GOVERNANCE OF BIOFUEL PRODUCTION IN THE UNITED STATES

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Introduction

Until now, U.S. ethanol production has remained tied to the location of the industry’s primary resource, corn. however, abundant corn is not enough to make a U.S. region an ethanol production center. Industrial scale production was not economically viable until federal and state policies created captive markets that incentivize regional production. Furthermore, the emergence of a unique set of policy conditions conducive to the development of a regional ethanol industry depended on the coming together of technological, operational, and business knowledge of agri-processing corporations and the close connection between farmers, industry, and policy makers. This chapter examines how U.S. policies at both the federal and state level interact to create convergent and divergent forms of regional non-renewable energy production pathways. Using a comparative approach that contrasts how multiple regions respond to federal policies, this chapter contributes toward an understanding of the space–time evolution of policy, technology, and industrial development within the United States.

Regional interest groups shape regional concentrations of ethanol production by aligning local policies with the regulatory and market frameworks created by federal environmental governance structures. That is, regional concentrations of ethanol production depend on the coordinated development of policies executed by different levels of government, with each level addressing different industry needs. Both convergent and divergent patterns of regional policy formation and industrial structure exist. Divergence results from prior variation in the pre-existing structure of related industries, interest group organization, and policies among regions.

This chapter has two goals. First it examines national and regional patterns of ethanol production and innovation. Second, this chapter analyzes regionalization of ethanol development by examining causal mechanisms. Emphasis is placed on convergent and divergent industrial development patterns within the United States’ largest ethanol producing region. In the Midwest, a six state region represents 70 percent of all U.S. ethanol production, and 50 percent of all U.S. ethanol facilities (RFA 2013). Analysis of this region and its relationship with differing forms of national environmental governance provides insight into regional patterns of government induced techno-industrial pathways.
To understand why regional variation in industry structure exists and how it relates to the environment, we must understand the evolution of industrial development policies and environmental governance in each state. To do so we must move beyond separate research on economic and environmental impacts and refocus on the development of governance (Bridge 2008; Coenen et al. 2012; Truffer and Coenen 2012; Patchell and Hayter 2013). Such a focus raises three questions that guide this chapter (i) what policies exist, (ii) how do those policies seek to promote ethanol development, and (iii) what does the focus of those policies tell us about how and why the United States’ leading ethanol producing region is incorporating environmental concerns into industrial policies?

**Characteristics of ethanol production**

Biofuels account for 22 percent of U.S. renewable energy consumption and 45 percent of U.S. biomass energy production (USEIA 2013). Corn-based ethanol, produced through the fermentation of starch rich corn kernels, currently accounts for 98 percent of U.S. biofuel production and consumption (USEIA 2013). Blended with conventional forms of energy, ethanol contributes to domestic heating and electricity use. However, ethanol’s principle use is as a transportation fuel oxygenate.

In the United States, ethanol production occurs in regional clusters supported by inter-regional innovation systems and promotional government policies organized around existing agricultural interests. A number of particular interest groups constitute the main actors promoting the regional clustering of production. First, industrial farming interests and developers of genetically modified crops generate abundant ethanol feedstocks at reduced cost leading to the concentration of production in corn-rich regions. Second, corn farmers operate cooperatively owned ethanol biorefineries with production capacities under 100 million gallons per year (mgy) as value-added extensions of their agricultural businesses. Third, related industry interests (e.g., grain processing companies, oil refineries) operate multiple biorefineries with production capacities greater than 100mgy as secondary business interests. For both ethanol producer groups, small and large, biorefinery operation permits integration of suppliers and distributors, and internalization of up- and down-stream market risks. Furthermore, such internalization reduces transportation costs associated with moving grain to market. However, internalization through ethanol production is only feasible in the presence of government policies that create and maintain markets. The federal government mandates ethanol production as a means of emissions reduction and industrial development. State policies promote regional production systems to meet such policy-constructed market needs.

The effectiveness of ethanol production as a form of either industrial development or environmental governance remains contested. Low and Isserman (2009) suggest new biorefineries have very different direct and indirect economic impacts that arise with existing regional economic complexity, although research suggests that these impacts may be less than often claimed (Swenson 2006; Swenson and Eathington 2007). Job multiplier estimates for the ethanol industry vary from 3.4 to 50, an indication of the variation among study assumptions and findings (Swenson 2006). Similarly the environmental impacts of industrial scale ethanol production remain unclear. Estimates of the industry’s net energy balance and net emissions reduction vary greatly (Hammerschlag 2006; Hill et al. 2006; Koh and Ghazoul 2008; Searchinger et al. 2008). Corn-based ethanol’s intensive use of agricultural crops has also increased concern about its impact on food prices and agricultural land use (Cassman and Liska 2007; Thompson 2012).
Development of a new techno-economic paradigm

Networks of firms, institutions, and end users organize the external coordination of production through the use of information and communication technologies (Freeman and Perez 1988; Freeman 1992; Hayter 2008). However, Bridge, Cooke, and Hayter argue that in the future this currently dominant form of industrial production will integrate environmental concerns into industrial networks and renewable energy will be considered in every transaction (Bridge 2002; Hayter and Le Heron 2002; Cooke 2002, 2004; Hayter 2004). Within a “green” techno-economic paradigm competitiveness will depend on the ability to leverage both environmental and industrial change into favorable market conditions. Renewable energy industries face unique investment barriers (e.g., resistant energy interests) that limit the effectiveness of market centered industrial development policies (Esslezbichler 2012; Simmie 2012). Without industry adoption and support the impact of environmental regulation is likewise limited. Effectiveness depends on the convergence of industrial development and environmental policy, and their emergence as a form of combined governance. The process that leads to convergence between industrial and environmental governance giving rise to a new techno-economic paradigm is of interest in understanding the emergence of industrial pathways and regional development (Rodriguez-Pose and Storper 2006; Rafiqi 2009).

The role of federal policy

Federal government policies created a governance framework favoring the development of selected alternative energy industries over others. Responding to lobbying by farmers and agri-processors, government officials built a system of biofuel subsidization alongside existing support for agricultural production. Initial policies focused on market formation insulated ethanol producers from foreign competition, and reduced start-up costs by providing tax credits and subsidized financing. Environmental concerns (e.g., greenhouse gas emissions) expanded government support for alternative energies but initially had limited direct impact on production. Ethanol production remained at a commercial scale until 2003 when a change in environmental regulation created a captive market for the fuel. Prior to 2003 oil refineries commonly used two alternative fuel oxygenates, ethanol and MTBE, to meet emissions reduction standards put in place for major metropolitan areas in the Clean Air Acts of 1970 and 1990. Reacting to groundwater contamination concerns, the USEPA began a planned phase-out of MTBE in 2000. In 2003, New York and California announced plans to ban MTBE, which ultimately led to twenty-five states banning the chemical’s use as a fuel oxygenate (EIA 2003; USEPA 2004, 2012). Ethanol then captured the fuel oxygenate market as the primary oxygenate viable for industrial scale production.

Federal policies shifted to further support ethanol industry development. The Energy Policy Act of 2005 established a national renewable fuel standard (RFS) that mandated production of 7.5bgy of renewable fuel by 2012, a target later expanded to 36bgy by 2022 in the Energy Independence and Security Act of 2007. Alignment of interest group and policy maker interest coalesced into initiatives such as 25×25, a broadly supported (U.S. Congressional Members, farmers, ethanol refiners, university members) agenda calling for 25 percent of the U.S. energy supply to come from renewable sources by 2025 (25×25 2013). Expanded legislative support for production and infrastructure development followed. Until 2012, refineries blending ethanol into fuel received a $0.45 per gallon tax credit. Small ethanol producers received a $0.10 per gallon tax credit for operations producing 60mgy or less.

Governance of biofuel production in U.S.
Despite rapid growth, uncertainty about the economic viability and environmental impact of ethanol remained. In response, federal policy shifted focus to improving the economics of ethanol production absent policy support, and its impact on emission levels, food prices, and land use. In particular, policy placed emphasis on cellulosic technologies that produce ethanol using non-food feedstocks and an improved net energy balance. For example, the Food, Conservation, and Energy Act targets ethanol research by making available $300 million for cellulosic ethanol research, and $250 million in loan guarantees for renewable energy investments. Similarly, the Biomass Research and Development Act of 2000 aimed specifically at ethanol research projects by setting aside funding of $200 million per year. Policy changes were similarly incorporated into the RFS. The 2007 Energy Independence and Security Act amended the RFS to include a progressive shift to “advanced biofuels” based primarily on cellulosic production technologies.

There are currently twenty-three federal policies in operation that directly focus on some segment of the ethanol industry value-chain (Table 20.2). Of those policies, eleven are grant and loan programs, and ten are regulations. In the six states making up this chapter’s study region there are sixty-two ethanol related policies.

The emergence of regional patterns of U.S. industrial ethanol production

Promotional federal policies align environmental and industrial interests to support the development of ethanol production within existing agriculturally intensive regions. Corn-rich regions capitalize on that policy framework through regional policy initiatives that draw necessary investment and innovation to sites of ethanol production.

Like other resource-based industries, ethanol refineries have agglomerated in regions rich in their primary resource. The largest ethanol producing region in the United States (Iowa, Nebraska, Illinois, Indiana, Minnesota, South Dakota) accounts for 70 percent of national ethanol production (9.9 bgyl), 68 percent of national corn production (8.4 billion bushels), and 55 percent ($1.47 billion) of national corn subsidies (USDA 2012; EWG 2013; RFA 2013). In addition, those states received $55.6 billion in corn subsidies from 1995–2012, two-thirds of all national corn subsidies during that time (EWG 2013). Table 20.1 outlines the distribution of ethanol

Table 20.1 Industry characteristics of the largest U.S. ethanol producing states

<table>
<thead>
<tr>
<th>State</th>
<th>Ethanol production*</th>
<th>Corn production**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total (Local)</td>
<td>Non-Local (Local)</td>
</tr>
<tr>
<td>Iowa</td>
<td>3,573 (40) 897 (11)</td>
<td>2,793 (29)</td>
</tr>
<tr>
<td>Nebraska</td>
<td>1,917 (24) 186 (03)</td>
<td>1,731 (21)</td>
</tr>
<tr>
<td>Illinois</td>
<td>1,374 (13) 93 (02)</td>
<td>1,281 (11)</td>
</tr>
<tr>
<td>Indiana</td>
<td>1,038 (13) 0 (00)</td>
<td>1,038 (13)</td>
</tr>
<tr>
<td>Minnesota</td>
<td>1,032 (21) 532 (10)</td>
<td>500 (11)</td>
</tr>
<tr>
<td>South Dakota</td>
<td>1,012 (15) 220 (04)</td>
<td>792 (11)</td>
</tr>
<tr>
<td>United States</td>
<td>13,819 (209)</td>
<td></td>
</tr>
</tbody>
</table>

Source: compiled by authors from EWG (2013); Nebraska Energy Office (2013); RFA (2013); USDA (2012)

* Production in millions of gallons per year with the number of facilities in parentheses
** Corn acreage, bushels, and subsidies in millions
and corn production within these states for the year 2012. Iowa is the largest U.S. producer of ethanol and corn, and receives the greatest amount of corn subsidization from the U.S. government, $370 million in 2012. By comparison, the average ethanol refinery in the state of Minnesota has a production capacity, 56mgy, roughly half that of the average Illinois refinery, 103 mgy.

There are 126 biorefineries operating in these six states (RFA 2013). Industry growth occurred unevenly through time. In 2003 only thirty-three biorefineries operated within the region. Expansion occurred rapidly between 2004 and 2007. By 2007 the number of ethanol refineries operating in the region increased to ninety-four (RFA 2007). The rate of growth slowed as the 2008 financial crisis restricted funding. However, increasing refinery numbers only capture a portion of overall regional growth. Average production capacity at a plant within the region rose from 65mgy in 2003 to 80mgy in 2012. Two factors contributed to that rise. First, early entrants undertook capacity expansion projects to match technological changes within the industry. Second, new ethanol refineries incorporated those advancements into their designs. By 2012 a new biorefinery typically opened with an annual production capacity of 100mgy (RFA 2013).

The financial crisis also impacted the organization of the ethanol industry in the region. Local-ownership as a proportion of total ethanol production declined as related industry interests consolidated their position within the industry. Unable to secure project funding from tightening credit markets and unable to control the prices of their commodity inputs (e.g., corn) or their commodity products (ethanol), biorefineries suspended production or filed for bankruptcy protection. Recognizing an ongoing need for ethanol supplies, agri-processors and oil refiners seized the opportunity to vertically integrate failing biorefineries into their larger operations. Three producers Archer Daniels Midland, POET, and Valero now account for one-third of all U.S. biofuel production (RFA 2013).

Divergent regional policies and industrial patterns

While federal policy encourages ethanol production in the U.S. corn-belt, state policy differentiates production within that region. A divergent industrial pattern emerges as state-to-state policy variation selectively echoes, amplifies, and extends promotional federal policies. Alternative state policy configurations develop as officials and regional interest groups coordinate government action to support the varied interests of related pre-existing industries and emerging ethanol production structures.

<table>
<thead>
<tr>
<th></th>
<th>Tax incentives</th>
<th>Grants and loans</th>
<th>Regulations</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iowa</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>12</td>
</tr>
<tr>
<td>Nebraska</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Illinois</td>
<td>3</td>
<td>3</td>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td>Indiana</td>
<td>2</td>
<td>2</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>Minnesota</td>
<td>1</td>
<td>3</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>South Dakota</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Federal</td>
<td>2</td>
<td>11</td>
<td>10</td>
<td>23</td>
</tr>
</tbody>
</table>

Source: compiled by authors from US AFDC (2012); USEIA (2013).
The role of state-level policies

States within the region vary in the number and focus of their existing ethanol industry regulations. Table 20.2 organizes existing ethanol support policies of each state within the region. Each state provides policy support but incentives focus on different avenues. While states continue to provide a range of incentives there appears to be a preference for regulations at this time. Iowa’s continued use of tax incentives and loans is notable in this respect, although some of these programs target cellulosic ethanol development specifically. How these policies will extend into the future is unclear. For example, following a long history of support for the ethanol industry, Minnesota is currently reassessing many of its ethanol policies. Table 20.3 provides further detail on selected policies of each state. States share a policy focus on market creation measures, production subsidies, and research credits for cellulosic ethanol development. However, the implementation of these policies varies by state, and this variation produces divergent regional industrial structures.

Production policies

Recognizing the opportunity industrial development of corn–based ethanol provided to the United States’ largest corn producing region, state governments enacted supportive policies that matched and at times preceded the intent of federal ethanol governance. Each state in the region mirrored federal market creation efforts with policies designed to facilitate access to ethanol and mandate its use. The most expansive policies amplified the federal government’s renewable fuel standard by instituting larger state usage mandates. For example, the Minnesota legislature passed a law mandating that 20 percent of state’s transportation fuel use is replaced with ethanol by 2013. Although this target was later amended to 2015, the policy exceeds related federal targets that remain limited by the E10 and E15 blend walls. Selected states match Minnesota’s policies. In Iowa the state government has targeted a 25 percent reduction in state gasoline usage by 2020.

To achieve overarching ethanol usage goals, state policy makers instituted regulations facilitating the supply and use of ethanol. In 1997 Minnesota extended emissions reduction mandates within the Clean Air Act to the entire state. The federal legislation targets reduction in only metropolitan areas. Combined with a state-wide ban on MTBE use in 2000, three years before other states banned the chemical, Minnesota created a state-wide market for ethanol. States paired general market creation strategies with incentives that targeted demand through the purchase and use of vehicles capable of operating on higher ethanol mixtures (flexfuel vehicles). For example, Indiana provides direct monthly payments to state agencies based on the number of flexfuel vehicles they operate. Iowa mandates 60 percent of all state-owned vehicles use E85. However, these targets cannot be met without infrastructure alterations. Existing fueling stations cannot dispense higher blend ethanol mixtures through pumps dedicated to lower blend fuels. Recognizing this gap, state governments provide direct loans and tax credits to encourage development and expansion of these distribution facilities. In Iowa, the 2006 Biofuel Infrastructure Program provided grants up to $50,000 for ethanol equipment installation. Similar legislation in Illinois funds the retrofitting of fuel stations to manage the sale of higher ethanol blends.

State policy similarly extended beyond federal policy in direct payments supporting ethanol production. For example, Minnesota, Nebraska, and South Dakota all administered direct payment or tax credit programs to ethanol producers. Minnesota’s direct payment program operated from 1987 to 2012, and distributed $350 million to local ethanol refineries. That program paid ethanol producers a $20 per gallon direct payment for each gallon of ethanol produced. Similarly,
### Table 20.3 Ethanol policies of selected states

<table>
<thead>
<tr>
<th>Policy</th>
<th>Date</th>
<th>State</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nebraska Ethanol Board</td>
<td>1971</td>
<td>NE</td>
<td>Institution created to promote, support, and manage development of the Nebraska ethanol industry.</td>
</tr>
<tr>
<td>Ethanol Development Fund</td>
<td>1986</td>
<td>MN</td>
<td>Provided direct payments of $0.20 per gallon of ethanol to producers. 2000, closed to new applicants.</td>
</tr>
<tr>
<td>Ethanol Production Incentive (SD)</td>
<td>1989</td>
<td>SD</td>
<td>Provides an incentive of $0.20 per gallon to ethanol producers with a maximum of $1 million per facility.</td>
</tr>
<tr>
<td>Ethanol Production Incentive Fund</td>
<td>1990</td>
<td>NE</td>
<td>Incentive program to attract/develop Nebraska ethanol refineries.</td>
</tr>
<tr>
<td>Alternative Energy Loan Program (IA)</td>
<td>1996</td>
<td>IA</td>
<td>50 percent funding for ethanol refinery development project cost, up to $1 million.</td>
</tr>
<tr>
<td>Office of Renewable Fuels (IA)</td>
<td>1997</td>
<td>IA</td>
<td>Established Office of Renewable Fuels and Co-Products.</td>
</tr>
<tr>
<td>Biofuels Production facilities grants (IL)</td>
<td>2003</td>
<td>IL</td>
<td>Funds the construction of production facilities (Min 5mgy) with grants of up to $4 million.</td>
</tr>
<tr>
<td>Ethanol Blend Mandate (MN)</td>
<td>2003</td>
<td>MN</td>
<td>Mandates all gasoline sold in Minnesota must contain 10 percent ethanol, rising to 20 percent in 2015.</td>
</tr>
<tr>
<td>State Agency Petroleum Reduction (MN)</td>
<td>2004</td>
<td>MN</td>
<td>State agencies must achieve a reduction in gasoline use of 25 percent by 2010 and 50 percent by 2015.</td>
</tr>
<tr>
<td>Domestic Energy Research Initiative (NE)</td>
<td>2005</td>
<td>NE</td>
<td>Funds renewable energy projects within the state of Nebraska.</td>
</tr>
<tr>
<td>Biofuels Infrastructure Program (IA)</td>
<td>2006</td>
<td>IA</td>
<td>Provide grants of up to $50,000 to upgrade and install ethanol infrastructure equipment.</td>
</tr>
<tr>
<td>Iowa Office of Energy Independence (IA)</td>
<td>2007</td>
<td>IA</td>
<td>Established Iowa Office of Energy Independence and appropriated $100 million for ethanol research.</td>
</tr>
<tr>
<td>Biofuels Promotion (SD)</td>
<td>2008</td>
<td>SD</td>
<td>Support of the state legislature for the “25x25” initiative.</td>
</tr>
<tr>
<td>E85 Retailer Tax Credit (IA)</td>
<td>2010</td>
<td>IA</td>
<td>Provides a tax credit of $0.20 per gallon to fuel retailers selling E85 ethanol.</td>
</tr>
<tr>
<td>Cellulosic Investment Tax Credit (MN)</td>
<td>2010</td>
<td>MN</td>
<td>Tax credits up $250,000 in support of cellulosic ethanol R&amp;D.</td>
</tr>
<tr>
<td>Corn-to-Ethanol Research Plant (IL)</td>
<td>2010</td>
<td>IL</td>
<td>Funds operation of a pilot plant focused on R&amp;D to reduce the costs of ethanol production.</td>
</tr>
</tbody>
</table>

Source: compiled by authors from state legislative databases.
Nebraska’s Ethanol Incentive Cash Fund distributed $190 million until its closure in 2012. The goal of both programs was to expand in-state ethanol production after tax credits provided to consumers failed to provide sufficient incentive to increase supply. The direct payments also indirectly addressed entry barriers by raising the operating margins of new producers, which improved their ability to manage market volatility. Loan programs that provided start-up funding of up to $0.5 million in Minnesota and $1 million in Iowa for new refinery projects further bolstered these payments.

Administration of related policy measures varies by state, which produces divergent patterns of industrial ethanol production. States established special agencies to coordinate payment programs, infrastructure expansion, and industry promotion efforts. Agencies such as the Nebraska Ethanol Board, Minnesota Ethanol Commission, and Iowa Office of Renewable Fuels and Co-Products pursue similar mandates to promote and facilitate ethanol industry development in their respective states. However, coordinating agencies pursue alternative pathways to development. For example, the Minnesota ethanol commission pursues what Bevill (2008) calls the “Minnesota Model” of ethanol development. The commission targets program support at small local producers in order to ground ethanol profits within the state and insulates biorefineries from price fluctuations in grain and oil markets and competition from established industry interests.

In contrast, direct payment programs in other states do not distinguish payment by ownership type. For example, Nebraska provided direct payments to all ethanol producers. Variation relates to the structure of related industry interests during the establishment of the regional ethanol industry. Minnesota instituted policies favoring local-ownership as a reaction to the early concentration of ethanol production in nearby states. Prior to 2000, the majority of ethanol production was concentrated in Iowa, and operated by ADM. ADM used ethanol as a value-added extension to its primary grain business and placed production facilities near its major transshipment points throughout the state. The company made direct appeals to the federal government for ethanol industry support.

Research policies

Variation in policy support for ethanol research is also responsible for divergent industrial development patterns. National support for ethanol research focuses primarily on development of cellulosic ethanol technologies. However, uncertainty about cellulosic technologies disconnected federal policy support from corn-rich regions, connecting it instead with centers of biotechnology innovation or alternative feedstock abundance. To counteract this trend, policies of corn-rich states support research focused on development of corn-based cellulosic technologies. This amplifies divergence as states select policies that further the interests of related industries and existing industrial structures.

Iowa has been particularly aggressive in its pursuit of cellulosic ethanol research that amplifies existing industrial trajectories. Through Iowa’s Enterprise Zone Program a variety of tax credits, exemptions, and refunds are available for ethanol production projects. As part of the Enterprise Zone Program it is possible to double research tax credits given to ethanol projects. The Iowa
Power Fund appropriated $100 million dollars to be distributed in support of ethanol industry research projects. The fund provided $14 million in research funding for POET’s development of a cellulosic ethanol plant in Emmetsburg Iowa. Research policies also target other segments of the value-chain. The state’s AFV demonstration grants fund research that aims to improve ethanol use in vehicles. Iowa similarly funds development of cellulosic technologies that can be added to existing production facilities. The Power Fund provided $2 million to an algae-based cellulosic project that captures carbon emissions from corn-based ethanol production, and uses them in algae growth.

In contrast to Iowa, Minnesota’s policy makers are beginning to question past government support programs for the ethanol industry. In a 2009 report, the state Office of the Legislative Auditor raised a series of questions about how the state should support the ethanol industry (Christiansen 2009). In particular that report noted subsidization of ethanol production continued even as the industry recorded significant profits. The report also brought into question the environmental impacts of state ethanol production, highlighting the uncertainty surrounding real environmental benefits and the potential for improved results through expansion of cellulosic production. Recent state policy changes are more in line with the report’s findings. Minnesota instituted a cellulosic investment tax credit in 2010 (H.F. 2695) that provides up to $250,000 in support of cellulosic ethanol R&D. However, those projects target alternative markets outside the traditional transportation fuels sector. For example one project explores the possibility of using cellulosic technologies to develop the industrial chemical butonal.

**Discussion and conclusions**

The need for resources ties the ethanol industry to specific locations, but the customization of regional policies to match related industry interests and regional histories geographically differentiates development of industrial scale ethanol production and its environmental impacts. Broadly, the shift in state policies matches the federal reorientation in support for cellulosic ethanol development. However, unlike federal ethanol policies that do not differentiate among industrial feedstocks, regional policies target development of corn-based technologies, or technologies compatible with current forms of ethanol production. Whether differences in federal and regional research policies produce inter-regional divergence or convergence remains unclear. If multiple cellulosic technologies become economically viable, regions may converge in their total ethanol production, albeit along different technological trajectories. Such equalization in regional production would likely shift production toward the U.S. South, where cellulosic feedstocks are abundant and multiple cellulosic research projects are already underway. If one technology emerges or becomes dominant through policy manipulation ethanol production may remain tied to the current production region or shift to another. In either case divergent national patterns would result. Must environmental governance be tied to industrial development policy to produce meaningful environmental, economic, and social impact?

These are industrial development policies that are acting in lieu of environmental governance policies. Policies and governments create environments but firms are principle agents making decisions that structure industries. In such an industry, expanded policy support for the development and transfer of applied research that firms have the capacity to absorb and leverage is likely to produce greater social returns (Rodriguez-Pose 1999; Jensen and Tragardh 2004). Methodologically, this chapter highlights the need for policy analysis to examine the relationship between energy policies and industrial structures. The implementation and impact of energy policies depend on their incorporation into existing industry interests that are themselves varied in both space and time. Methods emphasizing governance and how and why policies favor
some interests over others are needed to understand energy–industry relationships as producers incorporate environmental consideration into decision making.

This chapter contributes to theoretical discussions about the role of regional governance on development of innovation and industrial development. The need to consider how multiple scales of governance interrelate to produce both convergent and divergent regional industrial development trajectories is highlighted. In collaboration with regional interest groups policy makers design interventions that capitalize on opportunities created by national policy frameworks. Variation in regional interests (e.g., large/small farmers, agri-processing firms) differentiates those interventions and the coordination of policy mechanisms. Although not examined in this chapter, those interest groups and regional policy makers also work to alter national policies in their favor. A further examination of that dynamic in relation to the development of cellulosic ethanol policies with clear inter-regional competition is one area of possible future research. Avenues for comparative research exist to show how regional pathways have developed in North America, Europe, and Brazil. With globalization, companies are investing in each other’s markets and collaborating with unusual partners and new industries (e.g., oil refineries, biotechnology) are entering this market. International comparative work exploring how national and state level policies of different countries interact to structure global ethanol industry development would be of particular interest.

Note

1 In other parts of the world, a variety of feedstocks are used for biofuel production such as sugarcane in Brazil.

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