Fischlein et al., *supra* note 273 (forthcoming 2014) (on file with authors).

markets. Similarly, issues of transmission congestion (for example, when there is not enough transmission capacity to move all the electricity being generated) led both to new multi-actor initiatives to build transmission and to the development of new algorithms to automate the dispatch of wind by grid operators.[37] These details highlight the linkages of turbine technology (hardware and software) development, policies promoting renewable energy and wind deployment to the larger energy system, and demonstrate that to understand energy system change one has to move beyond isolated analysis of individual types of technologies. Wind power development is more than just building turbines; rather it is intricately linked to regional transmission system planning, dynamic energy markets, and rural economic development. We realized that integrated analysis requires a framework that could capture the system-wide dynamics of interactions among social and technological changes in energy. Such a framework encourages assessment of the reciprocal relationships between technologies and policies, for example how policies influence technological deployment, and in turn, influence institutional changes, the need for additional new policies, and new technological change. Assessment of this kind reveals, for example, that deploying wind turbines is only one step, but multiple other changes also occur including additional technological change (building of new transmission lines), legal change (regulatory reform to streamline siting and permitting of transmission lines across states),[38] economic change (wind being embedded in energy markets) and social change (new appreciation for the long-term security of renewable energy). Deploying wind power involves much more than erecting turbines, so characterization of the rich socio-technical context in which these interconnected changes take place offers valuable information for energy policy development and implementation. While the original SPEED framework was designed to be applied to specific, individual emerging energy technologies, the revised SPEED framework enables analysis and contextualization of both individual technologies and also initiatives designed to encourage system-wide changes. Rather than focusing only on individual energy technologies, the revised SPEED framework encourages the analyst to systematically consider the larger socio-political context for energy system change, with the goal of closing the gap between energy policy design, energy policy implementation, and energy system change.

---

[37] *Id.*

[38] AM. WIND ENERGY ASS'N, U.S. WIND INDUSTRY SECOND QUARTER MARKET REPORT 54 (2011).

Our past research highlighted the importance of a systems approach to effectively characterizing socio-technical transitions occurring within complex socio-political landscapes. Our results demonstrated that while focusing on deployment of specific technologies is important, many of the crucial factors affecting adoption are embedded within an integrated energy system; for example, wind deployment patterns are limited by transmission line development that is determined by a different set of actors, institutions, and regulations than those specific to developing wind turbines.[39] Socio-technical change in energy is embedded within social systems; socio-technical transitions are influenced by the social system, and the social system influences the socio-technical transition.

B. The Enhanced SPEED Framework

Building on our experience with the original SPEED framework, the enhanced SPEED framework specifies six categories of factors influencing energy technology deployment at the level of integrated socio-technical systems[40] (Table 1). Four of the categories are the same as in the original SPEED framework—technical, economic, regulatory and legal, and political—while the environmental and cultural categories are new additions that replace the institutional and social categories in the prior framework. As in the original SPEED framework, each type of factor has the potential for both negative and positive associations, for generating perceived risks and benefits to the larger social system.

The enhanced SPEED framework focuses on energy systems by adapting and operationalizing Luhmann's theory of society as a system of self-organizing subsystems that function interactively.[41] SPEED builds from Luhmann's notion of function systems, in which specific categories of societal function are articulated, and relates and adapts those functions to SPEED categories that capture factors influencing socio-technical change. Systematic assessment of how each of the six categories of factors (Table 1) manifest themselves in specific state, regional or community contexts can help design energy policy that integrates consideration of the broader socio-political context relevant to policy implementation and evaluate energy policy successes with relevant indicators.

---

[39] *See* Fischlein et al., *supra* note 273 (forthcoming 2014) (on file with authors).

[40] Integrated socio-technical systems in the context of this article represent a way to conceptualize technology that captures connections among technologies and connections with social components including actors, individuals and institutions.

[41] *See* LUHMANN, *supra* note 34; *see also* Peterson, *supra* note 35, at 256–58.

TABLE 1. The Enhanced SPEED Framework

SPEED	Benefit	Risk
Technical	Engineering advancements; technical change and developments; interactions to create new opportunities	Potential negative technical aspects of system change; interaction of technologies to create new risks; needs or vulnerabilities
Economic	Strengthening the economy (jobs, manufacturing); saving money; creating economic opportunity across the system	Increased costs to different actors; increased economic uncertainty or financial risk
Political	Positive political ramifications, such as energy independence, enhanced national security, energy security, improved reputation of a state or region from system improvements	Negative political ramifications, such as public frustrations, and difficult legal and regulatory processes from system changes
Regulatory and Legal	Progress toward policy goals; effectiveness of legal framework to enhance system function	Frustrating, difficult, or deadlocked legal and regulatory processes stalling or derailing system change
Environmental	Reduced GHGs or carbon emissions; mitigation of and adaption to climate change; energy conservation; less air and water pollution; improved environmental and public health	Potential threat to human or ecological health, such as threats to protected species and habitat destruction or disruption; shifting risks to new environmental areas
Cultural	Community pride; positive behavioral change	Concerns of privacy; aesthetics; loss of control; inequality; perceived negative impacts on way of life

Within the SPEED framework, the technical category includes factors related to engineering details, technical feasibility, and the challenges and opportunities of integration and interconnections among technologies. The technical category is the one in which conventional technology assessment would be integrated.[42] The economic category includes any factors related to financial details, markets, costs, and savings. The regulatory and legal category includes regulatory structures that may encourage or discourage system change. The political category includes factors influencing deployment related to political gain (benefits to reputation or meeting policy goals) or political risk. The environmental category includes all factors that relate to environmental impacts, including environmental health and public health. Finally, the cultural category includes all other social dimensions that may influence energy system change, such as aesthetic considerations, community engagement, social expectations and practices, and other cultural priorities.

The enhanced SPEED framework responds to the challenges of technology integration that determine energy system change. Accelerated change in energy systems is necessary to respond to the threats of climate change as well as other societal problems,[43] so assessment tools that contribute to enabling energy system change are valuable. As energy systems are incorporating more distributed electricity generation, the enhanced SPEED framework provides a structure to systematically assess the broad range of factors that are influencing and being influenced by these changes. SPEED assessment can help to tailor energy policy design to improve the effectiveness of implementation by integrating consideration of the heterogeneous socio-political context of different places.

II. USE OF SPEED TO ENHANCE UNDERSTANDING OF INNOVATION IN ELECTRICITY SYSTEMS

The enhanced SPEED framework was designed to analyze complex systemic change, such as current efforts to change the world's energy systems by linking traditional and emerging technologies together into "smart"

---

[42] For a review and critique of technology assessment, see Rodemeyer et al., *supra* note 14. For additional details on the technology category within SPEED, see Stephens et al., *supra* note 12.

[43] INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2014: MITIGATION OF CLIMATE CHANGE 4 (2014), *available at* https://www.ipcc.ch/report/ar5/wg3.

electricity grids.[44] These efforts are embedded within larger, interconnected energy systems. Research and analysis of specific energy technologies, and the policies designed to advance them, needs to be coupled, therefore, with research and analysis of energy system change. This section describes the value of applying SPEED to enhance understanding of innovation in electricity systems with a focus on smart grid initiatives. This section begins by introducing the notion of smart grid acknowledging its complexity and ambiguity. Then specific technologies often included in discussions of smart grid are described followed by a discussion of the many societal actors involved in smart grid innovation and its jurisdictional complexity. We end this section explaining why SPEED is valuable to considering smart grid policy design.

Recent efforts to enhance electricity systems, commonly referred to as the development of "smart grid", exemplify attempts to change an entire socio-technical system (including laws, markets, policies, and consumer behavior), as opposed to efforts to deploy a specific, individual technology. Smart grids integrate multiple technologies throughout the electricity system. Examples of such technologies include advanced meters, sensors, and other information communication technologies that enable real-time measuring and monitoring.[45] The enhanced, more efficient management of electricity enabled by smart grid technology could allow more renewable electricity generation on the system. One of the biggest challenges of integrating high levels of renewable generation into the electric system is the variability of wind and solar resources. Seasonal, daily, hourly, and minute-to-minute fluctuations in when the sun shines and when the wind blows require new management approaches; smart grid technologies can help electric grid operators to monitor and manage this variation. The enhanced efficiency of smart grid can also promotes other societal goals, such as enhanced reliability (fewer power outages) increased resiliency (faster recovery if the system goes down), and more flexibility (enabling a diverse mix of energy resources), by enabling closer monitoring of the electric grid. By allowing operators to better monitor the state of lines during storms, reliability can be increased; by pinpointing where an outage occurred and what is necessary to recover, distribution network operators can

---

[44] *See* Jennie C. Stephens et al., *Getting Smart? Climate Change and the Electric Grid*, 4 CHALLENGES 201, 206–208 (2013).

[45] PETER FOX-PENNER, SMART POWER: CLIMATE CHANGE, THE SMART GRID, AND THE FUTURE OF ELECTRIC UTILITIES 34 (2010); NATIONAL ENERGY TECHNOLOGY LABORATORY, A VISION FOR THE SMART GRID (2009), *available at* http://www.netl.doe.gov/File%20Library/research/energy%20efficiency/smart%20grid/whitepapers/Whitepaper_The-Modern-Grid-Vision_APPROVED_2009_06_18.pdf.

accelerate recovery times during disruptions; and by raising the level of sophistication of overall grid management the vital electricity system can integrate more low-carbon resources. In addition to technological change, smart grid can facilitate social change, as it can empower individuals, businesses, and communities to have more control over their energy management, production, and choices.

The term smart grid has been widely associated with the recent push in U.S. energy policy for grid innovation.[46] But smart grid is actually an umbrella term under which myriad electricity system technologies and innovations (both hardware and software) are developing; moreover, social and behavioral change is an integral part of smart grid development. Thus, the type and degree of technological change that the term smart grid represents may vary by locality. For some, smart grid refers primarily to the addition of an information communication technology (ICT) overlay to existing infrastructure. For others, smart grid represents the installation of new transmission lines and meters and increased reliance on renewable generation. Finally, smart grid may simply mean a routine upgrade to existing infrastructure,[47] or, on the other extreme, a futuristically radical shift in the generation and use of electricity that topples the long-standing status quo and shifts power away from incumbent actors.

The SPEED framework is designed to analyze this type of socio-technical change in and across energy systems. As such, smart grid offers a prime example of how our enhanced SPEED framework provides a valuable mechanism with which to evaluate and characterize energy system change. First, smart grid innovation involves many institutions, legal frameworks, time scales (near-term installation of smart meters versus long-term system-wide cost savings), and geographic scales. Smart grid innovation also involves multiple different possible technological configurations, so different actors with different goals, including federal and state policy makers, regulators, utilities, businesses, consumers, as well as other constituents, often disagree on how innovation in grid modernization should be planned, structured, regulated, and financed. Given this complexity, smart grid provides an important example to demonstrate how the SPEED framework

---

[46] *See* NAT'L ENERGY TECH. LAB., A VISION FOR THE SMART GRID 3–4 (2009); M. GRANGER MORGAN ET AL., THE MANY MEANINGS OF "SMART GRID" 1–4 (2009), *available at* http://www.epp.cmu.edu/Publications/Policy_Brief_Smart_Grid_July_09.pdf.

[47] *See* Stephens et al., *supra* note 44, at 206–08 (proclaiming that electricity system technology has historically been static; once utilities installed basic electricity infrastructure it was expected to last for decades; however, some actors view smart grid as a simple upgrading and updating of older electrcity infrastructure).

can be applied to structure research on smart grid to tailor policy design and implementation. SPEED analysis can comparatively assess the context for different smart grid conversations are taking place in different regions and among different actors. Such analysis can provide a characterization of the socio-technical landscape for smart grid in a specific state or region and can be used to identify potential opportunities and barriers to smart grid deployment.

Particularly in a large country like the United States, socio-political heterogeneity results in large regional disparities in energy deployment, which affect local energy system change and national U.S. politics. U.S. energy law is notoriously complex as it vests local, state, and federal authorities with jurisdiction over different aspects of electricity generation, transmission, distribution, and use.[48] For example, there is an inherent tension between a system-wide need for transmission capacity and the localized nature of planning and implementation for new transmission lines.[49] Individual entities are generally unable to pursue energy system change without cooperation and coordination with others. The interconnectedness of energy systems requires a high degree of cooperation, integration, and planning. These tensions between regulation and federalism are particularly important for smart grid.[50] As this discussion illustrates, the landscape within which smart grid innovation occurs is dynamic and complex. Given such complexity, conventional approaches to technology evaluation, assessment, and policy are ill-equipped to effectively analyze and support smart grid innovation. Energy systems influence our lifestyles and social and cultural aspects of how we live in ways that conventional economic analysis does not capture.[51]

Among the many challenges in smart grid innovation, standardization, privacy concerns, fear of obsolescence, and cybersecurity all directly intersect

---

[48] *See* Alexandra B. Klass $ Elizabeth J. Wilson, *Interstate Transmission Challenges for Renewable Energy: A Federalism Mismatch*, 65 Vand. L. Re. 1801 (2012); Alexandra B. Klass & Elizabeth Henley, *Energy Policy, Extraterritoriality, and the Dormant Commerce Clause*, SAN DIEGO J. CLIMATE & ENERGY L. (forthcoming 2014), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2376411. Alexandra B. Klass & Danielle Meinhardt, *Transporting Oil and Gas: U.S. Infrastructure Challenges*, IOWA L. REV. (forthcoming 2014), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2410977.

[49] Ashley C. Brown & Jim Rossi, *Siting Transmission Lines in a Changed Milieu: Evolving Notions of the "Public Interest" in Balancing State and Regional Considerations*, 81 U. COLO. L. REV. 705 (2010); *see* Klass & Wilson, *supra* note 48 at 1802.

[50] Joel B. Eisen, *Smart Regulation and Federalism for the Smart Grid*, 37 HARV. ENVTL. L. REV. (forthcoming), *available at* http://www3.law.harvard.edu/journals/elr/files/2013/05/Eisen.pdf.

[51] Elizabeth Shove, Beyond the ABC: Climate Change Policy and Theories of Social Change, 42 ENVT. & PLANNING 1273, 1278 (2010).

with the socio-political dimensions of smart grid development. These critically important aspects of smart grid highlight the value of applying the SPEED framework to research on smart grid deployment. The Information Communication Technology (ICT) industry is a fast-paced, rapidly evolving sector.[52] In contrast, electric utilities have been traditionally slower to change because of infrastructural lock-in and path dependency, and state-level rate regulation controlling investments and expenditures.[53] Evolving ICT standards for smart grid components are being promulgated at the international and national levels, interacting with multi-state Regional Transmission Organizations (RTOs), which operate electricity markets and work with member stakeholders to plan future electric systems.[54] Multiple state-level institutions are also shaping smart grid development, such as policies like Renewable Portfolio Standards[55] and entities like energy and environmental agencies and Public Utility Commissions, which approve electric system rate cases in traditionally regulated states. Utilities[56]—which can operate across multiple states—are shaped by their portfolio of sources of electricity (often referred to as the generation mix), changes in the demand for electricity in the regions they serve, and their ability to recover costs from smart grid investments.[57] Given the complexity of smart grid deployment and the dynamic socio-technical contexts within which smart grid is being deployed, conventional approaches to technology evaluation, assessment and policy are ill-equipped to effectively analyze and support smart grid innovation. To understand the variation in how smart grid is developing, the SPEED framework offers a particularly valuable analytical tool.

---

[52] THE WORLD BANK GROUP, SECTOR STRATEGY APPROACH PAPER: INFORMATION & COMMUNICATION TECHNOLOGIES 4–5 (2011), *available at* http://siteresources.worldbank.org/INTICTSTRATEGY/Resources/2010-11-23_ICT_Sector_Strategy_Approach_Paper.pdf.

[53] SANYA CARLEY, HISTORICAL ANALYSIS OF U.S. ELECTRICITY MARKETS: REASSESSING CARBON LOCK-IN (2011), *available at* https://scholarworks.iu.edu/dspace/bitstream/handle/2022/14436/History_of_the_elec_market_EPforthcoming.pdf?sequence=1.

[54] *See* Howard L. Shearer, *Smart Grid in North America*, 60 HITACHI REV. 128, 129 (2011).

[55] A regulation that requires a certain amount of a state's electricity to come from renewable sources.

[56] *See* Clark Koenigs et al., *A Smarter Grid for Renewable Energy: Different States of Action*, 4 CHALLENGES 217, 217–233 (2013).

[57] *See* Cassarah Brown, *States Get Smart: Encouraging and Regulating Smart Grid Technologies*, NAT'L CONF. OF STATE LEGS. (July, 2013), http://www.ncsl.org/research/energy/regulating-and-encouraging-smart-grid-technologies.aspx; FOX-PENNER, *supra* note 45, at 157–174.

A. Systemic Socio-Technical Change Throughout the Electricity System

The application of SPEED to smart grid demonstrates the value in structuring a way to research systemic socio-technical change. Promoting innovation in electricity systems has become an energy policy priority throughout the United States, prompting, among other innovations, large-scale investments in a "smarter" grid. The American Recovery and Reinvestment Act (ARRA) of 2009[58] provided $4.5 billion in federal support for smart grid deployment,[59] and multiple local, state, and regional smart grid initiatives have also emerged.[60] The result has been the promotion and development of a patchwork of smart grid systems throughout the United States.[61]

Smart grid includes both technological and social changes throughout electricity systems. An electricity system is conventionally understood as a sequence of centralized, unidirectional steps involving electricity generation, transmission, distribution, and use.[62] Electricity is generated in large, centralized power plants (such as coal, nuclear, or natural gas plants). High voltage electricity is then transported from the power plant to substations closer to electricity consumers. Afterward, low voltage networks distribute electricity from substations to households and commercial buildings. Electricity is then used by refrigerators, computers, lights, and other industrial and commercial end-use devices in homes, offices and industries.

One of the greatest benefits of a smart grid system is that it can integrate renewable energy technology into existing electrical systems. For example, distributed generation,[63] such as rooftop solar technology, and large-scale renewable generation, such as wind farms or centralized solar plants, both rely on smart grid technology to enable their integration into electrical systems.[64] In fact, a wide variety of technologies are associated

---

[58] *See* American Recovery and Reinvestment Act of 2009, Pub. L. No. 111-5, 123 Stat. 115 (2009), *available* at http://www.gpo.gov/fdsys/pkg/BILLS-111hr1enr/pdf/BILLS-111hr1enr.pdf.

[59] U.S. DEP'T OF ENERGY, FY 2010 CONGRESSIONAL BUDGET REQUEST: BUDGET HIGHLIGHTS 1, 3 (2009) [hereinafter BUDGET].

[60] Zhen Zhang, Smart Grid in America and Europe: Similar Desires, Different Approaches, PUB. UTILITIES FORTNIGHTLY, Jan. 2011, at 46–50.

[61] *See, e.g.*, *Industry and Local Government Leaders Create Silicon Valley Smart Grid Task Force*, PR NEWSWIRE (June 25, 2010), http://www.prnewswire.com/news-releases/industry-and-local-government-leaders-create-silicon-valley-smart-grid-task-force-97158749.html; FOX-PENNER, *supra* note 45, at 203–204.

[62] STEVEN W. BLUME, ELECTRIC POWER SYSTEM BASICS: FOR THE NONELECTRICAL PROFESSIONAL (2007).

[63] Making electricity generation in smaller amounts in facilities that are more evenly distributed spatially instead of relying on fewer, large, centralized power plants.

[64] FOX-PENNER, *supra* note 45, at 109.

with this integrative function of a smart grid, including various generation technologies (like photovoltaics and wind turbines), high-efficiency transmission lines, distribution technologies (such as sensors that measure power flow and quality on transmission lines), as well as household-level smart meters.[65]

Although renewable energy technologies are often lumped together as a single set of technologies, the technologies, policies, and activities used to promote large-scale renewable energy generation are quite different than those used to promote small-scale distributed energy generation.[66] For instance, the socio-political impacts of solar energy generation vary substantially depending on scale; a small-scale project, like a privately owned rooftop solar system, has considerably different social and political effects than a large-scale solar farm and requires different technologies and management strategies. Different smart grid technologies allow for different system capabilities. For example, smart meters provide two-way communication between electricity users and the electric utilities allowing for more efficient energy management at the household level and more efficient system management at the utility level. In contrast, rooftop solar PV panels enable households to generate their own low-carbon electricity contributing to greenhouse gas reduction goals and empowering individuals to engage in electricity system change, but could undercut utility profits and require costly distribution network upgrades. In both of these cases we see how different smart grid technology helps different societal actors achieve a different set of goals.

Among the most important smart grid technologies associated with the high voltage transmission system is the synchrophasor. Synchrophasor technology gives the grid operator more detailed information on power quality across the system. This should allow the operator to more closely monitor power quality and flows and more rapidly respond to any system disturbance.[67] This increased monitoring ability is valuable to consumers and to system operators. The grid operator can monitor the system to

---

[65] For a discussion regarding the technologies associated with the integrative function of a smart grid, see FOX-PENNER, *supra* note 45.

[66] *See* Fischlein, *supra* note 23, at 102–03. (demonstrating the challenges of large-scale renewable energy deployment which are distinctly different than small-scale decentralized wind).

[67] U.S. DEP'T OF ENERGY, SYNCHROPHASOR TECHNOLOGIES AND THEIR DEPLOYMENT IN THE RECOVERY ACT SMART GRID PROGRAMS 1–4 (2013) [hereinafter SYNCHROPHASOR], *available at* https://www.smartgrid.gov/sites/default/files/doc/files/Synchrophasor%20Report%2008%2009%202013%20DOE%20%282%29%20version_0.pdf.

ensure the high voltage electric power grid is functioning as anticipated,[68] enhancing its capacity to balance power flows, report outages, and receive weather, demand, and performance data in almost real time.[69]

Another category of smart grid technologies that help electricity systems accommodate higher levels of renewable energy are electricity storage technologies.[70] Some energy storage technologies, such as pumped hydro storage,[71] have been around for decades.[72] In contrast, other forms of electricity storage, such as compressed air storage,[73] batteries, and flywheels have been deployed in a limited capacity but have potential for growth.[74] Smart grid initiatives have potential to support and encourage development and integration of these different energy storage options.

In addition to enhanced monitoring capabilities, smart grid technologies also offer improved substation automation and control. Communication improvements enhance remote management which reduces operational and capital expenses, assists in regulatory compliance, and enhances grid security.[75]

A final category of smart grid technologies includes advanced metering infrastructure (also known as "smart meters") as well as other consumer-facing innovations that encourage better management and reduce industrial,

---

[68] Known as "wide-area situational awareness."

[69] SYNCHROPHASOR, *supra* note 67, at 2–4.

[70] *See* INTERNATIONAL RENEWABLE ENERGY AGENCY (IRENA), SMART GRIDS AND RENEWABLES: A GUIDE FOR EFFECTIVE DEPLOYMENT 15–16 (2013)., *available at* http://www.irena.org/DocumentDownloads/Publications/smart_grids.pdf; CALIFORNIA PUBLIC UTILITIES COMMISSION, ELECTRIC ENERGY STORAGE: AN ASSESSMENT OF POTENTIAL BARRIERS AND OPPORTUNITIES (2010), *available at* http://www.cpuc.ca.gov/NR/rdonlyres/71859AF5-2D26-4262-BF52-62DE85C0E942/0/CPUCStorageWhitePaper7910.pdf.

[71] Pumped hydro storage relies on low-cost electricity to pump water from a low-level reservoir to a higher-elevation reservoir. Once the water is at the higher elevation reservoir it can generate electricity on demand by releasing the water back to the lower-level reservoir letting gravity power drive the turbine to generate electricity.

[72] E. ELA ET AL., NATIONAL RENEWABLE ENERGY LABORATORY (NREL), THE ROLE OF PUMPED STORAGE HYDRO RESOURCES IN ELECTRICITY MARKETS AND SYSTEM OPERATION 1 (2013), *available at* http://www.nrel.gov/docs/fy13osti/58655.pdf.

[73] Compressed air storage relies on a similar logic as pumped hydro and it could be used with natural-gas-fired turbines. Low-cost electricity compresses air to a high pressure underground media (porous rock formations, depleted gas/oil fields, or caverns). When the pressurized air is released it reduces the amount of natural gas required to generate electricity.

[74] *See* Jeff St. John, *Texas to Host 317MW of Compressed Air Energy Storage*, GREENTECH MEDIA (July 9, 2013), http://www.greentechmedia.com/articles/read/texas-calls-for-317mw-of-compressed-air-energy-storage2.

[75] CISCO, SUBSTATION AUTOMATION FOR THE SMART GRID 2–3 (2011).

commercial, and residential consumer electricity demand.[76] For example, smart meters allow for two-way communications between households and utilities. This enhanced communication lets utilities identify and respond more quickly to potential consumer problems.[77] In many systems today, the utility first hears of an outage when a customer phones them; smart meters could change this. If paired with dynamic energy pricing, smart meters could communicate real-time electricity prices to households or businesses, allowing them to adjust their electricity consumption practices based on price signals. Many Public Utility Commissions, however, have been reluctant to implement dynamic pricing schemes. Smart meters also have potential to reduce peak electricity demand because consumers could shift and lower electricity usage when demand and prices are high. However, many utilities are not installing meters with any consumer communication component and many consumers have raised privacy concerns.[78] Finally, smart meters permit electricity meters to be monitored and read remotely, rendering door-to-door meter readers redundant.[79]

B. Multiple Smart Grid Actors and Jurisdictional Complexity

In addition to the breadth of technologies associated with smart grid, electricity system improvements are complicated by jurisdictional complexity and multiple actors involved in electricity system change, each of whom view the potential of smart grid with their own priorities and perspectives. Key actors engaged in electricity system change include individuals and organizations in public, private, and civic sectors.[80] Key actors can be grouped into four distinct categories: (1) electric utilities and companies involved in producing electricity; (2) government representatives including federal, regional, state, and local entities in the public sector; (3) consumers of electricity; and (4) civil society. Interactions among these actors include promoting the use of smart meters, creating technology standards for

---

[76] *See* David J. Hess et al., *Wireless Smart Meters and Public Acceptance: The Environment, Limited Choices, and Precautionary Politics*, PUB. UNDERSTANDING OF SCI. 1 (2012); *Advanced Metering Infrastructure and Customer Systems*, SMARTGRID.GOV (2014), https://www.smartgrid.gov/recovery_act/deployment_status/ami_and_customer_systems.

[77] Tamar Krishnamurti et al., *Preparing for Smart Grid Technologies: A Behavioral Decision Research Approach To Understanding Consumer Expectations About Smart Meters*, 41 ENERGY POL., 790, 791–792 (2012).

[78] Krishnamurti et al., *supra* note 77, at 795–796.

[79] Like most technology automation, some have viewed this reduction in jobs as a valuable cost-savings measure, while others view it as a loss of well-paid blue-collar jobs.

[80] Stephens et al., *supra* note 44, at 206–08.

interoperability, addressing cybersecurity and privacy concerns, approving specific utility smart grid projects.

Within each of these categories, different societal actors have diverse interests. Electric utilities are private or public companies and depending on the jurisdiction, a utility may be "vertically integrated" and serve a defined service territory and singly fulfill all of those functions, or in restructured areas, each of those services (generation, transmission, and distribution) will be provided by a separate entity.[81] The utility ownership models in the United States include four main types of utilities: (1) investor owned utilities (IOUs), (2) municipally-owned utilities, (3) cooperatively owned utilities, and (4) federal power agencies.[82] These different ownership structures shape the utility's motivations for making smart grid investments, their relationship with federal and state regulators, and their relationship to their customers.[83]

Suppliers of electricity system equipment are another set of key actors in smart grid development. These suppliers produce the hardware and software for the electric system. Electricity systems integrate equipment for generation, transmission, and distribution of electricity; and some suppliers of these technologies want to continue to sell the equipment they have been supplying for years, while others may be eager to open-up new business opportunities with new kinds of equipment that facilitate new approaches to energy management.

Government initiatives influence smart grid development in many different ways at different levels ranging from national to local. At the national level, government supports smart grid development in multiple ways including investing in research, development, and demonstration programs, establishing interoperability standards, as well as passing legislation to require, incentivize, or fund smart grid projects. Regulations and policies relevant to smart grid and electricity system change span a broad range including national-level regulations administered by the Federal Energy Regulatory Commission,[84] regional level electricity system management by Regional Transmission Organizations (RTOs), state-level energy policy, and local level siting, distribution and pricing regulations.[85]

---

[81] R.F. HIRSH, POWER LOSS: THE ORIGINS OF DEREGULATION AND RESTRUCTURING IN THE AMERICAN ELECTRIC UTILITY SYSTEM (1999).

[82] STEVEN W. BLUME, ELECTRIC POWER SYSTEM BASICS FOR THE NONELECTRICAL PROFESSIONAL 181–184 (2007).

[83] FOX-PENNER, *supra* note 45, at 157–174.

[84] FERC Transmission Planning and Cost Allocation, 18 C.F.R. § 35 (2010).

[85] Brown & Rossi, *supra* note 49.

Electricity consumers are other key actors because smart grid offers new ways to control and manage their electricity use, but skepticism about benefits to consumers is strong in some places.[86] The value of smart grid to electricity users varies in part because different types of consumers are more or less able to take advantage of energy management. People consume electricity to fulfill and engage in a wide variety of societal activities. Residential comfort (heating, cooling, lighting) and function (cooking, bathing, watching TV or gaming), commercial business use, and industrial production of goods all drive electricity consumption.

Other civil society actors, including environmental organizations and consumer organizations are other key players in smart grid development that bring different priorities to considering smart grid futures.[87]

Jurisdictional complexity associated with all of these different societal actors results in a complex socio-political landscape for smart grid development.

Tensions emerge within and among these groups often vary by region or community according to the socio-political contexts within which the actors operate.

C. SPEED: A Valuable Approach for Smart Grid

Given these complex technologies and multiple actors involved in and affected by developing a smart grid, conventional approaches of technology evaluation, assessment, and policy which focus largely on technical and economic factors, are ill-equipped to effectively understand the intricacies of smart grid innovation and deployment. Conventional technology evaluation and assessment often focuses on singular technologies rather than system-wide change, and focuses more narrowly on direct impacts of that new technology rather than considering the broader cultural, environmental and political interactions of complex system change. Smart grid deployment therefore offers a rich set of cases that highlight the importance of developing system-based approaches to assess technical change and underscores the value of systematically evaluating the social and political contexts within which emerging energy technologies are being deployed.

The complexity of smart grid technologies, societal actors, and jurisdiction means that the socio-political landscape for implementing smart

---

[86] *See* Krishnamurti et al., *supra* note 77, at 796.

[87] Stephens et al., *supra* note 44, at 206–208.

grid initiatives involves many nuanced and localized details that are difficult for policy-makers to consider. The SPEED framework provides a structure to analyze this socio-political context to inform and improve smart grid policy implementation.

III. APPLYING SPEED TO SMART GRID

The enhanced SPEED framework can be used to guide analysis of policy documents, news media, interview transcripts, focus group transcripts, or other content to assess the relative contributions of different factors to electricity system change. Below we provide a brief review of two recent applications of SPEED in smart grid social science research.[88] These examples demonstrate the value of analyzing factors influencing energy technology deployment other than just technical and economic ones.

A. SPEED Applied to Media Analysis of Smart Grid

Our research team recently applied SPEED to an assessment of how the mainstream media presented smart grid in three national newspapers: the *New York Times*, *USA Today*, and the *Wall Street Journal*.[89] We retrieved a total of 214 articles from these three newspapers through a search of smart-grid related articles from 1998–2012, including 105 articles from the *Wall Street Journal*, 25 from *USA Today*, and 105 from the *New York Times*. We then conducted content analysis of these smart grid articles using the enhanced SPEED framework.

Across all three newspapers, benefits of smart grid (positive framing) were mentioned more often than risks (negative framing). Among the SPEED categories, the technological and economic categories dominate the smart grid discourse in these newspapers, while political framing was largely absent. While more than 70 percent of articles included technological framing of smart grid technology, and at least 60 percent of articles included economic framing, political framing was included in less than 10 percent of the articles. This general lack of political framing in the smart grid context differs from media analysis of other emerging energy technologies, such as

---

[88] Ria Langheim et al., *Smart Grid Coverage in U.S. Newspapers: Characterizing Public Conversations*, 27 ELECTRICITY J. 77 (2014).

[89] *See* Ria Langheim, Smart Grid in the US: Visioning and Framing Opportunities for Electricity System Change (2013) (Masters Thesis) (on file with Clark University Environmental Science and Policy Program).

wind and carbon capture and storage.[90] Such a comparatively low amount of smart grid political framing may therefore reflect that basic grid infrastructure has a correspondingly low level of political salience. Low levels of political salience are especially relevant to smart grid technology development and deployment, as low political salience may make significant investments less likely.

Across all three newspapers, benefits of smart grid were mentioned more often than risks. Specifically, the benefit to risk ratio in technological framings of smart grid technology was approximately 6:1, and 3:1 for economic framings. These ratios highlight the optimistic framing of smart grid in the mainstream media. Technical benefits of smart grid were mentioned in more than 70 percent of articles, economic benefits were mentioned in 60 percent of articles, and more than 20 percent of the newspaper articles on smart grid mentioned environmental benefits. The articles also discussed cultural benefits associated with smart grid—explaining, for example, how information provided through smart grid technologies can positively affect energy use by increasing consumers' ability to control the electric bill. Many articles even contained examples of specific homeowners who made changes that significantly reduced their electricity bills.[91]

On the other hand, privacy concerns are among the most frequently mentioned cultural risks in these newspaper articles.[92] Several articles also expressed concern that smart grid technology (particularly smart meters) collects data that could reveal private information about how people live their lives. The following example from the *New York Times* demonstrates these privacy concerns:

> Before long, the meters in our homes will be able to measure electricity usage down to the level of individual air conditioners, plug-in cars and microwave ovens. That data is potentially valuable, and it may reveal more about customers than they want to disclose. [. . .] Now utilities, which are not accustomed to handling data in the way Google and Facebook have, will know a great deal about people's lives. They might let the information

---

[90] *See* Rumika Chaudhry et al., *Policy Stakeholders' Perceptions of Carbon Capture and Storage: A Comparison of Four U.S. States*, 52 J. CLEANER PRODUCTION 21, 25 (2013); Feldpausch-Parker et al., *supra* note 22, at 7 (media analysis of CCS showed that political framing was dominant); Fischlein et al., *Policy Stakeholders and Deployment of Wind Power in the Sub-National Context: A Comparison of Four U.S. States*, 38 ENERGY POL'Y 4429, 4434 (2010).

[91] *See* Langheim et al., *supra* note 88.

[92] Cultural risks were mentioned in 9 percent of the articles. *See* Langheim et al., *supra* note 88.

> leak. They might package and sell it. They might leave it open to hackers or stalkers.[93]

This suggestion that utility companies are not accustomed to managing and keeping this kind of personal data secure demonstrates mistrust about how electricity data might be used and what private details this data could reveal. Such privacy concerns represent a potentially powerful negative cultural association with smart grid.

This application of the SPEED framework thus provides a structure for assessing public discourse surrounding smart grid. News media analysis is instrumental to understanding public discourse and the social dimensions of energy innovation because the media represents and reflects public conversations.[94] The media also has the potential to influence public perception and reinforce—or potentially change—the direction and scope of public discourse on a particular issue.[95] Furthermore, with respect to technical issues surrounding energy policy and technologies, the news media also plays a critical role in linking technical assessments of experts to the more socially recognizable assessments of laypersons.[96] Analysis of public discourse using the SPEED framework therefore provides insight on the public salience of different perspectives that bear directly on smart grid deployment. Integrating consideration of these insights into the design of energy policy could lead to improvements in policy implementation and regulatory effectiveness by proactively considering public concerns and understanding. Gaps between public understanding and technology deployment often create implementation problems.[97] If policy makers, including utilities and state officials incorporate public understanding of smart grid and public framings of salience into their policy design and policycommunication some implementation challenges could be avoided or minimized.

---

[93] David Greising, *Promise and Peril in Utilities' Smart Grid*, N.Y. TIMES, May 28, 2011, at A27A.

[94] *See* DORIS A. GRABER, MASS MEDIA AND AMERICAN POLITICS 5 (5th ed. 1997).

[95] MAXWELL MCCOMBS, SETTING THE AGENDA: THE MASS MEDIA AND PUBLIC OPINION 1–3 (2004).

[96] *See*, *e.g.*, Sharon Dunwoody & Kurt Neuwirth, *Coming to Terms With the Impact of Communication on Scientific and Technological Risk Judgments*, *in* RISKY BUSINESS: COMMUNICATING ISSUES OF SCIENCE, RISK, AND PUBLIC POLICY 11, 11–15 (Lee Wilkins & Philip Patterson eds., 1991).

[97] *See* Krishnamurti et al., *supra* note 77, at 796–797.

B. SPEED Applied to State Comparison of Smart Grid Deployment-Level Policy Documents

Our research team also applied the SPEED framework to content analysis of documents posted on state government websites.[98] This research used the SPEED framework to compare state-level smart grid discourse across seven states with very different energy system landscapes. The seven states were selected to highlight the diversity of contexts for smart grid development in the United States (Figure 1, Table 2). California, New York, and Texas have large populations and single-state electricity markets. In contrast, Minnesota, Illinois, Massachusetts, and Vermont participate in Regional Transmission Organizations (RTOs) that coordinate transmission system planning and wholesale electricity markets across multiple states. Minnesota and Illinois are members of the Midcontinent Independent System Operator (MISO) RTO, while Massachusetts and Vermont belong to the New England Independent System Operator (ISO-NE).[99] On a local level, Minnesota[100] and Vermont[101] follow a traditional paradigm of energy regulation, in which the local utility owns generation, transmission, and distribution infrastructure and is regulated by the state Public Utilities Commission. The remaining five states have undergone some form of electricity market restructuring in which different companies own different parts of the system. The level of state regulation also varies across these seven states. For example, California[102] and Texas have supported heavy

---

[98] Koenigs, et al, *supra* note 56. Our search included smart grid documents posted between October 2012 and June 2013 on various government web sites, including the sites of state legislatures, state public utility commissions, and state energy offices. For each of the seven states, we identified smart-grid-related documents by clicking on these three state websites and then using the search engines embedded within each site to search for the terms "smart grid" and "smart meter." Finally, we conducted content analysis on the twenty most relevant articles from each state by applying the SPEED framework to assess variation in the socio-political context for smart grid in seven states: California, Illinois, Massachusetts, Minnesota, New York, Texas, and Vermont.

[99] AMERICAN PUBLIC POWER ASSOCIATION (APPA), A BRIEF DESCRIPTION OF THE SIX REGIONAL TRANSMISSION ORGANIZATIONS (RTOS) 1–2 (2008), *available at* http://www.publicpower.org/files/PDFs/IssueBriefRTOs.pdf.

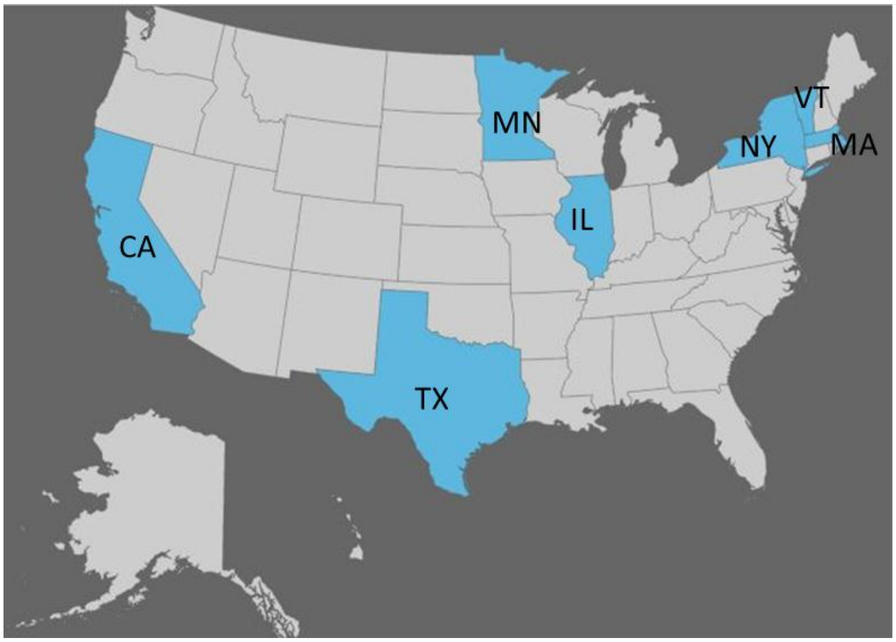
[100] MIKE BULL, RES. DEPT. MINN. H.R., REGULATION OF ENERGY UTILITIES IN MINNESOTA (2002), *available at* http://www.house.leg.state.mn.us/hrd/pubs/ss/ssegutil.pdf.

[101] VERMONT NATURAL RESOURCES COUNCIL (VNRC), ENERGY PLANNING & IMPLEMENTATION GUIDEBOOK FOR VERMONT COMMUNITIES 5–7 (2011), *available at* http://www.vlct.org/assets/Resource/Handbooks/Energy-Planning-Guidebook.pdf.

[102] CALIFORNIA PUBLIC UTILITIES COMMISSION, REPORT TO THE GOVERNOR AND THE LEGISLATURE: CALIFORNIA SMART GRID 7–9 (2012), *available at* http://www.cpuc.ca.gov/

utility investment in smart grid and smart meters.[103] While Illinois, Vermont, and New York have plans to make such investments, Massachusetts and Minnesota have supported more limited initial investments.[104] All seven states have renewable portfolio standards (RPS) or goals,[105] and have invested to some degree in renewable energy technologies.[106] They also all have interconnection policies and other financial incentives to promote renewable energy technologies and to connect them to the electric grid, though the degree and type of state support varies.[107]

FIGURE 2. Location of the Seven States in Comparative Analysis. California (CA), Illinois (IL), Massachusetts (MA), Minnesota (MN), New York (NY) and Vermont (VT) All Have Different Levels of Smart Grid Deployment and Renewables Penetration.



NR/rdonlyres/7AB03474-E27C-4EB6-AB8D-D610A649C029/0/SmartGridAnnualReport2012Final.pdf.

[103] GRIDWISE ALLIANCE, SMART GRID POLICY CENTER: 2013 GRID MODERNIZATION INDEX 3–4 (2013), *available at* http://www.gridwise.org/documents/GridModernizationIndex_July2013.pdf.

[104] Koenigs, et al, *supra* note 56, at Appendix Table A1.

[105] *Id.* At 220.

[106] *See, e.g.*, BUDGET, *supra* note 59; Koenigs, et al, *supra* note 56, at 221.

[107] *See* Koenigs, et al, *supra* note 56, at 219.

TABLE 2. **(a) Demographic and Electricity System Profile of Each State. (b) Renewable Generation and Percent Electricity From Renewables Does Not Include Nuclear Generation But Does Include Large Hydropower. Sources: U.S. Energy Information Administration 2013, Sherwood 2012, NREL 2012.**[108]

State	Population (Million)	Total Electricity Generation (TWh)	Total Electricity Consumption (TWh)	Total Renewable Generation (TWh)	Renewable Generation (%)	Average Electricity Price (⊠/Kwh)	Installed Wind (GW)	Installed Solar (MW$_{DC}$)
CA	37.2	204	260	60	29	13	5.5	1,564
IL	12.8	201	145	5	2	9.1	3.6	16
MA	6.5	43	57	3	7	14.3	0.1	75
MN	5.3	54	68	8	15	8.4	3	5
NY	19.4	137	144	31	23	16.4	1.6	124
TX	25.2	412	360	29	7	9.3	12.2	86
VT	0.6	7	6	2	30	13.2	0.2	12
US Ave.	12	80	74	8.6	14	9.8	0.79	79

In these documents, economic framing was the SPEED category most frequently used to discuss smart grid, followed by political framing, and then technical framing. Cultural and environmental framing of smart grid was less common in these documents.

Economic and political framing for smart grid development were often coupled, highlighting the role of the public sector in financing smart grid development. The importance of federal support, particularly references to the financial support from the American Recovery and Reinvestment Act, was also evident in many of these documents. In addition to federal support, government-sponsored sites frequently mentioned integrated economic and political framing in reference to state-level initiatives designed to support smart grid.[109] Many of the documents we found also employed economic and political framing to discuss the financial costs of smart grid.[110] This framing indicates the importance of the perceived need for political support and cost allocation to fund smart grid development.

---

[108] *Electricity*, U.S. ENERGY INFO. ADMIN., http://www.eia.gov/electricity (last visited June 28, 2014).

[109] Koenigs, et al, *supra* note 56, at 227.

[110] *Id.*

By applying SPEED to systematically analyze these documents, we were able to compare very different state-level socio-political contexts that shape smart grid deployment. Some states, like California, view smart grid as a set of necessary technologies to meet their climate and energy goals. While some California utilities experienced problems with smart meter roll-outs, other California utilities, such as the Sacramento Municipal Utility District, were lauded as exemplary models. In contrast to California's smart grid discourse, smart grid in Texas is often presented as a way to enhance the economics of their energy sector, while in Illinois investments in smart grid were locked in a political battle between the utilities, the commerce commission, the legislature and the governor.[111]

By systematically analyzing these very different contexts for smart grid deployment, we were able to present a more nuanced understanding of the comparative advantages that smart grid offers different state-level organizations and identify specific challenges which smart grid poses. Our SPEED assessment provides valuable context-specific insights relevant to smart grid deployment in these seven states. This analysis can be used by policy-makers at the national level to improve understanding of the large heterogeneity of socio-political contexts within which smart grid implementation is taking place in the United States. This analysis can also be integrated by policy-makers involved in smart grid implementation in specific states or communities in an attempt to anticipate implementation challenges.

C. The Value of SPEED Analysis

This example of application of SPEED to smart grid demonstrates how the SPEED framework provides a structure for assessing socio-political contexts within which smart grid policy is being implemented and smart grid technologies are being deployed. SPEED offers a structure for assessment that enhances the effectiveness of energy policy design and implementation. Analysis using the SPEED framework is not prescriptive, for example SPEED analysis does not necessarily result in a clear or simple result that can be applied to policy-making processes. Rather, SPEED analysis offers a systematic approach for policy-makers to assess, review and understand the evolving socio-political context of energy system change. This allows for the targeted identification of opportunities and risks of

---

[111] Koenigs, et al, *supra* note 56, at 227–229.

energy policy implementation within specific contexts. This assessment provides a valuable context-specific background that reduces the likelihood of unforeseen consequences of general policy approaches. Writes McLaughlin, "These lessons frame the conceptual and instrumental challenge for [. . .] implementation analysts—integrating the macro world of policymakers with the micro world of individual implementors[.]"[112] SPEED can help to bridge this gap.

CONCLUSION

As research on energy technology innovation increasingly requires a systems-based approach, the SPEED framework presented in this Article provides a valuable structure to guide future analysis and research. The energy system change envisioned in current smart grid initiatives and investments throughout the United States illustrates the need for SPEED. The SPEED framework is valuable because it encourages and supports analysis that integrates cultural, political, legal, and environmental factors influencing energy deployment into the technical and economic analyses that dominate most assessments of energy technology innovation.

We have illustrated how the SPEED framework provides a more nuanced and socially, politically, and culturally integrative approach to technology assessment. Rather than considering technologies, economics, and policies in isolation, SPEED enables and helps operationalize a socio-technical systems perspective to inform analysis of emerging energy technologies and energy system change.

Applying the SPEED framework to analyze framings of smart grid in news media and state-level policy documents demonstrates the value of analyzing a wide range of social and political conditions that influence energy technology deployment. While we often tend to assume that economics and engineering dictates whether and how technologies are deployed, the SPEED framework demonstrates how cultural, political, and environmental factors critically influence energy system change. If these factors are not systematically acknowledged and integrated into policy analysis, laws, and regulations, energy policy risks being ineffective and technologies may, as a consequence, fail to adapt to and capture the full system benefits. By applying the SPEED framework to characterize the social and political influences on energy system change, we can improve

---

[112] *See* McLaughlin, *supra* note 26, at 171.

policy effectiveness to accelerate a transition to a more just and sustainable energy future.

The application of SPEED analysis has great potential to improve policy and regulatory effectiveness. SPEED analysis enables characterization of the socio-political context at a regional or local scale that can inform policy implementation. SPEED analysis also offers a way to identify likely obstacles and barriers that may emerge during deployment of energy technologies. This is a powerful function given the powerful influence of community opposition to many energy technology deployment initiatives. SPEED analysis can also encourage policy makers to question simplistic claims that justify system change (or oppose such change) based on a single social function system. For example, within the energy system, new metering technologies may be technologically feasible and economically profitable to some actors. But a more sustainable justification for deploying them can be developed if it also includes consideration of cultural, legal, and political functions.

The value of the SPEED framework's structure to compare the socio-political contexts of different regions is evident when considering the implementation of U.S. EPA's June 2014 proposed rules for regulating carbon dioxide emissions from existing power plants.[113] The proposed rule considers the existing energy infrastructure in each state and, using a complex methodology,[114] develops state-specific goals that offer compliance flexibility among states.[115] Responding to 111(d) will be very different in Kentucky and California. The structure of the proposed rule explicitly acknowledges the importance of different state contexts, and the SPEED framework will be helpful to compare and evaluate each state's implementation strategy.

---

[113] Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units, 79 Fed. Reg. 34829 (proposed June 2, 2014) (to be codified at 40 C.F.R. § 60).

[114] *Id.*

[115] Tim McDonell, *How Much Cleaner Will Obama's Climate Rules Make Your State?*, GRIST MAGAZINE, June 4, 2014, http://grist.org/climate-energy/how-much-cleaner-will-obamas-climate-rules-make-your-state.