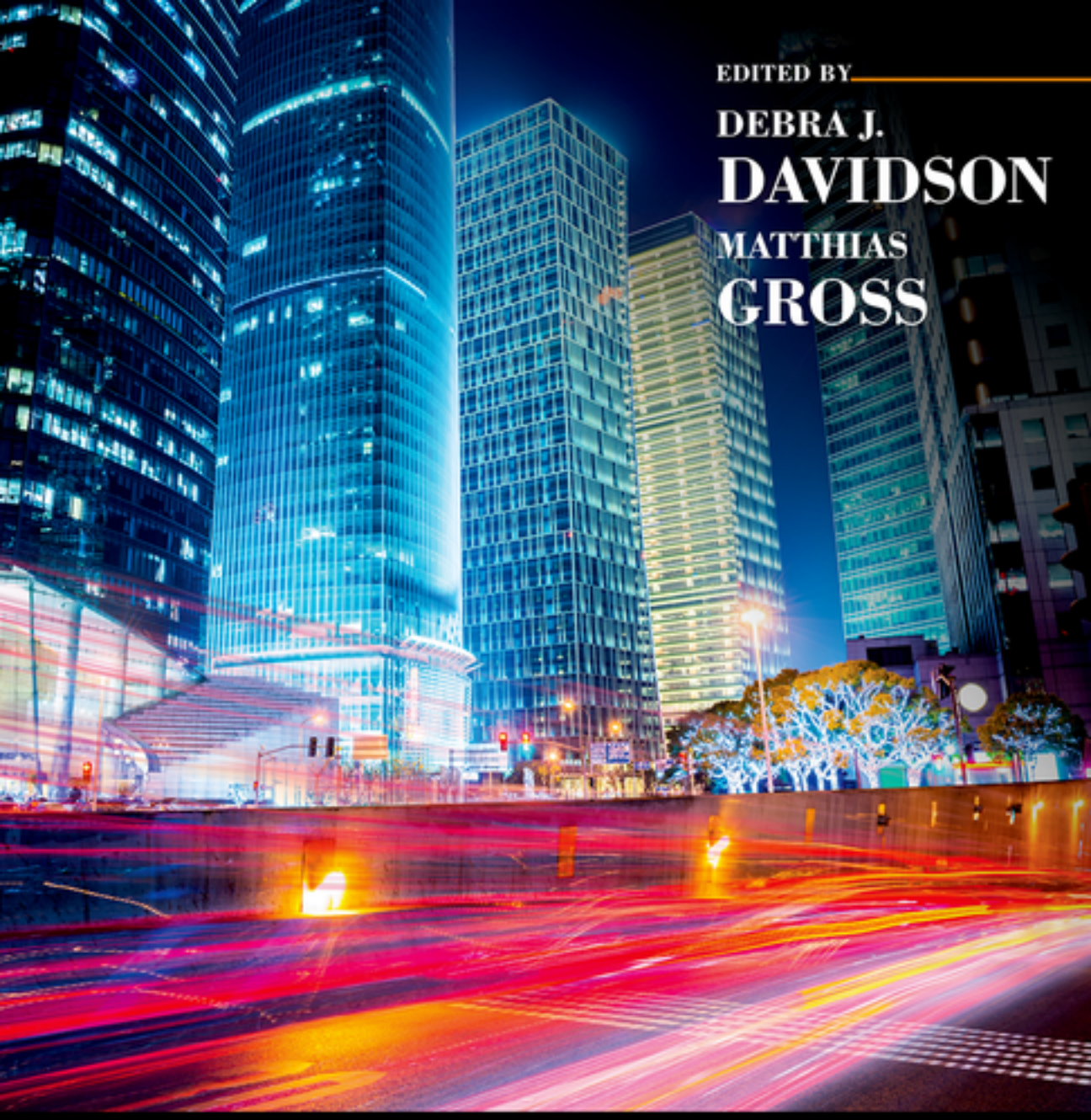

EDITED BY

DEBRA J. DAVIDSON

MATTHIAS GROSS

The Oxford Handbook *of* ENERGY AND SOCIETY

THE OXFORD HANDBOOK OF

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Edited by

DEBRA J. DAVIDSON

and

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Debra J. Davidson is Professor of Environmental Sociology in the Department of Resource Economics and Environmental Sociology at the University of Alberta. Her primary areas of teaching and research include the social dimensions of energy and food systems, with special interest in the impacts on, and the observed and potential institutional transformation in, energy and food systems due to climate change. She is co-author of *Challenging Legitimacy at the Precipice of Energy Calamity,* with Mike Gismondi (Springer, 2011), and co-editor of *Consuming Sustainability: Critical Social Analyses of Ecological Change* with Kierstin Hatt (Fernwood, 2005). Recent articles have been published in *Science, Society and Natural Resources, British Journal of Sociology, Global Environmental Change*, and *Agriculture, Food and Human Values*, among other journals. She also served as Lead Author on the 5th Assessment Report of the Intergovernmental Panel for Climate Change, Working Group II, with contributions to Chapter 26: *North America*; the *Technical Summary*; and the *Summary for Policymakers*. Dr. Davidson's current research projects are focused on urban agriculture and food security, the social impacts of hydraulic fracturing, and discourse analysis of the political framing of fossil fuel development. Dr. Davidson received her PhD from the Department of Rural Sociology, University of Wisconsin-Madison, in 1998.

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CHAPTER 1

A TIME OF CHANGE, A TIME FOR CHANGE

Energy-Society Relations in the Twenty-first Century

DEBRA J. DAVIDSON AND MATTHIAS GROSS

Energy, simultaneously ubiquitous and invisible, is the current upon which cultures, economies, polities, technology, and relations of social power have ridden throughout human history. Invisible, but eminently directional, that current describes a historic trajectory ever uphill. Just as increased energy inputs enrich our ecosystems in increasingly complex webs, so too has there been a clear relationship between energy consumption and social complexity, despite significant leaps in efficiency (Smil, 2010; Tainter, 1988). As noted by Urry (2014, p. 9), "contemporary cultures presuppose huge concentrations of energy so as to power the modern world and its machines." Securing access to energy over time is a key task for ensuring the survival of any society, but at least since the close of World War II, those fortunate enough to live in Western, developed countries have had the luxury of complacency—so long as the lights turn on and the gas station is open, most people in the West could leave it to a handful of engineers, politicians, and corporate executives to figure out the details outside the limelight. The 1973 oil crisis did capture attention, but at least in the USA it was mainly understood as political crisis—a response to US support for Israel during the Yom Kippur War—rather than an oil supply crisis per se. That attention was all too brief; the solar panels installed on the White House by Jimmy Carter later in the 1970s were ceremoniously removed by Ronald Reagan. Taking society's cue, sociologists too largely ignored energy, although there have always been those on the outskirts who have attempted to draw the discipline's attention for a century.

That current, always turbulent, is beginning to shift in ways that have begun to jar scholars, politicians, and business executives alike. The political, social, and economic importance of energy has come to the fore at the beginning of the twenty-first century, and there are no signs of it receding again into the background. First, as has been made strikingly clear in international climate negotiations, this current is made up of a few

main channels and many small streams, with the populations of a small number of developed countries consuming vastly more energy resources than the remainder, with over a billion people today lacking secure access to electricity (see, e.g., Chapter 17 of this volume). As has been noted repeatedly in these negotiations, developing countries have a right to enjoy the benefits of fossil-fuelled economic development, too. And yet, as has also been noted, energizing the rest of the world up to the standards enjoyed in the highest-income countries is not climatologically, ecologically, or even geologically possible with fossil fuels (Smil, 2010). Even for those developed economies, there is a rapidly receding confidence in our ability to continue to rely on conventional fossil fuels to foster economic growth. Remaining global reserves of fossil fuels are indeed quite large, but they consist primarily of unconventional sources, including shale, heavy oil, bitumen, and kerogen. The economic costs of their exploitation, not to mention the environmental and social costs—through methods like oil-sands mining, hydraulic fracturing, deep-sea drilling, gas-to-liquids and coal-to-liquids processes—are currently higher than those same costs associated with conventional deposits, and they may well continue to escalate in the future in the absence of substantial technological advances or alternatives. Regardless of their quantity or quality, burning them currently accounts for upward of 70% of the greenhouse gas emissions that have been attributed to rapid climate change.

However, there are few indications that fundamental shifts in the current consumption patterns and energy-intensive lifestyles that characterize modern societies will emerge with ease. To the contrary, the world's hunger for energy appears to be following an upward trajectory, and fossil fuels remain the most readily accessed, due in no small part to preexisting political and physical infrastructures that have evolved to support those fuel types. The present challenge is considerable: to effect a socio-technical transition to energy-society relations that are greenhouse-gas-emission free, while also minimizing other environmental impacts, and at the same time ensuring equitable access to energy resources. Whereas the Industrial Revolution was effectively an energy revolution, as coal and oil were used to industrialize and mobilize the Western world, contemporary transitions will necessarily be equally revolutionary. As with earlier energy transitions, doing so promises to both require and facilitate concomitant transformation of forms of social organization that may very well leave no social subsystem unaffected. One important driver of this transition is political-economic in nature, and given the political power of fossil-fuel interests today, any efforts toward transition away from reliance on such fuels have been and will continue to be fiercely resisted. Investment decisions that shape the direction of research and development are also pertinent. A third key driver pertains to the organization of energy access: our current, highly centralized systems of energy production and delivery increasingly are being called into question, and in some cases are being replaced by decentralized modes of energy production, including small-scale, community-based, and cooperative models. Other drivers are subtler, described by discourses and cultures of energy that follow unpredictable pathways, yet strongly shape everything from legislation to consumption practices.

New Political Realities

The reluctant acceptance by members of the international political elite of the inevitability and severity of the impacts of climate change has marked forever a fundamental shift in the politics of energy. The title of Jörg Friedrich's recent book, *The Future Is Not What It Used to Be* (2013), describes a notable decline in confidence in our prospects for continuation of the economic progress enjoyed by the West since the close of World War II. Historical trajectories of economic growth stop here, and twenty-first-century societies seem to be left with a rather poor set of choices: put the brakes on the economy, or set the climate to boil.

The crux of the issue is a dilemma dubbed the *carbon bubble*: representing the carbon content of remaining fossil-fuel reserves that must be kept in the ground to prevent dangerous levels of global warming. According to an analysis published in *Nature* (McGlade & Ekins, 2015), a third of global oil reserves, half of natural gas reserves, and over 80% of coal reserves should remain unused from 2010 to 2050 in order to meet the target of limiting global warming below 2°C. The implications for the world's economies in general are alarming. Fossil fuels are used to heat and electrify homes, offices, and factories, and, perhaps most crucially, to move things. The mobility of people, material goods, and currencies defines contemporary societies to such an extent that there are almost no activities that are significant in the modern world that do not entail movement of some kind, virtually all of which depends upon oil (Urry, 2012). But the implications of the carbon bubble also have a far more specific character: much of those fossil fuels are already "owned" by energy companies, whose portfolios depend on their expected future exploitation; ergo, a bursting of this bubble would render some of the largest and most powerful corporations in the world, and many petro-states, penniless. As quipped by Biel (2014, p. 186), "in a bizarre way, wealth flows to those who cause the most entropy," and collective efforts to restrain that entropy constitutes a direct threat to those interests.

This context sheds light on the increasingly acerbic politicization of climate science. As research by McCright and Dunlap (2010) indicates, efforts by members of the US federal government to manipulate climate science at the behest of conservatives goes back decades. None of this should come as a surprise since, as noted by Friedrichs (2013: p. ix), "when our entire way of life is at stake, the struggle over knowledge is bound to be political." Global social movement attention to climate change has nonetheless continued to grow alongside these efforts. And, sharing less of the limelight, but no less consequential, growing resistance in civil society to fossil-fuel development has also emerged, taking the form of divestment campaigns, local resistance to pipelines and hydraulic fracturing, and a growing number of legal efforts to hold government and industry accountable. Personal- and community-level experiments in low carbon transition are also growing in number, and with the increasing availability of small-scale renewable electricity-generation technologies, many consumers have become "prosumers,"

demanding more control over the goods and services that they consume (Wood, 2016). Attention by civil society to energy and climate change is significant, and already has generated results: a number of nations, states and provinces, and municipalities have instituted bans on hydraulic fracturing; fossil-fuel divestment campaigns continue to grow in number and effectiveness; and protests such as No Dakota Access Pipeline (#NODAPL), which 10 years ago would likely not have attracted even national attention, has generated an international response.

Underlying this momentum, however, lurks an elephant: optimism regarding prospects for a smooth and rapid renewable energy transition are increasingly recognized as overly naïve. Research by York (2010), among others, illustrates that expanding the use of non-fossil-fuel energy sources does not necessarily suppress the use of fossil-fuel energy sources. In response, Geels (2014) urges his transition-focused colleagues to focus not just on up-scaling green alternatives. As he argues, ironically, the prevalence of academic attention among transition theorists on new innovations in renewable energy "may serve to protect existing regimes by detracting attention from the fossil fuel burning problem" (Geels, 2014, p. 37). In short, environmental social scientists need an equally ambitious research program focused on preventing existing fossil-fuel reserves from being burned. There is no better example of this than the inflated subsidies committed to fossil fuels. According to a recent International Monetary Fund (IMF) Report, pre-tax basis subsidies for petroleum industries reached $480 billion in 2011. When the negative externalities from energy development and consumption are factored in, that subsidy rises to $1.9 trillion. Favoritism toward fossil fuels is not the only constraint; even renewable energy alternatives generate opposition or introduce challenges of their own, and are, furthermore, also associated with environmental impacts (Shaw, 2011), and thus, as Venderheiden (2011) reminds us, the politics of energy involves selecting from among a set of imperfect options, and some scholars believe that many of the alternative energy resources are simply not up to the job of powering our current global economies (e.g., Baghat, 2008).

Even further backstage are enduring political issues that are not in the limelight (but then again, they never have been) as the geopolitics of fossil fuels has more often than not been a behind-the-scenes affair. The consistent backstage position of oil geopolitics is, in and of itself, remarkable: struggles to control world energy resources played a role in both world wars and the Iraq War (Amineh & Houweling, 2007). The need to secure transport routes has always been the centerpiece of maritime military movements, constituting heavy state revenue commitments. Marriott and Minio-Paluello (2014) note that the "oil roads" that run from extracting states to consuming states have remained remarkably constant over the decades. These researchers describe the pipeline routes from the Caspian region to EU markets as a tangled web, laid atop a checkerboard of unstable and conflicting states, with Iran, Russia, Kazakhstan, Azerbaijan, and Turkmenistan squabbling over control of production, and this mass relocation of fossil fuels requires constant coordination of logistical and financial resources. Meanwhile, the emergence of both new producing states, including several underdeveloped African

nations like Algeria and Angola, and new consuming states like China has disrupted a decades-old geopolitical regime previously dominated by a small set of Organization of Petroleum Exporting Countries (OPEC) and the United States. China may have plenty of coal, but must import oil to support its rapid industrialization. Production in the extreme periphery, like Nigeria, has had disastrous social, economic, and ecological effects (Watts, 2008).

New Material Realities

While energy and society relations are in many ways socially constructed, with numerous social factors shaping demand, supply, and delivery of energy resources—many of which will be explored in detail in the chapters to follow—those resources still have a physical (and ecological) reality that comes into play in markets, politics, and cultures. Underlying this materiality is a simple fact: one cannot produce or create energy, but can only transform it from one source into another. A power plant does not produce energy, or "power," but rather transforms it, as when nuclear energy is transformed into electrical energy. Energy is not something that simply disappears or "evaporates"; it is merely transformed, either by itself or by human activity, and is thus always a part of social life. Through the process of transformation, from a raw material into a product that can be used, another transformation takes place, from more concentrated and organized, to more dissipated and disorganized forms. Interest in this entropic law has been largely limited to energy scholars, although a number of social scientists, from Marx to Georgescu-Roegen, have given it attention. Today, the arguments of these scholars that entropy is far more than esoteric are beginning to resonate.

That resonance is associated with a new material context that is unprecedented for our century-long relationship with fossil fuels. The concept of "peak" fossil fuels (e.g., Kerr, 2011; Murphy & Hall, 2010) has been largely misrepresented in public and political discourse to imply that we are running out of oil, gas, and coal reserves. As energy analysts are quick to point out, the earth's crust is still replete with the stuff. But the quality of those reserves has been in decline since the first moment of extraction, and continued reliance on fossil fuels portends an increasing intensity of investment and ecological impact as the quality and accessibility of remaining reserves declines (Davidson, 2018; Davidson & Andrews, 2013). This historic trend is alarming for environmental reasons—the explosion on British Petroleum's Macondo drilling rig has been attributed to corporate negligence, but the fact that the well was drilled to an unprecedented depth of nearly 25,000 ft (7.6 km) rendered such an accident more likely, and more disastrous. Why would British Petroleum choose to drill at such a depth? Simply because more accessible reserves are becoming harder to find (Smith-Nonini, 2016), to the extent to which we may no longer be able to rely on increases in fossil-fuel-based energy consumption to support growth. As noted by Moore (2011, pp. 22), our turn

toward lower quality fuels "has brought with it a monstrous turn towards toxification on a gigantic scale—from unprecedented oil spills to the 'hydraulic fracturing' of natural gas exploitation to coal's mountaintop removals, energy production in late capitalism increasingly manifests as a qualitative leap forward in the erosion of the conditions of human, never mind extra-human, well-being."

This historic trend is just as alarming for economic reasons. Again referring to Moore (2011), the prospect of discovering new global reserves capable of underwriting the next century's progress at anything close to the pace enabled by the capture of fossil fuels during the previous century is slim. The recent boom in fracking has been hailed loudly by proponents as the rebirth of energy independence in places like the United States, but for those with any understanding of the limited quality of shale reserves, and the costs of their exploitation, this moment in the history of fossil fuels is more accurately conceived as the retirement party (Berman, 2015; Love & Isenhour, 2016). Over the past few years, energy companies have adjusted to current economic realities by taking on increased debt, while petro-states lower royalties and offer other forms of subsidy, but these management strategies clearly have their own limits. Why does this matter to our economies? "If the dollar is pegged to anything today, it is pegged to a barrel of oil" (Sager, 2016, pp. 38–39).

New Epistemological Realities

Energy is in many ways a special field of study. Energy is an inherent, intrinsic aspect of social change that can be seen not only as the glue that holds together different elements of the social order, but also as a force that helps to transform them, by facilitating the creation of new social arrangements. Energy also sets the boundaries by which such transformations must abide. The structuration of energy access is a complex problem that touches on many areas of science and culture. Access to energy and the development of innovative new technologies are interlinked with geology and engineering, as well as economic and political processes, and cultural patterns of energy use. The social sciences have in many ways remained on the sidelines of inquiry, but that appears to be starting to change.

The genre of energy and society research in the social sciences has evolved quite dramatically over the past century, a course that began with the prevalence of structural, political economy treatments. To these were added social-psychological attitude studies, particularly during the 1980s oil embargo, which motivated efforts to stimulate conservation in the West. Toward the end of the twentieth century, the field began to open up considerably, with the inclusion of cultural studies, social practice and actor-network theories, multilevel systems transition theories, and, most recently, a return to those original materialist accounts, but with the integration of recent advances in complexity theory, among other insights. This historical trajectory has brought forth a conceptually and methodologically exciting field that is well represented in the chapters

in this volume. The developments in social analysis of the energy-society relationship that have emerged have the potential to fertilize the discipline of sociology and related fields with pertinent new ideas and findings germane to contemporary politics and economics, while simultaneously advancing social theory.

Sociology has not always been fertile ground for the consideration of energy and society relations. Major parts of the discipline were founded on principles of what Catton and Dunlap (1978) called human exemptionalism—the belief that social processes can only be explained by other social processes—and thus adherents to the discipline for the most part neglected the role of energy in society, as well as any other causal mechanisms other than those originating in the social sphere (McKinnon, 2010). The handful of scientists speaking to energy-society relations came from neighboring fields in the social sciences—like anthropology and economics—or even further afield, in the natural sciences. Wilhelm Ostwald, having coined the term *sociological energetics*, was a chemist by training; Howard T. Odum developed the concept of *emergy*—an effort to capture the embodied energy in all material components of social life—from his disciplinary home in ecology. Herbert Spencer, despite his development of a concept of *energetic sociology*, was more of an evolutionary biologist and philosopher than a sociologist in today's understanding. Spencer developed an ambitious theory of social evolution based on the principles of energy—an effort largely lost on contemporary scholars due to strong criticism of other aspects of his work. Leslie White was also an anthropologist, and drew heavily from the natural sciences to develop his understanding of the material (energetic) bases of social, and in particular economic, change (Love & Isenhour, 2016).

William Cottrell's work, published in book form in 1955, is among the few works focused on energy to emerge from sociology prior to the 1980s, and continues to be held in high regard among energy and society scholars today. Cottrell provided a history of social development from low-energy societies to modern industrial societies, placing particular emphasis on the explanatory power of the forms of energy available, and the role of technology in determining that availability. Many current sociologists and others have continued to find merit in the work of economist Georgescu-Roegen (e.g., O'Hara, 2009; Sager, 2016). Georgescu-Roegen was quite preoccupied by energy's entropic character, and its implications for economies and societies, in which we continually yet fruitlessly attempt to oppose this force (Georgescu-Roegen, 1971). As noted by both Georgescu-Roegen and Cottrell, economic growth necessitates an increase in overall material and energetic flows; equally important, power is intimately associated with control over energy, and shifts in energy availability and form thus have enormous disruptive potential.

More recently, the changing material circumstances discussed in the preceding have reinvigorated materialist approaches, integrated with more recent scholarship in complexity theory (e.g., Biel, 2014; Demaria & Schindler, 2016; Sager, 2016; Urry, 2004, 2014). These scholars frame energy-society relations in metabolic terms of *funds* and *flows*, path dependency and transition. John Urry (2014, p. 8) stated, "the human and physical/material worlds are utterly intertwined and the dichotomy between the two is a construct that mystifies understanding of the problem of energy." And yet

he devoted much of his last decade of life to seeking that understanding (Urry, 2004, 2008, 2014). His treatment of the private automobile offers an exemplar of the integration of materialism and complexity theory. The car is strangely absent from sociology, he notes, and yet Western society has been wholly shaped physically and culturally to accommodate it. Importantly to his analysis, it is also the single most important form of personal environmental impact, and wholly dependent upon a resource access to which is in decline: oil. And yet the "car-driver"—a hybrid assemblage of activities, technologies, infrastructures, and cultures—is frustratingly resilient. Urry (2004, p. 26) notes, "what is key is not the 'car' as such but the system of these fluid interconnections."

Working our way down to the bottom of the pecking order are individual consumers. Consumer attitude studies emerged in the 1980s (e.g., Rosa et al., 1988), and attention to energy consumers has continued to grow in the ensuing decades, although today this field has expanded considerably to include, at one end of the spectrum, more sophisticated computer-based statistical behavioral modeling. Much of this work identifies a consistent "value-action-gap" between the expressed sentiments of consumers and their actual behavior, reinforcing what Jevons (1865, p. 140) quipped so long ago: "It is wholly a confusion of ideas to suppose that the economical use of fuel is equivalent to a diminished consumption. The very contrary is the truth." At the other end of the spectrum are actor-network-theory-influenced analyses that place far more emphasis on the cultural context within which consumption practices emerge. Currently the repertoire of energy and society analysis within sociology also includes a panoply of studies at all scales, but particularly, an explosion of work focused on communities, albeit with a postmodern twist. As described by Campbell and colleagues (2016, p. 136) the very concept of community has been recast within sociotechnical energy systems, highlighting the roles of spatially-delimited communities of interest and practice, described in terms of "flows of agency, capacity, and value . . . [and] the sociocultural role of power within any energy production regime." Similarly, sociologists have begun to play with the concept of energy culture, defined by Sheller (2014, p. 134) as "specific assemblages of human mobility, transport of goods (logistics), and energy circulation . . . embedded in ongoing processes of mobilizing, energizing, making and doing" (see also Stephenson et al., 2010). These conceptual innovations have been stimulated in large part by the socio-technical innovations unfolding around us, particularly the opening up of energy politics due to the increased access to decentralized and less capital-intensive forms of electricity generation, disrupting entrenched power relations (Wood, 2016). Those power relations themselves have received renewed attention, with a greater degree of focus on the role of energy itself in shaping those relations (e.g. Boyer, 2014).

While attention to energy issues is growing in sociology, as well as other areas of the social sciences and humanities, many of these efforts remain at the fringes of academic inquiries into energy. We hope that this *Handbook* will help to close that gap, while presenting an overview of a field that has achieved a considerable level of maturity and relevance.

Outline of the Book

Our contributors represent the discipline of sociology primarily, but we also have included contributors in complementary fields, where we believe such complementarity is valuable to the study of energy and society. The frequency with which we have felt the need to do so reflects the necessarily interdisciplinary nature of the research inquiries involved, and the cross-fertilization across disciplines that has enriched this body of scholarship as a whole. We also have sought to bring together contributors who can provide a broad international perspective, and we have included both senior scholars as well as emerging scholars whose work we feel has strong potential to make significant new contributions to the field.

The organization of this *Handbook* was done with a number of specific objectives in mind. First, we have attempted to capture a variety of scales and methods, and a range of both conceptual and empirical analyses that define the field. We include contributions that focus on the continued importance of, and rapid changes in, the roles of individuals, communities, industries, scientists, states, and civil societies. Recent developments in energy production, consumption, politics, and governance are all highlighted, notably as they pertain to the rapidly growing sectors of renewables and non-conventional fossil fuels. The book is divided into seven parts capturing what we believe are the primary sociological fields of inquiry into energy and society today. Each part contains a handful of diverse perspectives within each of these fields, and is prefaced with a short essay synthesizing the key themes.

In Part I, "Key Contemporary Dynamics and Theoretical Contributions," we highlight sociology's response to calls on global society to radically transform its relationship with energy away from dependence on fossil fuels, or to confront the collapse of civilization's ecological foundations. Necessarily broad in scope, this field draws on complexity theory and systems thinking to grapple with society's precarious relationship with energy today. Part II, "The Persistent Material and Geopolitical Relevance of Fossil Fuels," offers a set of contemporary analyses, highlighting the renewed interest among many scholars in structural and political-economic perspectives, and the persistent material and geopolitical relevance of fossil fuels.

Part III, titled "Consumption Dynamics," highlights the elemental role played by individual consumers in energy consumption and the prospects of energy system transition. Attention is given, first, to global consumption patterns, exploring in particular geographic shifts in sites of consumption, with consumption rates growing rapidly in emerging economies. Attention then turns to research on recent empirical studies that have attempted to quantify the "behavioral wedge," the potential efficiency gains that could be realized with relatively minor shifts in household behavior, and its flip side, the so-called value-action gap, before turning to more recent work that evaluates energy consumption for a social practice lens.

Part IV, "Perspectives on Energy Equity and Energy Poverty," offers perspectives on equity, and poverty in energy access, highlighting the extent to which sources of the earth's energy resources are by no means equitably distributed. The negative social and environmental impacts of development, moreover, are borne by communities at the sites of production, while the resources themselves and the wealth they generate are most often exported for consumption elsewhere. Analyses that integrate both the sociopolitical and biophysical structures of energy-society relations raise uncomfortable questions about energy, poverty, and justice.

Part V is focused on "Energy and Publics." The role of public perceptions, their expression in politics and the market, and their emergent effects have in many circumstances had a notable influence on energy policymaking, and in ways that do not necessarily favor improvements in sustainability, energy conservation, and efficiency. This section will especially focus on agenda-setting processes for critical energy issues by using different social theoretical frameworks. We then turn in Part VI, "Energy (Re) takes Center-Stage in Politics," to the role of states and social movements to explore dynamic shifts in energy politics and governance taking place today, including the growth in number, and successes, of mobilized opposition to energy developments such as pipelines, mountaintop removal (coal), coal/open-cast mining in general, and hydraulic fracturing, as well as renewable energy developments. These encounters raise the possibility that we are experiencing the emergence of a new energy-focused global social movement, one that is independent of and yet has several implications for the politics of climate change. At the same time, significant shifts in governance have had their effect on energy politics, with de-decentralization in some cases, while in others more centralized governance structures have emerged.

We close in Part VII, "Emerging Trends in the Energy-Society Relationship," with a relatively retrospective section, contemplating emerging trends in the energy-society relationship. We are experiencing rapid shifts in several aspects of contemporary society with direct or indirect implications for the energy and society relationship. Drivers of these changes include technology, politics, and the growing political salience of climate change, among others. One compelling trend of note involves the "prosumer" movement: describing the rapid expansion of household-level micro-generation of renewable energy and citizen-led developments of new technologies, representing a dismantling of the centralized control structure that has defined energy delivery for decades. Other observations have opened up new lines of sociological inquiry, including case studies of local energy transition.

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PART I

KEY CONTEMPORARY DYNAMICS AND THEORETICAL CONTRIBUTIONS

The attempt to grapple with society's relationship with energy has inspired fruitful and often interdisciplinary pursuits among sociologists, as well as some of the most exciting systems-based conceptual developments one can identify anywhere in the discipline. The chapters in Part I of this volume emphasize some contemporary intellectual spaces that have served to shift our collective gaze in our inquiries into energy-society relations, and that we believe are worth watching in the coming years.

The first is unquestionably the sociopolitical upheavals wrought by growing acknowledgment of climate change's human origins and impacts, and by extension, scholars' attempts to grapple with these sociopolitical shifts. As discussed by John Vogler in Chapter 2, climate change has shifted the ground upon which political economies have rested, and has challenged our continued reliance on governments in decision-making, despite trends that may suggest the fruitfulness of other governance arrangements. Ironically, developments in international governing regimes to address climate change have far surpassed analogous efforts on the energy front: energy continues to be a comparatively domestic and private affair.

Chapters 3 and 4 describe tandem upheavals in the academy that have had a particular impact on the sociological study of energy: social practices and sustainability transitions. Both of these conceptual frameworks offer unique and valuable sociological contributions to understanding (and attempts to manage) energy-society relations. Both have also been subject to critique. Ana Horta's Chapter 3 details how substantively social practices theory departs from an entrenched (rational) actor paradigm versus social structure, to boldly resituate energy as an integral feature of all of our social activities undertaken in everyday living, while drawing empirical attention to the interactions between social and material elements and infrastructures. Sometimes intentional, sometimes not, our practices are nonetheless always embedded in sociocultural systems that dictate the norms governing those practices. In Chapter 4, Harald Rohracher describes emerging attention toward sustainability transitions based on a strong conviction that the political, economic, and cultural institutions defining our current energy-society relations must be transformed fundamentally in order to avoid fundamental lowering of standards of living and health, as well as the more catastrophic implications of climate change. This conviction has motivated renewed interest in complex systems, and the elements that aid in their transformation, namely niches in which innovations can flourish, and their potential upscaling through the multilevel systems that characterize modern societies. While in many ways the conceptual frameworks in Chapters 3 and 4 could not be more different, the common link here is growing acknowledgment of system complexity and attempts to accommodate that complexity epistemologically, while simultaneously acknowledging the dynamic role of actors. The extent to which actors are indeed *agents* in this system, however, is a point of contention among scholars involved in recent research in this vein, which has facilitated a fruitful discussion.

CHAPTER 2

ENERGY, CLIMATE CHANGE, AND GLOBAL GOVERNANCE

The 2015 Paris Agreement in Perspective

JOHN VOGLER

STUDYING the International Relations (IR) of the environment is a relatively recent academic endeavor for a discipline that has been generally more concerned with questions of war and peace, order and security. Climate change, of course, is critically associated with anthropogenic CO_2 emissions, two-thirds of which arise from energy production and use (IEA, 2015, p. 20), and IR scholars are no strangers to international conflicts over scarce hydrocarbon resources. It also has become clear in both academic and policy circles that the impacts of climate change are likely, at the very least, to provide a "threat multiplier" complicating existing conflicts and are likely to spawn entirely new international and intra-state confrontation (Detraz & Betsill, 2010; European Council, 2008). Such matters were not at the heart of IR approaches to issues of atmospheric pollution and natural resource depletion. Rather, their overriding concern, within a liberal institutionalist tradition, was to study the ways in which international cooperation and policy coordination to manage common environmental problems could be achieved within a "fragmented and often highly conflictual political system" of sovereign states in which there was no central authority (Hurrell & Kingsbury, 1992, p. 1). This is now commonly seen as an exercise in "global environmental governance"—with the management of climate change being regarded as its primary task.

However, the actual meaning of "global climate governance" is variously interpreted. For a long period in official circles, the term was merely used as a synonym for intergovernmental cooperation. Strictly speaking, the term "governance" is appropriate because there can be no government in a system composed of sovereign state entities, but the term has come to embrace the myriad private, transnational, regional, and local activities that serve to shape and control climate-related activities (Bulkeley & Schroeder, 2012; Pattberg, 2007). The apparent failure of governments to cooperate effectively in fulfilling the aspirations of the 1992 United Nations Framework Convention on Climate

Change (UNFCCC) has led to a focus on such non-state activity and frequent denial of the continuing relevance of international action (Andonova et al., 2009). This chapter attempts to redress this balance in the light of the Paris climate agreement that was achieved in late 2015. It considers the ways in which the international system has framed climate and energy issues and how international climate action—or more often, inaction—has been shaped by the seismic structural changes in the global political economy over the last three decades and by the day-to-day pursuit of national interest and prestige, which is also indissolubly connected to normative demands for climate justice in a very unequal system.

While it is true that the key decisions and actions that shape humanity's response are located at many social and economic levels and particularly involve private economic entities, there is still an important role for state governments acting in a coordinated manner. In order to avoid over- or underestimating the role of international cooperation in general and the UNFCCC climate regime in particular, it is important to establish what this might be. It has several components. First, international cooperation is required to monitor and restrict transboundary movements of pollutants and to regulate trade. Second, it is generally the case that only governments are in a position to fund the major research and aid and technology transfers upon which effective environmental action depends. It is no accident that the impressive international scientific enterprise for the production of authoritative knowledge and advice on a changing climate is named the Inter*governmental* Panel on Climate Change (IPCC). Although there are frequent optimistic references to private-sector development and adaptation funding, the bulk of this derives from coordinated government donations through international agencies such as the Global Environmental Facility of the World Bank and the more recently established Green Climate Fund. The extensive international climate architecture that will be discussed below is not integrated, with or matched, by attempts at international energy regulation. This has been rudimentary. The International Energy Agency (IEA) was a collective response to the energy security issues of the 1970s; more recently, there has been an attempt to stimulate renewables technology in the International Renewable Energy Association (IRENA) (Van de Graaf, 2013). Potentially, there is an enormous role for governments in funding and organizing the kind of energy transition that most experts argue will be required if the most damaging effects of climate change are to be avoided (Victor, 2011). Third, there is the key matter of providing governance arrangements for a global commons to cope with "market failure" at the international level, where unrestricted economic activity will lead to collective "tragedy." International standards and rules are thus required, but governments will not be prepared to restrict polluting activities within their own jurisdiction if they cannot be assured that others will do likewise. For economists, dealing with this "free-rider" problem is a key function of an international regime that directs attention to its monitoring, compliance, and enforcement arrangements (see, for example, Stern, 2007). Finally, there is the more intangible dimension of norm generation that provides the context and justification for particular actions: shared understandings on principles such as the "polluter pays" or the "precautionary principle," definitions of sustainability,

what constitutes dangerous climate change, and the responsibility of the international community for loss and damage. A great deal of international activity from the 1992 Earth Summit, with its Agenda 21, to the UN's millennium goals and Article 2 of the Paris Agreement, displays such normative intent.

The UN Framework Convention on Climate Change (1992)

In a world still divided by the second phase of the Cold War, climate change began to be recognized as a policy problem during the 1980s. This was a decade characterized by a dawning awareness of environmental problems at a global scale. Notable was the discovery of the depletion of the stratospheric ozone layer caused by emissions of chlorofluorocarbons (CFCs) and other "man-made" gases. In 1985 the Vienna Convention outlined the problem and called for international action to ban or restrict ozone-depleting chemicals. This was to occur quite rapidly with the signature of the 1987 Montreal Protocol, which soon came to be regarded as a paradigm for successful international environmental action that incorporated emergent scientific findings into an ongoing program of regulation that would successively ban production and trade in a range of ozone-depleting substances (ODS). The interconnections between the stratospheric ozone and climate regimes were established early on, not the least of which was that the ODS were in themselves powerful greenhouse gases (GHGs) (their regulation is specifically excepted from the scope of the 1992 Climate Convention). Significantly, the negotiation of a new climate treaty commenced shortly after the signature of the Montreal Protocol and adopted its legal and institutional approach—a "framework convention" to define the problem and encourage and respond to scientific findings (the IPCC was set up in 1988) and a "control protocol" to initiate concrete action. This primary framing of the climate issue seemed appropriate at the time but failed to adopt a similar targeted regulatory approach. Of course the ozone problem was very specific, involving a set of gases for which substitutes were usually available, while the problem of excess GHGs was infinitely more complex and wide-ranging, touching the very essence of a hydrocarbon-based civilization. It still might have been possible, but exceedingly difficult, to follow the Montreal model by identifying and restricting particular emission sources, such as the mining of and trade in coal. In the event, the International Negotiating Committee (INC) adopted a much looser universal approach by attempting to reduce overall national emissions of GHGs and to conserve carbon sinks (Articles 2 and 4 of the UNFCCC). Because the lion's share of anthropogenic CO_2 emissions (the principal GHG) is related to power generation and transport, this implied, but did not propose, energy policy measures. In the international transport sector, rising aviation- and shipping-related emissions were excluded from the developing climate regime on the grounds that this would cut across the remit of other international organizations

(the International Civil Aviation and International Maritime organizations, ICAO and IMO). The European Union (EU) was subsequently to fail in its 2012 attempt to include international aviation emissions in its Emissions Trading Scheme, and aviation fuel and maritime bunkering remain largely uncontrolled, pending ongoing and protracted attempts by the ICAO and IMO to erect their own schemes for international carbon reduction. One further problem with the drafting of the UNFCCC was that emissions were to be calculated on a national territorial basis, which provides scope for extreme distortions in terms of assigning responsibility. Thus the physical shifts in production and pollution under economic globalization mean that while the emissions of developed economies in Europe have been reduced, they may simply have been transferred to less developed economies with a "spatial disconnect between the point of consumption and emissions in production" (Peters et al., 2011, p. 5).

Academic and popular commentary has often located the source of the climate problem in population growth and related patterns of consumption in an expanding global economy (Newell, 2012; Royal Society, 2012). These "drivers" of climate change lie well beyond the formal remit of the climate regime. For a number of religious and cultural reasons, population is not an issue that can be comfortably addressed at the international level. Consumption, rather than population growth per se, is evidently the key driver of rising GHG emissions and is inextricably linked with the economic and cultural processes of globalization. In spite of this, the UNFCCC framing of economic issues reflects the circumstances under which it was created and contains text on the beneficial effects of open markets in a globalizing economy. Unlike the ozone protocol and other international instruments, such as the Cartagena Protocol to the Convention on Biodiversity CBD, there are no evident clashes with World Trade Organization (WTO) trade rules. The latter's approach to the environmental consequences of trade is the assertion that if the "externalities" of production are priced into the costs of products, then open markets will provide the most efficient means of environmental protection and indeed the restriction of GHGs. There may be problems if national attempts at internal energy taxation designed to achieve emissions reduction targets lead to "border tax adjustments" to maintain the competitiveness of national industries in ways that are incompatible with WTO rules.

The final, and probably most significant, framing of the Climate Convention is noted in its preamble and reflected in the allocation of responsibilities to developed (as defined in Annex I) and less developed countries (LDCs). It is contained in the principle that the Parties should act to reduce GHG emissions according to their "common but differentiated responsibilities and respective capabilities" (art.3.1). In the early 1990s, the idea that it was the responsibility of developed nations to make the first moves in reducing emissions was not as controversial as it subsequently became. The climate convention itself was sponsored by the UN General Assembly, where developing countries, grouped in the G77, constituted a large majority. It was signed during the epochal United Nations Conference on Environment and Development (UNCED), more popularly known as the Rio Earth Summit, which proclaimed the norm of sustainable development. Accordingly, there could be no

North-South agreement on international environmental questions unless the development requirements and demands for "climate justice" of the South were fully taken into account. In the negotiations that drafted the climate convention, the principal antagonism was between the Europeans, who were prepared to move immediately to emission-reduction commitments, and a reluctant United States. The question of "differentiation" between the Parties was to become the major issue that dogged the development of the regime as "the respective" economic capabilities of the Parties were increasingly subject to dramatic alteration.

The Kyoto Protocol

Despite the efforts of the EU to include a GHG-reduction commitment in the 1992 UNFCCC (a reduction to 1990 levels by 2000), the only binding obligations in the Convention were related to the important preliminary step of national reporting and the drawing up of inventories. The Convention entered into force in 1994 and its first Conference of the Parties (COP I) in Berlin took the ambitious step of mandating that a new substantive and binding agreement be negotiated by 1997. This was to become the famous Kyoto Protocol. Remarkable in many ways, it included a set of varied but binding "top-down" international commitments by developed countries to reduce their emissions by an aggregate 5.2% against a 1990 baseline by the end of the first commitment period, 2008–2012. As the price of agreement, the Clinton administration successfully managed to add a set of "flexibility mechanisms" within the Protocol to assist Parties to meet their "quantified emissions limitation and reduction objectives" (QELROs). The mechanisms included complex and innovative arrangements on emissions trading and related offset mechanisms for Joint Implementation (between developed countries) and the Clean Development Mechanism (CDM). The latter enabled developed countries to gain credits against their own emissions targets by funding GHG-reducing projects in developing countries—sometimes known as internationally transferred mitigation outcomes, or ITMOs. The system continues to operate, with Chinese enterprises as a major beneficiary. Inherent possibilities of fraud and sharp practice, in mis-representing the levels of reductions, achieved required the creation of an extensive and unprecedented international compliance, enforcement, and facilitation apparatus. The Kyoto approach to emissions reduction owed much to the prevailing intellectual climate in which essentially liberal, market-based solutions had long been in vogue. The Kyoto Protocol was to stimulate the United Kingdom and then the EU as a whole, contrary to its previous policies, to adopt an Emissions Trading Scheme to cover the power-generation sector. This has subsequently been through a number of difficult iterations but remains the foundation of the Union's climate and energy policy. Elsewhere, similar carbon-trading arrangements have been established in China and North America, created and then abandoned in Australia, and are planned in no less than 39 other states (IEA, 2015, p. 23).

The Kyoto Protocol followed the Convention's principle of "common but differentiated responsibilities" in that it requires only developed countries to make emissions reductions. This was already controversial as economic globalization, in the wake of the ending of the Cold War, meant that the "respective capabilities" of the Parties and their relative share of global CO_2 emissions were beginning to shift in a process that was to accelerate into the new century. By the time of the ratification of the Protocol in 2005, it was evident that non–Annex I emissions would soon surpass those of the Annex I Parties. Adherence to an international agreement that appeared to penalize US industries in the face of their new competitors in China and elsewhere had already been condemned by an overwhelming majority of the US Senate in the 1997 Byrd-Hagel Resolution. The incoming administration of George W. Bush proceeded to denounce US signature of the Protocol and to actively oppose its provisions. This left the EU to lead the complex negotiation that turned the Protocol into a ratifiable and operational international instrument. By February 2005, this task was accomplished in the face of US opposition. The net effect of the Protocol in terms of actual emissions reductions was quite marginal, in terms of the scientific estimates of what was required to avoid dangerous climate change. In fact, the reductions achieved as a byproduct of the Montreal Protocol's removal of ODS GHGs was of the order of five times greater than that achieved within Kyoto's first commitment period (UNEP, 2011, p. 21). But as CFCs were phased out, they were often replaced by stratospheric ozone–friendly hydrofluorocarbon chemicals (HFCs). Unfortunately, these were also extremely potent GHGs. In parallel with developments in the climate convention, the Parties to the Montreal Protocol arrived at a solution to the problem in the 2016 Kigali Amendment. The claim has been made that scheduled reductions of HFCs under the Amendment will yield a reduction of 0.5°C in the temperature rise that would otherwise have occurred in the period to 2100 (UNEP, 2016).

Attempts were made to achieve a second phase of Kyoto after 2012, but in the context of the global economic downturn that began in 2008, Japan, Canada, and Russia declined to take part. The developed world commitments in Kyoto remained an important *quid pro quo* for any future participation in emissions reductions by developing countries, and the EU and its allies obliged with a 2011 agreement to adhere to a second phase of the Protocol. Advocates of Kyoto tended to admit its limitations in terms of the actual control of emissions, but stressed the longer-term importance of its institutional legacy.

Copenhagen (2009) and the Search for a New Agreement

Successive assessment reports of the IPCC strengthened what had become, despite some well organized climate change skepticism in the Anglo-Saxon world, an

overwhelming case for international action to stabilize the global climate system. Essentially, the problem was political and economic, rather than one of disputed or inadequate scientific evidence: how to re-engage the United States and to involve all those developing countries, and notably China, that would soon be responsible for the bulk of anthropogenic GHG emissions but which also had very good reason, in terms of climate justice, to insist that the developed world should continue to pay for their historic responsibility for climate change. This normative minefield was made more lethal by the way in which justice claims and counterclaims tended to reflect short-term national energy interests. The domestic political barriers to international action were also significant. The first Obama administration was hamstrung by pressure from fossil-fuel interests and a hostile Congress. There was an awareness that any US administration would have enormous difficulties in passing federal legislation to comply with any future agreement. Likewise, the Chinese and Indians tended to conceptualize climate action as an economic burden that would impede their development and poverty-reduction priorities.

Some progress had been achieved in the 2007 Bali Plan of Action. This enabled the inclusion of the United States in the search for a new climate agreement by splitting negotiations into two tracks, one on the future of Kyoto and the other on the Convention, in which the United States could be persuaded to participate. As far as the developing countries were concerned, there was a significant recognition of the importance of "adaptation" alongside the matter that had previously dominated proceedings: the "mitigation" of emissions. Adaptation to the adverse effects of climate change, which were already beginning to be apparent, was a key national interest of those developing countries likely to be hardest hit and least able to cope. The other side of the Bali deal represented the first crack in the rigid wall of differentiated responsibilities and annexes between developed and developing Parties. Carefully limited "nationally appropriate mitigation actions" (NAMAs) for non–Annex I countries were now to be recognized. The intent was to conclude a new climate agreement at the 2009 COP to be held at Copenhagen, but the global economic downturn of 2008 was to diminish the prospect that governments would be prepared to make bold emissions pledges or to provide the funding necessary for adaptation and mitigation in the developing world.

The Copenhagen COP was an enormous and highly public disappointment—some said a disaster. The Parties had failed to negotiate a clean text to which the many national leaders who had been encouraged to come to Copenhagen (including the new US president, Barack Obama, and his Chinese and Indian counterparts) could sign their names. Instead, a hastily cobbled together "Accord" was produced in a conclave between the United States and the four BASIC countries. The BASIC group—Brazil, South Africa, India, and China—had been formed earlier in the year to represent the climate interests of the four large "emerging economies." The Accord gave some pointers to the future in that it legitimized the target of keeping global mean temperatures below a 2°C (above pre-industrial levels) threshold of "dangerous" climate change. It was also determinedly "bottom-up" in its approach, inviting Parties to state publicly the kind of emissions reductions that they were willing to undertake. In the case of China and India, these

were not cuts at all, but predictions of future improvements in energy efficiency. The development and adaptation needs of many Parties were also recognized by the creation of a Green Climate Fund (GCF). A distinguishing feature of the climate convention was its relatively open and democratic character in terms of the involvement of even small countries, especially small island states, and an army of critical nongovernmental organizations (NGOs). Understandably, the cabalistic manner in which the Copenhagen Accord was drawn up was widely resented, with calls for a more open and "Party-driven" process.

In the years following the Copenhagen COP, climate diplomacy within the highly institutionalized structures of the UNFCCC moved to construct a new climate agreement that would be operative from 2020. In the interim there was to be limited participation in a second phase of the Kyoto Protocol, but it soon became clear that a new comprehensive agreement would be very different from its predecessor, involving a "bottom-up" approach to mitigation and some form of "pledge and review" process that would encourage, rather than require, Parties to make reductions in their national emissions. Such a voluntaristic strategy, mapped out originally in the Copenhagen Accord and formalized at the Cancun COP of 2010, provided a politically feasible route to engaging the relatively small group of major emitters, including the United States and the BASIC countries. By 2013, the United States and China alone accounted for around half of total global CO_2 emissions, and the EU, which pressed for a more robust agreement, accounted for a diminished share of about 11%. The bases of a new agreement were set out in the "Durban Platform" of 2011, which replaced wording on national commitments with the much looser term "intended national contributions" and set in motion a negotiating process to conclude an agreement at the Paris COP, to be held in 2015. The legal form of a new agreement was left open in order to accommodate the US government's problem with a potentially hostile Congress. It is also worth noting that in contrast to the period leading up to Copenhagen, the increasing attraction of renewable energy sources, alongside horrendous levels of urban air pollution, appears to have led to a recalculation in China and elsewhere as to the costs of making "contributions." Between 2008 and 2013, the cost of solar-power generation fell by 80% and wind power by 18% (IRENA, 2014, pp. 14–15). Widespread awareness of the increasing competitiveness of such renewable energy sources certainly assisted the negotiations for a new agreement (IEA, 2015, pp. 21–22).

In his second term, President Obama was determined to make a climate agreement part of his legacy, using executive action to cut US emissions under preexisting legislation. Climate policy also provided a cooperative element in the largely conflictual relationship with China. This yielded a November 2014 consensus between the two, expressed in the concept that contributions in the new agreement would be made ". . . in the light of different national circumstances." This phrase was to be appended to the well-worn "common but differentiated responsibilities and respective capabilities" (Paris Agreement, Art. 2.2) in a formula that allowed universal participation in mitigation efforts. By the time of the Paris COP 21, 180 countries had presented nationally defined mitigation plans.

After the events of Copenhagen and amidst fears that major players would simply abandon the UNFCCC, a new agreement, if it were to be legitimate, would also have to receive support from the majority of the international community. In the developed North, the extent to which the Convention and its procedures are valued in the South is often insufficiently understood. European Union policy has always recognized this, and the Union, after the setback to its leadership aspirations at Copenhagen, embarked on an active program of diplomacy to build support for a new agreement across the international system. This required the development of areas of the climate regime that are sometimes neglected when mitigation targets provide the headlines. Climate funding for both adaptation and mitigation was a critical element, and in the years after Copenhagen the structure and procedures of the GCF were elaborated. There were also funding pledges by developed countries, with the aim of reaching a reaching a $100 billion per annum target by 2020. Significant developments, to include sustainable management and enhancement, also occurred in the arrangements for forest preservation under the "Reducing Emissions from Deforestation and Forest Degradation in Developing Countries" program REDD+. Additionally, new procedures were set out in the 2013 Warsaw Mechanism for "loss and damage" assistance for vulnerable countries subject to the impact of actual climate change. Also important in securing developing world support for a new agreement was the undertaking by the EU, virtually alone, to commit to a second phase of the Kyoto Protocol.

After the Durban COP, ongoing dialogue between the EU and around 12 small states provided the core of what was to become the "High Ambition Coalition." As the United States and then Brazil, among others, joined in, the Coalition lent significant momentum to the final negotiation in Paris (Brun, 2016, pp. 120–121). The specifics of the Paris COP and preceding meetings demonstrated that many of the lessons arising from the previous failure at Copenhagen had been learned. In a long but transparent and inclusive process (the snappily titled Ad Hoc Group on the Durban Platform for Enhanced Action, or ADP), a usable, albeit heavily bracketed, negotiating text for the final COP at Paris was produced. This was only one part of a major diplomatic effort by France and the previous presidency, Peru, to ensure that the Paris COP would succeed. As in 2009, the COP was portrayed as an event of high political salience with preliminary interventions by the UN Secretary General and the Pope, but a repetition of the endgame at Copenhagen was avoided as heads of state and government were invited to the beginning rather than the end of the Paris meeting.

The Paris Agreement (2015)

For two decades, the objective of the climate convention lacked precise definition, ". . . the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (Art. 2). The Copenhagen Accord, formalized at the Cancun COP of 2010, provided a 2°C

threshold definition of "dangerous anthropogenic interference," but this was never sufficient to ensure the survival of small island states threatened with inundation. Their Alliance of Small Island States, AOSIS, demanded recognition of a 1.5°C threshold. To the surprise of many, this was partially achieved at Paris, where Parties agreed to hold ". . . the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature to 1.5°C" (Art. 2.1). In the same article, two other critical elements of the consensus in Paris are highlighted: the importance of adaptation, and the provision of "making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development."

Since its inception, the climate regime has been dogged by the issue of differentiation, reflecting, of course, the underlying structural inequalities of the international system and core arguments about climate justice and historic responsibilities. The Paris Agreement represents a compromise on these issues, which has facilitated a loose but comprehensive approach. There is no mention of Annex I, and all Parties are involved in mitigation; however, the detailed wording of the agreement indicates some subtle differentiation between developed countries and the rest. For example, while developed countries "should [not shall!] continue taking the lead by undertaking economy-wide absolute emission reduction targets," LDCs and SIDs (Small Island Developing States) "may prepare and communicate strategies . . ." for low GHG development (Arts. 4.5, 4.6), while developed countries "shall" provide support for developing countries in implementation (Art. 4.5). It is also significant that in comparison to the original Convention, the agreement greatly upgrades the status of "adaptation," giving it some equivalence to mitigation, backed up by promises on the scale of the GCF and by the provisions on "loss and damage" as a separate item from adaptation (Art. 8).

In US Secretary of State Kerry's view, the nationally determined contributions were in themselves "a monument to differentiation," as each country determines its "fair contribution," according to its respective capabilities and in the light of "its different national circumstances" (ENB, 2015, p. 43). There is no defined overall emissions target similar to that set out for the developed countries in the Kyoto Protocol. Instead, the Paris Agreement is ambitious yet vague. It can be read as seeking to achieve its temperature control objectives by moving to an essentially de-carbonized global economy at some point after 2050. It states that the Parties should aim to reach "global peaking of greenhouse gas emissions as soon as possible" and thereafter to make "rapid reductions" so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century" (Art. 4.1). Each successive nationally determined contribution (NDC) "will represent a progression" beyond its current NDC and ". . . and represent its highest possible ambition" (Art. 4.3). The Paris Agreement contains no direct mention of emissions trading or a global carbon price. There is some reference back to the international flexibility mechanisms that were at the heart of the Kyoto Protocol. Joint action and "internationally transferred mitigation outcomes" with robust accounting rules are recognized as means to achieve NDCs. However, engagement with them by Parties is strictly voluntary, and there is even a new framework to facilitate "non-market approaches to sustainable development" (Art. 6.9).

This leads to questions of how the objectives of the Agreement can be met without any enforceable commitments. In reading the text, "shall" indicates a binding obligation, and some precise yet important disagreements at Paris centered on the alternative use of "should" or "may." The binding parts of the Paris Agreement are procedural, rather than substantive, and this provides a key to understanding how it is envisaged that the new system will operate. Parties will be required to produce and communicate NDCs in a five-year cycle. These will account for "anthropogenic emissions and removals," and there is also reference to the use of existing methods and guidance and the setting up of common time frames (Art. 4). National communications will be recorded in a public registry and subject to an "enhanced transparency framework" (Art. 13). This brings together various existing procedures within the Convention to subject national communications to expert scrutiny and review. National sensitivities to such monitoring and review activities are indicated by the stipulation that the transparency framework will be implemented in a "facilitative, non-intrusive, non-punitive manner, respectful of national sovereignty and avoid placing undue burden on parties" (Art. 13.3). There was a key disagreement between the EU, the United States, and the BASICs on the independence and extent of monitoring and verification provisions. Nonetheless, the intention to gain a clear understanding of Parties' mitigation and adaptation actions, "including clarity and tracking of progress towards achieving Parties' individual" NDCs, is clear. If there is to be enforcement, it will thus have a horizontal character, encouraging or shaming Parties to keep to and expand their contributions through publicity and the hope that they will be concerned to safeguard their reputation both at home and abroad.

The other crucial element in fulfilling the objectives of the Agreement is the assessment of Parties' actions against scientific evidence. This has always been central to the operation of the climate regime, which has operated in tandem with the IPCC and has its own Subsidiary Body for Scientific and Technological Advice SBSTA. What has been in question has been the "adequacy of commitments" in relation to Article 2 of the original Convention. The Kyoto Protocol failed to come anywhere near the level of reductions that were required, and the estimates of the impact of Parties' published intended NDCs in advance of Paris yielded a mean temperature increase of 2.7°C (UNFCCC Secretariat, 2015). Now the "contributions" of Parties will need to match against the newly demanding aspirations of the Paris Agreement—a 1.5°–2° threshold for dangerous climate change. To ensure this, the Agreement mandates a "Global Stocktake" to assess progress toward achieving its purposes. This progressive element may be regarded as an important counterbalance to the voluntary nature of self-determined contributions (Brun, 2016, p. 118). The first such "stocktake" will occur in 2023 (one will be conducted every subsequent five years), and will include funding and adaptation actions, alongside mitigation. Beyond this, there is no further detail on what will be involved, except that Parties will be expected to revise their NDCs in accordance with the outcome (Art. 14). While the "stocktake" is scheduled for 2023, the Paris Agreement entered into force in November 2016, having achieved the necessary 55 ratifications, representing 55% of global GHG emissions. Much work remained to be done in "operationalizing" the terms of the Agreement and in ensuring that pre-2020

action on reducing GHG emissions was enhanced (ENB, 2016, pp. 36–38). Despite negotiating success in Paris, the UNFCCC with its new Agreement remains a weak and limited form of commons governance. This is especially evident if comparisons are drawn to the regime for the restoration of the stratospheric ozone layer. Unlike the latter, the Paris agreement contains no mechanisms for dealing with "free-riders." Inadequately framed from the outset, the regime that emerged from Paris rejected the central targets and timetables of the Kyoto Protocol for a "pledge and review" system of the type that had been discussed and discarded during the negotiation of the original Convention. This appears to have been the inevitable price of a comprehensive agreement and has all the hallmarks of a system of sovereign states that rejects central direction and in which enforcement, if not impossible, is very difficult. On the other hand, it is also true that some vestiges of the Kyoto system remain in the form of common rules for transparency and in the facilitating (but not enforceable) compliance mechanism (ENB, 2015, p. 43). The novelty of the new system is that it creates a potential dynamic between domestic energy policies and international standards and aspirations: a "new logic of international climate politics" that "acknowledges the primacy of domestic politics in climate change" (Falkner, 2016, p. 1107). For better or worse, it will provide the framework for international climate cooperation for decades to come, and the outcome at Paris was a great deal more productive than many had predicted, both before and after Copenhagen. Then there were many rivals to the UNFCCC and attempts to "forum shop" by promoting other institutions, such as the APEC initiative or Major Economies Forum, which threatened to fatally undermine a universal approach within the UN system.

Arguably the most significant aspect of the Paris Agreement is in the way that it achieves one of the other functions of international environmental cooperation. It sets up generally agreed-upon norms and expectations of behavior for a future decarbonized global economy. In the discourse surrounding previous attempts to erect a successor to Kyoto, there were constant complaints from business that governments had failed to agree on a clear framework to facilitate climate-friendly investment decisions over the next 25–50 years. The IEA claimed that the measure of success would be the "extent to which it conveys to energy sector stakeholders a conviction that the sector is destined to change" (IEA, 2015, p. 32). Paris may provide the basis for a future investment framework, but it remains to be seen how actual decisions within both public and private energy sectors will be made and the extent to which they will reflect the ambitions of Article 4. There is some encouraging evidence that despite its acknowledged weaknesses, the Kyoto Protocol was associated with a significant upturn in investment in renewable energy (IPCC, 2014).

Under circumstances where the social and economic damage wrought by the enhanced greenhouse effect is becoming manifest, the adaptation provisions of the Agreement and its promised funding arrangements are another noteworthy contribution, alongside a long-standing concern with technology transfer and its financing (Art. 10). Here the developmental trajectory of economies that previously were uninvolved, other than as recipients and critics of the failures of the Annex I countries to live up to

their historical responsibilities, will play a huge part in the long-term achievement (or otherwise)of the Agreement's objectives.

How the Paris Agreement Was Achieved and May Be Sustained

In seeking an explanation of how the international community managed to formulate a new climate agreement, the first resort would be to an analysis of coincident national interests. There is no doubt that the persistent scientific findings of the IPCCC and the evidence, for example, of very serious atmospheric pollution in Chinese cities led to some recalculation of national priorities, which often have been seen in terms of a balance between the economic costs and the environmental benefits of taking action. In the United States, the arrival of the Obama administration was marked by a clear reversal of the obstructionist approach of its predecessor. Having once been seen as an economic cost, climate policy came to be viewed in a more favorable light as the costs of alternatives to hydrocarbons fell and as economic gains from investment in solar and other technologies came to be more fully appreciated. The EU had long stressed the benefits of taking a progressive approach to climate policy, but from 2009 Chinese policymakers appear to have become more receptive to this view. India and some other developing countries continued to prioritize an absolute right to development and poverty reduction and to insist that the old industrialized countries no longer had a right to a diminishing "carbon space." The fact that all could be accommodated within the new agreement arose rather obviously from its permissive nature. Governments could now simply determine what they were prepared or could afford to contribute in terms of mitigation, and there was little question of non-compliant states free-riding on the efforts of others. Contributions would be set nationally, subject to transparency and expert analysis.

While unlike many other international issues, relative military strength and hard power do not figure in climate negotiations, there is still an important respect in which shifts in structural power have affected the development of the regime. The rise of the BASIC countries (particularly China) in relation to Europe and the United States changed the nature of climate politics in a way that was graphically demonstrated by the events of the 2009 Copenhagen COP. The old "Annex I versus the rest" division was no longer tenable under circumstances in which China had become the largest emitter and many saw the future of climate politics in a G2 agreement between the United States and China or in some form of ruling "concert" of large and economically powerful emitters. Although Sino-American agreement was doubtless important, the time and diplomatic energy that was expended in meeting the concerns of a large number of small and often insignificant (in terms of the scale of their economies and emissions) states is a remarkable feature of the UNFCCC. The regime did not collapse into a deal between

a few powerful emitters, and the Paris Agreement resists analysis in simple terms of relative power.

Normative arguments about climate justice in general and the rights and survival of small island developing states played a central role in building support and momentum for the Paris Agreement. This started with the Cartagena Dialogue, which brought together a range of developed and developing countries in pursuit of a new basis for negotiation after Copenhagen, and then continued, before and during the Paris Conference, with the High Ambition Coalition. This represents a continuation of a long-term trend in which AOSIS has played a disproportionately large part in climate deliberations. Arguments for climate justice are doubtless an important motivator in themselves, but they have been unusually potent within the climate regime. In part, this derives from its relatively "democratic" character and links to the UN General Assembly, along with the effective advocacy of some of the leaders of small island states, the Maldives at Copenhagen and the Marshall Islands at Paris. For them, climate change is a matter of national survival, as their territories face inundation with the inexorable rise of global mean temperatures and resulting sea levels.

A substantial proportion of the activity within the UNFCCC is not directly related to climate issues, but rather to the pursuit of many other symbolic causes that have reputational significance. Consider, for example, this extract from the Paris preamble: "Noting the importance of ensuring the integrity of all ecosystems, including oceans . . . recognised by some cultures as Mother Earth." Or the following portmanteau clause on adaptation which should ". . . follow a country-driven, gender responsive, participatory and fully transparent approach, taking into consideration vulnerable groups, communities and ecosystems . . . guided by the best available science and, as appropriate, traditional knowledge, knowledge of indigenous peoples and local knowledge systems . . . " (Art. 7.5).

At the end of the Copenhagen COP, the Bolivarian Alliance (ALBA) Latin American states, including Cuba and Venezuela, used the occasion to make an explicitly "political" anti-imperialist point by refusing to agree the terms of the deal that had been crafted by the United States and BASIC countries. It therefore had only informal status as an "Accord." There are numerous other examples of symbolic politics within a regime that provides ample scope because of its lengthy plenary sessions, in which all Parties make formal statements, and the large public audience, made up of NGOs and others that attend the annual COPs. While this can be irritating, if not destructive, of the real work of the UNFCCC, the politics of recognition and prestige also has a positive side. It partly accounts for the tenacity with which the EU has pursued a climate leadership role in order to burnish its credentials as a significant international actor (Bretherton & Vogler, 2006). Hosting a successful COP is also regarded as a significant indicator of national status: witness the major diplomatic effort put in by France in advance of and during the Paris COP, where climate change became one of a small number of national policy priorities.

What might be regarded as the politics of esteem between governments has provided a motor for regime development (Vogler, 2016, pp. 108–130). In the early period the

EU attempted to shame others into action and emulation by announcing targets and timetables, pre- and post-Copenhagen, and there were other occasions, at the 2007 Bali COP, for instance, when a reluctant United States was persuaded/shamed into joining a virtuous consensus. Comparison and emulation lie behind the post-Copenhagen stress on the publication of contributions. In the absence of internationally agreed-upon targets and related enforcement, the regime has been designed to operate on the basis of peer pressure and emulation with its progressive five-year cycles, binding review processes and the "Global Stock-Take." National reputation was always important, but it now became the intended driver of a central mechanism of the regime by which governments will, hopefully, be held accountable not only by their international peers but by their own domestic publics.

Overall, the Paris Agreement has been hailed as a revival of multilateralism after fears of collapse and a splintering of the regime in the aftermath of Copenhagen. It entered into force on November 4, 2016, but within four days the election of President Donald Trump cast a shadow over its future. On June 1st 2017 the President announced that the United States would be withdrawing from the Agreement but the other Parties responded by re-affirming their commitment, leaving the United States isolated. It remained unclear whether the Paris Agreement would henceforth be regarded as a the high water mark of a diminishing liberal international order or whether some of its more heroic assumptions about the "ratcheting up" of efforts to de-carbonize national economies and energy systems would be fulfilled over the coming decades. Equally uncertain was the continuance of the political alignments and understandings between major emitters that had, after 20 years of stalemate, made a new climate agreement possible.

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CHAPTER 3

ENERGY CONSUMPTION AS PART OF SOCIAL PRACTICES

The Alternative Approach of Practice Theory

ANA HORTA

Research on energy consumption has been based largely on an understanding of society and energy as two separate realms. On one side, engineers measure energy use and develop the technological innovation needed to overcome energy crises and sustainability issues; on the other side, social scientists identify the barriers that impede the adoption by individuals of energy-conservation actions. As argued by Elizabeth Shove (1998), this conventional view of energy and society obscures the social character of technological change; an alternative approach that can generate new knowledge on the social structuring of energy consumption is needed. The recent development of social practices theory has provided key advances in the understanding of energy consumption. However, this new approach requires a transformation of the conventional view of energy and society as different domains to a view of energy as part of the social practices that constitute society.

This chapter provides a brief account of social practices as an alternative and promising approach to conventional social science research on energy consumption. It begins by briefly tracing the evolution of social science research on energy consumption, highlighting how it progressively flowed toward recent developments in theories of practice while trying to overcome the limitations of the dominant theoretical frameworks. The chapter then summarizes the "practice turn" in sociology and its extension to research on energy consumption. The next section is an attempt to synthesize the most prominent features of practice theory used in the field of research on energy consumption. The following section presents an example of empirical research on energy consumption, using a practice theory approach. To conclude, the main advances in the understanding of energy consumption are synthesized.

Confluence of Research on Energy Consumption and Practice Theory

Early research on energy end uses in households tried to explain variations among the behaviors of users mainly according to economic rationality and attitudinal models. These models have been based on attitudes, values, and responses to information and energy prices. Despite the complexity of consumers' behavior, as well as controversy about the effectiveness of attitudes in predicting behavior, these factors have been considered by mainstream research as predominant influences on energy consumption. Research on energy consumption has been motivated by the need to increase energy conservation; by prioritizing the identification of key variables that might promote (or hamper) behavior change toward energy saving and/or efficiency, the most influential theories of pro-environmental behavior—that is, individualized rational actor approaches—became dominant in social science research on energy consumption. Many studies have illustrated that consumers are generally unaware of the fact that their everyday life activities imply energy use, and energy bills do not establish connections between concrete actions or technologies and consumption. This recognition that energy consumption is largely invisible to users has led to repeated calls for education: raising individuals' awareness through more information and feedback on their own energy use. However, these approaches have not been able to explain fully energy consumption, and many times the results of interventions aiming at changing consumer behavior have been inconsistent.[1] Research has shown a gap between individuals' values and what they actually do. Indeed, social groups sharing pro-environmental discourses do not necessarily practice energy-saving behaviors.

In the 1980s and 1990s, sociological research on energy consumption was scarce and also tended to rely on individualized approaches to consumers' conscious choices. Consumption was predominantly analyzed as a means of communicating to others one's lifestyle, social status, and individual identity. As summarized by Alan Warde (2014, p. 283), "the model of an active and reflexive agent predominated, implying that conscious and intentional decisions steer consumption behaviour and explain its sense and direction." However, research premised on this theoretical model, which prevailed in the sociology of consumption, failed to capture ordinary and inconspicuous activities of everyday life (Warde, 2015) and their implications for energy consumption. The recognition that sociology of consumption was not able to account for environmental issues related to inconspicuous forms of resource consumption, such as energy, and that it was necessary to shed new light on mundane routines of everyday life (Shove & Warde, 2002), was a key development, creating openings for fundamentally new conceptual and empirical directions in research.

As research revealed the cultural significance of services provided by energy use and their integration in routines (Wilhite et al., 1996), researchers were becoming more aware of the need to attend to the relationship between energy use and the organization of everyday life (Guy & Shove, 2000). As proposed by Lutzenheiser (1993), research

should go beyond individualized approaches focused on prices and attitudes and, with households and communities as units of analysis, should consider energy use as a social process. At the base of this alternative approach, key notions were emerging: the need to examine actual processes and contexts of energy use in everyday life; how energy intensive habits become normalized (i.e., embedded in everyday life as taken-for-granted expectations); and how a complex mix of institutional factors (instead of individual choices of consumers) influence energy demand. A new approach was needed, one that could go beyond the individual and could analyze the systemic transformation of habits and conventions (Shove, 2003). However, despite growing interest in routine and mundane aspects of everyday life, practice theory had not yet emerged in the research then conducted (Halkier, Katz-Gerro, & Martens, 2011).

A crucial step toward this new approach was convergence with recent developments in the sociology of science and technology. These promising insights were focused on the "seamless web" of technology and society, instead of separately analyzing the social, technical, economic, or political aspects of technological development (Bijker, Hughes, & Pinch, 1987). These new studies pointed to the inextricability of technical change and social contexts, some of which were based on the idea that both nonhuman actors (such as infrastructures and technological innovations) and social actors co-evolve and play creative parts in the construction of socio-technical systems (Guy & Shove, 2000). Traditionally, social thought has not taken materiality into account, in accordance with the distinction between culture and nature; however, in the last decades several theories have challenged the boundary between society and materiality (Schatzki, 2010). Actor-network theory, for example, analyzes relations between different kinds of actors (including objects) and how their networks form the social (Latour, 2005). Based on these theoretical developments, to understand energy use in everyday life it would be necessary to analyze the interactions between social and material elements and infrastructures. Thus, instead of limiting the analysis to the understanding of the social obstacles (attitudes, ignorance or lack of economic rationality, for example) to technological innovation that hinder energy conservation, with these new insights social science research could go further—investigating the material and social contexts and circumstances in which energy demand is structured. This strand of analysis did not just reinforce the need to explore the relationship between energy use and everyday life (Guy & Shove, 2000), but also generated awareness that socio-technical systems can support escalating levels of consumption by structuring certain patterns of daily life and related consumption practices (Shove & Warde, 2002).

The Practice Turn in the Sociology of Energy Consumption

At the beginning of the twenty-first century, a small but increasing number of studies in several fields of social science had begun to investigate practices. In spite of the

diversity of activities considered "practices," as well as their heterogeneous theoretical orientations, these studies shared the "practice idiom" (Rouse, 2007), considering social practices as their basic object of study. This trend, proclaimed "the practice turn in contemporary theory" (Schatzki, Knorr Cetina, & Savigny, 2001), was inspired by diverse authors, such as Pierre Bourdieu (1977), Anthony Giddens (1979, 1984), and Charles Taylor (1985), among others. The practice-oriented approach emerged as an alternative to the duality between human action (or agency) and system (or structure). As synthesized by Sherry Ortner (1984, p. 159), by accepting "that society is a system, that the system is powerfully constraining, and yet that the system can be made and unmade through human action and interaction," practice theory was a unique and promising approach, allowing the integration of Marxist and Weberian theoretical frameworks. However, a coherent and systematized overview of practice theory was lacking. Theodore Schatzki (1996) and Andreas Reckwitz (2002) contributed significantly to developing this approach, later followed and complemented by Elizabeth Shove, Mika Pantzar, and Matt Watson (2012). Other authors have also contributed to systematizing the diversity of theories of practice, as well as advocating the potential of this approach for research in several fields related to consumption and environmental sustainability (e.g., Ropke, 2009; Sahakian & Wilhite, 2014; Spaargaren, 2011; Warde, 2005, 2014; Watson, 2012), some of which specifically focus on energy consumption (Gram-Hanssen, 2011, 2014; Shove & Walker, 2014; Strengers, 2012; Walker, 2014; Wilhite, 2013, 2014).

Shove's article, "Beyond the ABC: Climate Change Policy and Theories of Social Change" (2010), represents a key contribution, exemplifying theory of practice's usefulness over the dominant paradigms of economics and psychology. In an incisive critique of the "ABC model," which she argues has been embedded in most contemporary climate change policy, Shove (2010, p. 1273) contends that the conventional focus on individual responsibility for responding to climate change is based on a "strikingly limited understanding of the social world and how it changes." The ABC model describes a well-known social psychology model proposed by Paul Stern (2000), in which individual behavior (B) is driven by attitudes and values (A), as well as contextual factors (C)—which in Shove's view stands for choice, due to this concept's central role in this framework. The model presumes that through the identification of these determinants of pro-environmental behavior, it would be possible to plan strategies of intervention targeted at providing the right motivators and overcoming the barriers to behavior change (Shove, 2010). However, as she argues, this framework is not only unable to overcome the gap between values and action, it is also unable to account for the evolution of how needs and aspirations become normalized. In contrast, by focusing on how practices evolve, a practice-based approach allows the analysis of the emergence and reproduction of patterns of consumption, as well as the social conventions sustained and changed through the evolution of practices (Shove, 2010). Crucially, practices (not individuals) are taken as the central unit of analysis. This constitutes a considerable change in social analysis. Furthermore, by focusing on how practices evolve over time, this alternative

approach is suitable for understanding the dynamics of social change. Thus, as clearly put by Tom Hargreaves (2011, p. 84),

> [s]ocial practice theory, in this view, raises a series of radically different questions about how to create more sustainable patterns of consumption. The focus is no longer on individuals' attitudes, behaviours and choices, but instead on how practices form, how they are reproduced, maintained, stabilized, challenged and ultimately killed-off; on how practices recruit practitioners to maintain and strengthen them through continued performance, and on how such practitioners may be encouraged to defect to more sustainable practices.

The recognition of the potential interest of practice theory for the development of the understanding of energy consumption has led to growing adoption of this framework. Some examples of research include practices of heating and cooling (Shove, Walker, & Brown, 2013; Strengers & Maller, 2011), residential heat comfort (Gram-Hanssen, 2010; Winther & Wilhite, 2015), use of information and communication technologies (Ropke & Christensen, 2012), use of mobile phones (Horta et al., 2016), energy retrofitting of dwellings (Bartiaux et al., 2014), car driving (Ryghaug & Toftaker, 2014; Shove, Watson, & Spurling, 2015), commuting (Cass & Faulconbridge, 2016), several household practices (Bartiaux & Salmón, 2014; Friis & Christensen, 2016), or a comparison of practices at home and work (Palm & Darby, 2014). The practice turn in social science research on energy consumption has become so resonant that a considerable number of articles and conference presentations use the terminology of practice theory while not explicitly adopting this approach.

In spite of an increasing number of studies engaging with practice theory, there is still some heterogeneity in the analytical assumptions guiding their approaches. Thus, a synthesis of features common to practice theories is "somewhat hazardous" (Warde, 2014, p. 285). Still, there are some understandings that are becoming prominent in the field of study of energy consumption. The following is a tentative synthesis of these.

Social Practices

According to the idealized model of practice theory proposed by Reckwitz (2002, p. 249) to systematize the diversity of theoretical approaches to social practices,

> [a] "practice" (*Praktik*) is a routinized type of behavior which consists of several elements, interconnected to one another: forms of bodily activities, forms of mental activities, "things" and their use, a background knowledge in the form of understanding, know-how, states of emotion and motivational knowledge.

Such blocks of interconnected elements, rather than the individual, are the units of analysis of practice theory. As proposed by Reckwitz (2002, p. 250), the individual is analyzed

as a carrier of practices: in fact, "not only a carrier of patterns of bodily behavior, but also certain routinized ways of understanding, knowing how and desiring." Since each individual carries out multiple practices, he is "the unique crossing point of practices" and his understandings (of the world and himself) depend on his practices (Reckwitz, 2002, p. 256). Thus, to analyze a practice such as cooking or walking a dog, it is necessary to identify the connections between elements such as bodily performances or movements, mental patterns, objects handled, and specific forms of collective knowledge—in other words, routinized ways of understanding, knowing, wanting, and feeling.

This acknowledgment of the role of materiality in social life is an important feature of practice theory. Like other contemporary theories that have contested the distinction between society and nature, and the consequent neglect of materiality, practice theories acknowledge the interaction of humans and their material surroundings (Schatzki, 2010). Although there is still some controversy regarding the role of objects in social practices (Warde, 2014), the most recent developments in practice theory point to more than just analyzing the interaction between materiality and practices. Recently, Schatzki (2010, p. 128) claimed that "material phenomena are part of society," since "practices are carried on amid and determinative of, while also dependent on and altered by, material arrangements" (Schatzki, 2010, p. 130). Shove, Pantzar, and Watson (2012, p. 14) do not simply acknowledge materiality as part of practices, they emphasize it; indeed, in their simplified definition of the three elements that compose practices, materials are deemed to be one:

"By elements we mean:

- *materials*—including things, technologies, tangible physical entities, and the stuff of which objects are made;
- *competences*—which encompass skill, know-how, and techniques; and
- *meanings*—in which we include symbolic meanings, ideas, and aspirations."

Other authors have proposed that practices are constituted by somewhat different elements. Specifically regarding the study of energy consumption, Gram-Hanssen (2011) argues that the most appropriate elements of practices are (1) know-how and embodied habits, (2) institutionalized knowledge and explicit rules, (3) engagements, and (4) technologies. Strengers and Maller (2011), on the other hand, prefer to define these elements as (1) practical knowledge, (2) material infrastructures, and (3) common understandings. In both of these conceptions, materiality is included as an essential element.

Besides emphasizing the role of objects and materiality, practice theories also accentuate the role of bodies in social practices, through embodied skills, tacit knowledge, sensory knowing, habits, dispositions, or emotions, for example. Along these lines, research has included performances that "can be shown but not said, or competently enacted only when freed from verbal mediation" (Rouse, 2007, p. 515). This allows the analysis of doings that are not easily translated into words (Martens, 2012). However, as argued by Warde (2014), while this has also contributed to minimizing the relevance of

discursive consciousness and decision-making (which is characteristic of the individualistic models of action criticized by practice theories), the role of bodily processes still need clarification.

It is important to emphasize the dynamic character of practices. According to Schatzki (2010, p. 129), "a practice is not a set of regular actions, but an evolving domain of varied activities linked by common and orchestrated items," such as understandings, rules, normative teleologies, and material arrangements. The linkage between elements has a central role in Shove, Pantzar, and Watson's view of how practices evolve: the elements are actively combined or integrated when practices are enacted and, as the connections between these elements are established, sustained, or broken, practices "emerge, persist, shift and disappear" (Shove, Pantzar, & Watson, 2012, p. 14). Thus, practices are invented when links between materials, competences, and meanings are established. In order for practices to endure and remain effective, these connections "have to be renewed time and again" (Shove, Pantzar, & Watson, 2012, p. 24). Practices disappear when these links are broken or no longer maintained. When new elements are introduced, as the result of technological innovation or as a consequence of changes in meanings, for example, previously established links may erode and practices change (Shove, Pantzar, & Watson, 2012). Thus, as asserted by Warde (2005, p. 140), the sources of change are within practices themselves: "The concept of practice inherently combines a capacity to account for both reproduction and innovation." From this point of view, an analysis of the evolution of social practices needs to take into account the establishment and history of connections between all the elements of practices, instead of focusing on just one of these aspects, as in conventional histories of technology (Shove, Pantzar, & Watson, 2012).

The establishment of connections between the elements that compose practices does not just trace the trajectories or histories of practices (recognized as specific activities or entities, such as driving a car or bathing), it also conditions different performances of practices (how they are effectively reproduced in everyday life across different times and spaces). Importantly, practices are not carried out in identical ways and can take differentiated forms (Warde, 2005). The fact that practices are enacted in specific spaces and times and depend on historically situated contexts contributes to the variability of performances. As stated by Shove, Pantzar, and Watson (2012, p. 122), "each performance is situated and in some respect unique."

These notions of practices as entities and as performances have been the object of some controversy. By centering the analysis on practices instead of individuals, practices become conceived as "entities." Indeed, sometimes researchers have referred to practices as "recruiting" their practitioners. However, as pointed out by Galvin and Sunikka-Blank (2016), this conception of practices is a "heuristic device" or model constructed by researchers to help explain complex phenomena; therefore, such assertions of practices as entities (nearly beings) leading the action lack clarity. The underlying issue, which has divided theories of practice, is the ontological and methodological status of practice (Warde, 2014).[2] More radical versions of practice theory consider practices as recognizable entities, while others embrace a more limited analytical conception of practices

as performances. However, both notions can be compatible. As asserted by Southerton et al. (2012, p. 240): "practices configure performances, and practices are reproduced, and stabilized, adapted and innovated, through performances."

It should be highlighted that individuals do not passively carry out pre-formatted practices; they can improvise, experiment, and adapt to local situations (Shove, Pantzar, & Watson, 2012; Warde, 2005). In addition, since individuals carry out multiple practices, these can influence each other, and there may be dependencies and tensions between different practices. Changes in one practice may also trigger changes in related practices (Sahakian & Wilhite, 2014). These interactions between practices, as argued by Shove, Pantzar, and Watson (2012), may have consequences such as mutual adaptation, destruction, synergy, or radical transformation.

Empirical Example: Energy as an Ingredient of Mobile Phone Management

The process of formation of the practice of managing the mobile phone can be presented as an example of how energy consumption can be analyzed with a practice theory lens. The following is a reinterpretation of data from a study of the energy consumption related to the use of electronic media by teenagers in Lisbon, Portugal.[3] The data collected reveal not just how different elements are combined in the process of emergence and normalization of the practice of mobile phone management, but also how energy consumption takes part in this process.

Teenagers were chosen as a preferential group of practitioners since a previous study indicated that their energy-intensive routines of electronic media are not likely to change toward energy saving due to a strong engagement and integration of these technologies in their everyday life (Schmidt et al., 2014). The research included a survey carried out with 748 teenagers enrolled in the ninth through twelfth grades in three schools with very different socioeconomic backgrounds. Their average age was 16 years. After the survey, respondents were invited to volunteer to be interviewed. Twenty-two interviews were conducted. The survey and individual interviews took place between November 2014 and March 2015.

Adopting the conceptualization of practice theory proposed by Shove, Pantzar, and Watson (2012), this example illustrates how the establishment of connections between materials, competences, and meanings give rise to the practice of mobile phone management, with direct implications for energy use. In an initial stage, these three elements already existed in the everyday lives of these teenagers, but had not yet been integrated in a way that enabled the emergence of this practice. Indeed, at this stage users had been given their first mobile phones, but the functionality of these devices was very

limited—these phones were used mostly to call their parents and let them know where they were and at what time they should be picked up from school or after-school activities. Thus, the meanings associated with these devices were mostly related to connectivity between family members, and perhaps also security or control. Even though having a mobile phone was already socially valued and thus was considered desirable by the children, their competences to use this technology were in most cases minimal.

However, changes in the material arrangements related to mobile phone use, together with changes in the meanings attributed to these technologies, have accelerated the rhythm of use. Among this sample of teenagers, this co-evolution of elements happens when they start using a smartphone and in addition have access to Wi-Fi networks. Smartphones have touch screens, advanced operating systems, and enhanced hardware, and these features allow engaging in multiple activities, such as taking photos, recording videos, browsing the Internet, playing games online, posting messages on social networks, and so on. Thus, there is the possibility of developing an increased number of practices, many of them connoting desirable meanings, particularly among young people, such as having easy access to entertainment (e.g., music, games, countless applications) and information (through web browsing), communicating with friends, or being popular. Additionally, due to an institutional framework favorable to the development of wireless infrastructures, since 2006 all public schools in Portugal have free wireless broadband access to the Internet. There is also a large number of free Wi-Fi spots, including in the main commercial and public transport spaces. Thus, these material arrangements grant access to entertainment and other meanings valued by teenagers nearly everywhere throughout their daily life. As some teenagers admit, their mobile phones have become "an addiction" (Horta et al., 2016) for themselves and almost all other teenagers they know. However, this co-evolution of material arrangements (smartphones and access to free wireless infrastructures in different spaces and times of the day, not just at home) and the meanings related to these activities demands some orchestration. Indeed, in spite of the remarkable development of mobile phones in recent years, their enhanced technological features have significantly increased their energy consumption, which is limited by batteries. Hence, the daily reproduction of practices related to mobile phones, such as social networking, listening to music, or coordinating activities with family and friends, requires the development of competences that can assure that smartphones have enough power to function. There is a need to orchestrate the practices related to mobile phone use with the battery power available. As users develop the competences, embodied skills, and dispositions for charging and managing the power of their mobile phones in order to keep their routines flowing, a new practice develops and becomes normal. The reproduction of this practice allows the successful integration of the mobile phone in practitioners' everyday life, since the normalization of this practice guarantees that the smartphone has utility for the performance of other practices. Interestingly, if the practice of managing the mobile phone does not become normalized, tension and disruption emerge, since the inoperability of the device affects and can even thwart co-dependent practices.

The practice of managing mobile phones includes actions such as regularly checking the remaining power of the device, calculating how much power will be needed to perform other practices (important phone calls or messages, for example) until the battery can be charged again, curtailing unnecessary practices (e.g., listening to music while walking), turning off functions and features when these are not necessary (such as Wi-Fi), turning on applications or features that allow power saving (through lowering the brightness of the screen and turning off wireless connections), or charging the battery earlier than necessary. Although some of these actions may increase the energy efficiency of the device, the meaning of energy saving does not seem to be part of it. Indeed, as pointed out by some of the teenagers interviewed, their concern is solely to avoid draining the battery, and for that reason they sometimes use other devices (such as computers or MP3 players) that can execute the same tasks (checking social networks or listening to music, for example) instead of their mobile phones. For the same reason, some interviewees indicated that they use their mobile phones while the devices are charging: from their point of view, this way they are not running down the battery.

This empirical example thus shows how the establishment of links between the elements of practices allows the formation of new practices, and also how different practices sharing common elements (in this case the mobile phone) are co-dependent. More important, this case illustrates how energy is as an ingredient of social practices. Thus, from this point of view, energy participates in the reproduction of social practices—not as a resource that is consumed, but rather as part of the flow of elements that compose everyday life and need to be orchestrated.

This example can also illustrate a critical methodological issue that needs to be addressed when conducting empirical research based on practice theory. As pointed out by Warde (2014), a key question results from the fact that practices are considered the unit of analysis. The need to clearly conceptualize what should be analyzed as a practice is further complicated by the need to trace clear boundaries of specific practices, especially because practices form "bundles and complexes" (Shove, Pantzar, & Watson, 2012) with other practices. An example of the ambiguity in the delimitation of the practice of mobile phone management could be whether to view not making a phone call to a friend as part of saving power or, instead, as part of friendship management, so to speak.

Conclusion: Advances in the Understanding of Energy Consumption

The emergence of practice theory in social science research on energy consumption is a particularly insightful and promising conceptual turn. By focusing on the interaction between social structures and everyday life, and including materiality, practice theory provides a fruitful framework for the analysis of energy that corresponds to the research directions identified by social science.

Furthermore, as contended by Harold Wilhite (2014), after decades of ineffective policies intended to reduce energy consumption that have been based on dominant rational and economic behavioral models, practice-based approaches offer the potential for creative new energy-saving policies grounded in improved conceptual understandings of how energy is consumed in everyday practices. This alternative approach, however, introduces a particular challenge to energy policy, since it presupposes changes in social practices, and not in individuals' decisions. And, therefore, a "coordinated policy response" (Strengers & Maller, 2011, p. 166) is necessary. Indeed, a key advance in the understanding of energy consumption made possible with the contribution of practice theory is the acknowledgment that energy is an ingredient of social practices, as claimed by Shove and Walker (2014), in accordance with Schatzki's (2010) view of material phenomena as part of society. Thus, energy consumption should not be considered as something invisible that needs to be brought to light in order for consumers to reduce their energy use. Energy consumption is part of everyday life and society, and therefore the elements that constitute the practices of everyday life are what need to be changed. In fact, as clearly said by Wilhite (2013, p. 67), energy consumption should not be considered as "something performed by individuals," but rather as a "result of the interaction between things, people, knowledge, and social contexts." Practice theory thus offers an alternative to models of individual choice, and it "uncover[s] phenomena normally concealed in the cultural analysis of consumption" (Warde, 2015, p. 126). For these reasons, this alternative framework seems particularly suitable for research on sustainability and environmental issues involving the inconspicuous consumption of natural resources in everyday life.

Summing up, practice theory emerges as a useful way of understanding the relations between energy and society since it accounts for the collective structures of practices, including technological structures (Gram-Hanssen, 2014) and other material arrangements. This supposes the recognition of the fact that "energy consumption is not a practice in itself" (Gram-Hanssen, 2014, p. 94), but an intrinsic part of many daily practices that is taken for granted and is considered normal by most people. Indeed, as pointed out by Shove and Walker (2014, p. 42), energy "is best understood as part of the ongoing reproduction and transformation of society itself," instead of as an external factor; therefore, "understanding energy is first and foremost a matter of understanding the sets of practice that are enacted, reproduced and transformed in any one society" (Shove & Walker, 2014, p. 48).

Notes

1. For more extended accounts of early research on energy consumption see Rosa, Machlis & Keating (1988); Wilhite et al., (2000); Horta et al. (2014); Frederiks, Stenner & Hobman (2015).
2. The issues related to the articulation between practices and individual performances were thoroughly criticized by Turner (1994) and were later discussed by Rouse (2007).

3. More information can be found in Horta et al. (2016). This research had the support of the Institute of Social Sciences, University of Lisbon, and was funded by the Portuguese Foundation for Science and Technology under the award EXPL/IVC-SOC/2340/2013

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CHAPTER 4

ANALYZING THE SOCIO-TECHNICAL TRANSFORMATION OF ENERGY SYSTEMS

The Concept of "Sustainability Transitions"

HARALD ROHRACHER

Introduction

The way we produce and use energy plays a decisive role in some of the grand challenges our societies currently face: global warming and the need to reduce greenhouse gas emissions, the depletion of finite resources and the need to move away from a fossil-fuel-based economy, and not least, questions of global equity and justice in the way we are handling the impact of climate change and opportunities for sustainable development. Our current, unsustainable generation and use of energy are deeply entrenched in the sociocultural, economic, political, and material structures of our world-society: the infrastructures of production, transport, and housing that we have built over many decades; the geopolitical relations that have been shaped to allow for access to cheap fossil fuels; the organization of our economic systems and the global organization of production; and not least, the cultures of energy use that have become dominant in our consumer-oriented societies.

It is obvious that the immense reduction of greenhouse gas emissions required to keep global temperature rise under a level of 2°C or even 1.5°C cannot be achieved by optimizing our systems of energy, transport, or housing, or speeding up technological change. The required reduction of greenhouse gas emissions by 80% or more within the next decades can only be achieved by a radical change of our fossil-fuel dependent

economies, infrastructures, and ways of living—in other words, by a transition toward much more sustainable systems of production and consumption.

Social science research may help to increase our capacity for governing such change processes toward more sustainable energy generation and use. Of particular relevance are approaches that build on the deep entanglement of technologies and innovation with sociocultural, political, and economic elements and which thus frame the problem of energy transition as a socio-technical challenge. Such interrelations have long since been at the core of social studies of science and technology, and of more economically oriented innovation studies. The study of "sustainability transitions" as part of this interdisciplinary research field focuses on systemic, fundamental change processes toward greater sustainability. Along with the increasing social and political awareness of the need for a radical socio-technical change, this field has increasingly attracted academic attention over the past years (see Markard, Raven, & Truffer, 2012). At the core of transition studies is the ambition of a goal-oriented, transformative change. Contributing to such a goal requires a sound understanding of not only the socio-technical relations that create the stable structures characteristic of our current energy system, but also the dynamics of systemic change and of governance strategies aiming for a more sustainable energy system.

The aim of this chapter is to provide a short overview of concepts of socio-technical change and "sustainability transitions" in particular, and their relevance for the transformation of our energy system. Some of the main approaches in this field are the multilevel perspective of innovations, strategic niche management, transition management, and "technological innovation systems" approaches. Some of these approaches will be discussed in the next section of this chapter, along with critical perspectives pointing to their limitations and "blind spots," as well as more nuanced views and conceptual improvements. The following section will then discuss a concrete example of socio-technical change in the field of renewable energy—wind power—and will reflect on some of the lessons we can draw for our understanding of transitions toward a more sustainable energy system.

Studying Transition Processes: Conceptual Approaches

The concept of "socio-technical transitions" to denote fundamental, systemic change processes has been developed from the late 1980s onward as a "fusion" of different approaches to analyze innovation and socio-technical change, particularly from Neo-Schumpeterian economics of innovation or evolutionary economics (e.g., Dosi et al., 1988; Freeman, 1994; Nelson & Winter, 1977), history of technology, and social studies (or social shaping) of technology approaches (e.g., Bijker, Hughes, & Pinch, 1987; Hughes, 1983). The predominantly Dutch group of scholars brought with them a strong

policy orientation focusing on the development of strategies to shape socio-technical change, which was understood as a socially distributed and systemic process. Taking the idea of variation and selection from evolutionary economics and combining it with the science and technology studies understanding of a simultaneous, co-evolutionary shaping of the content and context of technologies, Schot (1992) proposed a "quasi-evolutionary model of technological change," which resulted in a three-pronged strategy to influence technological change: the development of alternative variations of technologies (experiments); the modification of the selection environment (regulation, government policies); and the creation and utilization of a technological nexus (i.e., the creation of institutional linkages between innovation processes, external policies, and long-term orientation). Also, the related concept of (socio-)technological regimes as a stable set of design configurations that have already profited from past learning processes, capital outlays, and so on (Kemp, 1994) is modeled on evolutionary economics thinking about technological paradigms and technological regimes (e.g., Dosi, 1982; Nelson & Winter, 1982). Creating protected spaces for experiments with new socio-technical constellations and for learning between producers, users, and a range of other stakeholders—the strategic management of niches (SNM)—was seen as the prevailing means by which to build up momentum and eventually overthrow existing regimes (Hoogma et al., 2002; Schot, Hoogma, & Elzen, 1994; Weber et al., 1999). Even during the formative phase of transition studies, "sustainability transitions" with a particular focus on energy, transport, and buildings took center stage in the discussions.

Transitions in a Multilevel Perspective

These strands of research were eventually consolidated in a multilevel perspective (MLP) of socio-technical transitions, which distinguishes socio-technical transformation dynamics at different levels of structuration: niches (technological projects, emerging technologies) as a source of variety, test-bed, and an "engine for change"; regimes (such as the energy system) providing stable structures and a selection environment for innovations; and socio-technical landscapes (deeply entrenched cultural norms, values) as slowly changing socio-technical structures at the level of societies (Geels, 2005; Rip & Kemp, 1998). MLP thus points to the multidimensionality of processes of socio-technical change, to the multiplicity of actors involved in the process, and to the embeddedness of local practices and niches in various social contexts with their own specific histories and dynamics.

The central element in this concept is the meso-level of the "socio-technical regime" at which socio-technical configurations are temporarily stabilized and supported by a rule set, or "grammar," that structures the socio-technical co-evolution process. A regime is defined by the fulfillment of a societal function, such as energy, transport, or

communication, and thus puts more emphasis on aspects of use and functionality than economics of innovation approaches (Geels, 2004). The regime level incorporates the mutually reinforcing technological and institutional structures of these specific societal domains and is characterized by a resistance to change (which, for example, may cause promising new technologies to fail). The way such a regime evolves "is structured by the accumulated knowledge, engineering practices, value of past investments, interests of firms, established product requirements and meanings, intra- and interorganisational relationships and government policies" (Kemp, Rip, & Schot, 2001, p. 273). Geels (2004) distinguishes between systems (resources, material aspects), actors involved in maintaining and changing the system, and the rules and institutions (not only at a regulative/legislative level, but also cognitive and normative rule sets) that guide actors' perceptions and activities.

Under specific circumstances, regimes may eventually transform into fundamentally new configurations, especially if radical innovations (technological and/or institutional) coincide with strong outside pressures on the regime (Geels & Schot, 2007). Such regime transitions are closely linked to "system innovations" (Elzen, Geels, & Green, 2004; Grin, 2008), resulting in new interrelations of technologies, institutions, actor networks, and social practices.

Socio-technical niches play a key role for the emergence of radical innovations as they provide "incubation rooms for radical novelties" and locations for learning processes, for example about technical specifications, user preferences, public policies, or symbolic meanings (Geels, 2004). Different patterns of how niches may impact on regimes, such as niche accumulation or the hybridization of niches with established technologies, have been identified (Geels, 2002; Raven, 2007), though these linking mechanisms between niches and regime still lack analytical depth (Smith, 2007). Further work has rather focused on niche-internal processes, such as the formation of social networks, the shaping of expectations and learning processes (Schot & Geels, 2008; Verbong et al., 2010), or on the growth and aggregation of niches as an interaction between local projects and increasingly global niches with an emerging community sharing cognitive, formal, and normative rules (Geels & Raven, 2006; Raven & Geels, 2010). Smith and Raven (2012; see also Raven et al., 2016) interrogate the concept of niches as "protective space" and the different ways in which niches may contribute to path-breaking innovations by shielding against mainstream selection pressures, by nurturing alternative socio-technical configurations, or by different forms of empowerment (e.g., adapting to dominant regimes through fit-and-conform, or pushing for change through stretch-and-transform strategies).

The creation of novel technologies and radical change thus is brought about not only by bottom-up processes in niches, but also by the interactions of multiple levels: niche innovations building up momentum; destabilized regimes creating windows of opportunity for niche innovations; and changes at the macro-level of socio-technical landscapes creating pressure on the regime (Schot & Geels, 2008).

Studies of transition processes have predominantly been carried out in a long-term historic perspective (as an example, see Geels, 2006), which typically results in a