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RESEARCH ARTICLE

Mixed feedback dynamics and the USA renewable fuel standard: the roles of policy design and administrative agency

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Abstract
Using the case of the USA Renewable Fuel Standard (RFS), this paper contributes to theorizing regarding the factors that affect feedback dynamics of a disruptive technology. Focusing on design elements of the RFS and governance features related to its implementation, it demonstrates the resulting feedback effects on first-generation conventional biofuels and second-generation advanced biofuels. In terms of policy design, the analyses highlight the significance of the calibration of policy instruments and the incorporation of multiple policy goals into a single policy instrument. In terms of implementation procedures, the analyses affirm the significance to feedback dynamics of the regulatory capacity and discretionary authority of administrative agents as well as the influence of interest group coalitions in rulemaking. In the case of second-generation advanced biofuels, the case study also reveals the limits of policy-induced feedback in the presence of regulatory uncertainty and unfavorable financial conditions.

Keywords Policy feedback · Policy design · Administrative agency · Biofuels

Introduction

For several decades, public policies of the US government have encouraged renewable fuels produced from biomass (biofuels) in the transport sector. In 2005, the USA added a Renewable Fuel Standard (RFS) to renewable fuel financial inducements. The RFS required American domestic fuel to include minimal volumes of renewable fuel annually.[1] Two years later, the US government increased the annual total RFS almost fivefold. The 2007 Energy Independence and Security Act (EISA) raised mandated amounts of conventional first-generation biofuels like cornstarch ethanol. RFS2, as the 2007 RFS is called,

[1] This paper uses the terms renewable fuels and biofuels interchangeably. The acronym RFS is used to refer to the renewable fuel mandate established in 2005 as well as to the policy more broadly.

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also gave a major boost to advanced, second-generation biofuels like cellulosic ethanol that the USA was not then producing.

Notwithstanding their mutually mandated market, conventional ethanol and advanced cellulosic ethanol have experienced very different deployment trajectories since 2007. By 2016, the USA was producing more conventional ethanol than was required to meet that year's 15 billion gallon limit (Voegel 2017: 1). Ethanol's share of the American gasoline market had more than doubled—from less than 5 percent to 10 percent—and the number of operational ethanol plants had also nearly doubled (Ibid: 2). However, production of the much more technologically complex cellulosic ethanol has lagged well behind mandated volumes. Indeed, available supplies of cellulosic ethanol accounted for about one-tenth of one percent of the legislated RFS2 cellulosic fuel target in 2017 (US Energy Information Administration 2019).

The different trajectories of the two technologies suggest two different feedback effects of the US RFS. The legislated mandate for conventional cornstarch ethanol is consistent with positive feedback effects associated with policy self-reinforcement. By contrast, the failure to meet the statutory mandate for cellulosic biofuel, even while it also remains intact, suggests the absence of feedback effects.

Investigating these different feedback dynamics of the US RFS is important for the possible lessons that can be drawn for policy-making in support of a transition to renewable energy sources. The USA is the world's largest producer of biofuels production and home to the largest percentage of advanced biofuel ventures (IRENA 2019). It has also been a world leader in government support for not only conventional biofuels but also advanced biofuels. It was the first country to require advanced biofuels use in its transport sector. Insofar as other countries are now taking steps to establish mandates for advanced biofuels, there may be important insights for them from the US experience and the RFS's differential feedback dynamics for conventional and advanced biofuels.

The objective of this article is to investigate the feedback dynamics of the RFS and their role in the different outcomes of first- and second-generation US renewable fuels. More specifically, it examines how RFS material, organizational, and interpretive feedback effects have been affected by two factors. The first is the design of the RFS: that is, the choice of its policy instruments and their configuration. Two features of the RFS policy design are theorized as important to its feedback dynamics. One is the calibration or setting of its policy instruments: that is, its level of ambition with respect to a disruptive technology (biofuels) replacing an embedded technology (fossil fuels). The second design feature that is theorized to affect RFS feedback dynamics is its constitution as a policy with multiple policy goals. The proposition advanced here is that both design features have shaped RFS feedback dynamics by affecting (a) the incentives and opportunities of organized interests to mobilize in support or opposition to the RFS and (b) the capacity of administrators to implement the RFS.

The second factor theorized to affect RFS feedback dynamics is the policy's implementation context. Its features include the discretionary authority and policy capacity of the administrative agents responsible for implementing the RFS, and the opportunities provided by administrative procedures for competing interest group coalitions to influence the implementation of the RFS. The outcomes of regulatory decisions determine the regulatory (un)certainty of the RFS, with feedback consequences for the willingness of financiers to risk investment in a new technology like advanced biofuels. Rulemaking decisions at the implementing stage also affect feedback dynamics by impacting on the incentives of winning and losing stakeholders for collective action and their motivation to remain coherent in their interpretation of the policy's workability and effectiveness.

With specific reference to the RFS, the analyses presented here show that positive material and interpretive feedback from the 2005 RFS, and its modest and achievable volumetric mandate, enabled first-generation cornstarch ethanol to gain further entry into the transport fuel market in the 2007 RFS2. The organizational and expertise resources of the conventional ethanol sector also enabled it to leverage the discretionary authority of the Environmental Protection Agency (EPA) and its rulemaking procedures to secure favorable regulatory outcomes in the RFS2 implementation stage. By contrast, the ability of second-generation cellulosic ethanol to generate self-reinforcing effects from the RFS has been handicapped by the EPA's evident difficulties in administering RFS2: a complex and flawed policy instrument when it comes to advanced fuels. The resulting regulatory uncertainty and political contestation surrounding RFS2 have added to the unfavorable market and financial conditions that have prevented cellulosic fuels from generating post-RFS2 feedback.

To develop its argument, the paper proceeds as follows. It first reviews the policy feedback literature to develop propositions regarding how features of policy design and administrative procedures affect feedback dynamics. Subsequent sections, in turn, (a) discuss the methods used to test the research propositions and demonstrate feedback dynamics; (b) provide background information on biofuels; (c) describe the introduction of the RFS and illustrate the role of its feedback effects in the design of the RFS2 in 2007; and (d) illustrate how the design of the RFS2 and the regulatory procedures to implement it have created policy uncertainty and different feedback dynamics for first- and second-generation ethanol since 2007. A final section concludes the paper.

Policy feedback: theorizing its mechanisms and dynamics

Policy feedback refers to the effects of policy choices at a given point in time in (re)shaping the political landscape for subsequent policy development. The feedback effect can be to stabilize or expand antecedent policy choices: a dynamic described as a positive or self-reinforcing feedback process.[2] Alternatively, the consequences of a policy can be negative or self-undermining; that is, to set in train developments that weaken its political viability and subject it to roll back (Jacobs and Weaver 2015). Neither self-reinforcing nor self-undermining feedback dynamics should be assumed, however, as policies may also fail to generate effects and outcomes that alter the political landscape.

The rich literature on policy feedback emphasizes the potentially transformative effects of policies on the resources, capacities, beliefs, and subsequent political behavior of non-state and state actors (Béland 2010; Béland and Schlager 2019; Campbell 2012; Pierson 1993, 2000; Skocpol 1992; Weaver 2010; Jacobs and Weaver 2015). Material policy effects stem from the fact that policies, usually intentionally, create winners and losers by bestowing resources on some but not other social and state actors. In their allocation of resources, policies affect actors' incentives as well as their organizational capacities to engage in collective action. Policies' interpretive effects arise from the information they provide political actors about what are workable/unworkable and legitimate/illegitimate policies, as well as

[2] Although some authors make finer distinctions among feedback processes (see, for example, Levin et al. 2012), this paper uses the simpler distinction of positive or self-reinforcing feedback, negative or self-undermining feedback, and no feedback effects. The rationale is that lock-in and increasing returns feedback effects can be subsumed under positive feedback effects.

deserving/unworthy recipients of public support (Campbell 2012; Pierson 1993; Schneider and Ingram 1997; Skocpol 1992). By virtue of the resources as well as obligations policies confer on the actors and agencies charged with implementing them, they also affect the policy capacity of these same actors and agencies (Skocpol 1992; Béland 2010; Oberlander and Weaver 2015). As suggested, material, interpretive, and capacity feedback effects can be positive, negative, or a mixture of the two (Schmid et al. 2019).

Theorizing regarding the factors that fuel feedback dynamics tends to emphasize the perceived material benefits or costs to targeted populations and their ensuing consequences. For example, Oberlander and Weaver (2015, 41) describe a self-reinforcing feedback process as constituted by a public perception of widespread benefits from the policy, the flow of concentrated benefits to a targeted constituency, and, in turn, a strengthened organizational capacity on the part of policy beneficiaries to defend the policy if it is threatened. By contrast, they identify the components of a self-undermining feedback process to be the perception of concentrated losses, an increase in the sense of public grievance leading to the development or strengthening of constituencies seeking policy change, and/or the fragmentation of existing support coalitions. The fact these authors are theorizing policy dynamics of social policy undoubtedly explains their attention to the public as the target population. In other policy areas, for example, those wherein policies are directed at changing the behavior of specific market actors—it is the effects on them that are likely to be most important to feedback dynamics (Meckling 2018).

Whether and what type of feedback effects emerge is recognized to be contingent on a number of factors. One is how the design of a policy—that is, the choice of policy instruments and their calibration (Linder and Peters 1988; Howlett and Cashore 2009)—affects political actors' perceptions of the policy's success or value (see also Béland et al. 2020; Daugbjerg and Kay 2019; Haelg et al. 2019; Jordan and Matt 2019, this volume).[3] A second contingent factor is institutional supports in the implementation phase (Jordan and Matt 2014; Oberlander and Weaver 2015; Patashnik 2008; Patashnik and Zelizer 2013; Skogstad 2017; Weaver 2010; see also Thelen 2000: 103). Highlighting both policy design and implementation supports, Patashnik and Zelizer (2013: 1076) state that while a poorly conceived policy may eventually generate strong feedback, "the odds are against it." These odds are shortened when defects in the original policy design are not repaired in the implementation phase with the result that political actors become skeptical of the policy's success or value. They are also shortened when reformers fail to undercut the institutional bases of support of the policy's opponents (Ibid. 1077).

The feedback literature specific to innovative technologies, including renewable fuels, has also theorized how policy design features and institutional supports are most likely to affect feedback dynamics. Beginning with policy design, some of the earliest thinking about policy feedback was derived from literature theorizing how policies that encourage sunk investments over a long term, particularly investments with high risks, are good candidates for self-reinforcing dynamics (Pierson 2000). The reason is that such policies give their beneficiaries direct incentives and resources to defend them; they also create requisite new constituencies of support for the policy when they induce learning and adaptive

[3] It is certainly likely that policy-makers do not always anticipate correctly the implications of a policy. However, attention to policy design offers important insights into how policies are put together, their flexibility and resilience over time, and how they can come unstuck (cf. Capano and Howlett 2019; Howlett 2014; Howlett et al 2015).

behavior on the part of others (Ibid.). Such policies are also difficult to reverse because of the costs to those who have invested in the technology (Levin et al. 2012).

Propositions derived from his logic would posit that policies mandating renewable fuels use are conducive to self-reinforcing feedback processes. An obligatory market expands market opportunities for renewable fuel technology producers and project developers (Meckling 2018); reduces the uncertainty for investors in the new technology; and gives its direct beneficiaries–biofuel producers and biofuel feedstock producers–strong incentives to remain mobilized to defend and expand mandates. Indeed, given the higher investment risks of second-generation biofuels, a guaranteed demand for second-generation biofuels should be especially conducive to self-reinforcing feedback effects.

However, the assumption of adaptive behavior, particularly on the part of the incumbent technology that incurs lost profits as a result of the replacement technology, appears unduly optimistic. Accordingly, propositions regarding how to design replacement technology policies so as to overcome resistance to them appear more helpful. Here theorizing stresses configuring policy so as to minimize or conceal its costs to incumbent technologies at the outset. Schmidt et al. (2018) find that policy instruments set at medium levels of intensity (in terms of the resources, effort, and political activity invested in them) are more likely to avoid backlash by perceived losers than are instruments set at high levels of intensity. Along the same lines, Stokes and Breetz (2018, 84) posit that uncertainty around the costs of a renewable technology to incumbent industries can help facilitate its initial adoption because incumbent industries tend to underestimate the costs of a renewable technology to their business models in the early stage of its adoption. They recommend that governments limit their support initially in order to attract less political scrutiny for the new technology (Ibid, 85). Propositions derived from this literature do not assume self-reinforcing logics; rather, the type of feedback dynamic is dependent upon the level of ambition of policy instruments with respect to replacement technologies (in this case, first- and second-generation biofuels). Less ambitious policy instruments and/or those whose costs are uncertain are more likely to be associated with self-reinforcing dynamics than their more ambitious and more transparent counterparts.

A third set of propositions relevant to feedback dynamics of US policies mandating renewable fuels use can be derived from the literature emphasizing the likelihood of multiple and incoherent logics in the design of policies (see Haelg et al. 2019; Béland et al. 2020, this volume). This literature observes that the need to build a consensus across multiple veto player actors and institutions in the US institutional context results in policies that are bargained outcomes, representing the deal that's possible, and hence likely not to be logically coherent. The complex and incoherent means–end logic that accompanies policies in the US political–institutional context has often been associated with negative feedback as previous supporters withdraw their support for the policy and/or join policy opponents when the policy fails to accomplish these actors' prioritized policy goals (Jacobs and Weaver 2015; Oberlander and Weaver 2015, 43; Weaver 2010).

The feedback dynamics of a policy with multiple logics is a matter of relevance to the case of US renewable fuels because, as documented below, the RFS was constructed as a policy with multiple logics. They are economic goals of raising farm incomes and creating jobs in rural areas; energy security goals of reducing dependence on imported fuels; and environmental goals of reducing greenhouse gas (GHG) emissions by reducing fossil fuel consumption (Mondou et al. 2014; Skogstad 2017; Skogstad and Wilder 2019). The multiple goals of the RFS created an opportunity for a wider basis of support for the RFS insofar as first- and second-generation biofuels are differently situated to contribute to its goals. The first-generation biofuels derived from domestically cultivated available food crops like corn and soybeans are generally credited with advancing economic and energy security goals; the second-generation biofuels, the environmental goal of GHG emission reductions. Rather than assuming negative or self-undermining feedback in the event of some of its touted benefits failing to materialize, the proposition advanced here is that feedback dynamics are uncertain in this situation, and contingent upon the cohesion of the coalition that originally supported the RFS.

Besides policy design features, the second set of factors hypothesized to affect feedback dynamics are, as noted above, features of the post-legislative or implementation stage. Contestation throughout the passage of legislation often continues into the implementation phase as opponents seek to roll back the legislation or suppress its effects, while supporters seek to maintain or amplify them. Accordingly, self-reinforcing feedback dynamics in the post-enactment phase depend on the emergence of a supportive coalition able to influence the rulemaking stage when legislation is enacted. Crucially, positive feedback dynamics also depend upon supportive administrative institutions (Béland 2010; Patashnik and Zelizer 2013).

Among the important institutional supports for renewable fuel technologies are financial institutions that provide them with steady flows of investment (Kuzemko et al. 2016). The confidence of investors, in turn, depends upon policy certainty, including in the regulatory authority to enforce it. To the extent that unanticipated problems arise in implementing a new policy, self-reinforcing effects are also likely to require that administrative officials have the capacity to repair these defects (Patashnik and Zelizer 2013). Accordingly, an administering agency's performance, including its expertise and discretionary exercise of its administrative authority, becomes important to feedback processes. Self-undermining effects, Oberlander and Weaver (2015) argue, are fueled by frequent high-profile failures of the policy. Such failures, they suggest, arise when the implementation task assigned the administrative agency is "complex and intrinsically difficult" (Ibid: 42). Self-undermining feedbacks are also likely, they suggest, when key provisions of a policy or administrative rule are vulnerable to legal challenge (Ibid: 41).

In summary, theorizing suggests various propositions about features of policy design and implementation procedures that affect US statutory renewable fuel mandates feedback dynamics. In terms of policy design features, they suggest there should be no assumption of self-reinforcing feedback dynamics. Rather, the RFS is associated with positive self-reinforcing feedback contingent upon the following design features: the RFS mandate is set at a level that provides clear material benefits for the renewable fuel sector; the initial setting of the mandate minimizes or renders uncertain the costs to the petroleum industry; and the setting of the policy instrument is feasible given the development of the technology. The feedback effects of the multiple logics of the RFS are unclear, but whether they are self-reinforcing will be contingent upon the presence of a coalition of organized interests defending the policy as it is administered. In the implementation stage, as well, the RFS will be conducive to self-reinforcing feedback to the extent regulatory authorities generate its expected and desired outcomes. By contrast, negative or null feedback effects will be associated with the inability of administrators to overcome any limitations in the design of the RFS and administrative procedures that contribute to ongoing contestation and regulatory uncertainty.

Research methods

To carry out its objectives of unraveling the feedback dynamics of the US RFS, the paper traces its legislative and implementation phases. To do so, it relies upon two informational sources: first, publicly available documents, including transcripts of Congressional committee proceedings, government documents, and secondary accounts; and, second, interviews with individuals knowledgeable about the RFS policy process. The interviews that constitute an information source here were conducted by the author in Washington, DC, over the period 2010–2013: a point in time at which the legislative process that resulted in EISA/RFS2 was still fresh in the minds of informants, the EPA had issued its first rules with respect to RFS2, and the challenges confronting the EPA with respect to administering the RFS2 were becoming fully apparent. The interviewees were eleven current or former government or political staff, four representatives of industry organizations, four environmental groups, and four independent experts. A semi-structured interview schedule was used to capture the specific experience and role of the interviewee in the legislative or administrative process surrounding the RFS and EISA. In place of subsequent interviews, publicly available documents, like the transcripts of Congressional hearings before which biofuel stakeholders and EPA officials regularly appear, have been a rich source of information for appraising feedback dynamics.

Biofuels: distinguishing conventional and advanced

A brief discussion of biofuels is in order to clarify the terminology used in this article and to explain the background to biofuel mandates.

Three elements are generally used to distinguish first- and second-generation biofuels: the feedstock type from which the biofuel is made, the process used to make it, and/or the biofuel's estimated greenhouse gas (GHG) emissions reductions (UNCTAD 2015, Table 1, p. 2). First-generation or conventional liquid biofuels are produced from food crops such as starch, sugar and vegetable oils; they include ethanol produced from cornstarch and sugar cane and biodiesel made from soya or palm oil. Second-generation or advanced biofuels are made from non-edible feedstocks; they include biodiesel made from algae and cellulosic ethanol made from corn stover, grasses, wood chips, and agricultural residues like straw. The processes used to convert the feedstock into fuel are fundamentally different for first and second-generation biofuels. They entail comparatively simple fermentation of sugars or starches in the case of ethanol produced from sugarcane or cornstarch, or transesterification of plant oils in the case of biodiesel. By contrast, the thermochemical or biochemical processes to break down cellulose (the fibrous material that constitutes the bulk of plant matter) into fermentable sugar are more complex and require more sophisticated processing equipment (UNCTAD 2008: 10; Environmental Protection Agency 2007: 20, 22). These technical differences contribute to the higher costs of producing second-generation advanced biofuels like cellulosic fuel as compared to cornstarch ethanol. The USA uses the last factor, their greenhouse gas (GHG) emissions reductions as compared to gasoline or diesel, to distinguish conventional and advanced biofuels. The US Renewable Fuel Standard requires advanced biofuels to reduce GHG emission reductions by 50–60% as compared to 20% for conventional ethanol produced from cornstarch.

American governments began supporting the production (supply) of ethanol through fiscal instruments in the late 1970s. However, it was not until the 2000s that the US government turned to its regulatory powers to create demand for ethanol and other renewable fuels. It did so in response to a provision in the 1990 Clean Air Act requiring gasoline to be mixed with an oxygenating agent in certain areas of the country in order to control carbon monoxide and ozone problems. By the end of the 1990s, the oxygenating agent being widely used, methyl tert-butyl ether (MTBE) had become associated with underground water contamination. As MTBE became recognized as a carcinogen, several states banned it from 2002 onward. Ethanol became a replacement for MTBE in the early 2000s because of its oxygenating requirements; it is thirty-five percent oxygen (Duffield and Collins 2006: 10). This context provided important background to that the 2005 Energy Policy Act.

The 2005 renewable fuel standard: positive feedback dynamics

The 2005 Energy Policy Act established the renewable fuel standard (RFS): a requirement for obligated parties (refiners and importers) to include a minimum volume of renewable fuel in their fuel supplies each year through to 2022. Set at 4 billion gallons in 2005, the RFS for ethanol produced from cornstarch was scheduled to rise to 7.5 billion gallons by 2012. The 2005 Energy Policy Act also gave incentives to encourage the production of cellulosic biofuels produced from switchgrass, crop residues, and forest residues and stipulated a requirement of at least 250 million gallons of cellulosic ethanol for 2013 and beyond. At least 250 million gallons of cellulosic biomass were required to be part of the RFS from 2013 onward (Congressional Research Service 2019, 4).

The 2005 RFS was a major victory for the Renewable Fuels Association (RFA) and the National Corn Producers Association, who had worked together for several years to obtain it.[4] The RFS raised minimal ruckus with oil companies when it was legislated.[5] Oil companies benefitted from the elimination of the oxygenate requirements in the Clean Air Act. Moreover, the 7.5 billion gallon renewable fuel target was sufficiently small not to be perceived as a threat to their profits.[6]

The positive feedback of the 2005 RFS for corn ethanol was soon evident. Conventional ethanol production rose and by early 2007 was already running well ahead of the RFS target for that year (Environmental Protection Agency 2007, 28). The accompanying new jobs in rural America, higher feedstock prices, and rising farm incomes provided tangible evidence of biofuels' material benefits. They demonstrated to the well-organized ethanol and biodiesel sectors the capacity of the RFS "to draw demand,"[7] and created a "euphoria of huge profitability" around biofuels.[8] Amidst rising fuel prices and a perceived energy

[4] As confirmed by a staff member of the Renewable Fuels Association, in conversation with the author in October 2011. The two associations shared office space.

[5] Mondou et al. (2014: footnote 8, 171) note one instance of the petroleum industry, in a 2002 appearance before the Energy Subcommittee of the House Committee on Government Reform and Oversight, to stop ethanol from replacing MTBE as a fuel additive, emphasizing ethanol's higher costs.

[6] A Congressional staffer as well as a long-time government employee interviewed by the author in October 2011 in Washington, DC, expressed the view that "The oil industry can live with liquid biofuels as long as they are blended in small amounts."

[7] This term was used by an analyst for the Congressional Research Service, interviewed in Washington, DC, in April 2012.

[8] This language was used by a representative of the National Biodiesel Board interviewed in Washington in April 2012.

crisis, it was also possible to interpret the RFS and renewable fuels as part of the solution to the long-standing American search for energy security via energy independence (Grossman 2013, 2019).[9]

Such positive feedback helps to explain how biofuel proponents were able to ward off a biofuel backlash over the period 2006–2007 when biofuel mandates became implicated in a sharp rise in world food prices for basic staples like corn and vegetable oils. The food price rise coincided with studies that disputed pro-biofuel proponents' claims about biofuels' environmental benefits, including their greenhouse gas emission savings relative to petroleum fuels. These perceived negative outcomes brought together a broad coalition of food industry processors and retailers, livestock farmers, petroleum companies, environmental groups, and hunger groups under the banner of "Food Before Fuel" (Mondou et al. 2014: 156). It did not, however, succeed in rolling back the 2005 RFS. It also failed to impede the "renewable energy bandwagon"[10] that led to bipartisan support in Congress to expand the RFS in the Energy Independence and Security Act (EISA) passed in December 2007.

Positive feedback effects of the 2005 RFS account for some but not all features of EISA. Positive feedback effects can explain EISA's almost fivefold expansion of the annual RFS (to a minimum of 36 billion gallons by 2022) in RFS2. They can also account for the increase of conventional mandates in RFS2 from 12 billion annual gallons in 2010 to 15 billion gallons in 2015. However, positive feedback effects of the 2005 RFS mandate cannot account for three other elements of EISA. They are, first, a cap on conventional ethanol (at 15 billion gallons); second, environmental requirements for renewable fuels; and third, aggressive mandates for cellulosic fuels. Unlike the 2005 Energy Policy Act, EISA required future RFS2-eligible fuels to meet environmental requirements. They included specified greenhouse gas emission (GHG) reductions relative to petroleum for each of the four categories of renewable fuels, as well as sustainability requirements with respect to land used to produce biofuel feedstocks. Renewable fuels already being produced in existing plants were exempt from these requirements. With respect to the third feature, EISA/RFS2 set annual targets for three advanced biofuels: cellulosic biofuel, biomass-based diesel, and other advanced biofuels. Although the USA was not producing cellulosic ethanol in 2007, the RFS2 mandates for cellulosic ethanol rose to 3 billion gallons by 2015, and 16 billion gallons by 2022.[11] Under these aggressive mandates, cellulosic and other advanced fuels would eventually account for the bulk of American renewable fuels (Congressional Research Service 2018, Tables 1, 6).[12]

Two of these features—the conventional ethanol cap and environmental requirements for biofuels—can be understood as concessions made to secure the support of critics

[9] This language was used, in a conversation with the author, by an individual who was a senior official in Department of Energy in the Bush Administration. During this same conversation, held in October 2011, the individual described the situation as "a brutal time, with oil at that price."

[10] This term was used by an EPA official interviewed in Washington, October 11, 2011. In a separate interview, a representative of the National Corn Growers' Association stated: "Before the 2007 bill passed, ethanol was the darling child of every Congressman. People I never knew came up to me in the halls and said they wanted to write an ethanol bill—to do something, even though they did not know anything about it." See also Mondou et al (2014).

[11] The remainder of the RFS consisted of 4 billion gallons per year of advanced biofuels and 1 billion gallons per year of biomass-based biodiesel.

[12] The target increased from 7% of the total RFS in 2010 to 58% of the RFS in 2022 (Congressional Research Service 2018, pp. 1–2).

who perceived negative outcomes of conventional ethanol mandates. To secure the support of environmental groups for EISA, House of Representatives' Speaker Nancy Pelosi, whose Democratic Party was keen to write an energy bill,[13] agreed to include provisions that would promote advanced and cellulosic biofuels.[14] Compared to fossil fuels, life cycle analysis (LCA) models have demonstrated that second-generation renewable fuels reduce GHG reductions more than conventional ethanol.[15] Besides the cap on conventional ethanol, RFS2 provisions required the LCA of each fuel category to include both direct land use emissions as well as significant emissions from indirect land use change (ILUC). ILUC effects arise when the increased consumption of biofuels on land across the globe results in previously non-arable land being converted into agricultural use, and thereby adding to carbon emissions. Although the impact of ILUC effects in reducing the GHG emission reductions of conventional biofuels subsequently became a matter of considerable controversy, when EISA was being formulated this debate was just beginning. This context of limited knowledge of and contestation around ILUC likely explains why corn and ethanol producers believed they would be able to meet sustainability standards.[16]

The third feature of EISA—the high and growing RFS2 mandate for cellulosic fuel—is puzzling because the USA was not producing advanced cellulosic ethanol in 2007. Its inclusion in EISA can be attributed to the support of President Bush, Congress, and organizations representing both first- and second-generation biofuel producers. President Bush was an early supporter of cellulosic fuels. His 2006 State of the Union Address proposed new funding initiatives for renewable fuels and stated that cellulosic ethanol would be commercially viable within six years. His 2007 State of the Union Address reaffirmed financial support for cellulosic fuels, saying they had the potential to displace up to 30% of the current petroleum in automobile use by 2012. This figure was consistent with the conclusion of a joint report produced during his administration regarding domestic supplies of available biomass from all plant and plant-based materials (United States Department of Agriculture and United States Department of Energy 2005). Amidst a division of views within his administration on whether cellulosic fuels did indeed have the potential to displace up to 30% of the petroleum used in automobiles by 2012, President Bush appears to have been persuaded by venture capitalists of its promise.[17] Congress also supported a high cellulosic mandate: an action that has been described as an instance of intra-institutional competition, with Congress "bidding up" the President's proposed mandate (Stokes and Breetz 2018, 507). Both second-generation and first-generation renewable fuel producers also supported the cellulosic mandate. Even so, the advanced ethanol industry's concern

[13] Information obtained from a conversation with a staff member for a Democratic Senator on the Energy and Natural Resources Committee, October 2011, Washington, DC.

[14] This observation is based on information obtained from congressional staff, environmental groups, and administration officials interviewed by the author in Washington, DC, in October 2011. See also Breetz (2017, pp. 28–29).

[15] Life cycle analysis models are a tool used to evaluate the environmental benefits of alternative renewable fuels relative to fossil fuels. They consider GHG emissions from all stages of the renewable fuel from its production through to its use in vehicles, including emissions in the production of the renewable fuel feedstock as well as emissions in the transportation of the renewable fuel to a processing facility, its processing, its distribution to the retail outlet, and in its use in vehicles (Environmental Protection Agency 2007: 219).

[16] Information obtained in an interview with an EPA official, October 11, 2011, Washington, DC.

[17] This information is based on an interview with a senior official in the Department of Energy who stated that "venture capital got to Bush." This same individual, and another government official, interviewed in October 2011 in Washington, DC, offered the following explanation for why the President and other enthusiasts endorsed high cellulosic mandates: "They believed what they wanted to happen."

that the high cellulosic mandate would “bring down the entire RFS” resulted in EPA being granted authority to waive the cellulosic volumes if the fuels were not yet available (Breetz et al. 2018, 508). Such waivers are common in environmental statutes (Grundler 2013, 22).

In summary, positive feedback from the 2005 RFS interacted with concerns about the negative outcomes of first-generation corn ethanol and political goals of elected politicians to result in some significant design elements in RFS2. First, it was an ambitious policy with respect to the mandates it set for renewable fuels, and even more so when it came to second-generation/advanced biofuels. The technology for cellulosic fuels was still at the experimental stage, and there was not yet any cellulosic fuel in the supply chain. As such the RFS2 had a major policy design defect from the perspective of the proposition that replacement technology policy instruments should be modestly calibrated. This potential defect in terms of generating the positive feedback needed for self-reinforcing feedback dynamics was also jeopardized by a second feature of RFS2: it required rulemaking in a context of scientific uncertainty. Life cycle analysis (LCA) models to estimate the GHG emissions of renewable fuels and take into account their indirect land use change (ILUC) effects, were, like cellulosic ethanol, also still in the early stages of development. Moreover, their complexity and uncertainty lead to variable results in estimates of ILUC effects across LCA models, a situation that invites skepticism regarding the reliability of any given model (Broch et al. 2013). Third, the RFS2 implicated both conventional biofuels and advanced biofuels in its capacity to realize its multiple economic, energy security and environmental rationales. Although conventional biofuels comprised by far the largest component of the statutory total renewable fuel target through to 2020, the RFS2 targets and goals could only be met in full by the availability of at least some advanced biofuels. The latter included the cellulosic fuels that were not commercially available when the RFS2 took effect.

As the following section documents, these design elements have imposed a heavy burden on the expertise of the Environmental Protection Agency delegated authority to implement the RFS2 and augmented the significance of its administrative procedures and decisions to RFS2 post-enactment feedback dynamics.

Implementing RFS2: mixed feedback dynamics

The implementation of the RFS2 since it took effect in 2010 has been beset with administrative challenges and fraught with controversy. The EPA has often failed to meet RFS2 statutory rulemaking deadlines, its rules have been subject to litigation, and, when court challenges have not upheld its rules, the EPA has been forced to amend them. The ongoing controversy surrounding the EPA’s RFS2 rulemaking, which has spilled over into the political arena (Skogstad and Wilder 2019), has contributed to regulatory uncertainty. This uncertainty is blamed for deterring investment in advanced cellulosic ethanol, and for cellulosic fuel production lagging well behind its RFS2 mandate. The regulatory contestation and uncertainty have not, however, prevented mandates for conventional fuels being met.

To what extent have features of the administrative context—as compared to RFS2 policy design features–contributed to the challenges and controversy in implementing the RFS2? What are the subsequent implications for RFS2 feedback dynamics for conventional and advanced biofuels? To address these questions, this section first describes the EPA’s rulemaking authority and administrative procedures. It then turns to two important EPA rulemaking tasks to illustrate how administrative procedures and the nascent policy capability of the EPA have interacted with RFS2 policy design features to result in a mix of positive and negative material and interpretive feedbacks. These feedback effects are manifest in the competing interest group coalitions and discourses around RFS2, as well as in the different trajectories of conventional ethanol and advanced cellulosic ethanol since RFS2 took effect.

In exercising its responsibility to administer the RFS, the EPA's rulemaking procedures must conform to stipulations in the Administrative Procedures Act. They require the EPA to base its rules on scientific evidence. At the same time, interested parties must have opportunities to participate and comment on EPA's proposed rules and the EPA is required to respond to public comments and to disclose the information that forms the basis for its decisions.[18] EPA final rules can be—and usually are—appealed to federal courts.[19] In addition, the EPA is subject to oversight by Congressional committees. The parameters of this procedural context have been described by former EPA Director Lisa Jackson (2010) as giving the EPA "room to exercise discretion" in keeping with the general directives of Congress and the courts.[20]

The EPA's rulemaking powers and its procedural requirements have had important implications for RFS2 feedback effects. First, the requirement for public comment opportunities has given pro- and anti-biofuel stakeholders incentives to remain mobilized and to strengthen their informational and organization capacity to influence EPA rules.[21] Despite the requirement for scientific evidence to form the basis of EPA rules, the incentive for collective stakeholder mobilization has been strengthened by the state of uncertainty and contestation of the scientific knowledge underpinning some RFS2 regulations. Second, the fact that the EPA's discretionary rulemaking authority with respect to RFS2 directly threatens the material resources of economically powerful stakeholders (the petroleum sector) has further strengthened their counter-mobilization efforts to discredit EPA rules and its rulemaking authority. Third, the implementing capacity of the EPA has been undermined by its need to develop new policy capabilities—the case for the two regulatory tasks discussed further below (Congressional Research Service 2019: 8). And fourth, the uneven success of administrative officials in implementing the RFS2 policy has provided interpretive fodder for the discourses of supporters and critics alike regarding the RFS's administrative (un)feasibility and its success or failure.

To illustrate these mixed feedback effects, the next two sections discuss EPA rulemaking with respect to two important regulatory tasks. The first task is determining whether the different categories of renewable fuels meet EISA GHG emissions reduction requirements, and therefore qualify as renewable fuels. This regulatory task placed an early demand on the EPA's expertise; the regulatory outcome was important to the material and interpretive feedbacks of the RFS2. The second regulatory task is the annual obligation to determine

[18] Interested parties have informal access to EPA personnel at the pre-proposal stage, the public notice and comment stage, and the rule finalization stage.

[19] Cook (2018: 469) states: "Once an EPA rule is published in the Federal Register, it has the effect of a law. Stakeholders may file litigation via the petition for reconsideration process and the EPA can make changes to the rule via this process. If the agency declines those petitions, stakeholders are then able to file litigation in the federal court system." Over 80 percent of major EPA regulations under new environmental statutes are challenged in court (Kochtcheeva 2009, 242) on grounds that the EPA acted in an arbitrary fashion or trespassed beyond its legislative authority. Cook (2018) reports that the courts typically uphold agency rules.

[20] See also Kochtcheeva (2009, 262).

[21] Cook (2018) documents that parties that participate in the earliest, pre-proposal, stage of EPA rulemaking are especially successful in securing rule changes, as are those with expertise.

the adequacy of existing supplies of renewable fuels to meet statutory (EISA) total renewable fuel volume obligations as well as volumes for the four specified categories of biofuels. In the event that supplies of renewable fuels fall short of annual volumetric RFS2 statutory obligations, the EPA is required to adjust the final volumes of renewable fuels. This task has sorely tested the EPA's capacity for effective and legitimate rulemaking. The material, organizational and interpretive feedbacks of the consequent regulatory uncertainty for advanced biofuels have been competing pro- and anti-biofuel coalitions divided in their discourses regarding RFS2's workability.

Regulating renewable fuels' GHG emissions

The EPA's obligation to determine whether a renewable fuel qualifies under the RFS2 program was an early test of its administrative capacity. It could not turn to any domestic or international lifecycle analysis (LCA) model to determine whether different renewable fuels achieve the EISA-specified amount of GHG emission reductions, as compared to a 2005 petroleum baseline, when both their direct and significant indirect emissions were considered. Accordingly, the EPA was obliged to construct such a model to calculate the direct and indirect land use emissions of the four categories of renewable fuels specified in EISA.

This task unfolded amidst considerable controversy over how to measure indirect land use change (ILUC) and the magnitude of its effects. Recall that quantifying ILUC effects requires estimating the carbon released when land (including forests and grassland) is converted or cleared for agricultural production as a result of renewable fuel consumption. Because ILUC effects can only be modeled, not directly measured, ILUC estimates are uncertain, and, hence, controversial.[22] As noted in an earlier section, the ILUC controversy erupted in the final stages of the passage of EISA, when studies claimed that biofuels provided few GHG emission reduction benefits relative to petroleum once account is taken of their ILUC effects. The controversy remained when the EPA constructed a model to determine the eligibility of future renewable fuels to qualify for the RFS. Relative to their gasoline or diesel counterparts, the EISA/RFS2 required a 20% GHG emission reduction for conventional ethanol produced from cornstarch, a 50% reduction for advanced (non-corn) biofuels and biodiesel, and a 60% reduction for cellulosic ethanol.

Required to do new research where "the science was not there," the EPA held one on one discussions with all stakeholders and public hearings across the country in order to base its decisions on "the best available science and data."[23] The hearings process took 2 years, delaying the implementation of RFS2 until 2010. On the basis of its initial model, the EPA released draft RFS2 regulations in 2009 under which neither cornstarch ethanol nor soy diesel qualified as renewable fuels because they failed to meet RFS2 GHG emission requirements.

Not surprisingly, the threat the draft regulations posed to the conventional biofuel industry produced a strong backlash. Using procedural challenges of peer review and public comment, the ethanol industry, corn producers, and biofuel traders challenged EPA's

[22] As an official in the EPA Office of Transportation and Air Quality explained in an interview with the author in April 2012, "It [ILUC] is all based on modeling possible consequences resulting from projected decisions. It is always a counterfactual statement. You cannot measure the land use in the future policy-on versus policy-off. There will always be this type of uncertainty."

[23] These terms were used by a senior EPA official in a telephone interview with the author March 20, 2012.

methodology. Their input led to EPA revising its model regarding ILUC effects so that it "found medium ground with different estimates and models."[24] Under the final RFS2 regulations, cornstarch ethanol and soy-based diesel qualified as renewable fuels (Gillon 2014, 324).

The consequences of the EPA's final determination that conventional biofuels qualified under RFS2 were material, organizational, and interpretive. The material victory of the EPA ruling for conventional biofuels ensured the RFS2 retained its support, and that the appreciable organizational and material resources of the first-generation biofuel sector could continue to be leveraged for the biofuels sector as a whole, including for the much smaller advanced fuel industry. In terms of interpretive effects, the difference between the EPA initial draft regulations and final rules constituted evidence for critics, including environmental groups, of the EPA's inadequate administrative capacity on the subject of land use change (Gillon 2014: 325). The conflicting estimates of conventional biofuels' carbon emissions resulted in many environmental groups withdrawing their support for ethanol (Breetz 2017).

Regulating annual renewable fuel volumetric requirements

The 2007 EISA requires the EPA to establish the annual volumes of renewable fuels that refiners and importers of gasoline or diesel fuel must blend with transport fuels. The annual Renewable Volume Obligation (RVO) must be publicized fourteen months in advance of when it comes into effect. The EPA generates a Renewable Identification Number (RIN) for each qualifying gallon of renewable fuel. Refiners and importers comply with their allocated RIN, either by blending physical quantities of biofuels or by purchasing RINs on the open market. The EPA has authority to waive the statutory (EISA) requirements, in whole or in part, when there is an inadequate domestic supply of the fuels (Congressional Research Service 2017). When it lowers cellulosic fuel obligations, the EPA can allow obligated parties to meet their cellulosic fuel requirement by purchasing waiver credits (Congressional Research Services 2019. 3).

The RVO obligation has sorely tested the implementing authority of the EPA. It has frequently failed to meet the statutory deadline for setting the RVO and, in the face of insufficient supplies of cellulosic fuels, often used its waiver authority to reduce RFS2 targets below EISA targets. Legal challenges to its rulemaking have followed. In 2013, the American Petroleum Institute successfully challenged the EPA requirement for refiners and importers to purchase cellulosic waiver credits; the court agreed that cellulosic biofuels did not exist in sufficient amounts to meet the 2012 cellulosic requirement.[25] The renewable fuels industry also mounted a successful legal challenge to the EPA using its waiver authority to reduce the total renewable fuel volumetric requirements for 2014–2016 (Congressional Research Service 2019, 8). Controversy surrounding the EPA's rulemaking has also enveloped the political arena. Congress has held multiple hearings on the RFS (Congressional Research Service 2019, footnote 9; Congressional Research Service

[24] This explanation of the changes that occurred between the proposed rule and the final rule was given in an April 2012 interview by an official in the EPA Office of Transportation and Air Quality. The official explained: "EPA has its models, but it works with industry and considers their data." Gillon (2014, 323) observes that results across different life cycle models calculating biofuels' carbon and energy balances were highly variable.

[25] The EPA eventually dropped the 2011 and 2012 cellulosic requirements to zero.

2018: footnote 6), and anti-RFS Congressmen have introduced a slew of bills since 2013 to reform or eliminate the RFS (Skogstad and Wilder 2019).

EPA's administrative challenges are directly related to the flawed policy design of EISA/RFS2. More specifically, its mandate for cellulosic fuel has far exceeded commercial supplies of cellulosic fuel; they have fallen well short of the volumes mandated in EISA (Gruenspecht 2016). Analysts generally agree that the shortfall in cellulosic biofuels production can be attributed to some considerable degree to the difficulty of attracting private investment for these fuels. With the prices of petroleum products falling since the RFS2 came into effect, the low profit margin potential of cellulosic fuels relative to petroleum products has deterred investment in cellulosic fuels (Ebadian and McMillan 2018). So, too, however, has the policy uncertainty surrounding the RFS (Irena 2019).

Analysts and pro-biofuel stakeholders implicate the EPA's decision-making, including the regulatory uncertainty its decisions have created, in the shortfall in cellulosic fuels production. The discretionary actions of the EPA are alleged to have deterred the growth of the cellulosic feedstock sector and impeded realization of the RFS2 goal to increase demand for cellulosic ethanol (Skolrud et al. 2016). The President of the Advanced Biofuels Association (ABFA), Mike McAdams (2016, 2018) has argued that the EPA's repeated failure to set annual RFS requirements by deadlines and its reduction of annual renewable fuel requirements below statutory levels have created policy uncertainty and other significant barriers to investment in cellulosic and advanced biofuels. In McAdams' view, the EPA has also failed to create a market for cellulosic fuel by allowing obligated parties to purchase a refundable waiver credit to buy out cellulosic fuel RFS2 obligations, and by making it cheaper for oil companies to buy waiver credits instead of producing cellulosic biofuel (Ibid.). In defense, EPA Directors have cited the challenge of rulemaking that relies on difficult-to-predict supplies of advanced biofuels (Oge 2012; McCabe 2016).

Mixed feedback effects of RFS2

The feedback of the EPA's implementation of the annual volumetric requirements for renewable fuels is a mixture of positive and negative material and interpretive effects. First, as already noted, there are reasons to believe the context of regulatory uncertainty has deterred investment in cellulosic fuels. The material benefits associated with a positive RFS feedback dynamic for first-generation biofuels have not materialized for this second-generation biofuel. Second, pro- and anti-RFS stakeholders directly affected by the administrative decisions of the EPA have had strong incentives to remain mobilized and cohesive in order to influence EPA rules. Third, the mixed RFS2 outcomes for conventional and advanced biofuels have challenged the multiple and conflicting logics of the RFS insofar as they have fueled competing interpretations of whether the RFS2 is or is not working as it was intended. Since the first feedback effect has already been discussed, the discussion turns to the second and third effects.

In terms of organizational feedback, the post-EISA implementation context has been marked by considerable mobilization and counter-mobilization. Organizations representing the biofuels sector have increased in number and often worked together. Growth Energy, a trade association representing ethanol plants and biorefineries, was created in 2008. The Advanced Biofuels Association was formed in 2009 to represent the advanced biofuels sector. The Advanced Ethanol Council was founded in 2011; it changed its name to the Advanced Biofuels Business Council in 2015 to reflect its representation of all advanced fuels. These new organizations have joined long-standing organizations representing renewable fuel companies and producers of biofuel feedstocks. Particularly prominent among the latter are the Renewable Fuels Association, which has represented the ethanol industry since 1981; the American Coalition for Ethanol, representing producers of ethanol feedstocks since 1987; the National Biodiesel Board, representing biodiesel producers since 1992; the National Corn Growers Association, representing American corn growers since 1957; and the Biotechnology Innovation Organization (BIO). Called the Biotechnology Industry Organization until 2016, BIO has represented producers of industrial enzymes, biofuels, and the genetically modified seed industries since 1993. Together, this array of organizations represents the full renewable fuel supply chain.

These multiple organizations, which span first- and second-generation biofuels, have cooperated at various times to present the case for the RFS2. Several of them joined an umbrella organization known as Fuels America in 2012 to launch a communications strategy to emphasize the benefits of biofuels for the economy, the environment, and energy security. The Biofuel Producers Coordinating Council was also formed in August 2012, uniting eight biofuel industry organizations.[26] To cite yet another example, Americans for Clean Energy constituted an umbrella organization of several groups formed to petition the Court to review EPA's Renewable Volume Obligations for 2014–2016.[27]

The obvious EPA challenges in administering the RFS have similarly given the anti-RFS coalition reason to remain mobilized in opposition to RFS2. Its coalition is comprised of organizations representing the petroleum-producing and retail sectors (the American Fuel and Petrochemical Manufacturers, American Petroleum Institute, the Society of Independent Gasoline Marketers of America); auto manufacturers (the Alliance of Automobile Association)[28]; poultry and livestock sectors (American Meat Institute, National Chicken Council, National Cattlemen's Association); and food manufacturers and restaurants (Grocery Manufacturers; the National Council of Chain Restaurants). Besides its legal challenges to the EPA's implementation of the RFS2, the anti-RFS coalition has mounted media campaigns across radio, television and internet to inform consumers of the negative effects of ethanol and EPA final rules, and directly lobbied politicians to repeal or amend the RFS2. These efforts have met with similar counter-tactics on the part of the renewable fuel coalition (Sapp 2015; Lane 2014a, b).

Turning to the interpretive effects of the RFS2, they are a mixture of conflicting discourses. On the one hand, the EPA's delays and its repeated use of its waiver authority have created ample fodder to interpret the RFS as "broken" and "unworkable." This discourse is especially prominent among anti-renewable fuel critics.[29] On the other hand, organizations representing first-generation renewable fuels have been joined by organizations

[26] They are the Advanced Biofuels Association, Advanced Ethanol Council, American Coalition for Ethanol, Renewable Fuels Association, Biotech Industry Organization, Algal Biomass Organization, and Growth Energy.

[27] It included the American Coalition for Ethanol, BIO, Growth Energy, the National Corn Growers Association, the National Sorghum Producers, and the Renewable Fuels Association.

[28] The major auto manufacturers are part of this coalition by virtue of their concern that engines in post-2001 vehicles could be damaged by fuels that blend ethanol beyond 10 percent (the normal rate).

[29] See the testimony of the petroleum sector and other critics at a Joint Hearing before the Subcommittee on Environment and Subcommittee on Oversight, Committee on Science, Space and Technology. House of Representatives, November 3, 2015.

representing advanced fuels to present a more favorable interpretation of the RFS2's effects (despite EPA's rulings). They make the case that the RFS2 is working as Congress intended: producing jobs and economic activity, spurring technological innovations, reducing GHG emissions, and improving energy security (Voegele 2017).[30]

Evidence of the maintenance of a united discourse across first-generation and second-generation biofuel stakeholders regarding the RFS's workability can be seen as a further test of the feedback dynamics of the multi-logic RFS. In addition to pointing to evidence that some, if not all, of RFS's multiple goals are being realized, the pro-biofuels coalition also draws on the success of conventional ethanol to argue that the RFS2 can yet work, as Congress intended, to promote advanced biofuels. The rationale was explained by Brooke Coleman, Executive Director of the Advanced Biofuels Business Council, to a Congressional Committee. Coleman stated that the "first mover" companies in cellulosic ethanol were all corn ethanol companies "who are taking revenue streams from the selling of corn ethanol, and because the RFS sends a clear signal to diversify feedstock and innovate, they are doing that" (Coleman 2015). This linkage between first- and second-generation technologies was also made by the Global Business Director for Du Pont Biorefineries: the advanced biofuels industry, he observed, "would be much more difficult, if possible at all, if there was not a corn ethanol industry as well that provides tremendous energy and provides an example for further diversification of feedstocks" (de Coninck 2014). Despite being critical of the EPA's administration of the RFS (as noted above), Advanced Biofuels Association President McAdams has opposed the repeal of the RFS sought by the petroleum industry. McAdams (2016) has argued that repealing the RFS "would change the rules in the first half of the game, benefit incumbent players, and disadvantage those trying to finance and build new innovative technologies." In a reference to the sunk costs of the biofuels sector, McAdams reported that "In the last 6 years, US businesses have spent $14.72 billion dollars in pursuit of the policy goal you [Congress] collectively laid down for this country."

In summary, the post-EISA implementation context has lacked some of the features theorized to be important for positive material and interpretive mechanisms to take hold and generate a self-reinforcing dynamic. The EPA's need to acquire new rulemaking expertise and its inability to patch up flaws in the design of the EISA have handicapped the effectiveness and legitimacy of its rulemaking. Its administration of EISA has proven inadequate in creating a context of regulatory certainty that demonstrates RFS2 is a workable and effective policy for promoting advanced renewable fuels. At the same time, however, positive feedback effects in the form of material benefits to biofuels stakeholders and organizational and discursive cohesion across the two biofuel generations have counterbalanced the negative or self-undermining effects of the RFS2 as articulated by the strong anti-RFS lobby. The positive interpretation of the RFS—that it is advancing many of its intended goals and that the success of second-generation biofuels is contingent upon the revenues that accrue to first-generation biofuels—appears to have resonated with a sufficient number of Congressional representatives to impede the reform or repeal of EISA to date (Skogstad and Wilder 2019).

[30] EPA directors have also argued their administrative actions are consistent with the intent of Congress in legislating EISA: that is, to replace petroleum with renewable fuels, and especially advanced biofuels (Oge 2011; McCabe 2016).

Conclusion

Observing that the mandates set by the USA under its Renewable Fuel Standard have been met for first-generation biofuels but not for second-generation advanced biofuels, this article has investigated how feedback effects from the RFS have contributed to this outcome. To do so, it has traced how features of the RFS's policy design and its administration in the implementation phase have affected the material, organizational, and interpretive effects of the RFS.

Consistent with existing propositions in the literature, the analyses affirm the role of policy design features in policy feedback. More specifically, this study demonstrates that the calibration or setting of a policy instrument—that is, its level of ambition with respect to a disruptive technology replacing an embedded technology—is important to its feedback effects. The initial 2005 RFS was sufficiently small not to pose a material threat to petroleum companies' profits. It was achievable but also large enough to provide incentives to increase corn ethanol production and to generate exorbitant enthusiasm among policy-makers regarding the future of biofuels. The positive material and interpretive effects of the 2005 mandate fueled a self-reinforcing feedback that saw an increase in conventional biofuel mandates in the 2007 EISA.

The feedback from the RFS established in the 2007 EISA also demonstrates the significance of policy design features and the calibration of policy instruments. In terms of material effects, the fivefold increase in renewable fuel mandates in 2007 has been a major incentive for the pro-biofuel coalition to remain mobilized and cohesive behind the RFS. However, the large mandate has also triggered a countervailing backlash from the petroleum industry, which along with other critics, has used all available legal, political, and administrative venues in their attempt to unravel the RFS and create a context of policy uncertainty. The overly ambitious calibration of the RFS2 with respect to advanced cellulosic fuel also proved commercially and administratively infeasible, contributing further to negative interpretations of the RFS as "unworkable."

The article has also theorized the feedback impacts of another feature of policy design: the incorporation of different logics and goals, not fully compatible, within a single policy instrument. RFS2 was presented as a policy that could achieve multiple goals of economic growth, energy security, technological innovation, and climate change mitigation. Success in achieving the multiple goals could be expected to fuel a positive or self-reinforcing dynamic for RFS2—through material benefits to an enlarged group of stakeholders, a wider and united base of organizational support from both conventional and advanced biofuel stakeholders, and a positive interpretation of the policy. As its multi-logic rationale has been jeopardized—in the form of controversy regarding the environmental benefits of conventional biofuels, and the significant gap between the EISA targets for advanced fuels and their commercial production—a self-reinforcing feedback dynamic has also been jeopardized. Evidence that the RFS2—although not its implementation by the EPA—has maintained support from organizations representing the two different technology generations helps to explain why the negative feedback effects of the RFS2 have not led to its repeal.

The article has also affirmed existing feedback theorizing that the post-statutory phase when policies are implemented is crucial to feedback dynamics. The analyses here have demonstrated the significance of regulatory capacity in contributing to a context of regulatory certainty: something especially needed to foster investment in a novel and risky technology. Delayed and contested rulemaking jeopardizes self-reinforcing dynamics, most notably by delaying material benefits to would-be policy supporters. Regulatory procedures, too, matter to feedback dynamics. As the US RFS illustrates, regulatory contexts that require formal opportunities for public comment on draft rules enable organizations with appreciable informational resources to influence rulemaking, especially on matters where administrators lack prior expertise. The subsequent rules clearly affect feedback dynamics through their material effects on beneficiaries and losers. At the same time, regulatory procedures that are transparent and open to public comment can also be expected to affect feedback dynamics, for example, by exposing the extent to which the scientific information that underlies a regulation is robust or contested.

As Patashnik and Zelizer (2013: 1072) remind policy feedback scholars, “the capacity of public policies to remake politics is contingent, conditional and contested.” Policies like the US RFS that allocate a share of the transport fuel market to renewable fuels provide ample evidence of the contested nature of efforts to remake politics when policies impose losses on economically powerful stakeholders. At the same time, this case study reaffirms the broader literature on renewable fuels in demonstrating some conditions—those associated with policy design and implementation procedures—whose feedback dynamics can be anticipated. Even so, the imperatives of consensus-building, be it in legislative or administrative arenas, mean contingencies will always impede efforts to construct policies whose feedback effects remake politics.

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