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Conditions Necessary for Private Investment in the Ethanol Industry

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While agricultural economics literature has become rife with the economics of ethanol production and cellulosic ethanol feedstock production, little has been written about capital investment necessary for the magnitude of industry development mandated by the Energy Security and Independence Act of 2007. Financing the development of the ethanol industry to meet the 36 billion gallon production capacity set for 2022 (with 16 billion gallons from cellulosic ethanol) will require capital investments exceeding $100 billion for production facilities, plus extensive investment in feedstock establishment and transportation/handling infrastructure. Federal support associated with political mandates does not address all of the financial issues related with the development of the industry in such a relatively short timeframe. This article addresses the challenges associated with and the conditions necessary for achieving the private investment needed to expand the ethanol industry in the United States.

Key Words: biofuel policy, cellulosic ethanol, industry legitimacy, private investment

JEL Classifications: Q13, Q42, Q43, Q48

The Energy Security and Independence Act of 2007 established both a timeline and targeted production/utilization goals for renewable fuels in the US By 2022 U.S. renewable fuel production must grow to 36 billion gallons, with 16 billion gallons supplied by cellulosic ethanol. Current ethanol production capacity, including both operating plants and plants under construction/expansion, is approximately 11 billion gallons (Renewable Fuels Association, 2008). Virtually all of this current production capacity is grain-based, with only trace amounts of ethanol derived from nongrain feedstocks. The development of the cellulosic ethanol industry will also require the establishment of dedicated energy crops and the infrastructure for the harvesting, handling and storage of feedstocks.

Meeting the renewable fuel mandate of the 2007 Act will require an investment in facilities, transportation and storage infrastructure, and feedstock production that could total over $100 billion in a timeframe of just over a decade. The development of this infrastructure will be one of the greatest challenges for rural America since the advent of rural electrification in the 1930s. Rural electrification was originally funded by a $40 million loan program established by the Rural Electrification Act (REA) of 1936 (Carmody, 1939). Depending upon the inflator used, the original REA program value would equate to $480 million in current dollars, or less than five percent of the anticipated investment to establish

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cellulosic ethanol and meet the mandates of the 2007 Act. Unlike rural electrification, meeting the mandates of the 2007 Act requires the commercialization of currently unproven technologies for deriving ethanol from biomass. An entire industry, required by mandate, has yet to be formed. Despite the extensive discussion of biomass values and cellulosic ethanol production issues in the current literature, the challenge of financing the expansion of the U.S. renewable fuel infrastructure has not been adequately addressed.

Development of the Grain-Based Ethanol Industry

While ethanol had been used in motor vehicles in the U.S. since the Model T rolled off assembly lines in 1908, the U.S. ethanol industry did not develop until the 1970s, encouraged by state and federal tax incentives and mandates for oxygenated gasoline. Ethanol production grew from 175 million gallons in 1980 to 900 million in 1990 and 1.6 billion gallons in 2000 (Renewable Fuels Association, 2008). In 2007 the U.S. produced 6.5 billion gallons of ethanol. Production in 2008 is forecast at 8.5 billion gallons. Current ethanol production capacity including both operating plants and plants under construction/expansion is approximately 11 billion gallons (Renewable Fuels Association, 2008). This growth trend occurred despite some periods of time with unfavorable corn/ethanol price ratios. During the mid-1980s, 88 ethanol plants (mostly smaller plants) closed down (USDA). Ethanol production also declined for a brief period in 1995–1996. Despite these blips, the industry has successfully attracted an unprecedented amount of capital to rural projects.

A variety of policy incentives contributed to the growth of the grain-based ethanol industry (Koplow, 2006). The Energy Security Act of 1980 instituted federally insured loans for ethanol facilities. The Crude Oil Windfall Profits Tax Act of 1980 initiated tax credits for ethanol blenders. This credit has undergone several revisions and has remained as an important incentive for ethanol production. Its current version, the Volumetric Ethanol Excise Tax Credit (VEETC) provides a $0.51 credit for each gallon of pure ethanol blended into gasoline. The credit can only be used at one level of the supply chain by the registered blender. Additional support for developing ethanol facilities was provided by the small producer tax credit first passed in the Omnibus Budget Reconciliation Act of 1990. The subsidy provided a $0.10/gallon credit on the first 15 million gallons produced by plants with a nameplate capacity under 30 million gallons. The capacity limit was doubled to 60 million gallons in the Energy Policy Act of 2005. Ethanol import tariffs were also created to help support the domestic ethanol industry. Ethanol imports are subject to a 2.5% ad valorem tariff and a $0.54/gallon secondary tariff. An exemption from the secondary tariff is made for an amount up to 7% of U.S. ethanol production imported from the Caribbean Basin nations.

Policies designed to stimulate ethanol consumption have also been enacted. The Energy Policy Act of 2005 established minimum consumption per year of ethanol and other renewable fuels. These minimums, commonly referred to as “Renewable Fuel Standards” (RFS), set minimum consumption levels of 7.5 billion gallons by 2012. Incentives for the production of E-85 compatible vehicles and E-85 fueling infrastructure were also put in place to stimulate consumption. Federal incentives for ethanol have also been complimented by a variety of programs at the state level targeting both production and consumption.

While policy incentives helped initiate the grain-based ethanol industry, technology standardization, information technology, and the development of appropriate business models have been major factors in its growth and expansion. In their article discussing the role of information technology on the growth of the ethanol industry, Crooks and Dunn (2005) discussed the role of standardized technology. In the early 1990s ethanol project developers had to go through a very traditional construction process which involved hiring a process management firm, an engineering design firm, as well as a construction management firm. The lack of experience at every level of the process added to costs and start-up problems. As experience in ethanol developed a few prominent equipment firms developed a standardized design technology that cut construction costs in half while reducing project development time by 6–9 months (Crooks and Dunn, 2005). The designs also increased conversion yields while reducing operating costs.

Technology standardization in grain-based ethanol production resulted in the development of "cookie cutter ethanol plants" which minimized construction time while offering predictable construction costs and operating performance. Information technology such as distributed control systems which allowed the design/builder firms to simultaneously monitor and manage the operations of multiple plants supported this business model. The development of procurement, management, marketing, and even project development partnerships helped producer groups and investors to outsource almost every stage of the project (Crooks and Dunn, 2005). This standardized technology allowed new plants to routinely exceed their nameplate capacity, reducing the risk of the venture from the lender's perspective (Bryan, 2003).

Through the early growth stage of the grain-based ethanol industry, local farmers and business people were the primary developers of ethanol projects. Producer investment was driven by a desire to add value and/or mitigate the price swings of their corn production. Local project teams identified site locations, selected technology providers and managed the development process with close support from the designer/builder. Financing for the projects was obtained from the new generation cooperative (NGC) equity structure coupled with debt financing provided by or coordinated by local relationship lenders. As the size of ethanol projects increased, due to significant economies of scale, and the density of projects increased, the capital requirements exceeded traditional (farmer-based) equity and debt financing models. Ethanol projects shifted toward combined producer/investor business models and sought a larger pool of general investors. Project developers began to increasingly look to relationships outside the rural community for both the equity and debt financing (Alexander and Alcala, 2006).

By 2003 a relatively small number of banks were taking the lead role in providing debt financing for ethanol ventures. Five lenders, including CoBank, AgStar Financial Services and First National Bank of Omaha, were the lead lenders on roughly two-thirds of the existing ethanol plants (Bryan, 2003). These lenders had developed the expertise to examine feasibility studies in great depth and analyze access to feedstocks, energy supply, transportation, water, and other project variables. The banks' interest in ethanol projects was limited by capital position and on how much of the banks' total loan portfolio they chose to make available to the ethanol sector (Bryan, 2003).

As the ethanol industry developed, the average size of new ethanol facilities continued to increase. In 2006 there were five ethanol plants under construction with capacities of 100 million gallons/year or greater. A Midwest venture (Aventine Renewable Energy in Pekin, IL) was undergoing an expansion to put its total capacity at 160 million gallons/year. This increase in the number of large-scale projects coincided with an increase in the number of money-center banks lending to ethanol developers, and an increase in the number of private equity firms investing in ethanol companies (Alexander and Alcala, 2006). Access to this expanded pool of capital presented new challenges for the ethanol business model. Money-center banks had a relative lack of experience with ethanol venture financing and did not have long-term relationships with the developers. As a result, these lenders demanded increased documentation with covenants (both affirmative and negative) controlling critical aspects of business operations and applied a higher level of scrutiny to project contracts and to project-related risk management.

The shift toward private investors or institutional equity funds, as well as continued involvement of additional local partners, also created challenges. The expectation of the various investors with respect to the rate of return on equity investments, allocation of voting rights, and control over management had to be reconciled. The equity was typically divided into classes, with each class having a different rate of return on its equity investment and/or different voting rights. Each class also had differential rights to appoint members to the project company's board of directors, and to weigh the votes of each class of equity on different types of management decisions. Certain management decisions could be taken with the vote of less than all classes of equity interests, while other decisions might require the vote of all classes.

The institutional equity funds often demanded covenants to recoup their initial investment before developers or local investors became eligible for equivalent distributions. Both institutional investors and private investors preferred structures which gave them a higher percentage of the initial project profits with those percentages reducing dramatically after the amount of their initial investment had been returned and, in many cases, a nominal return on that investment had also been achieved (Alexander and Alcala, 2006).

Challenges in Financing the Cellulosic Ethanol

Financing the development and expansion of the cellulosic-based ethanol industry will be a greater challenge relative to financing grain-based ethanol. Cellulosic ethanol technology has not been standardized. There are currently competing technologies for pretreatment (acid hydrolysis, steam explosion, ammonia fiber expansion, alkaline wet oxidation, ozone pretreatment) and conversion (chemical hydrolysis, enzymatic hydrolysis, gasification). Cellulosic ethanol plants are likely to use a variety of feedstocks (corn stover, switchgrass, miscanthus, wood waste) with the optimal feedstock depending on regional availability. The optimal scale of a cellulosic plant involves a tradeoff between feedstock transportation and processing economies. The determination of optimal plant size is just one aspect of the standardization desperately needed in order to attract private capital.

Technology Issues

Technological advances in cellulosic ethanol production are likely to be a double-edged sword. Advances will be necessary to move the technology from the pilot plant or demonstrational level to commercial viability. On the other hand, private investors will be reluctant to commit to projects if the development of superior technology appears imminent. The development of the standardized "cookie cutter" cellulosic ethanol plant is not likely to occur in the near future. Until cellulosic technology is standardized, the benefits of standardization such as minimized construction time, and predictable construction costs and operating performance will not be available to investors.

Cellulosic ethanol will require a higher capital investment per gallon of capacity. On February 28, 2007, the U.S. Department of Energy announced $385 million in grant funding to six cellulosic ethanol plants (Wallace et al., 2005) This grant funding accounts for 40% of the investment costs. The remaining 60% comes from the promoters of those facilities. The total of $1 billion will be invested for approximately 140 million gallons of capacity. This translates into $7/annual gallon production capacity in capital investment costs for pilot plants, although construction costs are likely to decrease as the technology is commercialized. Taheripour and Tyner (2008) estimate the cost of a 100 million gallon cellulosic facility at $400 million ($4/gallon of annual production capacity). Even using this conservative estimate, the capital cost of an additional 25 billion gallons of capacity (the difference between the capacity of currently operating and plants under construction and the 36 billion gallon target of the renewable fuel standard) will be $100 billion.

Feedstock Production and Handling

Another major challenge associated with private investment in cellulosic ethanol production relates to feedstock availability and transportation/handling infrastructure. Grain-based ethanol relied upon a readily available feedstock and took advantage of the storage and transportation infrastructure that the grain industry developed extensively during the past century. The development of cellulosic ethanol will require investment in feedstock production and in harvesting, storage, and handling infrastructure. This will involve a substantial investment which will be influenced by feedstock sources and other factors.

Corn stover and other crop residues have been suggested as cellulosic ethanol feedstocks. Crop residues are abundant in Corn Belt states and in certain pockets of agricultural zones throughout the country. Crop residue feedstocks will not require additional crop production costs. However, they will have a limited harvest window which will lead to substantial storage costs for a year round supply. The density of production will depend upon the amount of residue that can be harvested without sacrificing soil quality or land cover requirements. Cellulosic ethanol facilities focusing on crop residue feedstocks may face higher investment costs in feedstock storage and transportation infrastructure, relative to their dedicated energy crop counterparts.

Many advocates of cellulosic ethanol have suggested that dedicated energy crops, such as switchgrass, miscanthus, and other crops, represent a greater long-term opportunity and eventually a lower-cost feedstock for cellulosic ethanol production. Switchgrass has received considerable attention due to its specific inclusion in past Presidential State of the Union addresses and the focus on switchgrass in various federally-sponsored renewable fuels research programs. This fast-growing grass has been touted for its ability to produce tons of biomass on marginal land with relatively small amounts of inputs (i.e., fertilizer and pesticides). However, switchgrass and similar biomass feedstock crops represent a long-term commitment on behalf of the producer, with little or no revenue generated in the first year of production. Furthermore, dedicated energy crops do not have the market flexibility of cereal grains, which have value in both food and feed markets. Thus, a long-term commitment for a dedicated energy crop places significant risk on agricultural producers unless guarantees and contracts are provided.

A number of switchgrass production budgets have been developed in recent years to provide an estimate of feedstock costs for cellulosic ethanol plants. Some of the most recent budgets have examined the products costs associated with switchgrass production. These budgets estimate the costs per ton at the field considerably higher than the $30/ton at-the-plant prices USDA estimates are necessary to make cellulosic ethanol cost competitive with grain-based ethanol (Collins, 2007). Estimates of crop establishment costs vary greatly, from less than $150/acre to over $400/acre depending on the study and the geographic region, and per-ton production and harvesting costs ranged from near $20/ton to near $90/ton (e.g., Haque et al., 2008; Perrin et al., 2007; Popp, 2007; Bangsund, DeVuyst, and Leistriz, 2008). Similarly, the expected yields per acre in these studies range from less than 2 tons/acre to near 10 tons/acre. The five-year production study in three different Midwestern states by Perrin et al. (2007) found yields of 1.1–4 tons/acre. These recent studies are indicators of the relatively unknown and inconsistent feedstock issues facing the cellulosic ethanol industry.

Using a relatively robust estimate of 5 tons/acre, a high-end establishment cost of $400/acre, and assuming a 90 gallon/ton conversion rate, producing 20 billion gallons of cellulosic ethanol from dedicated energy crops would require over 44 million acres and an establishment investment that could near $18 billion. Additional investment will be required for harvesting and transportation equipment, transportation infrastructure (roads, bridges and pipelines for final product), feedstock storage structures, and for the funds to finance the raw material inventory.

Industry Legitimacy

An impediment to raising all of this capital required for the cellulosic ethanol industry is the *legitimacy* of the industry. Aldrich and Fiol (1994) refer to "legitimacy" as an additional hurdle faced by start-up ventures in an industry so young that few if any precedents exist for these ventures to follow. They point out that, in addition to the typical pressures associated with a start-up venture in an established industry, a new industry with questionable legitimacy also requires new ventures to "carve out a new market, raise capital from skeptical sources, recruit untrained employees, and cope with other difficulties stemming from their nascent status." Lawrence (1999) adds to this concept by pointing that certain "legitimating" steps must be taken as part of an industrial strategy to overcome the skepticism from both those who might be capital contributors to the venture and those who might become customers of the firm. A more simplistic way to make the point may be to use the cliché about the settling of the Old West: "Pioneers got the arrows, but settlers got the land." Private investors in individual biofuel ventures are looking to capture both market share and economic rents from technology by being early entrants in the industry, but venture capitalists and philanthropic investors alike still fear what Herrick (2008) calls the "cash flow 'valley of death'" that exists between pilot scale technological assessment and commercial scale production.

Cellulosic ethanol and other biofuel ventures in the category referred to as "Advanced Biofuels" by the RFS face challenges gaining legitimacy. Economic feasibility depends in part upon market mandates and incentives which carry with them the possibility of policy changes. Cellulosic ethanol technologies are unproven on a commercial scale, there are accordingly no established industry norms for these "second generation" technologies, and in general there is a lack of industry leadership. Cellulosic feedstocks do not align with the interest of commodity and producer groups which help promote grainbased ethanol.

Grain-based ethanol ventures of the late 1970s likewise suffered from legitimacy issues, but during the past decade grain-based ethanol found ways to gain legitimacy, and thus capture greater levels of private investment. Sociopolitical legitimacy (Aldrich and Fiol, 1994) was gained through the buy-in of commodity and producer organizations, along with legislative action to promote both ethanol production and utilization, which made ethanol a norm in parts of the country. External legitimacy was gained by successful operation of a handful of Corn Belt ethanol plants, which worked collectively to educate the public, producers, politicians, and private investors. Markets were formed and expanded, technologies became so standardized that plants had nameplate capacities and operational guarantees, employee and managerial training programs were created, and a track record of industry financial performance was established. Legitimacy makes it easier for participants in an industry to obtain resources (Aldrich and Auster, 1986; Shane and Foo, 1999), and this theory was supported by the influx of private investment from both Main Street and Wall Street into the grain-based ethanol industry during the first half of this decade. One could easily argue that the record grain prices of 2007–2008 and the financial woes of 2008 have rocked the foundation of the grain-based ethanol industry, but the same could be said of practically any grain-based agribusiness venture during the same time period.

Overcoming the Challenges

Just as the U.S. successfully developed an electricity distribution infrastructure for rural America, it is possible to overcome the barriers of financing cellulosic ethanol production. Overcoming the financing barriers will require several essential elements: long-term price competitiveness with petroleum-based fuels, proven and standardized technology, consistent public policy, and appropriate business models.

Competitiveness with Petroleum-Based Fuels

As in any industry, private investment capital will flow to cellulosic ethanol if the industry is sufficiently profitable. Over the long run, the ethanol industry must be able to provide transportation fuels at a lower cost relative to petroleum-based alternatives if it is to remain viable. Recent bankruptcies and plant closings of grain-based ethanol and biodiesel plants demonstrate the challenges of maintaining profitability in a volatile price environment. Long-term profitability provides the only guarantee for a sustainable ethanol industry.

Proven and Standardized Technology

Cellulosic ethanol production technology is an important prerequisite to a profitable and competitive industry. While public policy support can encourage investment in cellulosic ethanol, private investment is unlikely to flow until conversion technology is commercialized and standardized. Ethanol design firms, the entities that must guarantee a nameplate capacity, are currently much more cautious about the timeframe for commercialization relative to many industry proponents. After construction, a design firm has a short period of time, typically one to two weeks, to demonstrate that the plant can operate at its stated capacity. Cellulosic ethanol production, due to its more complex conversion process and variable feedstock, faces greater challenges in optimizing processes. Industry leadership toward one or more standardized technology packages for cellulosic production will be an important step in facilitating investment.

Leadership in cellulosic ethanol is beginning to develop, as energy and automobile industry giants lend their name and dollars to cellulosic ethanol joint ventures and strategic alliances (Jordan and Landen, 2008). General Motors, DuPont, Marathon Oil, and BP Amoco are examples of well-known companies who have either invested in or entered into strategic alliances with cellulosic ethanol companies. Their commitment should further remove much of the skepticism associated with cellulosic ethanol, which will hopefully benefit future ventures as they pursue private investment.

Through its technology investment agreement (TIA) program, the Department of Energy (DOE) essentially serves as a venture capital entity for a project with sound technology, thus providing the seed investment to hopefully capture greater private investment. TIAs allow the DOE to function much like the Defense Advanced Research Projects Agency (DARPA) arm of the Department of Defense, which takes financial stakes in projects where both risks and potential payoffs are very large but the potential for field-advancing technology warrant the efforts (Herrick, 2008).

Consistent Public Policy

Policy incentives have played an important role in the development and growth of the grain-based ethanol industry. The RFS mandates of 16 billion gallons of "advanced" biofuel and 36 billion gallon of total ethanol by 2022 are important steps in legitimizing demand for cellulosic ethanol, but consistency in public policy is necessary to draw in private investment. Commitment by the DOE of more than $1 billion to commercial-scale cellulosic ethanol ventures in 2007 and programs ensuring future commitments are indicators of consistent policy and provide sociopolitical legitimacy to the ethanol industry, which helps reassure private investment. These DOE commitments have taken many forms, but primarily consist of grants, cooperative agreements, technology investment agreements, and loan guarantees (DOE, 2007).

For the grants, the DOE acts as "a cost sharing benefactor of equity R&D," while through the cooperative agreements the DOE acts as "a cost sharing research/development partner" (Herrick, 2008). In both cases, the DOE is providing matching funds to support the technological legitimacy of the industry. The DOE's loan guarantees place the department on the "debt side of traditional energy project financing" (Herrick, 2008). These loan guarantees, provided for by Title 17 of the 2005 Energy Policy Act, are similar to the Business & Industry Loan program (B&I Loans) offered through USDA and utilized by many food and fiber value-added ventures. B&I Loans played a critical role in the financing of many grain-based ethanol plants in the U.S., providing guaranteed loans for ventures and alleviating equity risks of private investors. Similarly, the DOE loan guarantees are expected to play a critical role in "second generation" biofuel ventures.

Another existing policy that adds to the legitimacy of the cellulosic ethanol industry is the Biomass Crop Assistance Program initiated by the 2008 Farm Bill. This support is expected to draw producer support and help alleviate uncertainty associated with input availability (Schill, 2008). Feedstock risks are one of the greatest issues concerning private investors in cellulosic ethanol ventures, especially for ventures dependent upon new crops such as switchgrass for their primary feedstock.

While these existing policies will help to overcome the challenges of private investment for the cellulosic ethanol industry, additional support is possible, such as, at the state and local level, tax-exempt solid waste facility bonds and tax increment financing (TIF) bonds. According to Morgan (2008), state and local development/financing entities "have the right to finance tax-exempt facility bonds for the construction of solid waste disposal facilities to be used by private companies." Morgan further points out that "at least 95% of the bonds' net proceeds must be used toward qualified solid waste disposal property and equipment." These bonds, typically with a low but variable interest rate and backed by a lending institution's letter of credit, may prove to be a local source of investment to cover the high costs of plant, property, and equipment associated with ethanol ventures, and could prove to be an important source of funding for cellulosic projects involving wood waste or municipal waste feedstocks.

TIF bonds may also represent a local source of investment for ethanol ventures. Morgan (2008) points out that local or state agencies, after issuing the bonds, can authorize the return of specific sales and/or property tax payments to the venture's organizers to be used in servicing the bond debt.

Business Models

The final piece in attracting the necessary capital to the cellulosic ethanol industry is the development of appropriate business models. Many early grain-based ethanol plants were organized as New Generation Cooperatives (NGCs). The NGC model provided a mechanism to guarantee a feedstock supply. As the industry developed, and investors' understanding of the grain marketing system improved, project developers shifted toward business models which could access nonproducer capital while relying on open market purchases for the grain supply. Developers of cellulosic ethanol projects will face a two-pronged challenge of much higher capital requirements along with the development of a feedstock supply. In the classic "chicken versus egg" situation, producers are unlikely to invest in establishing an energy crop with a long time horizon until the local market is secure. Private investors will be reluctant to invest in production facilities unless feedstock uncertainty can be resolved. One alternative is for the cellulosic facility to contract for long-term production. However, this would significantly increase the capital requirements of the plant. A better alternative is likely to be a business model that provides the feedstock producers an ownership position and profit motivation linked to the project performance.

Hybrid business forms involving both producer and private investor owners will likely be required in order to access sufficient capital. These structures provide two classes of ownership: outside equity investors and patron stockholders. The entity returns are split between the two classes with the outside investors receiving investment-based returns and the patron stockholders receiving patronage-based distributions. This structure is part of a broader classification termed "investor-share cooperatives," which access outside equity through preferred stock, nonvoting common stock, and participation certificates (Chaddad and Cook, 2003).

A number of states, including Wyoming, Minnesota, Wisconsin, and Tennessee, have enacted legislation enabling cooperative/Limited Liability Company (LLC) hybrids. Efforts to develop a uniform federal law for this structure are underway by the National Council of Farmer Cooperatives. While there are differences in individual state statutes, this structure mandates control by farmer members but can allow the investor class to receive up to 85% of the profits (Hensley and Swanson, 2003).

While the structure for combining producer and private investor capital exists, the success of these models is largely unproven. Issues involving feedstock pricing, plant location, profit distribution and control can become controversial. Both groups, producers and private investors, seek to maximize their returns and minimize their risks as investment criteria. The cellulosic ethanol industry may provide the proving ground for the development of hybrid business models which meet the competing needs of producer and private investor members.

Conclusions

Despite the extensive discussion of cellulosic ethanol production issues, and strong initial policy support for the industry, the challenge of financing the expansion of the U.S. renewable fuel infrastructure in a relatively short time-frame has been largely ignored by the literature. Financing cellulosic ethanol is a major challenge, an order of magnitude greater than the development of rural electrification. Among the challenges are unproven profit potential, the lack of a commercialized and standardized conversion technology, high capital cost for plant construction, feedstock establishment and feedstock logistics, and the difficulties in attracting capital to an emerging, unproven industry.

Overcoming these challenges will require a policy environment providing continuing and stable incentives, rapid standardization of technology, and the development of business models which simultaneously stimulate investment in feedstock and processing facilities. However, much like the electrification of rural America, these challenges can be overcome with long-term planning and a clear understanding of the ordering of tasks necessary to reach a national goal.

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