US biofuel and climate policies duel over cellulosic biomass

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US biofuel policy requires that at least 16 billion gallons of cellulosic biofuels are in use by 2022. Current debate about climate policy suggests that energy producers might be given incentives to use biomass in place of greenhouse gas emitting fossil fuels, like coal, and they might be mandated to use renewable inputs. If cellulosic biomass can serve either of these two purposes, then the price will likely be bid higher. Competition for biomass feedstocks could make biofuel and climate policies more expensive. We explore the possibility that these two policies drive up prices of cellulosic biomass. We focus on two feedstock examples, corn stover and switchgrass, to simulate the expected market price effects that take supply and demand responses into account. We assess how interaction between existing biofuel policy and proposed climate policy could affect market prices for these biomass feedstocks and note the consequences for policy costs. Our preliminary results – which we believe to be the first of their kind – suggest that the effects of a renewable electricity standard on biofuel mandate compliance costs would be small under such conditions as a non-binding renewable electricity standard or a binding one that corresponds to an elastic portion of the biomass supply curve, particularly if compared to the effects of eliminating biofuel tax credits on compliance costs.

Implications of US biofuel policy and climate proposals for biomass feedstock demand

The Energy Independence and Security Act (EISA) of 2007 established biofuel use mandates. These are specific quantitative mandates that must be met by fuel blenders, agents who buy input fuels and mix them together into blended fuels for distribution to retail outlets. Every unit of biofuel blenders buy for domestic use is accompanied by a "Renewable Identification Number" (RIN). RINs are the means for blenders to prove they are in compliance with the mandates, but are also tradable. Fuel blenders must show that they have accounted for their allotted share of the total mandate in one of two ways: they must buy at least enough biofuels and accompanying RINs themselves, or else they must buy enough RINs from other blenders to make up any shortfall between the amount of biofuels they must blend to be in compliance and the amount of biofuels they actually blend. The RIN prices are a measure of the mandate compliance cost per unit of biofuel and the product of RINs prices and RIN volumes gives an estimate of the overall compliance cost.

There are four mandates. They are differentiated by the eligible feedstocks and the greenhouse gas reduction targets. The broadest mandate expands to 36 billion gallons in 2022. Conventional ethanol, primarily ethanol made from corn starch today, can count towards this mandate under certain conditions. The other three mandates are submandates; they are part of the broad mandate. The mandate for advanced biofuels grows from less than a billion gallons in 2009 and 2010 to 21 billion gallons in 2022. Imported sugarcane ethanol is an example of an advanced biofuel.[1] The difference between these two, 15 billion gallons, is the maximum contribution of conventional

[1] There are conditions that must be proven to have been met for imported sugarcane ethanol to qualify.

ethanol to the overall mandate.[2] The last two mandates are submandates of both advanced and overall mandates. Of these, the smaller is the biomass based diesel (or biodiesel) mandate that rises to 1 billion gallons by 2012.

The "cellulosic" mandate is for biofuels made from cellulosic matter or from agricultural waste. It was set to start at 0.1 billion gallons in 2010 and rise to 16 billion gallons by 2022.[3] The past tense for the 2010 mandate reflects the decision by the Environmental Protection Agency (EPA) to exercise its discretionary power to waive the cellulosic mandate. The 0.1 billion gallon mandate was judged to be infeasible according to the criteria set out in the EISA. If the cellulosic mandate is not waived in the future, then biofuel blenders will have to buy enough cellulosic biofuels to be in compliance with the EISA. They will bid up the price of these biofuels, encouraging suppliers to produce enough of this fuel. The consequence would be substantial increases in biomass purchases for conversion into cellulosic biofuels. For example, stover and switchgrass might be bought from farms, transported to biorefineries, and converted into ethanol for resale as a cellulosic biofuel, even though this process is at present more expensive than producing conventional ethanol from corn starch.

US climate change policy proposals might give incentives to other agents to buy biomass. At present, there is no climate change policy that has been passed by both chambers of Congress, let alone signed into law. However, there are proposals that might indicate some possible directions of US climate change policy. To explore the possibility, we focus on a key provision of one of these proposals, namely the renewable electricity standard of the American Clean Energy and Security Act (ACESA) of 2009, or HR 2454.

The ACESA has several relevant passages. Probably the most well-known provisions of the proposed law set out a cap-and-trade system for greenhouse gas emissions. An element that is more specific to biomass is a definition of renewable biomass that would clarify the definition given in the EISA. For example, an illustrative list of plant materials includes feed grains and other commodities as well as dedicated crops, and waste materials, such as crop residues. Another relevant part of ACESA sets out a "Combined Efficiency and Renewable Electricity Standard" that would require electricity generating facilities to achieve electricity conservation or use renewable feedstocks for a share of their overall electricity sales. The proposed requirement would rise from 6% in 2012 to 20% in 2020. To the extent that firms selling electricity choose to rely on renewable electricity to meet the target instead of greater efficiency, they will seek to generate renewable electricity and might buy biomass feedstocks. If energy produced from particular types of biomass also generated fewer greenhouse gas emissions and consequently also helped them to meet the limits under the cap-and-trade system, then electricity providers would have even more reason to seek out these feedstocks.

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[2] Corn starch ethanol is not an advanced biofuel, so it cannot count towards the advanced biofuel mandate. The reverse is not true: advanced biofuels also help to meet the overall mandate, so extra advanced biofuel RINs can be used instead of conventional ethanol RINs to comply with the overall mandate.

[3] Both the cellulosic and biodiesel mandates are submandates to the advanced mandate. Because biodiesel has greater energy content than ethanol, each gallon of biodiesel counts as about 1.5 gallons of ethanol towards the advanced mandate. In 2022, the maximum contribution of other advanced biofuels, such as sugarcane ethanol, to the advanced mandate is 3.5 billion gallons (21 billion gallon advanced mandate less 16 billion gallon cellulosic mandate less the product of 1 billion gallon biodiesel mandate times 1.5).

The ACESA did not become law. However, debate about US climate change policy continues. If US biofuel and climate policies compete for the same biomass, how does the addition of climate policy on top of existing biofuel policies affect selected biomass prices and what are the implications for the compliance costs? Here, we start with a partial equilibrium model that represents biofuel and agricultural markets and policies in a forward-looking context. This model represents switchgrass and stover markets that might be used as feedstocks for cellulosic biofuel. This model also represents markets for RINs, the traded certificates of biofuel mandate compliance, and can measure overall compliance costs. We link this partial equilibrium model to a model of electricity and coal markets. We introduce a selection of ACESA provisions to assess how these proposed programs could affect biofuel mandate compliance costs.

Method

Our representation of the biofuel use mandates is based on common partial equilibrium methods, but differs somewhat from other approaches in that the four RIN markets are explicitly represented. In contrast, some studies explore the nature of effects on welfare or on land use in the case of a single mandate (de Gorter and Just, 2009a; Feng and Babcock, 2010). Our RIN markets are part of the FAPRI-MU partial equilibrium model of key biofuel, crop, and livestock markets. This model is designed for forward-looking policy analysis either standing alone (Meyer and Thompson, 2010; Meyer, Westhoff, and Thompson, 2009; Thompson, Meyer, and Westhoff, 2009; Westhoff et al, 2008) or in combination with other model efforts (Thompson, Meyer, Kalaitzandonakes, and Kaufman, 2009; Whistance and Thompson, 2010; Whistance et al., 2010). The representation of crops and livestock markets, including biofuel co-products, are standard for a dynamic partial equilibrium model, and a broad overview of an earlier version of the model is still mostly relevant as regards biofuel demands and supplies (Thompson et al, 2008). This expansion of partial equilibrium modeling to capture the interactions of biofuels and related markets, in this case agriculture, are not unique to FAPRI-MU (OECD, 2006; Walsch et al., 2007), but remains much more narrowly focused than studies using general equilibrium models (Keeney and Hertel, 2009; Reilly and Paltsev, 2007).

The representation RIN markets is critically important: it indicates the degree to which each of the four biofuel mandates are binding, if at all, and the scale of total compliance costs. Supplies of each type of RIN are equal to the volume of the corresponding biofuel that is consumed domestically. The principal demand for RINs is for compliance; blenders submit RINs to prove that they are in compliance with the mandates. We also foresee a demand for RINs to be stored for the next year, within certain limits, which can add to the supplies in the next year. We use a Fischer-Burmeister nonlinear complementarity problem (NCP) to represent the two basic possible outcomes of each mandate, namely that the supply and demand for the corresponding RIN balance at a positive RIN price or that the supply exceeds the demand at a RIN price of zero. We add additional conditions because the mandates overlap such that the RIN for a submandate can count towards both submandate and broader mandate. For example, the cellulosic RIN price cannot be less than the advanced RIN price which, in turn, cannot be less than the conventional RIN price.

The biofuel mandates are not the only biofuel policies. The FAPRI-MU model includes other key policies that we assume in this exercise to remain in place throughout the projection period.

These include tariffs on ethanol imports and tax credits for biofuel use (De Gorter and Just, 2009b; Duffield and Collins, 2006; Gardner, 2007; Tyner and Taheripour, 2008). We also include elements of agricultural policy that relate to cellulosic biomass production; the supplemental tax credit to cellulosic biofuel producers and the support to initiating production and sales of cellulosic biomass (the Biomass Crop Assistance Program) are represented.[4]

The electricity and coal model used here is similar in character to the agricultural and biofuel markets – a dynamic partial equilibrium model – but much smaller in scope. Industrial, residential, and commercial electricity demands are functions of the electricity price specific to that use, plus income and a trend. Natural gas, nuclear, hydro, and other renewable (not biomass) electricity production is a function of the price to industrial users, the benchmark and market-clearing price, lagged production and in some cases trends. Own-price supply coefficients are constrained to be non-negative. Electricity prices to residential and commercial users are functions of the industrial user price. The production of electricity from coal and biomass is not modeled in the same way as for other electricity supplies. Coal and biomass electricity generation are combined into a single derived demand that depends on the relative price of the output (electricity) to the price of the combined input (the weighted average of coal and biomass prices). The coal used for electricity generation is the difference of this aggregate and biomass supplies for electricity generation. In the coal market, industrial, export, and stock demands and domestic production depend on the coal price and other factors, such as income, lagged dependent variables, and trends, all clearing for the price of coal to electricity users. In the forward-looking analysis, we allow for a deviation between the price to users and price to coal producers to reflect the price of carbon in the event that a cap-and-trade system is introduced. All data relating to the electricity and coal markets are from the Energy Information Agency.

We identify the quantities of stover and switchgrass used for biomass electricity production explicitly. We calculate their value in electricity generation based on the coal price to final users plus any bonus if there is a mandate for biomass electricity.[5] The quantity demanded rises rapidly if this value exceeds the price at which the feedstock can be delivered to plants. This value sets an effective floor to the plant price of switchgrass and stover. The quantity of other biomass used for electricity is a function of the coal price to final users, plus any bonus if there is a mandate for biomass electricity.[6] We represent the renewable electricity standard (RES) as a mandate for electricity generation from biomass and certain other renewable feedstocks, and again use a Fischer-Burmeister NCP to determine the price of this mandate if it is binding and to allow a zero price in the event that it is not binding.

Our key question is the indirect interaction in cellulosic feedstock markets of US biofuel and bioelectricity policies. For stover and switchgrass, demands for the commodity to be converted into biofuel or bioelectricity are explicit in the model, and they compete for these commodities at the market-clearing price. If the value to electricity use is greater, then the feedstock price will be bid up to that level and biofuel use will decline. If the value to biofuel production is greater, then that use will dominate and the plant price will exceed the value in electricity generation. For other feedstocks, we assume that there is imperfect substitution between feedstocks going to

[4] The model of agricultural commodities includes agricultural policies that are assumed to continue.
[5] We do not consider explicitly net greenhouse gas emissions from biomass electricity.
[6] We do not estimate this equation using historical data.

biofuel and bioelectricity: we assume that one hundred more unit of energy used for one purpose requires 40 fewer units for the other purpose. The unit of this trade-off is the British thermal units (Btu) embodied in the end product.

Initial values for the projection period for agricultural, biofuel, and RIN markets are based in part on the FAPRI-MU baseline (Meyer and Thompson, 2010; Westhoff and Brown, 2010).[7] There are key differences as regards cellulosic biofuels. First, equations to determine the biomass electricity value of stover and switchgrass are added. Second, the demand equations for stover and switchgrass to refine into cellulosic ethanol and the other cellulosic ethanol production equation are modified. The new specifications are semi-logarithmic functions that are chosen for consistency with the equation determining the quantity of other biomass for electricity. The third key difference from the FAPRI-MU baseline is that we assume here the cellulosic mandate is not waived, but instead that cellulosic biofuel use must be at least equal to the mandated volume.

Initial values for the electricity and coal markets are calibrated to the Energy Information Agency (EIA) 2010 outlook (EIA, 2010). The initial values for the ACESA are calibrated to the EIA's estimates of impacts on electricity and coal markets (EIA, 2009).[8] By calibrating to these results, the effect of the cap-and-trade system and other provisions can be represented indirectly in the analysis here. Our key contribution is to focus on the interaction between biofuel and bioelectricity demands for cellulosic feedstocks.

Scenarios

We simulate the combined biofuel, electricity, crop, livestock, and coal markets for three different scenarios that are differentiated based on whether or not we include ACESA coal prices and renewable electricity standard (RES), and whether or not biofuel tax credits and tariff are discontinued from crop year 2011 on:

1. Base case without ACESA, biofuel tax credits and ethanol tariff extended;
2. ACESA coal price and low effective RES, biofuel tax credits and ethanol tariff extended;
3. ACESA coal price and 15% RES, biofuel tax credits and ethanol tariff extended;
4. Base case without ACESA, biofuel tax credits and ethanol tariff end; and
5. ACESA coal price and low effective RES, biofuel tax credits and ethanol tariff end.

The comparison of the scenarios estimates the impact of a subset of ACESA provisions. Additional scenarios discuss the implications of a higher effective RES. We show results of biofuel policy scenarios for comparison. These scenarios focus on the renewable electricity standard, not any of the other effects on agriculture and biofuels. For example, we ignore the effect of ACESA for agricultural production and for distribution of commodities and goods. For example, if agricultural costs of production and commodity distribution are higher as a consequence of ACESA, we do not take this into account here. We do not consider offsets, so there is no incentive to remove land from agricultural uses or to change agricultural practices.

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[7] The FAPRI-MU model is frequently used for partially stochastic analysis, with specific exogenous data replaced by ranges of values based on historical distributions. Here, however, we use this model deterministically, with a single set of exogenous data.

[8] We apply the percent changes of EIA's 2009 analysis to the EIA's 2010 levels to estimate what would happen if the ACESA were in place instead of the assumptions underlying the EIA's 2010 outlook.

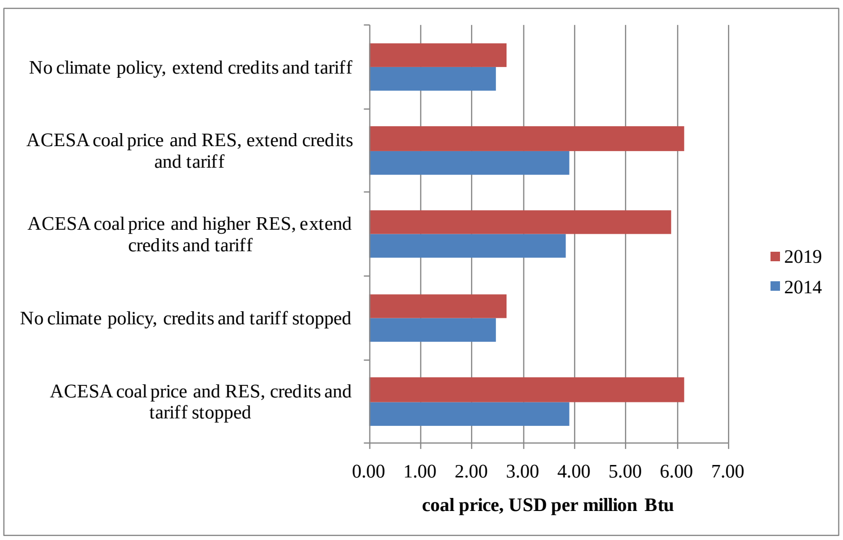
The economy-wide effects are also set aside, although the reductions in overall economic activity estimated by the EIA would have some impact on demands for crop and livestock products. The implications of petroleum product price changes are also largely ignored.

The key result is the effect on biofuel mandate compliance costs. We do not tally up all the costs and benefits of any policy. Many programs are affected as, for example, the budgetary costs of tax credits and the revenues of tariffs alter with volumes as well as with any assumption about whether or not they are allowed to expire. There are effects on motor fuel taxes, consumer expenditures, producer income, and farm program costs. We do not undertake a full calculation of all the welfare implications. Instead, our focus is on the biofuel mandate compliance costs.

Results

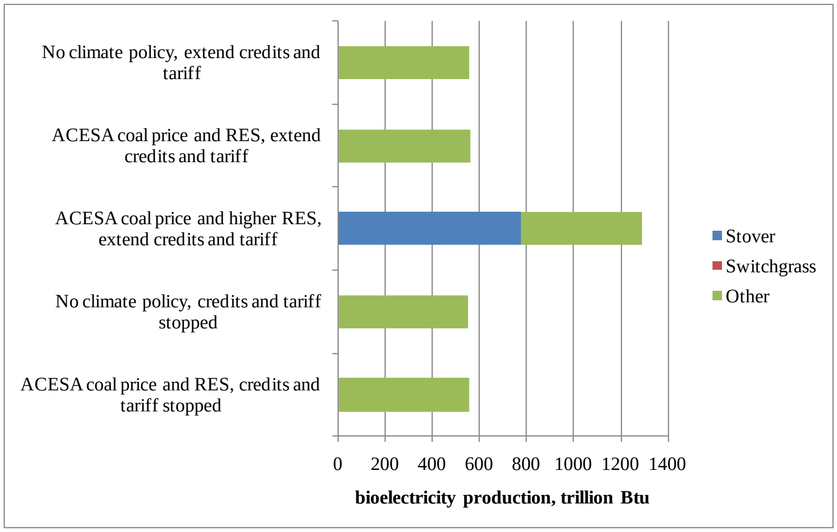
The comparison of the case without ACESA and with ACESA is not very important as far as biofuel markets are concerned – at least given our focus on selected aspects of ACESA and our calibration to EIA results for electricity and coal markets. The EIA judges that the RES is not binding relative to total renewable energies that would be used anyway, not after taking into account the contribution of energy efficiencies to the combined mandate. This element of ACESA has no direct impact on markets. The higher coal price to users that reflects both the commodity price and the carbon price make the alternative of co-fired biomass more attractive. However, the value is not bid high enough to cause any large diversion of biomass into bioelectricity production.

Figure 1. Coal prices to buyers, including carbon costs.



A key difference in this comparison is the coal price, specifically the coal price for buyers that takes into account the implied carbon costs introduced by a cap and trade scheme (Figure 1). The values of the first two cases are based on the EIA's projections, as noted before, and amount to about $1.42 per million Btu in 2014 and almost $3.50 in 2019. Our alternative assumptions about biofuel tax credit and tariff have little impact on the price coal users pay, under our assumptions. A higher RES reduces the user price of coal. When increased to 15% by 2020, the RES becomes binding and forces electricity generation from renewable feedstocks. This leads to substitution away from coal, lowering the coal price by $0.26 in 2019 relative to the case of ACESA with a non-binding RES.

Figure 2. Electricity from biomass, 2019.



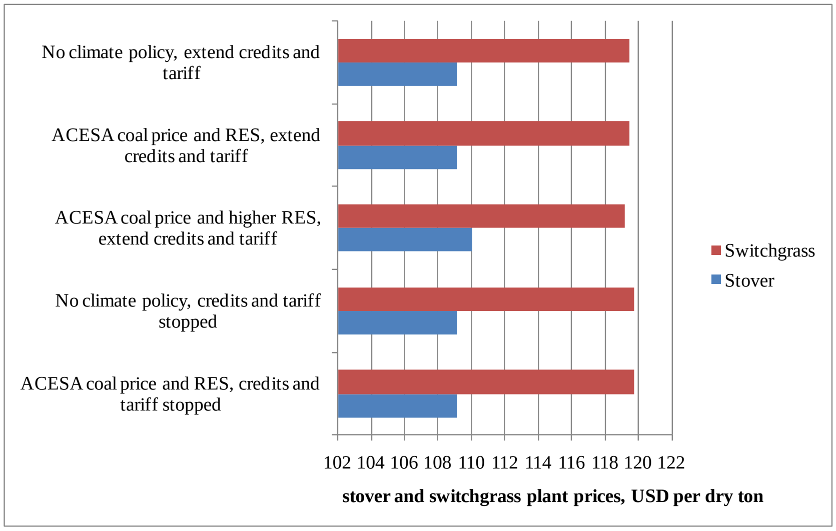
The impact of a higher RES is apparent when comparing electricity generated from biomass (Figure 2). The effective RES would be 15% if electricity generators choose to meet their obligations through purchases of renewable feedstocks, and in particular biomass, instead of through energy efficiencies. Our representation assumes that they would substitute renewables primarily for coal at least in the medium-term future. The expansion would draw in more stover in particular based on the working assumption that stover harvesting could expand rapidly at least enough to meet this demand.[9] In this case, the value of stover in electricity generation has the additional bonus that it helps to meet the higher RES.[10] The combination of factors encourages electricity generators to buy stover which, we assume, they can do at the same plant delivered price that a cellulosic biofuel refinery can. In the one case that the RES is binding, electricity generators and cellulosic biofuel refiners compete to buy stover, as well as other biomass feedstocks.

A key assumption underlying these results is that stover supply is very elastic over the range of this analysis, and that expanding cellulosic biofuel and bioelectricity production of these scenarios are in this range. The path is not altogether smooth; the start-up process for this commodity is critically important and our results are sensitive to the initial values as well as to assumptions about technological improvements, transportation costs, and other factors. For switchgrass, which can expand from very little harvested area to millions of acres if given enough time, we have the additional complication of the area trade-off with traditional crops. Given our assumptions and the fact that the expansion in stover harvesting remains below our assumed maximum stover take-off rate, the supply is very elastic in this region. Thus, the

[9] We limit stover harvesting, but these limits are not met in the scenarios we explore here.
[10] Also, as noted earlier, we use the higher price of coal for users to determine the electricity value of stover, implying that it has no penalty for greenhouse gas emissions of the sort that drive a wedge between coal buyer and seller prices.

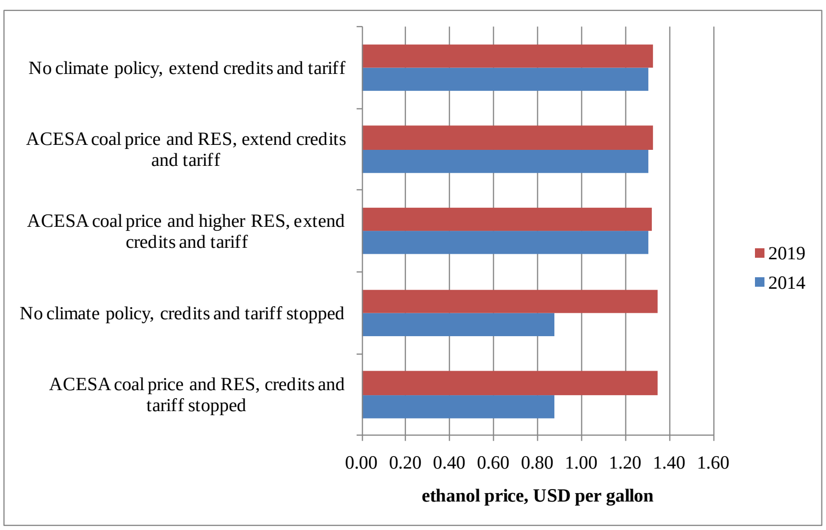
increased demand for the RES does not translate into a significantly higher stover price in this range (Figure 3).

Figure 3. Stover and switchgrass plant prices, 2019



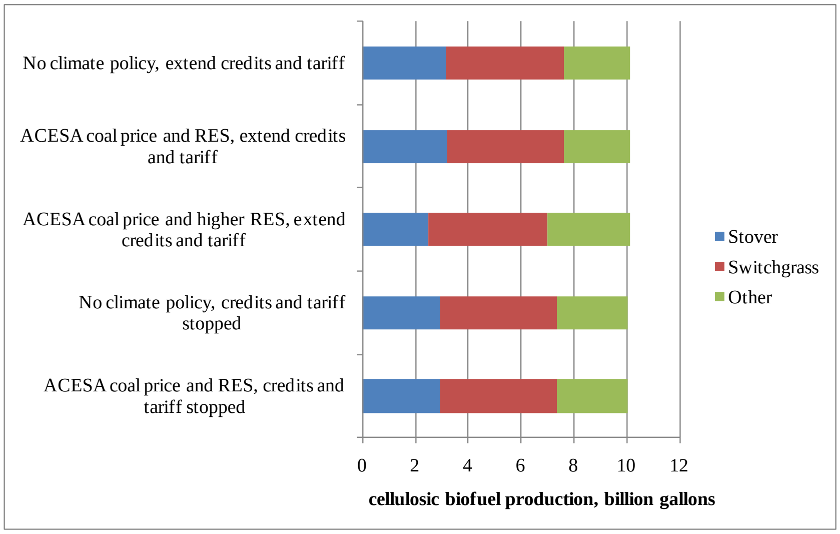
The demand elasticities also play a role in the results. The implications for the price of ethanol of the different combinations of policies are very small in 2019 (Figure 4). Judged here by the rack equivalent of the retail price of ethanol in blended fuels, the 2019 price is largely set by the assumed petroleum price. We assume that if ethanol is commonly used in high level blends, such as E85 (that is up to 85% ethanol), then demand for ethanol as a substitute for gasoline is very elastic.

Figure 4. Rack equivalent of the retail ethanol price.



Ethanol demand is inelastic in the case that use in low-blend fuels (E10, with 10% ethanol) is saturated and the E85 market is very small. This is the case in 2014 if tax credits were discontinued. If they are eliminated from crop year 2011 on, then E85 use is expanding but still too small for the overall ethanol demand to be elastic. Consumers and retailers must be induced to incur the extra expenses of adopting high-blend fuels by lower prices. The retail ethanol price is lower in 2014 if there are no tax credits. In either case, the expansion has occurred by 2019. If expansion was slower than we represent it in the model, then the price differences could persist. As it is, the price differences in 2014 help to explain some later results.

Figure 5. Cellulosic ethanol production, by feedstock, in 2019



The biofuel use mandates require that fuel blenders use at least a certain amount of biofuels, including a volume of cellulosic biofuel that rises to about 10 billion gallons by crop year 2019. This mandate is binding in all these scenarios, so the total volume of cellulosic biofuel equals the mandate (Figure 5).[11] The composition of cellulosic biofuel varies. In the base case, 3.2 billion gallons of cellulosic ethanol are made from stover, 4.4 billion gallons from switchgrass, and 2.5 billion gallons from other cellulosic feedstocks. The switchgrass volume varies little among these scenarios, but there is some trade-off between stover and other feedstocks. The competition for stover in the event that there is a binding RES stands out: there is one-fifth less cellulosic ethanol made from stover, with an offsetting increase in cellulosic ethanol made from other feedstocks.

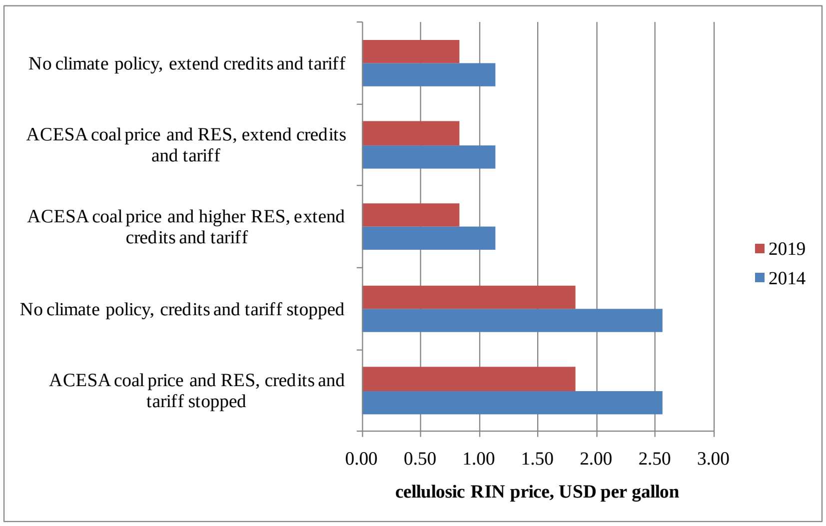
The RIN price measures whether or not a biofuel use mandate is binding and the degree to which it is binding (Figure 6). As noted before, the cellulosic mandate is binding in all the cases that we explore here, given our assumptions. The same cannot be said of the other three biofuel use mandates. Depending critically on the size of the mandate and the petroleum price – which determines the price of competing motor fuels –, and feedstock markets, the overall mandate, the advanced mandate, and the biodiesel mandate might or might not be binding. In every case, the tax credit for biofuel use makes it easier for blenders to meet, if not exceed, the mandates. The support for every gallon used helps blenders to cover costs between buying input fuels and selling retail blends. The tariff, on the other hand, makes it more costly for blenders to buy sugarcane ethanol from Brazil that can count towards the advanced mandate. Finally, the

[11] There are small differences because of RIN storage.

additional tax credit made available to cellulosic biofuel producers encourages them to increase production which tends to lower the price at which they sell their output.

The cellulosic RIN prices are $1.13 in 2014 and $0.83 in 2019 in the base case. The pattern depends on the ability of supply to expand – technologies to improve – at a pace that matches or exceeds the rate of growth in the cellulosic mandate during this period. The introduction of the selected provisions of the ACESA has little impact. The coal price effect and a non-binding RES do not affect the cellulosic RIN price. Even the higher RES can be met with higher stover supplies, at least in the ranges covered in this analysis, and some shifting among cellulosic biofuel and bioelectricity feedstocks.

Figure 6. Cellulosic RIN prices.

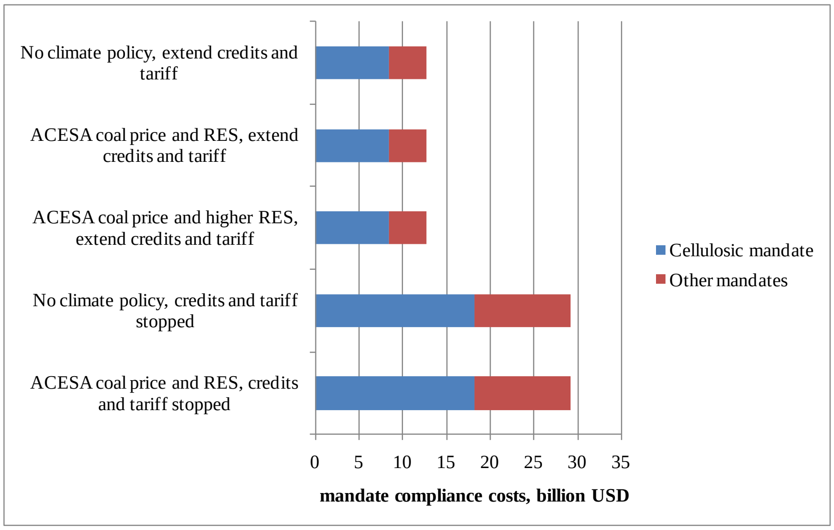


The elimination of tax credits and tariff cause the cellulosic RIN price to more than double in these experiments. The taxpayer had supported the effort to meet the mandated volumes. With the elimination of this support, the tax credits no longer help to meet the mandates. Instead, the costs fall initially on blenders who must still meet the mandated volume, even though they no longer get a tax credit for every gallon of biofuel that they blend. This is particularly important for cellulosic biofuels. For example, in 2019 the total tax credit is $1.01 per gallon. Without that support, the cellulosic RIN prices increase by an offsetting amount.

The compliance costs are calculated here as the product of RIN prices and volumes (Figure 7).[12] The costs of the base case of the mandates is about $13 billion in crop year 2019, of which the cellulosic mandate accounts for $8 billion. The addition of ACESA, even with the higher effective RES, does not lead to large changes given our assumptions here. For comparison, we include the compliance costs in the event that tax credit and tariff are allowed to expire, which rise to $29 billion in total with $18 billion coming from the cellulosic mandate, with or without ACESA.

[12] We omit RIN transaction costs. We also do not count as "compliance cost" the contribution of taxpayers in the form of tax credits paid over the mandated volumes. Instead, this calculation measures the cost beyond transaction costs that falls initially on blenders if the mandate is binding. We assume that these costs are eventually passed on to consumers.

Figure 7. Mandate compliance costs (RIN prices times volumes), 2019



Key uncertainties

This is a preliminary experiment. To the best of our knowledge, this is the first attempt to consider the potential that climate policy creates more competition for cellulosic feedstocks and causes biofuel mandate compliance costs to increase. There are many uncertainties, however, that prevent broad conclusions.

First and most obviously, there is no climate policy at this time. The experiment here is based on a proposal (ACESA or HR 2454) that did not become law. In that case, according to the EIA, the effective renewable energy requirement would not be binding. Analysis of a new climate law would differ from the preceding work if the law differs from the proposal. Moreover, a climate law could have other provisions that have a larger impact on biofuel mandate compliance costs.

Economics and technology that determine price responses are unknown at this time. Current cellulosic biofuel production is a few million gallons, but analysts must look ahead to a time when a mandate calls for many billions of gallons. There is considerable uncertainty about the pace of technological progress in biofuel refining, and the evolution in feedstock production and transportation costs. For example, a critically important assumption in the scenario of a binding RES explored above was that stover harvesting expands rapidly up to a certain percent (that was not exceeded here) if profitable. The results are sensitive to assumptions that determine the margins between ethanol price, feedstock plant price, and feedstock farm price, as well as the responses of refiners and farmers to these prices. Similarly, the margins between electricity prices and biomass feedstock prices are not clear. Even though there are some historical data about the small share of electricity production currently made from biomass feedstocks, these data do not seem likely to represent well the prices and relationships that are relevant in the event of a binding RES.

Trade-offs are uncertain. We assume that there is a quick trade-off between biofuel and bioelectricity uses of stover and switchgrass, ignoring technical obstacles to co-firing these cellulosic feedstocks with coal. The substitution between other cellulosic biofuel and other biomass feedstocks to electricity generation are difficult to estimate. The trade-off between switchgrass and traditional crops (how much area in traditional crops is displaced by area planted to switchgrass) is also unknown at this time. There are claims that switchgrass or other dedicated biofuel crops would be grown on marginal land. If true, then there would be a lower trade-off than we assume with respect to traditional crops, but perhaps instead some trade-off with pasture or hay area. Even the substitution between ethanol and gasoline in the future is uncertain. The nature of ethanol demand in the immediate future is uncertain because there is no historical experience of making the transition into the high-blend (E85) market.

Finally, the context is also uncertain. We assume a certain petroleum price, normal economic conditions, and average yields, for example, but changes in these assumptions would affect analytical results. A very high petroleum price, for example, would reduce mandate costs by making them less binding – even non-binding in the extreme case. The policy context is also unclear. The EISA includes provisions that allow the EPA to waive the mandates. In this analysis, however, the mandates are not waived no matter their impacts.

Summary

The key results of this preliminary experiment suggest some of the key factors that must be assessed to understand the impact of climate change policy on biofuel mandate compliance costs. The effects are contingent on the context, particularly the petroleum price, and the future improvements in biomass feedstock production, transportation, and processing. Other key economic factors include supply responses of biomass production, substitution with other land uses, and substitutability of biomass feedstocks for refiners. This host of uncertainties necessarily limits the strength of our conclusions.

The general conclusions we draw are two-fold. The more obvious one is that a non-binding RES has no direct impact on biofuel mandate compliance costs. The second is that if the supply of biomass is at least locally very responsive, then the introduction of even a binding renewable electricity mandate does not cause a large increase in biofuel compliance costs. The diversion of feedstocks in that case would be offset in time by greater biomass feedstock production. In comparison to the small impact of a renewable fuel standard associated with a hypothetical climate policy shock, our results suggest that there is a large impact if tax credits and also the ethanol tariff are discontinued. Discontinuing these policies can cause a large increase in the compliance costs paid at least initially by fuel blenders whose responsibility to meet the mandate becomes more difficult without taxpayer support. Recalling the discussion above, however, our conclusions are relevant to a specific range of values and should be developed in further research that addresses uncertainties about how these markets and technologies will develop.

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