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Change-actors in the U.S. electric energy system: The role of environmental groups in utility adoption and diffusion of wind power

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HIGHLIGHTS

- We study environmentalists′ impact on utility-scale renewable technology diffusion.
- Incumbent-dominated systems hinder the diffusion of new technologies.
- Environmental groups′ strategic actions increase legitimacy for new technologies.
- Environmental groups′ legitimating actions affect incumbent′s technology choice.
- Environmental groups create a favorable institutional context for new technologies.

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ABSTRACT

We study the contribution of environmental groups to new technology adoption and diffusion by dominant incumbents. Building on institutional and social movement theory, we develop a theoretical framework that sheds light on environmental groups as change-actors. We theorize that by approaching embedded key constituents with various strategic actions, environmental groups affect taken-for-granted beliefs, build legitimacy for renewable energy technologies, and convince skeptical constituents to support the new technology. We verify our theoretical framework with a case study of wind power development in Colorado. We find that environmentalists educate constituents on the benefits of the new technology, engage in activities leading to regulatory and legislative decisions for wind, while also providing direct assistance to the utility. As a result, utilities are both pressured and encouraged to adopt and diffuse wind power on a large-scale. This research directs attention to the role of environmental groups as change-actors and the legitimating effects of their actions. It highlights their part in creating a more favorable institutional environment for new technologies while directly influencing the incumbent's technology choice. This paper contributes to an understanding of bottom-up, actor-initiated changes in energy systems taking into account both the systemic technological infrastructure and the institutional context.

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> "Environmental problems must be solved through changes in the institutional arrangements that govern industry and social action." (Hoffman, 1999, p. 367)."

1. Introduction

Increasing renewable electricity generation in the U.S. electric energy system has become an important priority in discussions about how to address climate change issues and the environmental impact of electricity generation. The U.S. electricity system is largely dependent on conventional, fossil fuel burning generation technologies. Energy-related CO_2 emissions account for more than 80% of the U.S. greenhouse gas emissions, with electricity generation being the largest share, responsible for 40% of energy-related CO_2 emissions (EIA, 2011). Renewable energy technologies (RETs) for electricity production, such as wind and solar power, geothermal energy, forms of biomass, tidal power, and small hydropower, if deployed on a large-scale, are considered to have a great potential to meet future electricity demand (Neuhoff, 2005) while contributing, at the same time, to a significant reduction of CO_2 and greenhouse gas emissions. Apart from environmental benefits, a wide diffusion of RET can be a means to diversify domestic energy sources, diminish problems associated with dependence on foreign

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fossil-fuel supply, and contribute to a diverse electricity fuel mix, all of which are essential for ensuring a reliable electricity supply.

The U.S. electricity system is characterized by a systemic, incumbent-dominated technological infrastructure. Particularly major electric utility companies, i.e., investor-owned electric utilities (IOUs), would have the potential to widely diffuse RET and, consequently, to significantly reduce the environmental impact of electricity production and alter a state's electricity portfolio. However, despite the merits of a utility-scale diffusion of RET, most incumbent utilities seem to be reluctant to adopt new generation technologies. Electric utilities are found to defend established industry structures, inhibit regulatory changes towards the integration of RET, and to particularly lobby against their diffusion (Jacobsson and Bergek, 2004; Jacobsson and Lauber, 2006; Stenzel and Frenzel, 2008). IOUs seem to strongly prefer fossil fuel-burning technologies over RET. In fact, renewables represent only 1.4% of the IOU's electricity portfolio in the United States (excluding hydropower) (APPA, 2012a).

Over the past decade, several U.S. states have begun to employ various renewable policies that both encourage and require utilities to generate and sell renewable electricity. Thus, not all that surprisingly, most of the academic research examining drivers for utilities adopting RET has largely focused on policy incentives. For instance, a significant amount of recent research is dedicated to analyzing the effectiveness of different green power policies (e.g., Bird et al., 2005; Delmas and Montes-Sancho, 2011; Menz and Vachon, 2006). While this work is useful for informing about the design of a supportive regulatory environment for renewables, most of these studies assume policy incentives to be the initial and often only stimulus for utility investment in RET, and credit RET diffusion solely to regulatory changes. However, these studies cannot explain what drives electric utilities to initially adopt new generation technologies when no supportive policies are in place. Furthermore, these studies often treat policies as given, exogenous variables and do not provide information on what triggers the implementation of renewable policies in the first place. Basically, there has been little research on the essential role of change-actors in the process of encouraging incumbent utilities to adopt and widely diffuse RET. Yet, such research may contribute to a better understanding of the social acceptance and sustainable growth of a utility-scale renewable energy sector.

Motivated by this gap in the literature, we explore how environmental groups can introduce RET as an alternative technological solution to well-established, conventional electricity generation technologies and encourage incumbent utilities to adopt and diffuse RET in markets where enforcing policy mechanisms are initially absent. Environmental groups are known to be strongly concerned about the environmental impact of electricity production. In this study, we investigate their ability and strategies to introduce alternative technological solutions and create a supportive institutional environment for new technologies to prosper.

Building on insights from institutional theory and research on social movements, we understand environmental groups as change-actors acting from the periphery of organizational fields (Leblebic et al., 1991; McAdam and Scott, 2005). We develop a theoretical framework of how they introduce new technologies as an alternative to highly institutionalized practice used by dominant incumbents and verify our theoretical insights with a case study on wind power diffusion in Colorado. Our framework focuses on environmental groups' diverse strategic actions aimed at persuading relevant field constituents to support the new technology as a legitimate alternative, and encouraging incumbent firms to adopt and diffuse the new technology. While recent research has begun to acknowledge the influential role of environmental groups in the energy sector (Lee and Sine, 2007; Sine and Lee, 2009), past research mainly focused on the advocates' impact on entrepreneurial activity. We still know little about the influence of environmental groups on the technology choice of incumbent firms dominating a systemic technological infrastructure. Hence, in our study, we seek to fill this research gap by taking into account the incumbent-dominated technological infrastructure of the electric energy system, the role of other important field constituents, and the institutional barriers to new technology diffusion.

Our paper is structured as follows. In Section 2, we outline recent research on drivers for utility-scale renewable electricity generation, showing the need for an understanding of actor-initiated changes. We then describe the incumbent-dominated technological infrastructure of the U.S. electricity system and analyze the industry from an institutional perspective. In Section 4, we turn to our theoretical framework and elaborate on the ability and diverse strategic actions of environmental groups to encourage new technology adoption and diffusion. In Section 5, we present our case study of utility-scale wind power development in Colorado. We chose the case of Colorado since regulatory support for RET had not been achieved there and fossil-fuel burning technologies were perceived as the least-cost and most reliable, thus unchallenged practice for electricity generation. This case sheds light on the influential role of environmental groups and how their actions eventually led to the initial adoption of wind technology by the state's dominant electric utility, followed by a wide diffusion of wind power. Lastly, we discuss our findings.

2. Drivers for the adoption and diffusion of RET by incumbent utilities

Recent research examining drivers for utilities to adopt and diffuse technologies for renewable electricity generation has largely focused on the influence of public policy mechanisms. For instance, changes in the political agenda, such as electricity deregulation, have been shown to motivate utilities to invest in RET and offer green electricity. Under deregulation, incumbent utilities face competitive threats that are likely to foster the adoption of new technology (Delmas et al., 2007). Similarly, Markard and Truffer (2006) found that the liberalization of electricity markets has served as a driver for electric utilities to engage in innovation activities and that it has induced a shift towards new technology adoption in utility electricity generation.

In a similar vein, policy scholars have focused on the effectiveness of different renewable energy policies on the utility-scale diffusion of RET. For example, in a study on wind power development in California, Russo (2003) demonstrated that government support such as tax credits can initiate a market for RET. Bird et al. (2005) explored key factors that spur wind power development in 12 U.S. states and concluded that state policy instruments, particularly renewable portfolio standards (RPSs), are key drivers. While Menz and Vachon (2006) found that RPS and mandatory green power options have a positive effect on the diffusion of wind technology, Delmas and Montes-Sancho (2011) further differentiated between types of utilities and showed that RPSs in particular provide a stimulus for private utilities to invest in renewables.

A different line of research has shown that sudden events such as energy shortages, economic crises, or environmental disasters can give major impulses to change traditional incumbent practice (Meyer, 1982). Examples of such events are the oil crisis of the 1970s, the Deepwater Horizon oil spill in 2010, and nuclear accidents such as Chernobyl in 1986 and the Fukushima nuclear disaster in 2011. Such events can significantly alter the political and social perception of the benefits of environmentally friendly

electricity generation, and often eventuate in regulatory changes fostering renewable electricity generation. For instance, Sine and David (2003) showed that the 1970s oil crisis eroded the perception of electricity as an inexpensive and unlimited resource, created awareness for RET, and mobilized a new energy policy agenda in the United States.

To conclude, the main drivers for utility-scale renewable energy development have been found to be impulses such as new policy measures, regulatory changes, or unpredictable events. While this work sheds light on the positive effect of exogenous stimuli on changes in traditional utility practice, it often neglects the important role of change-actors such as environmental groups. For example, policy scholars typically assume that public policies provide the initial and often single stimulus for utility investment in renewables and that markets for RET are top-down government-induced (e.g., Loiter and Norberg-Bohm, 1999; Norberg-Bohm, 2010; Stenzel and Frenzel, 2008). The creation and implementation process of public policies as well as the importance of creating a supportive socio-cognitive institutional environment for RET are often neglected (for a notable exception, see Delmas and Montes-Sancho, 2011; Jacobsson and Lauber, 2006; Unruh, 2002; van Est, 1999). We know little about the essential role of change-actors in the process of encouraging incumbent utilities to adopt and widely diffuse RET, and their impact in creating a favorable institutional environment for renewables. In addition, very few of these studies take into account the high institutional barriers to new technology adoption and the technological infrastructure of the U.S. electricity system. This is surprising given that the inertia of the existing system is in large part governed by the utility-dominated infrastructure as well as the established institutional arrangements that favor conventional generation technologies.

3. Barriers to utility-scale renewable electricity generation

3.1. Empirical context: incumbent-dominated technological infrastructure of the U.S. electric energy system

The U.S. electric industry is served by approximately 200 IOUs and 2000 public utilities (Giles, 2010), of which the IOUs are large-sized and well established incumbent firms that hold a dominant position in the complex system of electricity generation, transmission, and distribution in most U.S. states. IOUs are major regional service providers supplying power to almost 70% of the U.S. consumers (EIA, 2009), representing 40% of the total U.S. generation capacity (APPA, 2012b), and manage most of their own transmission and distribution (DOE, 2002).

The technological infrastructure with the dominant position of vertically integrated IOUs can be traced back to the beginning of the 20th century. Prominent utility managers, politicians, and reform groups reached the consensus that IOUs are 'natural monopolies' (Hirsh, 1999), that is, utility companies were granted the exclusive right to sell electricity in their service territory and thus obtained a very privileged status in the American economy. To fulfill their mandate of serving the needs of captive customers in their geographic region in a reliable manner and at least cost, decisions regarding the design and operation of generation plants have been made in favor of building more and larger fossil-fueled power plants operated centrally by the incumbent utilities. Being accepted as natural monopolies and fostering such a scaling strategy, along with a growing demand for electricity, has helped IOUs to increasingly build up this practice and maintain their dominance over an expanding, fossil fuel-based electricity system (Hirsh, 1999).

Today, the U.S. electric energy system is still almost exclusively dependent on conventional electricity generation technologies. In 2011, about 86% of U.S. electricity was generated by coal, natural gas, and nuclear power (EIA, 2012a). For their own electricity generation, IOUs rely heavily on coal (ca. 45%) and natural gas (ca. 33%) (APPA, 2012a). Even though the introduction of RET was facilitated thanks to the Public Utility Regulatory Policies Act of 1978[3], the ensuing electricity deregulation on a state-by-state basis[4] as well as tax credits on the federal and state-level[5], IOUs have essentially made very little progress in using the potential of renewables. In fact, renewables represent only 1.4% of the IOU's electricity portfolio (APPA, 2012a).

Thus, on the one hand, the dominant and powerful position of incumbent utilities in the U.S. electricity system has led to inertia in terms of new technology adoption and diffusion; for decades, major electric utilities have strongly depended on, and still favor, conventional electricity generation technologies and are found to respond skeptically, or even hostilely, towards the adoption of RET. On the other hand, the systemic infrastructure makes a simple bypassing or substitution of the incumbent firms almost impossible when introducing new generation technologies on a large-scale. A large-scale diffusion of RET could be facilitated considerably through higher utility commitment in renewables. Particularly well-established IOUs, with their high market share, would have the potential to widely diffuse RET and to significantly reduce the environmental impact of electricity production. However, these major electric utilities typically argue that RET are incompatible with the established system of centralized power generation and the prevailing operational and technical standards (Markard and Truffer, 2006).

3.2. Institutional perspective on the U.S. electric energy system

While there are certainly technological barriers to a utility-scale diffusion of RET, the strong utility opposition towards renewables can best be explained from an institutional analytical perspective. From this perspective, the U.S. electricity system can be regarded as an organizational field made up of a community of relevant constituents including electric utilities, investors, regulators, customers, and policy makers that, over decades, have formed around traditional utility practice (DiMaggio and Powell, 1983; Leblebic et al., 1991; Scott, 1991; Sine and David, 2003; Wooten and Hoffman, 2008).[6] These central field constituents are banded together by common interests and share a common meaning system or institutional setting (Scott, 2008). Institutions can be defined as consisting of socially constructed beliefs, commonly shared norms, and regulative structures that provide stability and meaning to constituents' behavior and determine

[3] PURPA was passed in order to encourage the development of cogeneration and small power production facilities based on renewable energy sources. IOUs were required to purchase electric energy from non-utility generators, qualifying facilities, at the utilities' avoided cost. Thus, so far, federal legislation has only opened up the electricity wholesale markets in the United States.

[4] In states with deregulated energy markets, the monopoly system has been replaced to introduce competition to electricity markets. Retail customers are no longer captive and may choose to purchase electricity from competing sellers. There are 15 states that currently operate deregulated retail markets. Thus, most U.S. states still have regulated electricity markets (EIA, 2010).

[5] The federal Production Tax Credit (PTC) was first enacted in 1992 and offered a tax credit per-kilowatt-hour depending on the amount of eligible RET generated electricity sold to a third party in the taxable year. Since its enactment in 1992, the PTC has been altered several times (2000, 2002, 2004, 2009, and, most recently, in 2013). Before the PTC, a federal Investment Tax Credit (ITC) had been introduced in 1978 and had expired in 1985. It offered a tax credit for the capital cost of installing RE production facilities. As an example of a state-level tax credit, in California, an additional ITC was enacted in 1978 and expired in 1986 (DSIRE, 2012).

[6] The concept of an 'organizational field' needs to be distinguished from an 'industry': The first includes a broader range of relevant actors and key constituents and is the central unit of analysis in institutional theory (DiMaggio and Powell, 1983).

what practices are considered appropriate (DiMaggio and Powell, 1983; Meyer and Rowan, 1977; Scott, 2008). One core idea of institutional theory[7] is that field constituents are affected by the same institutional context. Put differently, field members are institutionally embedded. They are "captives" (Tolbert and Zucker, 1983, p. 22) of a common set of institutional forces that direct their actions, shape their perceptions, and define their interests (Clemens and Cook, 1999; DiMaggio and Powell, 1991; Friedland and Alford, 1991).

Given how institutional forces work on embedded field constituents, certain practices within an organizational field tend to become institutionalized over time; central field members conform to these practices, widely adopt them, consider them to be legitimate, and eventually take them for granted (Berger and Luckmann, 1967; Meyer and Rowan, 1977), so that alternatives, such as new technologies, become "unthinkable" (Zucker, 1983, p. 5). The more legitimate a practice is considered to be, the more difficult it is for field actors to deviate from the current practice or to envision new practices. Particularly dominant and powerful actors within an organizational field, who would have the resources to pursue alternative practices, are unlikely to bring about change. They are privileged and empowered by existing institutional arrangements and have their power and interests vested in current practices (Garud et al., 2007; Greenwood and Suddaby, 2006).

Applying institutional theory to the U.S. electric energy system, IOUs can be regarded as particularly powerful actors within the organizational field around the institutionalized practice of large-scale fossil-fueled energy generation (Hirsh, 1999; Sine and David, 2003). Electric utilities have conformed to this practice and widely replicated it, resulting in homogeneity in terms of generation technology (DiMaggio and Powell, 1983). Other central field constituents – including consumers, utility stockholders, regulators, and policy makers, banded together through a common interest in reliable, least cost electricity – have widely accepted this practice as being meaningful and legitimate, and do not challenge its appropriateness.

Moreover, the existing institutional arrangements have empowered IOUs as legitimate "experts on power" (Sine and David, 2003, p. 203), authorized and supported by embedded field members to maintain their practice over decades. RET were viewed with distrust and skepticism by utilities and field constituents and have not been perceived as a legitimate alternative to the highly developed conventional generation technologies (Hirsh, 1999; Sachs and Muller, 1992). For instance, state regulatory commissioners, established in the early 20th century as the result of the utility consensus treating electricity supply companies as natural monopolies, regulate IOUs and determine electricity rates, their rate of return, and the level of operating costs and expenditures (Gormley, 1983; Joskow, 1974). Although regulators have substantial discretion in regulating utility rates and approving investments in new technology such as RET, they have traditionally deferred to utility managers on most operational issues and supported their preference for constructing large fossil-fueled power plants operated centrally by the incumbent utilities. Intervening and stimulating investment in largely unproven RET would mean taking high risk and a radical departure from traditional regulatory attitude (Barkovich, 1989).

Hence, a strong set of institutions exhibiting relative stability and inertia, and suppressing new technology diffusion has been in place. Utility-scale fossil-fueled electricity production has become the taken-for-granted practice in the field. Central field participants generally do not challenge institutionalized practices, nor do they bring up or envision alternative practices, while dominant incumbent actors have no motivation to deviate from the status quo (DiMaggio and Powell, 1983; Greenwood and Suddaby, 2006). Since the systemic technological infrastructure makes a simple substitution of incumbent utilities almost impossible, RETs need to overcome high institutional hurdles and require acceptance by key constituents in order to become a legitimate technological alternative (Aldrich and Fiol, 1994). In the following section, we develop a framework of how environmental groups, acting from the periphery of an organizational field, can contribute to the adoption and diffusion of new technologies in incumbent-dominated systems.

4. Theoretical framework

Institutional theorists acknowledge that changes in the institutional context and perception of central field members regarding the appropriateness of new practices can be driven through certain change-actors (DiMaggio, 1988). In particular, social movement theory has recently been taken up by institutional theorists to study actor-initiated changes to established fields (McAdam and Scott, 2005). This recent stream of work emphasizes the role of agency and analyzes actors´ strategies for changing institutionalized practices (Leblebic et al., 1991). Social movements represent "purposive and collective attempt[s] of a number of people to change individuals or societies institutions and structures" (Zald and Ash, 1966, p. 329). They oppose the status quo with the goal of deinstitutionalizing existing taken-for-granted norms, values, and beliefs (Benford and Snow, 2000) and establish new, more favorable structures that create awareness and social acceptance for new technologies and activities (Sine and Lee, 2009). The U.S. environmentalism has generally been described as one of the most influential and largest social movements in the United States (Brulle, 2000; Dunlap and Mertig, 1992). Social movement theory can thus be meaningful when studying environmental groups as change-actors and their role in contributing to the diffusion of RET as an alternative to traditional utility practices.

Environmental groups are strongly concerned about the environmental effects of electricity generation and advocate the diffusion of clean energy technologies (e.g., Hawkins, 2009; Union of Concerned Scientists, 2011). Being strongly committed to their goals, they possess the necessary scientific and legal expertise to challenge the prevalent institutional logic maintaining that only fossil fueled technologies can generate reliable and least-cost electricity. In order to bring about change, they actively participate in field-level processes. For example, they litigate in courts and testify at public hearings (Mitchell et al., 1992), where they provide knowledge and expertise on new technological developments, explaining and justifying the new technology to key constituents. They possess in-depth knowledge about the technology and organizational field processes, and get to know the relevant field constituents. However, they have no formal interrelation with these field constituents, are therefore not directly affected by their actions, and can withstand overwhelming opposition (Gerlach, 2001; Hirst, 1994). Consequently, environmental groups are not institutionally embedded in the organizational field, and can challenge and change the established order and field participants' beliefs about the appropriateness and value of new technologies.

[7] In this paper, we understand institutional theory as sociological institutionalism or new institutionalism, as developed in the 1970s to explain organizational behavior (DiMaggio and Powell, 1983; Meyer and Rowan, 1977). New institutionalism emphasizes institutions as stable and relatively change-resistant. Actors of the same organizational field are subject to the same institutional context that exercises pressures of conformity on actors, leading to compliance of actors to the institutional rules in order to receive legitimacy and support (Scott, 2008). However, the institutional context is not simply constructed by the contemporary field actors themselves, but has historical origins (Meyer, 2008).

Indeed, as prior research suggests, they are "fringe" players (Leblebic et al., 1991, p. 359), acting from the periphery of organizational fields. They have the knowledge and commitment to change prevalent institutional practices because they "are less embedded in the organizational field, less privileged, and more exposed to institutional contradictions" (Greenwood and Suddaby, 2006, p. 29). Thus, we suggest that environmental groups, as peripheral actors to an organizational field, have the ability to introduce new technologies to established fields and to proactively engage in strategic actions that build legitimacy for new technologies among skeptical field constituents.

Building on these insights from social movement and institutional theory, we propose that peripheral change-actors introduce alternative technological solutions to the incumbent firm as well as to the various interlinked embedded field members, and engage in legitimating actions that involve disseminating information about the practicability of alternative practices, and educating field constituents about the benefits. Environmental groups can influence the taken-for-granted beliefs of the central field members, and convince them of the appropriateness of new practices. We argue that the strategic actions of peripheral actors can alter the prevailing institutional context and result in a higher level of legitimacy for the new technology among central field participants. We further suggest that these actions encourage new technology adoption by the incumbent firm, and support technology diffusion. Our theoretical framework (Fig. 1) illustrates environmental groups at the periphery of the organizational field introducing an alternative technological solution to central field members such as the incumbent firm, legislators, regulators, and consumers, and engaging in strategic legitimating actions, while encouraging the incumbent firm to adopt and diffuse the new technology.

In particular, our framework suggests that environmental groups approach and introduce the alternative technology to each constituent using various strategic actions. Environmental groups approach the *legislators* to lobby for regulatory changes that are in line with their values and goals (Hiatt et al., 2009; Zald et al., 2005). In this process, they create alertness for environmental issues among policy makers, depict alternative environmentally sound technological scenarios, and challenge current institutionalized practices. In their effort to build support for the new technology on the legislators' side, environmental groups try to embed their values into the regulative structure (Sine and Lee, 2009). In order to approach the state *regulators* who oversee the incumbent firm (Russo, 2001), environmental groups participate in regulatory hearings and provide testimonies. In doing so, they inform and persuade the regulators about the values and benefits of adopting new technologies, seeking to influence the regulators' decision on which technologies to include in the utility energy portfolio (Hirst, 1994). Therefore, we propose that environmental groups, by introducing the new technology to both legislators and regulators and engaging in strategic legitimating actions, create a more favorable regulative institutional environment, which contributes to the diffusion of new technologies through incumbent firms.

Environmental groups can also approach the *consumers* of the incumbent's product. By educating them about the benefits of the new technology and promoting new sets of assumptions, behavioral norms and values (Sine and Lee, 2009; Tolbert et al., 2010), they affect the consumers' perception and understanding, and create social awareness for environmentally friendly electricity. By doing so, environmental groups contribute to the creation of consumer demand for alternative solutions that triggers the diffusion of the alternative technology (Bird et al., 2005). Thus, we further suggest that environmental groups, by introducing the new technology to consumers and engaging in strategic legitimating actions, create a more favorable social institutional environment reflected in growing consumer demand, which contributes to the diffusion of new technologies through incumbent firms.

As electric energy systems are characterized by strong institutional forces and a systemic technological infrastructure that have formed around dominant incumbent practice (for a similar argument, see also Unruh (2000) in his discussion of carbon lock-in), a simple bypassing or substitution of the incumbent firms is almost impossible when introducing new technologies on a large-scale. Consequently, in such environments, incumbents represent key actors who can enable new technology diffusion. To account for the central role of incumbents in electric energy systems, our framework departs from the strategic actions of undermining or displacing the incumbent firm that are commonly referred to in the literature on social movements (Haveman et al., 2007; Hiatt

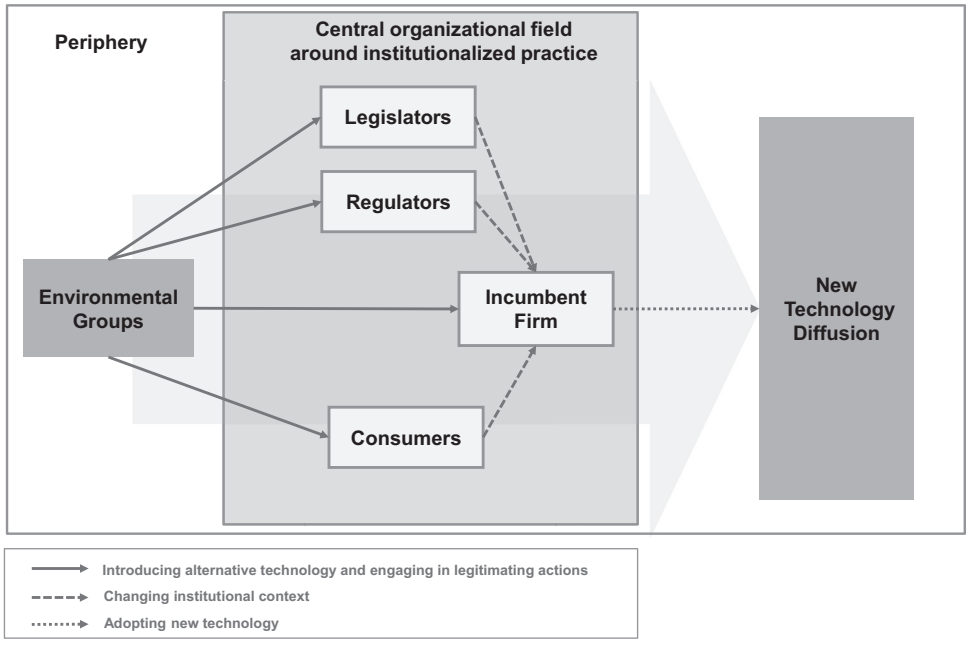

Fig. 1. Theoretical framework of new technology diffusion.

et al., 2009; Ingram et al., 2010; Weber et al., 2009), viewing displacement as the only effective way to induce change in the presence of powerful incumbents and strong institutional forces (Luders, 2006). In contrast, we argue rather that environmental groups, due to their technological and industry expertise, can directly approach and assist incumbent firms in adopting new, environmentally friendly technologies. For instance, the strategy of assisting rather than attacking incumbents has been found to be successful in the context of the adoption and diffusion of ozone-safe hydrocarbon refrigeration technology (Hartman and Stafford, 1997). Similarly, in their study of the creation of the U.S. recycling industry, Lounsbury et al. (2003) highlight the importance of alliances between social movements and industry incumbents. Environmental advocates are also found to offer technical assistance to incumbents in order to facilitate new technology adoption (Fischhoff, 2007). Following this, we propose that environmental groups, by introducing the new technology directly to incumbents instead of trying to displace them, contribute to the adoption and diffusion of new technologies through incumbent firms.

In the following section, we evaluate the usefulness of our theoretical framework with a case study on the diffusion of wind technology in Colorado.

5. Case study of wind power in Colorado

5.1. Analytical approach

While single case studies are often criticized when applied for theory generation (Eisenhardt and Graebner, 2007; Yin, 2009), they are of great relevance when they represent a critical case that can confirm, challenge, or extend existing theory (Yin, 2009). We chose to conduct this single case study to evaluate whether we can confirm existing theory on the impact of environmental groups on new technology diffusion, and to develop propositions by contrasting preexisting knowledge with observed events (Lee et al., 1999). We provide an in-depth analysis of *how* environmental groups can introduce and legitimate new technologies, which are insights quantitative data cannot reveal. We used theoretical sampling and chose to study the influence of environmental groups on the diffusion of wind power into Colorado's electric energy system from 1992 until 2009 for several reasons. First, Colorado's electric utilities used to rely almost exclusively on large, fossil-fueled generation plants, primarily fired by coal (EIA, 1999). Even though Colorado possesses a huge potential of renewable resources, particularly wind, there was no installed wind generating capacity for large-scale utility applications prior to 1999. However, by 2009, wind power had grown to become the primary renewable energy generation source, representing 67.3% of generated electricity from RET in 2010 (EIA, 2012b). Second, in Colorado, there were no state policy incentives prior to 2004, which provides an ideal field for studying utility adoption and diffusion of new technologies that is not induced by public policies. And third, Colorado's electric energy system is dominated by a vertically integrated IOU enjoying monopolistic structures and high market power, and whose electricity portfolio largely determines the state's electricity mix. In this setting, the institutional barriers to RET and the incumbent-dominated technological infrastructure are apparent and revelatory.

Various data sources were collected in a case study database to increase the reliability of the case study (Yin, 2009). Semi-structured interviews with experts in the field were the main form of data collection. We conducted a total of 21 interviews in person and 6 per telephone with experts from the electric utility, regulatory agency, research labs, environmental community, and wind power companies. The interviews were led by one investigator, while the second administrated the recording and took notes to allow different perspectives (Eisenhardt, 1989), and lasted from 1/2 h to approximately 3 h. Furthermore, archival records and annual reports from the electric utility, the regulatory agency, environmental groups as well as relevant databases were systematically analyzed. We supplemented our database with secondary sources, including book chapters, newspaper articles, and web pages. This triangulation was important to increase construct validity (Yin, 2009). During the process of data analysis, we used multiple iterations, moving between the theory's propositions and the different data sources to elaborate and reframe our initial analysis, seeking to increase the internal validity of the case study.

5.2. At the outset: established utility practice in Colorado

In Colorado, coal-fired electricity generation has been the most prevalent and established utility practice, while the state's electric energy system is characterized by a particularly dominant IOU enjoying monopoly power. In 1986, for instance, utility coal generation accounted for 89.5% and in 1996 for 86% of the state's total electricity generation, while gas accounted for approx. 1% and utility hydro for approx. 4% in 1996. The largest and most dominant incumbent utility has been the Public Service Company of Colorado (PSCo).[8] This vertically integrated IOU has developed into the state's dominant electricity provider, serving more than half of Colorado's electricity and operating four of the state's largest coal fired plants (EIA, 1999). The other electric utilities in Colorado are mostly public utilities (29 in 1996) and are significantly smaller electricity providers than PSCo in terms of customer reach, revenue, and electricity generation. PSCo used to respond rather skeptically to the adoption of renewable generation technologies. Even though Colorado is blessed with large amounts of windy land, the incumbent utility did not perceive wind as a legitimate alternative to coal and was reluctant to develop wind power for its electricity mix (Hirst and Swanson, 1994).

PSCo is overseen by Colorado's regulatory commission, the Colorado Public Utilities Commission (PUC). The PUC has jurisdiction over IOUs in Colorado and plays an influential role in decisions on which technologies to include in PSCo's electricity portfolio. Colorado's commissioners are appointed by the State Governor and confirmed by the Senate for a 4 year term. Research on regulatory behavior suggests that, compared to elected regulators, appointed regulators are not faced with election constraints and do not, therefore, consider consumer interests to the same extent as the elected commissioners do. While elected regulators may pursue short-term consumer interests at the expense of energy independence or environmental protection, their appointed counterparts tend to place more weight on utility interests (Besley and Coate, 2003; Holburn and Vanden Bergh, 2008). In the past, Colorado's regulatory agency has strongly emphasized the use of least cost energy sources for electricity generation. Thus, the "PUC was not seen as particularly renewable-friendly" (Komor, 2006, p. 137). Colorado's regulators did not perceive environmental benign generation technologies, such as wind, as appropriate and were skeptical because of them being supposedly more expensive.

Furthermore, Colorado's legislatures were slow in supporting RET for electricity generation. Whereas other U.S. states had

[8] The utility was founded in 1913 as Colorado Power Company, and was renamed the Public Service Company of Colorado (PSCo) in 1924. In 1997, PSCo was operated under New Century Energies, which merged with Northern States Power in 2000 to form the current electric utility Xcel Energy. As Xcel Energy operates in Michigan, Minnesota, New Mexico, North Dakota, South Dakota, Texas, and Wisconsin, we refer to PSCo to depict Xcel's activities in Colorado.

started to introduce renewable energy policies in 1978, there were no such policies in place in Colorado until 2004 (DSIRE, 2012). Although individual visionary political actors aimed to advance RET in the 1990s, their policy proposals were not further considered in the legislative processes (Cox, 2007) and, in addition, Colorado′s electricity consumers (residential, business, and municipalities) did not actively support the usage of RET.

5.3. Half-time: initial adoption of utility-scale wind power

While central field actors such as regulators, policy makers, and customers did not question traditional utility practice, environmental groups who challenged the use of fossil-fueled electricity generation technologies were active in Colorado. Particularly the Land and Water Funds of the Rockies (LAW Fund), later renamed Western Resource Advocates, a regional non-profit organization, was strongly concerned about the environmental effects of electricity production. In 1991, the LAW Fund started an energy project with the overall goal of building a sustainable energy future. Staffed with lawyers, an economist, and an engineer, who were highly committed to this goal, the LAW Fund possessed important legal and technical skills to challenge the "energy-efficiency, renewable-resource and environmental-protection practices of utilities" (Hirst and Swanson, 1994, p. 1). To begin with, the environmental group focused primarily on utility demand-side management and integrated resource planning (IRP).[9] Seeking to influence regulatory decision making, the LAW Fund drafted an IRP rule in line with their values (Hirst et al., 1992, 1993) and intervened in PUC hearings, cross-examined witnesses in these hearings, presented testimonies, and successfully convinced Colorado′s regulators to issue an IRP rule that forced utilities to incorporate environmental externalities into their resources planning (CPUC, 1992). Eager to implement the requirements from the new IRP rule, the LAW Fund provided technical assistance to PSCo. Thus, despite adversary targets, the environmental group "viewed the utilities as important allies, not as enemies" (Hirst, 1994, p. 71) and sought to work cooperatively with the utility in order to achieve its goal.

Although the LAW Fund managed to raise tentative environmental awareness, its lobbying efforts of the mid-1990s to introduce wind energy in Colorado failed. After assessing several RET and identifying wind as a valuable source for electricity in Colorado in 1992 (Hirst and Swanson, 1994), the group intervened in PUC hearings to introduce and advocate the idea of utility-scale wind power for the first time. However, the PUC was not very supportive of wind energy at that time, and PSCo had therefore little motivation to deviate from its current strategy. As one expert explained, the environmental group concluded after this rather unsuccessful introduction of wind power: "we are not getting anywhere in the regulatory sense. We go to Denver all the time and argue to the state … it′s not a viable strategy for us anymore."

As regulatory efforts were not enough to achieve utility adoption of wind technology, the LAW Fund decided to depart from its adversarial tactics and presented the PSCo with a proposal: a conjointly implemented green pricing program that would offer consumers the option of buying renewable electricity, at a premium price, generated from Colorado's first wind park to be developed by PSCo. Since PSCo was feeling threatened by a possible electricity deregulation at that time and was looking for a possibility to gain experience with market-driven forces, the LAW Fund and the utility agreed to partner in the development and implementation of Windsource, a voluntary customer program. In this astonishing partnership, the LAW Fund assisted PSCo in pricing the program and took on the role of building support for wind power among Colorado′s electricity buyers (Mayer et al., 1997). Supported by other local environmental groups such as Colorado Renewable Energy Society, the Boulder Energy Conservation Center, and the local chapter of the Sierra Club, the LAW Fund developed and coordinated grassroots techniques aimed at informing and educating residential and business electricity consumers about the environmental benefits of wind power and building awareness about their energy choice. The environmental groups sent newsletters to potential customers and informed Colorado′s citizens at community events, festivals, in supermarkets, and at other local venues, thus concentrating all their effort on creating electricity consumer support and demand for wind power to make this program a success for both the environmental community and the utility. PSCo, who had a poor environmental reputation, also benefited from this collaboration because it lent the necessary credibility to the green pricing program. The innovative partnership along with the environmental group actions mobilized support for wind power by many of Colorado′s electricity consumers and drove the number of subscriptions far beyond expectations. In 2000, Windsource was one of the largest green pricing programs in the U.S., with already more than 15,000 participants (Xcel Energy, 2000), and grew steadily.

As a response to the increasing demand for Windsource and the growing legitimacy of wind technology, other electric utilities in Colorado also started designing green pricing programs, while the first large-scale wind turbines (Ponnequin I) were installed by the end of 1999, providing 21.6 MW of wind energy from 29 wind turbines, owned and operated by PSCo. Having become more comfortable with wind technology, PSCo decided to build and operate a second wind park (Ponnequin II) in 2001. Thus, the strategic actions of environmental groups eventually paid off and led to the initial utility adoption of the new generation technology. Looking back, as one expert from the electric utility described it, the key initial factor for the PSCo investing in RET "was a program called WindSource …, a value-added product that had a customer choice element to it".

5.4. On the finish line: the diffusion of wind power in Colorado

Set on further increasing the amount of installed wind capacity in Colorado, in 2001, the LAW Fund, supported by the Colorado Renewable Energy Society, again made use of lobbying tactics and intervened in PUC hearings on acquiring additional electricity supply as part of PSCo′s IRP plan. PSCo proposed a gas-fired portfolio of new generating plants and excluded a wind farm proposal that would supply the output of 162 MW from a wind farm near Lamar, Colorado (Lehr et al., 2001). During the course of these hearings, the environmental advocates provided detailed analyses on wind power economics and technical performance characteristics. For instance, the LAW Fund directly testified and presented calculations to assess the cost-effectiveness and energy benefits of the proposed wind farm for PSCo's energy portfolio, proving that the wind project was not only the most environmentally benign but also the most cost-effective solution (Lehr et al., 2001). Based on these new perspectives on wind power and its economics, the regulators′ skepticism towards RET faded: "We find that adding Enron′s Lamar wind energy bid to PSCo′s preferred resources plan is in the public interest and comports with the IRP rules." (CPUC, 2001, p. 34). Unheard of before, the environmental groups were able to convince the PUC that wind energy was a legitimate and viable alternative to conventional fossil-fueled plants, which then directed PSCo to include more wind in its resource plan and to purchase the output from the proposed wind project. Colorado Green, the wind farm resulting from the PUC decision, was then built in 2003.

Encouraged by the PUC order as another step toward a sustainable electric energy system with a wider use of wind sources in Colorado, the environmental groups turned to Colorado′s legislatures in an attempt to obtain governmental support for RET. This time, the

[9] IRP is a planning tool that requires electric utilities to determine the type and amount of energy resources needed to meet the future demand for electricity.

Table 1
Diffusion of utility-scale wind power in Colorado: utility generated and purchased wind power
Source: Windpower Engineering & Development (2012).

Date	Wind farm	Capacity (MW)	Owner	Power purchaser
1999	Ponnequin I	21.6	PSCo	PSCo
2001	Ponnequin II	9.9	PSCo	PSCo
	Peetz Table I	29.7	Terra-Gen Power	PSCo
2003	Colorado Green	162	Iberdrola Renewables/Shell Wind Energy	PSCo
2004	Lamar	7.5	Lamar Municipal Utility/Arkansas River Power Authority	Lamar Municipal Utility/Arkansas River Power Authority
	Springfield	1.5	Lamar Light & Power	Lamar Light & Power
2006	Spring Canyon	60	Invenergy	PSCo
2007	Cedar Creek Ia	79.5	Infigen/BP America	PSCo
	Cedar Creek Ib	221	Infigen/BP America	PSCo
	Peetz Table II	400.5	NextEra Energy	PSCo
	Twin Buttes	75	Iberdrola Renewables	PSCo
2009	Northeastern Colorado I-a	151.8	NextEra Energy	PSCo
	Northeastern Colorado I-b	22.5	NextEra Energy	PSCo
Sum		**1248.50**	**2.5% PSCo share**	**98.8% PSCo share**

environmental groups′ activities focused on the implementation of an RPS that would require PSCo and other electric providers by law to obtain a certain percentage of their electricity from renewable sources. The LAW Fund approached individual policy makers who were willing to support renewable energy development in Colorado, and together they drafted and lobbied for the bill in the legislative process. However, after 3 years of legal battles (2002 until 2004) in which the bill failed to pass, due largely to opposing forces from RET opponents, the LAW Fund, flanked by other environmental groups, considered a different strategy: they decided to use the growing support for wind energy among Colorado′s electricity consumers and activated a ballot initiative in 2004, bringing the decision to pass an RPS directly to Colorado′s residents. Again, the environmental groups invested all their effort into obtaining their goal. They worked together with policy makers in drafting Amendment 37, and started an enormous public campaign to collect the necessary 60,000 signatures to place Amendment 37 on the ballot and to convince enough voters to approve it. In particular, they informed and educated Colorado's electricity consumers about the rural economic development opportunities associated with RET and their cost stability in comparison to conventional energy sources with volatile prices, and emphasized the positive environmental effects (Latour, 2007). This joint effort of environmental groups working together with engaged policy makers, along with the increasing legitimacy for wind power in Colorado′s society thanks to the environmental groups′ activities, finally led to Amendment 37 being passed. The environmental groups′ fight for legislative support and the establishment of the RPS further spurred the utility-scale diffusion of wind energy in Colorado (see Table 1).

In the following years, more wind farms were developed. PSCo increasingly considered wind technology to be a legitimate way of generating electricity and has become the largest purchaser of wind power in the U.S. (AWEA, 2009). As Table 1 depicts, PSCo purchased the power of almost 99% of all installed wind turbines in Colorado. Colorado′s electricity portfolio also changed greatly: in 2007, the cumulative amount of installed wind power reached 1068 MW, and by 2010, wind had become Colorado′s primary renewable energy source, with an installed capacity of 9.4% and a net generation of 6.8% of the state total (EIA, 2012b).

6. Discussion

6.1. Discussion of the theoretical framework

The purpose of this paper is to study the environmental groups′ ability and strategic actions in contributing to the adoption and diffusion of RET by incumbent utilities, while taking into account the systemic technological infrastructure of the U.S. electric energy system, the role of other important field constituents as well as institutional barriers to new technology diffusion. We take an institutional perspective and develop a theoretical framework to shed light on environmental groups as change-actors and their role in introducing and building legitimacy for alternative technologies among skeptical field constituents. Central to our theoretical framework is the assumption that environmental groups, by introducing the new technology to relevant field constituents such as legislators, regulators, and consumers, and by engaging in strategic legitimating actions, create a more favorable regulative and socio-cognitive institutional environment, which contributes to new technology diffusion through incumbent firms. The findings from our case study indicate that Colorado's environmental groups took initiatives regarding the technological choice of utility generated electricity, assessed wind as the most appropriate technological alternative to Colorado's highly fossil fuel dependent electricity portfolio, and spent substantial resources and time in convincing skeptical field constituents to support the new technology. They participated in field processes to firstly bring forward the idea of utility-scale wind power, approached relevant field constituents proactively and persistently, and eventually succeeded in convincing them of the appropriateness of the new practice. In particular, our case shows that environmental groups started to introduce wind technology to central field constituents at a time when it was barely considered as a potential and viable alternative to fossil fuels. In order to build support for the new technology, they actively informed state regulators about the environmental benefits and cost-effectiveness of wind technology, leading to regulatory decisions for wind. They also collaborated with Colorado's legislators which fostered the establishment of an RPS mandate and educated Colorado's electricity consumers about the benefits of wind technology, resulting in a growing awareness of energy choice and demand for wind powered electricity. While this case may be exceptionally successful, it indicates that the environmental groups′ strategic actions resulted in increasing legitimacy for the new technology among central field participants and led to changes in the prevalent institutional context, exerting pressure on the incumbent utility to adopt and diffuse wind technology. These findings from our case study are consistent with our framework′s assumption, indicating that the large-scale diffusion of new technologies through incumbent firms requires an institutional change process of the field and that environmental groups are able to bring about such change. However, this change process is slow and intense, and it requires substantial resources, expertise, and dedication to convince relevant constituents that the new technology is worthy of support.

Our theoretical framework also suggests that environmental groups can directly approach incumbent firms to introduce new practices instead of trying to undermine or displace them. We find that environmental groups did not only approach the incumbent

utility and introduce the idea of utility-scale wind power generation, but provided, in a more collaborative fashion, assistance to the incumbent utilities. Indeed, they considered them "as important allies" (Hirst, 1994, p. 71) in order to achieve a large-scale diffusion of wind technology in Colorado. Our results indicate that environmental groups had the professional skills to offer assistance to the electric utility in the process of new technology adoption. These findings are in contrast with previous studies on social movements' tactics which mainly emphasize protest and confrontational actions designed to disrupt the field and their unwillingness to compromise (e.g., Brulle, 2000; Carmin, 1999; King and Pearce, 2010). Our findings reveal, rather, that environmental groups can provide hands-on technical assistance (Fischhoff, 2007) to help utilities adopt new technologies, providing them with the opportunity to gain experience with very low risks (Bird et al., 2005), and thus encourage utilities to adopt and diffuse the new, unknown technology. In addition, our case study illustrates that the utility suffered from a poor environmental reputation because of its reliance on coal. This finding is consistent with prior research suggesting that the more the portfolio of utilities is based on coal, the more they lack the credibility among consumers to successfully implement green offerings (Delmas et al., 2007). However, the partnership with the environmental groups seemed to provide the electric utility with the necessary credibility to successfully commercialize the new technology. Thus, we extend our theoretical framework and propose that environmental groups, by assisting incumbents, support them in overcoming barriers and risks of new technology adoption and diffusion, and serve as a bridge to increased credibility.

6.2. Importance and contributions

While our paper highlights the importance of strategic legitimating actions by environmental groups, it makes several important contributions. First, the framework developed in this paper provides opportunities to better understand the process of bottom-up, actor-initiated market creation for RET in incumbent-dominated environments characterized by a systemic technological infrastructure. While previous research has found policy incentives or regulatory changes to be the main drivers for utility-scale RET diffusion, we suggest that by not taking into account the central role of change-actors, the institutional context, and the technological infrastructure, we might neglect important factors that facilitate the adoption and diffusion of RET. In doing so, we follow DiMaggio's (1988) call to study the role of agency and suggest that the diffusion of RET must be accompanied by an institutional transformation process of the organizational field, in which actor-initiated changes play an important role. By shedding light on the ability of environmental groups to induce institutional change, this study also enriches work by other scholars highlighting the importance of a supportive institutional environment for RET (e.g., Delmas and Montes-Sancho, 2011; Jacobsson and Lauber, 2006; Unruh, 2002; van Est, 1999). The findings from our case study suggest that environmental groups' strategic legitimating actions, as well as their assistance to incumbent utilities, can drive utilities to initially adopt new generation technologies in the absence of regulatory incentives or mandates.

Our findings also indicate that environmental groups can play an essential role in the creation and implementation of renewable policies. In the case of Colorado, environmental groups were essential actors in lobbying for an RPS and pushing it through the legislative process using the increasing legitimacy for wind power among Colorado's constituents. Thus, second, our study makes important contributions to policy studies. While prior research has primarily treated public policies as exogenous variables, our study sheds light on the role environmental groups play in new policy adoption and suggests that, in line with findings from the innovation systems literature (e.g., Bergek and Jacobsson, 2003; Bergek et al., 2008; Hekkert et al., 2007), a higher level of social acceptance and understanding for a new technology lead to successful green policy implementation. In this sense, our study also advances work on the ambiguous effects of public policies. For instance, Delmas and Montes-Sancho (2011) suggest that the context under which polices are implemented, rather than solely the policy itself, can lead to positive outcomes on RET diffusion. From our case study, we could derive that efforts by change-oriented actors to increase the level of legitimacy for RET among relevant field constituents is likely to be a necessary condition for policies to truly make a difference and to foster the sustainable growth of a utility-scale renewable energy sector.

Third, this paper also extends research on social movements. Prior research has analyzed the impact of broad, large-scale movements on market creation for new technologies (Delmas and Montes-Sancho, 2011; Hiatt et al., 2009; Sine and Lee, 2009) using membership data of large U.S. movements as proxies of movement involvement. While these studies acknowledge the contribution of social movements to market emergence, they are lacking attention paid to the diverse strategic actions of social movement organizations that bring about institutional change and lead to market creation and growth. This would require more in-depth, qualitative approaches (Lounsbury et al., 2003). The framework presented in this paper may provide a useful point of departure for conducting such an in-depth analysis of the strategic actions of environmental groups. Moreover, findings from our case study suggest that local groups acting in a specific geographical area are distinct from the impact of national, large-scale environmental groups. As our case study indicates, small, local environmental groups might have substantial influence and play a vital role in bringing about new technology diffusion because of their understanding of the local issues and their ability to act as bridges among key constituents.

However, while our framework highlights the importance of targeting key constituents of the organizational field and convincing them about the benefits of environmentally friendly electricity generation, it does not include all potential field members, such as courts and other legislative oversight, suppliers of energy equipment, energy consultants, financial bodies, or insurance agencies. As the integration of all possible environmental groups – field constituents' interactions and linkages would have considerably increased the complexity of the framework, it would not have necessarily added to the qualitative insights of our analysis and the central finding of our paper – that environmental groups can create an institutional environment for new technologies and affect the incumbent's technology choice by targeting central field constituents and engaging in legitimating actions – would remain unchanged. Nevertheless, we encourage future research to broaden our framework and study interactions with an extended number of field constituents.

Another critical contribution relates to the type of social movement activity. While research on the impact of social movements on incumbents has largely focused on strategies of attack (Ingram et al., 2010; King and Pearce, 2010; Luders, 2006), this study highlights that environmental groups can also assist incumbents in the adoption and diffusion of new technologies. This might be especially important in markets with a systemic technological infrastructure. Thus, we suggest that the technological infrastructure is likely to be a key determinant in explaining social movements' choice of action in promoting new technologies.

Lastly, our study provides important options for policy makers, environmental activists, and other actors seeking to address environmental degradation. Overall, we could derive that the utility-scale diffusion of RET involves not only policy regulations, but also changes in the socio-cognitive institutional environment, and that environmental groups can play a pivotal role in changing key actors' perception about the value of alternative technologies. This finding

adds to previous research on the interlocking institutional and technological infrastructure of energy systems (Unruh, 2000), suggesting that changes to established practices can occur "when a sufficient number of influential members of society recognize or become convinced that continued expansion of a technological system is no longer tolerable" (Unruh, 2002, p. 322). Thus, our study advances this work by providing an in-depth analysis of *how* environmental groups can bring about such change in awareness and perception of the 'influential members of society'. Consequently, for policy makers or regulators, our analysis suggests that when designing supportive policies for green technologies, the institutional environment and the role of change-actors need to be considered. Cooperation with other actors in the policy making process might bring the debate into the public eye and create awareness and social support, leading to successful and supported regulatory changes. For policy makers, this insight would mean that finding an aligned partner to cooperate with in the policy making process improves the likelihood of bringing about regulatory changes and increasing the pace of new technology diffusion. For environmental groups, engaging actively with policy makers to bring about change seems to be a feasible alternative to strictly adversarial contesting and lobbying efforts (for an example of a successful collaboration between interest groups and policy makers, see also recent findings in the context of voluntary environmental agreements in the Netherlands, e.g. Bressers and De Bruijn (2005)).

This paper offers several directions for further research. Since our study presents a particular industrial and regional context, this research could also be expanded to other regions as well as to different systemic, incumbent-dominated industries such as telecommunications or railway. There is also a profound need for longitudinal research in this domain, particularly to statistically assess the presented relationships of environmental group actions, growing legitimacy for a new technology among constituents, and its diffusion. Such efforts are not without challenges as primary data on a large-scale basis are necessary. However, our study shows ways to measure the degree of acceptance of RET among constituents, such as customer green pricing subscriptions, PUC decisions in favor of RET, and the number of renewable policy bills presented in congress and senate. While our study highlights the importance of investigating particular types of environmental groups' actions in the process of new technology adoption and diffusion, future research could shed much needed light on other tactics of environmental groups or expand this research by studying other important change-actors, while further differentiating adoption and diffusion phases of green technologies. We hope that this study builds a richer understanding of the abilities and diverse strategic actions of environmental groups in fighting environmental problems and that it will inspire future works on the role of agency in the emergence and growth of green industries.

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