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The Politics of Decarbonization: A Framework and Method

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Our economic, energy, and transportation systems are locked in to carbon. This dependency obtains globally because multiple, interdependent systems (local, regional, national) are also locked in to carbon. Disrupting this reality is both immensely challenging and necessary if we are to avoid the worst consequences of climate change. In this article, we develop a framework to explore the efficacy and possibilities of disrupting carbon lock-in through diverse, decentralized responses that focuses on the politics of decarbonization. The framework identifies political mechanisms – normalization, capacity building, and coalition building – that contribute to the scaling and entrenchment of discrete decarbonization initiatives within or across jurisdictions, markets, and practices. The article also proposes an empirical research strategy for implementing the framework and provides and illustrative example that demonstrates how to apply the framework and its utility.

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1. Introduction

Our economic, energy, and transportation systems are locked in to carbon (Unruh 2000). This lock-in obtains globally because multiple, interdependent systems (local, regional, national) are also locked in to carbon. Disrupting this reality is both immensely challenging and necessary if we are to avoid the worst consequences of climate change. It is also a challenge being taken up, not in a coordinated global fashion (even the UN response is decentralized after the Paris Agreements of 2015), but instead through multiple, diverse interventions that seek to disrupt carbon lock-in by taking action in and among cities, subnational governments, and individual countries; by seeking to alter market systems and corporate behavior; and by changing the range of technologies available to individuals and societies. In this article, we develop a framework to explore the efficacy and possibilities of disrupting carbon lock-in through diverse, decentralized responses that focuses on the politics of decarbonization. It identifies causal mechanisms that operate specifically along political pathways. Such a framework is needed because decarbonization pathways will not be constructed only through identification of economically efficient policy mixes, nor are they solely about adopting particular technologies or practices of energy production. Instead, decarbonization implicates changes in social, technical, economic and political systems that underpin modern societies. Put simply, whatever else it may be, disrupting lock-in is fundamentally a political activity because lock-in has significant political foundations: it rests on norms, institutions, capacities, and coalitions that support fossil-fuel dependent systems.

Pathways to decarbonization are thus paved with political decisions, policies, and voluntary initiatives that promote, alter, enable, constrain, and sometimes demand technological and behavioural changes. The framework developed here offers a new conceptualization of

transformation towards decarbonization and an empirical strategy to explore how diverse interventions can catalyze change by altering political dynamics within and across jurisdictions, markets, and/or carbon-intensive practices.

We develop this political approach by first recasting the challenge of the politics of decarbonization. We posit that carbon lock-in is a fractal phenomenon (Bak and Creutz 1994; see also Perey 2014; Chettiparamb 2013 for applications of fractals to problems of sustainability and planning) whereby global carbon lock-in arises because multiple, overlapping, and interdependent parts of the global system are locked into the use of fossil fuels themselves. In other words, carbon lock-in is a multilevel and multi-sectoral challenge of overlapping political, economic, technological, and cultural forces in multiple systems that reinforce dependence on fossil fuels.

Diverse policy and governance interventions – intentional efforts to steer actors and/or change system dynamics in an authoritative way – designed to disrupt carbon lock-in have recently emerged to face this challenge of fractal carbon lock-in (Hoffmann 2011; Bulkeley et al. 2014). These include cities enacting carbon action plans and participating in transnational networks; states and provinces in North America developing emissions trading systems, carbon tax policies, and renewable energy targets; corporations and NGOs joining forces to promote smart grids, carbon accounting, and clean technology deployment; and nation-states developing targets for carbon neutrality and renewable energy industries. Our goal in this article, therefore, is to develop a theoretical framework that can examine how diverse and targeted interventions interact with and alter the politics of carbon lock-in in specific parts of the system (i.e., in a city) and how those interventions can contribute to broader disruption and transformation.

We posit that once initiated, interventions can alter political dynamics through three mechanisms: catalyzing normative change (normalization); building capacities to act differently, whether by mobilizing resources directly or via institutional change; and coalition building. These mechanisms determine whether and how the policies and practices interventions promote scale up and entrench in the parts of the system being targeted for disruption (local effects), as well as how they influence other systems that make up the carbon lock-in fractal (interdependent effects). These political dynamics generate three possible trajectories for the local and interdependent systems: unintentional reinforcement of carbon lock-in; improvements or efficiency gains in carbonized systems; or transformational decarbonization, a phase change in the system whereby fossil fuel use is not just lessened, but the system is on a trajectory toward replacement or zero use of carbon-based energy. Ultimately, analysis of these pathways toward scaling and entrenchment, and analysis of whether they also constitute pathways to system change, can lead to a greater understanding of how disruptions of carbon lock-in in specific places can catalyze, cumulate, or possibly tip the balance of larger systems of carbon lock-in towards decarbonization.

2. Existing Approaches to the Politics of Decarbonization

2.1 Deep Decarbonization

The most explicit approach to decarbonization—the "Deep Decarbonization" project developed by economists—recognizes that policies need to be put in place to spur decarbonization. However, this approach mainly focuses on getting prices and incentives right and forecasting costs of decarbonization under different technological and policy scenarios (E.g., Jagemann et al. 2013; Shinnar and Citro 2008; SDSN 2014). Typical policy-oriented analyses start with the desired outcome (decarbonization) and then test the cost effectiveness of different

"solutions" or "pathways" in the form: Problem (carbon emissions) → solutions (e.g., technology, price signals, behavioral change, regulation) → goal (decarbonization usually defined as reduced or captured emissions of fossil fuels) (Global Commission on the Economy and Climate 2014; SDSN 2014). They utilize cost-benefit analyses of adopting particular policies and technologies, estimate emission reduction potentials and technological feasibility, and propose behavioral, investment and regulatory responses required by governments, firms or individuals at different scales and/or sectors. These studies aim to generate support for these solutions among policy makers, targeted market actors, societal groups, and individuals.

However sophisticated, the absence of agency, strategy, and the myriad of factors that affect both policy choice and intended and unintended effects of policy renders them silent on why some policy tracks are chosen over others, political conditions or policy pathways through which change can occur, conditions under which policies scale, entrench or fizzle out, or their interactions with other policies or political goals. Indeed, this approach risks being off in two directions. It can overplay the possibilities for change because it does not provide analytic tools to track whether interventions in social and political systems reinforce carbon lock-in, produce only "faux" change (Cashore and Howlett 2007) such as efficiency improvements that do not decarbonize, or lead to transformative pathways towards decarbonization. It can also underplay the possibilities for nonlinear change because the neglect of politics leaves unexamined the potential for recommended policies to alter the political conditions for complementary and broader policy making.

2.2 Political Science and International Relations

Meanwhile, political science and international relations scholarship, not surprisingly, has paid significant attention to politics, but far less so to decarbonization as the underlying policy

problem. Traditionally it has treated climate change politics as a cooperation problem among governments faced with protecting the atmosphere as a common-pool resource (E.g., Barrett 2003; Aldy and Stavins 2009). Analytic work has thus concerned efforts to overcome the concomitant structural challenge of collective action (free riding, distributive issues, cheating) posed by an international system that lacks authority over states. The real world of international politics reflects a similar framing. For nearly 30 years, multilateral climate negotiations have targeted how far to reduce greenhouse gas emissions, how to distribute reduction commitments, how to achieve reductions, and how to pay the costs of reductions (or adaptation when reductions fail to occur).

As frustration grew with the slow pace of international negotiations, new scholarship emerged that acknowledged the fragmentation of governance arrangements to address climate change (Keohane and Victor 2011; Abbott 2012), with many analyses pointing to the practicality of a more polycentric (Dietz, Ostrom and Stern 2003; Cole 2015), bottom up (Rayner 2010; Victor 2011), or experimental (Hoffmann 2011) approach. However, even as this, and more comparative, work on climate politics and policies has proliferated, it has been difficult to shake the dominant framing of politics as actors contributing to a global collective effort to reduce emissions, even if through bottom up or decentralized processes.

Our move to shift the analytic focus from cooperation to reduce emissions to decarbonization is more than just semantics. Whereas it is accurate to say climate change results from the increasing emissions of greenhouse gases, emissions are only the proximate cause. Defining a problem (climate change) based on its proximate (greenhouse gas emissions) or its fundamental (carbon lock-in) causes invokes very different policy responses and understandings of the political challenge.

2.3 Socio-Technical Transitions

The socio-technical transitions literature, in line with this alternative frame, has taken direct aim at the decarbonization challenge. Traditionally this literature addressed the emergence and diffusion of specific new sustainable technologies in single jurisdictions (Geels 2002; Geels et al 2004; Meadowcroft 2007, 2009. 2011; Jordan 2009). Hypotheses included types of policy instruments (e.g., whether they are original initiatives, diffused from other jurisdictions, or re-frame existing policies to be for new purposes) and their support or not at different levels (i.e., niche, regime, and/or landscape) as explanations. More recently, this literature has taken a serious turn towards political dynamics—why or how support is gained, the political processes through which innovations scale, diffuse or entrench, or even whether change in the system towards decarbonization results—previously outside the scope of transition theories (Meadowcroft 2007, 2009, 2011; Shove 2010; Shove and Walker 2007; Jordan 2009. Geels 2014; Turnheim et al. 2015; and Grin 2010 are key examples of the turn towards political analysis in the transitions literature).

Geels, especially, has recently started to draw on political economy, and especially neo-Gramscian scholarship (E.g. Newell and Levy 2002) to point to broad patterns of how the power and interests of, and relationships among, important players (especially governments and firms) within existing regimes can present obstacles to change (Geels 2014, see also Grin 2010). For example, his analysis of resistance and resilience of "incumbent regime actors" in the electricity sector in the UK focuses on coal, nuclear and natural gas interests, their discursive strategies and framing effects, and links and/or access to power resources (finance, government, media) (Geels 2014).

The integration of these structural aspects of politics and policy dynamics into transitions theory broadens its explanatory power. It allows for the identification of political structures at the outset that define regimes and therefore serve as both the structure within which innovations emerge and obstacles to the scaling and adoption of innovations. In addition, the literature seeks to identify the governance and policy levers necessary for given innovations to disrupt technological regimes and move systems along transition trajectories. These moves to better incorporate politics clarify the challenges of disrupting carbon lock-in and allow for a fuller examination of the conditions under which new technological niches can disrupt established technological regimes.

2.4 The Politics of Decarbonization

We build on the economic and transition approaches to decarbonization, but our focus is on analyzing how the agentic politics of specific interventions play out in attempts to generate pathways toward decarbonization. We thus offer a more politically oriented approach than Deep Decarbonization, a new political framing that better characterizes the nature of the problem than as a global collective action problem, and a complementary analysis to the more structural approach to politics found in the socio-technical transitions literature. Rather than starting with a predetermined pathway or transition trajectory, our starting point is the way in which specific, on the ground interventions generate political dynamics and how those political dynamics might auger toward decarbonization in specific places and more broadly. We are specifically interested in political processes through which policies or governance tools emerge and function and how they shape decarbonization pathways and possibilities. The problem of decarbonization is a problem of politics within and between multilevel spaces and practices where the politics of decarbonization play out in the global system (i.e., political and economic activities that can

occur at, or cut across, jurisdictions or geographies of cities, provinces, regions, and nation-states).

3. Theoretical Framework

3.1 Carbon Lock-In as a Fractal Phenomenon

Conceptualizing political pathways to decarbonization thus begins with the realization that carbon lock-in is the result of multiple, interlocking, interdependent systems that exist at multiple levels. Global energy, transportation, and economic systems are locked-in to carbon because transportation, energy, and economic systems at the municipal, sub-national, state and regional level are locked-in to carbon. It is a *fractal* problem.

Fractal systems exhibit interdependence and self-similarity across scales. In mathematics intricate fractal systems are generated from relatively simple driving algorithms and the appearance and functioning of the 'whole' is similar to and dependent on the functioning of the parts:

> The nature of repetition (property/process/value/form) across scales leads to reinforcement of key characteristics in the system as a whole. When systems are self-similar in at least some aspects, they can become operationally coupled and consequently aligned and correlated across different scales. Through such alignments, change in one level can result in a change throughout the system, and the alignments can therefore be an important mechanism for co-evolution. The local and global in fractal systems can then be co-constitutive (Chettiparamb 2013, 13-14).

Carbon lock-in exhibits these characteristics and the political challenge of decarbonization is disrupting a fractal system. Carbon lock-in results because overlapping cultural, political,

technological, and economic forces auger towards the use of fossil fuels. This reinforcement happens across scales in an interdependent way. Cities are locked into the use of fossil fuels because (among other things) of how they are physically planned, the expectations practices of citizens around transportation and energy use, the political coalitions and institutional capacities that make cities run politically, and the range of technological options that are available to city dwellers. The same could be said of nation-states—they are locked in to the use of fossil fuels because of similar (not the same) cultural, economic, political, and technological dynamics on a larger scale (i.e., national energy and transportation policy, coalitions of interest groups, national culture, etc.). Further, the lock-in in cities reinforces the state-wide lock-in just as state-wide lock-in in turn reinforces it at the municipal level.

We focus on the *political* aspects of fractal carbon lock-in because no matter where you look—markets, cities, sub-national jurisdictions, or nation-states—there are institutional and normative processes, and structures (political factors) contributing to carbon lock-in. The substance and functioning of the political factors differs across levels—municipal politics and national politics are obviously not the same—reinforcing carbon lock-in in all parts of the fractal system. Difference can co-exist with similiarity in fractal systems as they always have "roughness" or "contextual phenomena that are unique and meaningful to a particular scale… that prevents the local from being subsumed in the global" (Chettiparamb 2013, 15).

Social systems are unlikely to perfectly match all parameters of fractal systems in nature, but our argument is that the global system of carbon lock-in shares enough characteristics of fractal systems, especially in terms of how political dynamics we identify interact with the social, economic, and technological dynamics of lock-in, to make the analogy productive for theorizing. The fractal analogy or ontology does not explain the politics of decarbonization; it is a

description of the challenge of the politics of decarbonization that generates two important parameters for analysis.

First, viewing carbon lock-in as fractal implies that changes in any part of the system as well as the system as a whole can be analyzed with a common analytic framework. This does not imply that the politics in these different levels are the same, it means that a single framework focused on politics can be used to make sense of carbon lock-in and attempts to disrupt it anywhere in the carbon lock-in fractal. The politics that reinforce and seek to disrupt carbon lock-in in cities can be *analyzed* the same way as the politics that reinforce and seek to disrupt carbon lock-in in nation-states (though the way those politics play out are *substantively* very different). In each case, the political dynamics of normalization, capacities, and coalitions are at play both in terms of reinforcing carbon lock-in and in attempts to disrupt it.

Second, understanding carbon lock-in as a fractal challenge indicates that the multiple systems of the carbon lock-in fractal are interdependent—the politics of carbon lock-in and its disruption in cities are connected to the politics of carbon lock-in and its disruption in nation-states. This implies the need to uncover mechanisms that mutually link or assimilate the local to the global—how actions and outcomes in specific places can catalyze broader transformation (or stymie it)—to account for change and to show how changes at different scales implicate changes across the system (Geels 2010). Thus moves towards decarbonization in multiple specific places can and should be analyzed for *both* their specific effects in targeted parts of the system and their potential to catalyze broader transformation in other parts or the system as a whole.

3.2 The Political Pathways of Decarbonization

Our analysis starts with an intervention. Any targeted part of the fractal has an initial state of carbon lock-in—a specific socio-economic-political configuration. The intervention is a

conscious attempt to disrupt the current state of the target and we consider that once an intervention is initiated, the system trajectory can move along one of the three (ideal-type) paths described above: (1) reinforcement of carbon lock-in, (2) improvement in carbon lock-in, or (3) decarbonization. The intervention, whatever else it is, is political, and it contributes to changing the trajectory of the targeted system by creating and/or contributing to political mechanisms of *normalization*, *capacity building*, and *coalition building*. These mechanisms help to determine if the changes the intervention promotes will *scale up* and become *entrenched* in the targeted part of the fractal, whether directly because the intervention itself grows, diffuses, and/or becomes institutionalized or because its policies and practices take on a life of their own, spawning further interventions or scaling and entrenching in other ways (changing other institutions, creating new legislation, altering business practices, etc.). Figure 1 provides a visual representation of this dynamic in a single part of the system. Crucially, the potential for altering the system trajectory is found in the feedback between the intervention and the political mechanisms that it catalyzes.

The fractal nature of carbon lock-in, however, means an intervention in one part of the larger whole can also alter the politics of other parts or even the whole fractal (Figure 2). This crossover impact emerges in two ways. First, it is felt when an intervention in one part catalyzes the emergence of new interventions targeting other parts. The C40 network emerged, in part, in response to what was seen as lacuna in the main existing transnational city network at the time (ICLEI's Cities for Climate Protection). Second, an intervention in one system can contribute to the political mechanisms at play in other systems that were catalyzed by extant interventions. Subnational emissions trading systems like California and Quebec, Canada reinforce one another, eventually became linked and have spawned a planned system that will join them, in

Ontario, Canada. In the following sub-sections we elaborate on the different parts of the framework.

Figure 1 – Decarbonization Pathway in a Targeted Part of the System

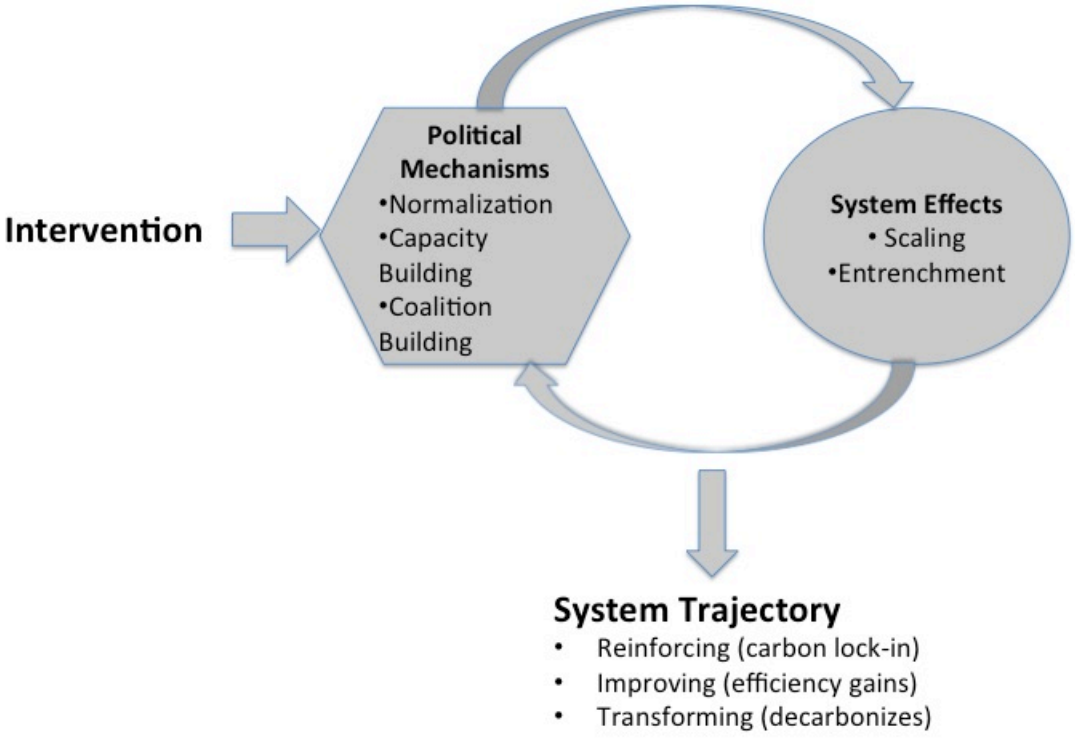
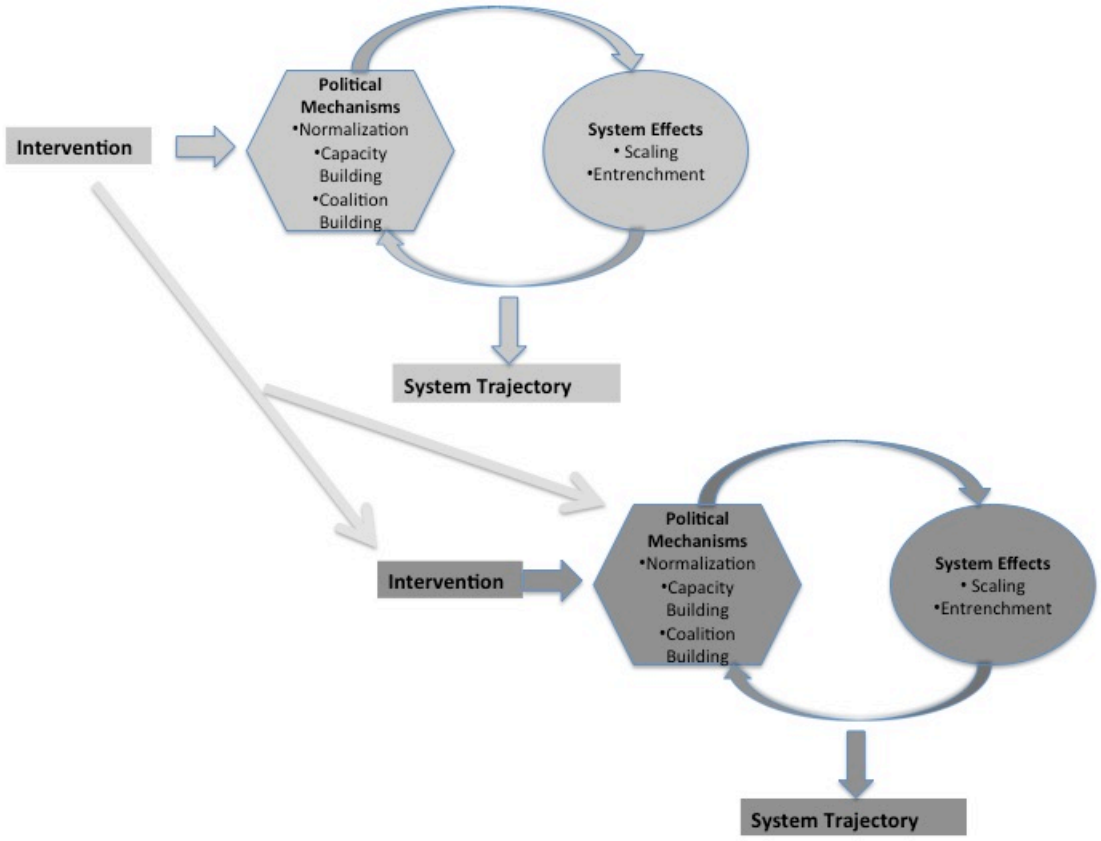


Figure 2 – Decarbonization Pathways Across Sub-systems



3.2.1 Targets

For simplicity's sake we identify three ideal types of targets:

1. *Political jurisdictions*. Interventions may target individual polities (cities, states or provinces, countries), multiple jurisdictions horizontally (e.g., the C40 city network or the 2014 China-U.S. agreement), or vertically (e.g., provinces and nation-states in a federally coordinated cap-and-trade system). From this perspective, even the UN process is just another intervention—at the global scale.
2. *Markets*. Targeted markets can be sectoral (e.g., an intervention aimed at the airline industry) or jurisdictionally bounded (e.g., carbon labeling that targets supermarkets in a

particular country). The distinguishing feature is that the intervention targets corporations and corporate practices directly.

3. *Practices*. Practices are often less bounded than other parts of the system. Relevant practices can be behavioral (e.g., cycling or energy conservation initiatives), cultural (climate fiction), and/or material (e.g., zero-carbon building design, consumer behavior).

These targets are not mutually exclusive and there may be overlap and nesting of the categories. For example, a practice such as zero-carbon building design may be jurisdictionally bounded (e.g., a demonstration project in a particular city) or can cross boundaries via a community of practice such as professional architects.

3.2.2 Political Mechanisms

These mechanisms are distilled from a broad reading of the politics of systemic change. Each one represents multiple literatures and theoretical approaches. Our attempt here is to provide a coherent framework that draws on a foundation of multiple strands of the political science literature.

3.2.2.1 Normalization

A voluminous literature in political science identifies norm change as an important source of shifts in public policies and interests, even if their effects are mediated by local politics and institutions (E.g., Keck and Sikkink 1998; Finnemore and Sikkink 1998; Meyer et al. 1997; March and Olsen 1998; Acharya 2004; Bernstein and Cashore 2012). Similarly, transition scholars have noted the potential mutual influence of "reframing" at both niche and landscape levels can lead to mutual influence and "higher-level changes in social and norms and values" (Upham et al. 2014, 790-791). Normalization shifts expectations about appropriate behavior, thus, "If policy advocates succeed in generating a political and public expectation that

[greenhouse gas] emissions should decline over time then policies and behaviors that further reduce GHG may be judged "better" and more appropriate than those that engender increases" (Selin and VanDeveer 2005, 371-372).

Two mechanisms of norm change are particularly salient for our framework. First, entrepreneurs can propose and advocate new ways to look at the world and act on problems like climate change, catalyzing norm change (Finnemore and Sikkink 1998; see also e.g. Kingdon 1995; Young 1991 on agenda setting). They reframe notions of appropriate action, work to convince others and alter the common sense of a system. Second, the buildup of everyday action on climate change—practices —can shift perceptions of the necessity and appropriateness of climate action; what people do "determines what they think" (Pouliot 2011, 21). The practices that interventions entail can shape how actors in different parts of the system, and ultimately society at large, understand climate change and their interests in taking aggressive action.

Decarbonization interventions can activate both of these mechanisms. Many interventions are entrepreneurial efforts that work on developing new practices of climate responses. For example, the Carbon Disclosure Project advocates for companies to account for and disclose their carbon emissions and exposure to climate risk. In response, many large corporations including GE, Google, Microsoft, and even Exxon have changed their practices and now engage in shadow pricing: they assume there will be a carbon price in the future and include the cost of carbon in their business planning (CDP 2013). The practice of treating carbon pricing as inevitable contributes to normalizing potential moves towards decarbonization in the corporate community and generates political support for public moves towards carbon pricing (Clark 2015).

3.2.2.2 Capacity Building

The second political mechanism operates through altering capacities – material, institutional, and cognitive (see e.g. Weible and Sabatier 2014; Pierre and Peters 2000; Bernstein and Cashore 2012; Selin and van deVeer 2005). Direct means through which interventions can increase capacity include, "direct funding, education, training, [technical] assistance, and… co-governance via partnerships between public and private actors and authorities" (Bernstein and Cashore 2012, 593). Similarly, capacity can be built via demonstration effects that act as policy learning vehicles (Selin and VanDeveer 2005; Rabe 2008). Interventions generate institutional capacity when they alter how governments make decisions and implement programs.

The electric vehicle pilot project of C40 nicely illustrates these mechanisms. C40 created a new institution, the Electric Vehicle Network, comprised of a subset of C40 cities as a first step. This network provides constituent city officials with detailed information regarding the benefits of pursuing an electric vehicle strategy, and nudges them towards a particular approach to unlocking local demand through the creation of a robust and extensive charging infrastructure (Interview with Steve Crolius, former Director of Transportation, Clinton Climate Initiative). In addition, the Electric Vehicle Network serves as a demonstration project, facilitated by C40's city-city interaction and sharing of best practices (SLoCaT 2014).

Capacity building can move across parts of the system as well. For instance, the Carbon Registry (a California-based intervention that develops greenhouse gas accounting methods) has provided information and expertise for multiple actors looking to account for carbon, including city networks, U.S. states (Massachusetts and California), and nation-states (United States and Brazil) (http://www.theclimateregistry.org/thoughtleadership/greenhouse-gas-accounting-verification/, accessed May 14, 2015).

3.2.2.3 Coalition Building

Coalition building and dynamics foundational in much of political science, here we are especially interested in how coalitions build and change to support or resist new initiatives—how, in other words, interventions can spur the emergence and strengthening of economic and political coalitions that back decarbonization. They can catalyze these coalitions by identifying and linking "winners" in the move towards decarbonization and neutralizing losers. This entails empowering actors who have an interest in climate change, building constituencies either through creating or altering incentives or by active social movement building, and utilizing larger market forces.

For example, efforts to promote renewable energy portfolio standards and feed-in tariffs are designed to create winners (renewable energy companies, consumers) that can become a political force for sustained and/or broadened action (though these coalitions often face counter coalitions) (Rabe 2007; Stokes 2014; Aklin and Urperlainen 2013). Even more overtly, carbon pricing initiatives commonly build in revenue distribution or compensation to build support or fend off counter coalitions, as Australia did by including subsidies to impacted sectors and flexibility mechanisms in its 2008 carbon pricing scheme (Gordon 2015, 131, 133). Similarly, research has documented how regulations, standard-setting and registries can foster "Baptist-bootlegger" coalitions of activists and businesses already following good practices who want to be recognized and rewarded in the marketplace, which can increase support for strong regulation in a sector or the spread of standards/regulations to other jurisdictions (Vogel 1995; DeSombre 2000; Levin et al. 2012).

3.2.2.4 Interactions of and Power in the Political Mechanisms

Interventions can contribute to normalization, capacity building, and coalition building around the substance of what they are trying to do (carbon labels, renewable energy, smart grids, etc.) both in targeted parts of the system and beyond, but the interventions only provide the potential for these mechanisms to generate scaling and entrenchment. These mechanisms do not function in a vacuum and other countervailing conditions and factors play a role in determining whether that potential is realized. Moreover, separating out these mechanisms is an analytic convenience. In practice, they interact—sometimes producing synergies (i.e., increasing normalization could alter coalition structures) and other times working at cross-purposes (i.e., if states learn to do certain kinds of climate practices from one set of interventions that disrupt the coalitions that other kinds of interventions generate). This framework cannot specify a priori all the ways that the political mechanisms can interact, but it does provide a basis for making sense of the details of particular interventions and tracing how the political mechanisms operate in specific contexts.

3.2.3 System Effects I: Scaling

When interventions successfully contribute to normalization, capacity building, and/or coalition building, the policies and practices they support have the potential to scale up. Scaling can take multiple forms. Most basically, climate governance interventions can produce ***simple scaling***—initiatives and/or the policies they promote start small and then grow. Growth can be in terms of size and/or range of activities; interventions attract more members and resources, expand their geographic scope, or begin to undertake different types of activities. For example, the C40 Cities Climate Leadership Group began as the C20, an ironic homage to the G20. Not

only has the C40 Cities Climate Leadership Group grown larger, it has also grown stronger—learning and demonstration effects within the network have enabled C40 cities to take the lead on climate change in a number of ways (Gordon 2013).

Ecosystems of interventions can also emerge and expand because interventions open up political and economic space for further activity. Intervention begets intervention in important ways. This kind of clustering effect facilitates ***self-organized scaling*** and has the potential to engender increasing returns to interventions—a dynamic whereby adding interventions reduces the barriers to further innovations and encourages the expansion of complementary activity. Clustering produces new niches that additional interventions can fill and opens up opportunities for cooperation and competition that produces more interventions (Hoffmann 2011). The voluntary carbon market is a quintessential example. Once carbon offsets producers emerged, this opened up room for additional interventions to make the market work—offset and carbon credit registries, carbon standard-setters, carbon accounting. The entire voluntary carbon market is an ecosystem of climate governance interventions; each of its functions is made relevant by the functioning of others.

Finally, conscious borrowing of ideas or policies is ***modular scaling***. This looks like some classic versions of diffusion (E.g., Graham, Shipan, and Volden 2012; Busch and Jorgens 2005). or what DiMaggio and Powell call "mimetic scaling" (DiMaggio and Powell 1983). A key example of modular scaling is the proliferation or similar forms of transnational city networks over the last decade that bring municipalities together to work on climate change at the local level (Betsill and Bulkeley 2004).

3.2.4 System Effects II – Entrenchment

Processes of entrenchment, like scaling, can take multiple forms. Here we draw primarily from the path-dependency literature. While others have noted the disruptive potential of policy innovation and experimentation to policies that lock in carbon (Jordan et al 2003), our interest is the mirror image of that dynamic: processes that make new initiatives and/or the policies or practices they promote "sticky" or difficult to reverse by triggering or reinforcing coalition building or broadening, normalization and capacity building. There are four primary processes of entrenchment (Levin et al 2012; see also Hacker 2002; Mahoney 2000; Page 2006; Pierson 2004; and Thelen 2004).

Lock in: when policies and practices have immediate durability or stickiness, such as when legislation is passed.

Self-reinforcing: when the costs to reverse a policy or change instigated by an initiative rise over time

Increasing returns: when the benefits to targets of an intervention increase over time.

Positive feedback: when an initially untargeted population joins an initiative and thereby reinforces the choices of the initial target population to be part of the intervention and/or policy.

Entrenchment may occur directly or indirectly. That is, it may result from direct targeting by the initiative and effects on the targeted population, or it may occur indirectly when the impacts of the initiative go beyond its original objective but still lead to durable changes that lead to decarbonization in another jurisdiction or because of knock-on effects in a related sector. This notion is comparable to the idea of modular scaling, but here the focus is on the durability and irreversibility of policies.

When focusing on entrenchment processes, it is equally important to pay attention to counter-dynamics, including negative feedback, when, for example, targets of an intervention experience costs and organize against it (Jordan and Matt 2014, 230; Weaver 2010; Aklin and Urpelainen 2013). Attention to both positive and negative dynamics, especially the formation of counter-coalitions, is especially important when analyzing indirect or unintended consequences in a forward-looking mode of analysis such as ours. It also provides an opportunity for analysis: attention to these processes directs our gaze to opportunities that arise in seemingly unrelated policies or initiatives that can indirectly create positive entrenchment dynamics for decarbonization.

4. Research Strategy

The logic of the theoretical framework is fairly straightforward even if there are a number of moving parts. The framework is designed to analyze an intervention that seeks to disrupt carbon lock-in in a specific part of the fractal system through intentional attempts to authoritatively steer actors, potentially contributing to or creating political ripple effects in the system: normalization, capacity building, and coalition building. When the political mechanisms move in a positive direction then the policies and practices promoted by the intervention scale up and out and

become entrenched in targeted parts of the system. Conversely if the mechanisms move in a negative direction (heavy contestation instead of normalization, strong counter coalitions, etc.) then scaling and entrenchment will decrease or fail to take off. The feedback between the political mechanisms and the system effects shapes the trajectory of the system and the intervention's potential for catalyzing decarbonization moving forward. Implementing the theoretical framework involves a three-part research strategy—case selection, development of analytic narratives, and forward theorizing.

4.1 Case Selection

The fundamental unit of analysis when using this framework is the intervention—an initiative that seeks to disrupt carbon lock-in in a specific part of the fractal system through intentional attempts to authoritatively steer actors. The catch, for rigorous case selection, is that there are no cases of wide scale (and only a few cases of small scale) decarbonization to compare with failed cases. Further, decarbonization is not a defined end state beyond the banal and obvious vanishing use of fossil fuels—we do not know what decarbonized systems will look like in any detail. Finally, the world is now awash in climate policies, emission reduction plans, low-carbon pilot projects and more from multiple diverse actors. This empirical context thus provides little in the way of definitive criteria to pick cases.

One answer is to follow a diverse case selection strategy and include a large range of initiatives that vary in terms of initiating actor (non-state, state, hybrid), target system (jurisdiction, market, practice), scope (from interventions that target specific activities like LED lighting in streetlights to interventions that focus on a combination of activities like renewable energy policy at the provincial or national level) and scale. As we elaborate below, the framework does not imply a comparative case study methodology with testing of propositions in

different cases, instead it augers toward a strategy of understanding the different pathways that various interventions are traversing using the same framework. A diverse case selection strategy has the advantage of generating insights in a variety of contexts and being sensitive to connections between initiatives and the potential for small changes to have large effects.

4.2 Analytic Narratives

Once cases are chosen the framework can be used to structure analytic narratives that tell the stories of the interventions through the lens of the framework. The goal of analytic narratives is to make sense of what the intervention 'does' and characterize its impact on the targeted system. The three political mechanisms (normalization, capacity building, coalition dynamics) combine with the two system effects (scaling and entrenchment) in a single framework that allows for tracking how interventions can disrupt carbon lock-in in the targeted part of the system and if/how the intervention has catalytic potential in other parts of the carbon lock-in fractal.

Scaling and entrenchment are observable implications of the political mechanisms at work and developing analytic narratives also makes it possible to observe how scaled and entrenched policies and practices can feedback (positively and negatively) on the political mechanisms. Sometimes what is observable is the intervention itself and sometimes it is the policies, even if the intervention itself remains unchanged or disappears. Changes in system states are observable implications of the disruption that does or does not occur as result of feedback between political mechanisms and system effects.

For each case, the framework offers the parameters for analyzing and monitoring the trajectory of the intervention, how it contributes to normalization, capacity building, and coalition building, and how those mechanisms do or do not produce scaling and entrenchment.

Since the politics of decarbonization are contested politics, much of the analysis concerns the obstacles to transformation—entrenched interests and coalitions, the capacity to perform practices associated with carbon lock-in, and the common sense around carbon lock-in, and how the intervention alters or fails to alter those dynamics.

A range of methodological tools can be employed in the development of analytic narratives and the various processes of scaling and entrenchment outlined above are observable through careful qualitative analysis of individual interventions. This process begins with descriptive analysis, identifying the goals, content, and activities of the intervention to provide an initial sense of whether its substance augurs towards decarbonization. Next is the analysis of how the activities of the intervention contribute to the political mechanisms and scaling/entrenchment dynamics (See Table 2 for indicators of scaling and entrenchment). This work is a matter of process tracing using data gleaned from intervention documents, media reports, and where appropriate and possible, interviews with intervention participants and actors that interact with the intervention activities.

Table 2—Indicators of Scaling and Entrenchment in NSS Climate Governance

Type of Scaling	Indicator *Has the intervention:*	Type of Entrenchment	Indicator *Did the intervention:*
Simple	Attracted more members, expanded in geographic scope, or accumulated more resources?	Lock-in	Use mechanisms that gave it immediate durability?
Self-organized	Inspired symbiotic interventions?	Self-reinforcing	Become more difficult to reverse over time?
		Positive-feedback	Attract non-target members thereby reinforcing the decisions of early adopters?

Modular	Been consciously emulated in a different context?	Indirect	Catalyze indirect impacts that create decarbonization benefits?

The process tracing in the analytic narratives allows identification of key leverage points and the primary dynamics of scaling and entrenchment (internally and externally) that are operative in the specific context of the intervention in question. This provides a way to understand the linkage between the intervention's activities and the trajectory of the target system(s) and to draw some conclusions about where that trajectory might head and why.

4.2 Forward Theorizing

The third aspect of the research strategy involves gathering the insights from the analytic narratives as a guide for conceptualizing pathways from intervention to decarbonization. To be sure, the framework itself is not a recipe for getting to transformation from an intervention. It is a coherent set of concepts and parameters that allows us to conceptualize, explain, and track system trajectories towards decarbonization (or, alternatively, reinforced or improved carbon lock-in). That doing so is largely an empirical and pragmatic (Friedrichs and Kratochwil 2009), rather than deductive, endeavor reflects our skepticism that it is possible to assemble a set of general conditions for decarbonization trajectories. Thus, our approach is consistent with what many in the transitions literature have recognized, that local conditions and the complexity of interactions in socio-technical systems makes forward reasoning (Bernstein et al. 2000) and monitoring of trajectories essential for good analytic and evaluative work on transformation. We see our approach as complementary to much of that work (Turnheim et al. 2015; Jordan and Matt 2014). At the same time, however, our approach identifies mechanisms that drive policies and

practices along particular pathways (reinforced lock-in, improving or transformative). We are focused on causal mechanisms (that can play out differently in different contexts) rather than (positivist) causal relationships where independent and dependent variables are linked in invariant propositions.

The strategy is similar to Levin et al.'s: "to identify possible policy interventions and reason forward to how the problem and interventions might unfold over time" (Levin et al. 2012, 130). We are interested "in other possible and likely futures, and in determining the ways in which [an intervention's] actions and the actions of others contribute—sometimes via unintended effects and consequences—to making some of them real'' (Patomäki 2006, 12). This approach recognizes a commonplace observation in analyses of complex systems: feedbacks can be both positive and negative (Weaver 2010; Jordan and Matt 2014) and the effects of relationships of components of a system and political mechanisms can be indeterminate.

Targeting analysis at the dynamics and trajectories of change allows us to approach multiple, diverse cases with the same framework and empirically observe the context specific details through which the processes we describe unfold in particular instances. What travels from case to case are mechanisms and system effects that can lead to transformation; what is contingent is how they play out in particular cases. Our hunch is that the relationship between the processes we describe here and the ultimate direction of the trajectories is conditioned by the substance of the intervention itself, but that politics (normalization, capacity building, and coalition building) will play out in unique ways in different systems. However, using our framework may also generate additional hypotheses for system transformation moving into the future.

5 Illustration

To illustrate this research strategy in operation and the generative capacity of our framework, we provide a skeletal analytic narrative from one of the intervention cases developed in our project—the middle step in the research strategy. What follows is thus not a full case, but rather a demonstration of the framework's utility for making sense of or characterizing the political impact of an intervention—a key initial step in the overall analysis of the politics of decarbonization. This analytic narrative examines the Carbon Trust's carbon labeling initiative, an intervention by a hybrid governance actor that targets markets (the Carbon Trust is autonomous but largely funded by the UK, Welsh and Scottish governments). It failed to scale domestically, but has shown signs of entrenching in supply chains and in non-UK political jurisdictions, and is on a system improving trajectory. We present this relatively simple case from our project so that the material can be conveyed concisely in ways that should be helpful for others who wish to apply the framework, and because it illustrates a wide range of the framework's mechanisms and effects in action.

5.1 The Carbon Trust's Carbon Labeling Initiative

The United Kingdom's Tony Blair government created the Carbon Trust in 2001 as an arms-length, not-for-profit organization as a vehicle to fulfill its promise to recycle revenues from its 1999 Climate Change Levy into support for decarbonization initiatives for businesses. Perhaps its most ambitious initiative was to create a standard for reporting the carbon footprint of products to facilitate carbon labeling and stimulate consumer demand for low carbon products. Ultimately, the initiative aimed to alter market dynamics in the United Kingdom, its target jurisdiction (Economist 2011). In its theory of change, consumer demand for low carbon products would lead companies to mitigate GHG emissions throughout their supply chains. This

logic augurs towards system-improving outcomes. Incentives for decarbonization are indirect because the assumed economic advantages would accrue to products with lower carbon footprints, not necessarily those that move away from carbon lock-in.

5.1.1 Capacity Building

The analysis begins with capacity building because this intervention's theory of change for scaling and entrenchment first required companies to build the capacity to measure individual products' footprints. In 2006, The Carbon Trust pioneered such a methodology and by 2008, in partnership with U.K. government agencies, developed Publicly Available Specification (PAS) 2050, a measurement method of product life cycle GHG emissions (The Carbon Trust 2008, 2). Accompanying PAS 2050, The Carbon Trust also developed a series of rules for communicating product carbon footprints and reductions and established a subsidiary (the Carbon Label Company) to help companies display their products' carbon footprint consistently and credibly (The Carbon Trust 2008, 7). This standard had the effect of enhancing the capacity of companies to engage with their supply chains.

5.1.2 Normalization

To scale and entrench, the new methodology would need to alter how businesses and consumers conceived of goods they produced or purchased. The carbon content would need to become a relevant consideration in the decision-making of both sides of the market system.

The business community initially reacted favorably. The Carbon Trust recruited a number of high-profile corporate partners to pilot carbon labels, including Cadbury, Coca-Cola and Coors. By late 2008, British consumers could find carbon labels on such household goods as orange

juice, potato chips and laundry detergent. Supermarket chain Tesco was an early-adopter and vowed to put carbon labels on every one of its 70,000 products (*Economist* 2011). However, enthusiasm for carbon labeling in the UK quickly waned. Participating companies complained about the cost of calculating a carbon footprint. Industrial giant 3M claimed it cost as much as $30,000 USD per product, which made it infeasible for a company with over 55,000 different products. (*Economist* 2011). In 2012, Tesco abandoned its pledge to label all products, citing insufficient take-up from other retailers and costs of life cycle analysis for each product (Vaughan 2012). By 2012, scaling and entrenchment seemed unlikely because even if capacity was in place to produce carbon labels, the idea of product-level labeling failed to normalize.

Despite the failure to generate norms around labeling in the U.K. market, corporations *were* normalizing carbon management of their supply chains because of the capacity enhancements Carbon Trust provided. It turned out that the Carbon Trust methodology helped companies identify the true drivers of GHG emissions, often revealing surprises (The Carbon Trust 2008, 4). For example, a British smoothie manufacturer mistakenly believed fruit transportation was the single greatest contributor to its product's carbon footprint. After applying the PAS 2050 methodology, it learned that raw materials production, packaging and manufacturing accounted for almost 80% of GHG emissions in a single product. As a result, the company shifted mitigation efforts away from local sourcing and towards energy-efficient recycled packaging, which resulted in a 20% reduction in materials and 55% reduction in carbon emissions from the bottle manufacturing process (The Carbon Trust 2008, 20).

Normalization of managing carbon in supply chains and production also spread beyond the corporations that initially agreed to participate in labeling pilot projects. Tesco's carbon labeling intervention led its suppliers to implement their own carbon reduction and energy efficiency

programs, as did other U.K.-based companies (The Carbon Trust 2008, 4). The Carbon Trust intervention thus did contribute to normalization, but not as intended. Instead of normalizing carbon-conscious consuming, its methodology helped normalize carbon-conscious production and supply chain management.

5.1.3 Coalition-Building

Given that this intervention's target was a market system and not a political jurisdiction, coalition building was the least relevant political mechanism to explain scaling or entrenchment. Moreover, initial support from the U.K. government suggests the intervention stemmed from pre-existing political coalitions. Early corporate enthusiasm appeared to be building an economic coalition that could have provided support for mandatory (rather than voluntary) carbon labeling, but that coalition rapidly eroded. No mass movement of consumer interest in carbon labeling emerged. In fact a 2010 survey found that: "just a fifth of British shoppers recognized the carbon footprint label, compared with recognition rates of 82% for Fairtrade and 54% for organic labeling"(*Economist* 2011).

5.1.4 Scaling

Because of the failure to normalize the idea of carbon labeling in the United Kingdom, little simple scaling occurred. Indeed, initial uptake by retailers reversed when consumer behavior failed to provide the expected economic incentive. However, this case demonstrates the importance of having multiple understandings of scaling since capacity building and normalization amongst corporations of the economic benefits of carbon management led to significant *modular* scaling of the intervention.

Following the launch of The Carbon Trust's standard in 2008, a range of carbon footprinting methodologies emerged in countries around the world. In 2009 France began developing a product-level environmental footprinting standard that explicitly drew on The Carbon Trust's PAS 2050 as a starting point (Vergez 2011, 11). Similar modular scaling effects were seen in partnerships that developed between the Carbon Trust and Japan (Ikezuki 2009; Sharp and Terada 2008); Korea (KEITI n.d.), Thailand, and Quebec. PAS 2050 also became the basis for a number of transnational carbon labeling standards. Chief amongst these is the World Business Council for Sustainable Development and the World Resources Institute's Product Life Cycle standard. Further, ISO 14067, a newly developed international standard for the quantification and communication of the carbon footprint of products, draws heavily on PAS 2050 and The Carbon Trust participated actively in its development (The Carbon Trust 2008, 5). Although unintentionally, the labeling intervention, through capacity building, catalyzed the emergence of multiple labeling interventions in other places that draw on the Carbon Trust methodology. An intervention targeted at one part of the system (the UK jurisdiction) helped spawn other interventions in the carbon lock-in fractal through modular scaling.

5.1.5 Entrenchment

Carbon labeling failed to entrench in the U.K. retail market, but footprinting in supply chains shows evidence of durability, exhibiting self-reinforcing and increasing returns logics. Once companies saw benefits from supply chain management of carbon footprints, those changes and the search for ongoing improvement became self-reinforcing. For example, one U.K.-based manufacturer who participated in Carbon Trust's footprinting pilot has begun to hold "supplier summits" to foster cooperation and drive innovation amongst suppliers (The Carbon Trust 2008,

4). Similarly, although harder to verify empirically, positive feedback appears to be at work since initially untargeted populations outside the United Kingdom joining the initiative should reinforce the benefits of early movers among U.K. manufacturers who encouraged footprinting along their supply chains. Less clear is whether carbon labeling itself will entrench in other jurisdictions where it is now being promoted, and whether that will increase populations of support and encourage further entrenchment in the United Kingdom. The interlocking nature of the carbon lock-in fractal means that the Carbon Trust intervention can have a disruptive effect well beyond its initial target system.

5.1.6 System Outcomes and Lessons

The substance of the Carbon Trust intervention suggested that it would catalyze a system improving trajectory. The initial failure of the intervention to scale or become entrenched through its intended theory of change would lead to a revision of that initial hypothesis and consider a system reinforcing trajectory to be the likely outcome. However, running this case through our framework highlights the importance of recursive evaluation to see what pathway it is on (i.e., improving as opposed to reinforcing or transformative), consideration of multiple forms of scaling and entrenchment, and the importance of unintended consequences.

Specifically, the combination of capacity building and normalization catalyzed scaling and entrenchment beyond the United Kingdom, but in unintended ways. Evidence suggests that carbon labeling has changed how companies mitigate their carbon emissions and interact with suppliers, helping to build coalitions of support and collaboration with suppliers, but entrenchment appears to be of management practices that saved costs, not the goal of reducing carbon footprints (Dauvergne and Lister 2013). Thus, this case also highlights how the substance

of the intervention has the potential to put boundaries on the possible trajectories of change, in this case toward system improvement rather than transformation.

6. Conclusions

Pathways to decarbonization are not only political, but politics is a crucial driving force behind their initiation, momentum, and ultimate transformative potential. This is well-recognized by scholars and practitioners seeking to understand and implement transitions to a more sustainable society. Our framework provides a new approach (though built on political science insights) to understanding how those politics of decarbonization function—how politics is not only an obstacle to decarbonization, but can also catalyze decarbonization pathways. In demonstrating how specific efforts to disrupt carbon lock-in catalyze political dynamics that have the potential for transforming both particular places and broader systems, we provide a direct way to incorporate the political dimensions of the transformations that we need to overcome the challenges of climate change.

One way forward with research on the politics of decarbonization involves analyzing a large number of cases through this framework in an attempt to understand and uncover the conditions that drive decarbonization trajectories. This is a framework in the literal sense—the concepts and interactions outlined illuminate the parameters and contours of the politics of decarbonization. The elements of the framework will play out in different ways as the politics of decarbonization unfolds in different ways, generating insights about transformative pathways both within and across systems. Our hope is that others will also find the framework useful and apply it, generating additional data on how the political mechanisms and effects play out, contributing to the building of cumulative knowledge about political conditions for transformative change

towards decarbonization. Additional work needs to bring together the insights on the politics of decarbonization generated through our framework with those from the sociotechnical transitions and economics literatures to provide a fuller understanding of the possibilities for transformation. Our political framework, most directly, aims to fill the missing links in those literatures between what is needed and why initiatives do or do not develop or track along those desired pathways.

Finally, it is crucial to note that there is clearly a normative element to the development and deployment of this framework and method, alone or in conjunction with other approaches to transitions. It is self-consciously pragmatic in its focus on causal mechanisms: problem-solving theory as opposed to critical theory (Cox 1981) that takes the desirability of decarbonization for granted. This has the potential to make the framework useful not only for studying decarbonization trajectories, but also developing them. Of course this raises crucial questions of contestation over the meaning and purpose of decarbonization, the ways in which pursuing decarbonization may empower certain groups over others, or even the possibility that decarbonization might be forced in undemocratic ways, exacerbate inequalities or pre-existing power dynamics, or be applied inappropriately in particular development contexts (Scoones, Leach, and Newell 2015). Decarbonization research should thus concentrate on understanding and imagining pathways to avoiding the worst impacts of climate change that are compatible with other social, political, and economic values. Analyzing the politics of how interventions play out in practice, however, is an essential component of such work as it makes those dynamics visible, a necessary step in guarding against or resisting undesirable outcomes.

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