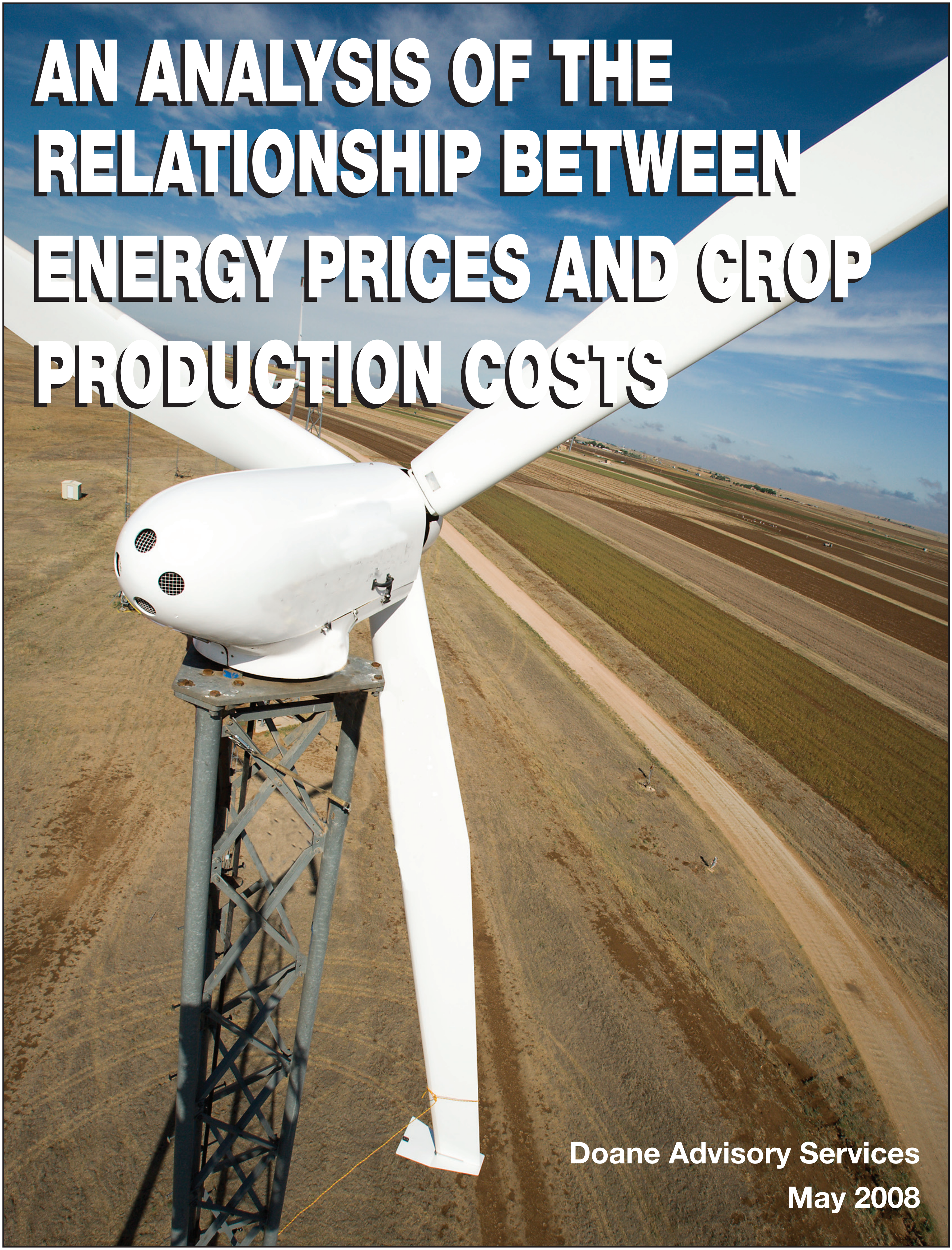
AN ANALYSIS OF THE RELATIONSHIP BETWEEN ENERGY PRICES AND CROP PRODUCTION COSTS



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EXECUTIVE SUMMARY

Energy prices are a major factor in the cost of production for major crops. Growers use significant amounts of diesel fuel, gasoline, electricity and propane to prepare the land, plant and care for the growing crops, harvest the grain and move the products to market. But the impact of energy prices goes well beyond those direct costs, impacting prices farmers pay for many other inputs, especially fertilizers. Rising prices for energy, regardless of the cause, will drive up production costs for farmers and cut into farmers profits.

Congress is considering legislation that would cap greenhouse gas emissions and this legislation is expected to drive up prices for energy, especially for crude oil and natural gas. This study is an effort to evaluate how these higher energy prices would affect production costs for the major crops grown in the U.S. The magnitude of the impact will depend on how much energy prices increase, but analysis by the Environmental Protection Agency suggests that the increases in energy prices could be quite large.

For the study, production costs estimates were projected through 2020 assuming no new legislation. Then, the impact of the energy price increases estimated by EPA were introduced to measure the change in production costs. The results of this effort showed that even with relatively modest energy price increases determined by the EPA study, production costs would increase substantially as a result of climate change legislation. The cost of producing an acre of corn would be $40 per acre higher and the increase in costs for rice would be even larger. The increase in total production expenses for the eight major crops considered would be around $6 billion in 2020.

Using scenarios in the EPA study that show less adjustment by the energy industry, the impacts on the costs of producing major crops would be even more dramatic. Using assumptions that nuclear power and biomass power generation do not increase more than in the base case, EPA suggests crude oil prices will rise by 36.6 percent and natural gas prices would be up 50 percent. This outcome for energy prices causes even bigger increases in crop production costs, pushing total production expenses up $8 billion in 2020 compared to the base case. If carbon capture and sequestration technology does not become available until after 2020, the increase in production expenses is near $12 billion with an $80 per acre increase in corn production costs and an increase of $153 per acre for rice.

The impacts of the high energy prices on production costs in this analysis are substantial. However, the actual impact on agriculture would be even greater. The study was designed to measure the impact of the higher energy prices on per acre production costs, but there would be other affects. It would cost more to transport crops to market, likely increasing the basis and lowering the prices that buyers would pay farmers for their crops. The farther a grower is from the end user — such as a flour mill for wheat or export ports for most crops — the bigger the impact of the increase in transportation costs.

Producers would also end up paying more for other inputs. It would cost more to produce and distribute farm equipment. It would cost more to process and distribute food. These and other costs would impact the price farmers pay for almost all goods and services and would impact what end users could afford to pay for the raw products. Further, the combination of higher production costs and lower prices received for the grains would lower farm production profits and probably cause a decline in land prices, a farmer's most valuable asset.

The data from this study clearly shows that legislation now under consideration could have significant impacts on the costs of producing major crops in the U.S. These higher costs will, at least partially, offset any economic benefits that may result from the proposed legislation.

BACKGROUND

Energy prices are a key factor in the cost of producing crops. The cost of energy affects all aspects of crop production, directly through the costs of fuels, lube, and electricity; and indirectly through the cost of producing and transporting inputs, especially fertilizers. Based on USDA's estimates of per acre corn production costs, fertilizer and fuels account for more than half of total operating expenses. Clearly, any development that drives up energy prices will have an impact on crop production costs and farmer profitability.

Congress is considering a bill that would establish a mandatory greenhouse gas allowance program and one of the consequences of this legislation would be to drive up energy prices. The impact of the proposed law on energy prices was one of the issues addressed by a study conducted by the U.S. Environmental Protection Agency (EPA). The study, titled, *EPA Analysis of the Lieberman-Warner Climate Security Act of 2008, S. 2191 in the 110th Congress,* was published in March 2008 and updated in May 2008. The results of the EPA study form the parameters of energy price increases evaluated to estimate the impact of the proposed legislation on the variable costs of crop production. The impact of three of the scenarios are evaluated here.

While most of the studies published so far focus on the impact of the legislation on energy prices and on the effect on the overall U.S. economy, our mandate is to trace the impact of higher energy prices on crop production costs. The effects of the legislation will build over time, and for our analysis we compared the per acre production costs for eight major crops estimated with no change in policy to costs with higher energy prices. The comparisons were made for 2020 to give time for the legislative changes to have an impact.

METHODOLOGY

The first step in evaluating the impact of changes in energy prices on production costs is to establish a baseline. This serves as a reference point to measure changes in the various cost components when energy prices change. Crop production costs vary widely among U.S. agricultural producers and across regions, making the identification of a benchmark data series critical to the analysis. USDA provides annual estimates of average production costs per planted acre for agricultural crop enterprises in the United States. Those data are published in late fall of each year for the prior year. Historical data for the series are available back to 1975 for most field crops. Those data may be accessed at *http://www.ers.usda.gov/data/costsandreturns/.* In order to develop a representative set of production forecasts, those USDA data were used to standardize cost categories and provide average cost benchmarks for this study.

In addition to the historical data series, USDA has also developed production cost estimates for 2007 and forecasts for 2008 and 2009 for the major field crops. Those 2007 through 2009 USDA forecasts were adopted as part of the baseline for this study and were used as a jumping off point for extending the study's baseline out through 2020.

Major crop production enterprises identified for this study include the eight primary field crops: Corn, soybeans, wheat, cotton, rice, sorghum, oats and barley. Those crops account for more than three-quarters of the 320 million acres devoted to crop production in the United States. When hay is excluded from the total cropland, those eight primary field crops account for more than 95 percent of the 258 million acres of crop area under cultivation.

Total crop production costs include a combination of operating costs and fixed costs. Operating costs are those directly attributable to the crop production enterprise such as seed, fertilizer, fuel, repairs and chemicals. In contrast, fixed costs are not directly related to the annual production decisions and include items such as land and machinery ownership costs, taxes, interest and family labor. The focus of this study is on the operating costs and there are no efforts to measure the impact of higher energy prices on the fixed costs. However, over a long period of time, the fixed costs would be affected by higher energy costs as well.

From the USDA crop production cost data series, eight operating cost categories were identified. Those costs items are seed, fertilizer, chemicals, custom operations, fuel and related energy items, repairs, interest on operating capital, and other variable expenses. Those production cost categories are summarized into annual total operating expenses per planted acre for each of the major crop enterprises.

The most energy sensitive operating expense categories are fertilizer and fuel costs. The impact of rising energy prices on fuel costs is very direct. Farmers have to buy fuel for their equipment to produce crops. The energy impact on fertilizer costs is more indirect, but is extremely critical for crop production. The production of fertilizer is very energy intensive. Fuel is also a major factor in the cost of custom operations, but larger equipment, changes in cultural practices and improving efficiency have dampened the impact of rising energy prices in this expense category. Agricultural chemical expenditures were also evaluated for sensitivity to energy costs. Industry sources suggest that energy comprises about 3 percent of the direct cost of agricultural chemical production. However, dynamic changes in the industry due to the adoption of biotechnology have limited the ability of agricultural chemical producers to pass along energy cost increases.

Other operating expense categories were determined to have limited direct exposure to energy cost changes. Of the other expense items, seed is perhaps the item that seems most likely to be influenced by energy costs. However, industry sources suggest that other factors overshadow the influence of energy costs. Further, the farm level production cost of seed is reflected in the expenditures for fertilizer and fuel since acreage devoted to seed production is included in the total crop acreage. For those reasons, seed expenditures were not included among the crop production expenses directly linked to energy costs.

EXTENDING THE BASELINE

Each of the expense categories for each of the eight crops was extended to cover the 2010 to 2020 period. The baseline costs are based on projections of crude oil prices and natural gas prices provided by government agencies and assume no additional impact from carbon credit legislation. Crude oil price forecasts from USDA were used for the baseline, along with forecasts for natural gas prices from the Energy Information Administration.

A detailed statistical model was developed to relate energy costs to crop production costs. Relationships between energy and crop production costs were determined from a combination of feedback from industry experts and statistical analysis. The operating costs were projected out through 2020 using the baseline crude oil and natural gas prices.

Fertilizer costs are greatly influenced by energy costs. Prices for nitrogen, phosphate, and potash were regressed against the annual index of prices paid for fertilizer as reported by USDA. In turn, the index of prices paid for fertilizer was regressed against annual fertilizer expenditures for each of the eight field crops included in the analysis. Based on data from 1996 through 2007, the correlation between the prices paid for fertilizer and fertilizer expenses for each of the crops exceed 90 percent, reaching a high of 98 percent for corn. Because of the strong fit between the prices paid index and the fertilizer expenses, application rate information was not expressly necessary for the study. Instead, historical trends in application rates and the relative usage of the three primary fertilizer nutrients are inherently embedded in the modeled equations.

To develop an equation to extend the index of prices paid for fertilizer, the individual prices for nitrogen, phosphate, and potash served as independent variables in a regression equation. Three forms of nitrogen: anhydrous ammonia, 28 percent nitrogen solution (UAN), and urea were weighted in proportion with their estimated contribution to total nitrogen usage. The average prices paid by farmers as reported in the *Agricultural Prices* report were converted to a price per nutrient pound. Similarly, prices for phosphate and potash on a nutrient pound basis were included in the regression equation. Using the r-squared statistic, those fertilizer prices explain 99 percent of the variability in the index of prices paid.

Nitrogen prices are closely tied to natural gas prices. Prices paid by farmers for the three nitrogen products for 1990 through 2007 were regressed against the cost of natural gas to derive forecasting equations. According to the analysis, natural gas costs explain on average about 77 percent of the variation in nitrogen prices. The statistical fit is in line with estimates furnished by industry sources with anhydrous ammonia exhibiting the strongest relationship with natural gas, followed by UAN and urea. Statistical relationships for each of the three nitrogen products were linked to the changes in projected natural gas prices through 2020 to drive nitrogen price forecasts.

Costs for potash and phosphate were determined to relate strongly to crude oil prices. Using a linear regression analysis, crude oil explained nearly 93 percent of the variation in prices paid for muriate of potash. The statistical fit for superphosphate dipped, but the r-square of 76 percent remained highly significant.

Once those relationships were developed and determined to be statistically valid, fertilizer expenditures per acre for each of the eight field crops were projected from 2010 through 2020 using the baseline energy price assumptions. USDA's 2009 fertilizer expense projections served as the starting point for measuring annual changes. After the baseline projections were in place, projected changes in energy prices in conjunction with S. 1766 were incorporated in the equations to project a corresponding set of fertilizer cost projections through 2020.

Crop production expenses for fuel, lube and electricity were examined next. Intuitively, that expense category could be expected to correlate quite strongly with the price of crude oil. However, in practice the relationship was not quite as positive as anticipated. Changes in crop production practices since the mid 1990s have reduced per unit expenditures for fuel. Adoption of biotech seed traits — particularly Roundup Ready production systems — and increasing use of conservation tillage have allowed growers to reduce tillage operations, helping to offset rising fuel prices.

Multivariate equations were developed for soybeans, wheat, rice and sorghum using the combination of crude oil and natural gas prices as independent variables. That procedure produced an exceptionally strong fit for wheat, boosting the r-square for the equation to 99.5 percent. The equation yielded a 97.5 percent r-square for soybean fuel expenditures. For rice, the two variables explained 92 percent of the variability, but the fit dipped to 78 percent for sorghum.

For cotton, oats and barley, fuel expenses per acre were regressed against the diesel fuel price to develop estimation equations. Diesel fuel explained most of the variability in fuel expenditures, while natural gas did not show up as a statistically significant independent variable for those crops.

The corn fuel expenses forecast was a bit more difficult. Regression equations explained only slightly more than half the variability. To improve the forecasting methodology, a February 2006 USDA publication, *Characteristics and Production Costs on U.S. Corn Farms, 2001*, provided helpful insight. Survey data in that report was used to quantify the various units of energy used for corn production. Using those quantities for diesel fuel, gasoline, natural gas and LP gas, a mathematical model of calculated energy cost for corn production was constructed. The mathematical model was used to project the impact of changes in energy prices through the forecast horizon.

Chemical costs were estimated based on the prices paid index for agricultural chemicals as reported in the *Agricultural Prices* reports from USDA. Empirical data show that expenditures for agricultural chemicals have been relatively flat since 1996. The researchers postulate that the minimal increase in the agricultural chemical expense category is due in large part to competitive forces in the industry resulting from the adoption of biotechnology, with emphasis on the widespread usage of Roundup Ready crop production systems.

Industry sources suggest that energy costs account for about 3 percent of the production costs for agricultural chemicals. The statistical analysis suggested a 2.3 percent response in agricultural chemical costs with respect to the change in crude oil prices. That relationship was incorporated in the forecasting model, resulting in only slight upward pressure on agricultural chemical costs through the 2020 forecasting horizon.

Custom farming operations comprised the remaining expense category linked to energy costs. For most crops, the relationship with crude oil prices was relatively strong, with r-square values ranging from about 50 percent for cotton to 92 percent for soybeans. For wheat, the yield per planted acre was included in addition to crude oil prices, to explain about 75 percent of the variability in custom farming expenses. Prices charged by custom harvesters for wheat usually increase when yields exceed a certain threshold, usually about 20 bushels per acre.

Developing equations for the custom farming expense category for corn was challenging from a statistical standpoint. Rather surprisingly, there has been a slight downward trend in custom farming expenses for corn despite recent steep increases in fuel costs. After several attempts to fit equations, the researchers defaulted to use the average coefficient for several other crops linking the projections to crude oil prices. The assigned coefficient was 0.1013, suggesting that about 10 percent of any subsequent change in crude oil costs will be passed on to corn producers who use custom farming in their operations.

Forecasts for the other operating expense items including seed, repairs, interest and other variable costs were adjusted in line with increases in the baseline consumer price index released by USDA in February 2008. Projected annual increases in the CPI from 2010 through 2017 are 2.5 percent. We extended the CPI through 2020 using the same rate of increase. The model allows different CPI assumptions to be used in the case of S. 1766. However, the researchers maintained the same rate of increase in the CPI for the baseline and the alternate scenarios.

EVALUATING ALTERNATIVE SCENARIOS

The development of the structural model provides a framework for determining the impact of changes in energy costs on the costs of production for each of the eight major crops. Changes to key energy prices, specifically crude oil prices and natural gas prices, will flow through to the various production expense categories. The energy price changes are introduced into the model as percent changes from the baseline. The resulting new expenses can then be compared to the baseline to determine the impact of the energy price change. The model is flexible enough to evaluate a wide range of changes in energy prices, not just those outlined in the EIA's study of the impacts of the *Low Carbon Economy Act of 2007*. The forecast for crude oil prices was provided by USDA, while the forecast for natural gas is from the Energy Information Administration of the Department of Energy.

The purpose of the development of the model was twofold. First, we needed a way to extend the baseline forecast out beyond 2009, the last point available in the USDA forecasts. We wanted to base the baseline forecasts on the government forecasts for the critical energy inputs. The development of the structural model allows us to change assumptions and project a new baseline if the energy inputs change substantially. Second, the structural model allows us to make projections for the key production costs using alternative energy price scenarios. The objective is to measure the magnitude of the changes in production costs under the various energy price scenarios.

Crude oil prices have soared over the past year or so, with the increases generally exceeding the forecasts. However, the USDA forecast used as the basis for the baseline forecast projects declining crude oil prices during the forecast period. The crude oil price provided by USDA rises through 2009, then declines modestly from 2010 through 2014 before turning higher again. Nominal natural gas prices from EIA rise over the forecast period, but at a rate below the rate of inflation. As a result, increases for operating costs that are closely related to energy prices generally rise less than costs increased by inflation. The assumptions about the rate of increase in energy costs may be suspect, but for this analysis the objective is to find out how changes in energy prices impact production costs, and the assumptions about energy prices do not prevent that evaluation. The assumptions used for crude oil prices and natural gas prices are outlined as follows:

	2007	2015	2020
Crude Oil Price ($/barrel)	$67.00	$80.20	$93.90
Natural Gas ($/MBTU)	$11.30	$12.54	$14.53

The first step in the process was the development of the baseline forecast. Table one shows the USDA forecasts for production costs for 2007 compared to the projections through 2020 based on the baseline energy price assumptions.

TABLE 1: Baseline Cost Of Production Estimates

CORN

Operating Costs:	USDA 2007 estimates	Baseline 2020 estimates	Change $/acre
Seed	48.93	67.19	18.26
Fertilizer	93.96	115.08	21.12
Chemicals	24.67	27.08	2.41
Custom operations	10.93	13.11	2.18
Fuel, lube, and electricity	30.98	39.03	8.05
Repairs	14.86	20.47	5.61
Other variable expenses	0.12	0.17	0.05
Interest on operating capital	5.16	7.62	2.46
Total, operating costs	229.61	289.75	60.14

SOYBEANS

Operating Costs:	USDA 2007 estimates	Baseline 2020 estimates	Change $/acre
Seed	38.27	52.55	14.28
Fertilizer	13.94	17.93	3.99
Chemicals	14.79	16.49	1.70
Custom operations	7.25	8.31	1.06
Fuel, lube, and electricity	16.98	24.22	7.24
Repairs	11.93	16.43	4.50
Other variable expenses	0.15	0.21	0.06
Interest on operating capital	2.37	3.46	1.09
Total, operating costs	105.68	139.60	33.92

WHEAT

Operating Costs:	USDA 2007 estimates	Baseline 2020 estimates	Change $/acre
Seed	9.51	13.06	3.55
Fertilizer	33.33	40.09	6.76
Chemicals	9.23	10.13	0.90
Custom operations	6.93	7.80	0.87
Fuel, lube, and electricity	19.20	25.32	6.12
Repairs	12.78	17.60	4.82
Other variable expenses	0.34	0.47	0.13
Interest on operating capital	2.14	3.16	1.02
Total, operating costs	93.46	117.63	24.17

COTTON

Operating Costs:	USDA 2007 estimates	Baseline 2020 estimates	Change $/acre
Seed	69.31	95.18	25.87
Fertilizer	52.21	61.85	9.64
Chemicals	65.79	72.21	6.42
Custom operations	27.54	32.45	4.91
Fuel, lube, and electricity	42.05	50.54	8.49
Repairs	23.16	31.90	8.74
Other variable expenses	115.59	166.50	50.91
Interest on operating capital	9.11	13.46	4.35
Total, operating costs	404.76	524.09	119.33

RICE

Operating Costs:	USDA 2007 estimates	Baseline 2020 estimates	Change $/acre
Seed	39.63	54.43	14.80
Fertilizer	86.35	104.29	17.94
Chemicals	60.84	66.77	5.93
Custom operations	81.92	97.70	15.78
Fuel, lube, and electricity	132.71	169.51	36.80
Repairs	24.36	33.54	9.18
Other variable expenses	12.90	17.95	5.05
Interest on operating capital	10.14	15.02	4.88
Total, operating costs	448.85	559.21	110.36

SORGHUM

Operating Costs:	USDA 2007 estimates	Baseline 2020 estimates	Change $/acre
Seed	6.04	8.31	2.27
Fertilizer	30.24	36.75	6.51
Chemicals	18.87	20.72	1.85
Custom operations	10.24	12.38	2.14
Fuel, lube, and electricity	37.16	46.69	9.53
Repairs	18.27	25.15	6.88
Other variable expenses	0.11	0.16	0.05
Interest on operating capital	2.77	4.12	1.35
Total, operating costs	123.70	154.28	30.58

BARLEY

Operating Costs:	USDA 2007 estimates	Baseline 2020 estimates	Change $/acre
Seed	10.34	14.20	3.86
Fertilizer	32.93	39.42	6.49
Chemicals	13.73	15.07	1.34
Custom operations	7.83	9.43	1.60
Fuel, lube, and electricity	20.91	25.44	4.53
Repairs	17.05	23.49	6.44
Other variable expenses	2.46	3.42	0.96
Interest on operating capital	2.46	3.63	1.17
Total, operating costs	107.71	134.10	26.39

OATS

Operating Costs:	USDA 2007 estimates	Baseline 2020 estimates	Change $/acre
Seed	12.48	17.14	4.66
Fertilizer	38.24	47.52	9.28
Chemicals	2.40	2.64	0.24
Custom operations	11.05	13.63	2.58
Fuel, lube, and electricity	21.81	28.69	6.88
Repairs	14.26	19.63	5.37
Other variable expenses	3.36	4.67	1.31
Interest on operating capital	1.71	2.53	0.82
Total, operating costs	105.31	136.44	31.13

SUMMARY

	USDA 2007 estimates	Baseline 2020 estimates	Change $/acre
Corn	229.61	289.75	60.14
Soybeans	105.68	139.60	33.92
Wheat	93.46	117.63	24.17
Cotton	404.76	524.09	119.33
Rice	448.85	559.21	110.36
Sorghum	123.70	154.28	30.58
Barley	107.71	134.10	26.39
Oats	105.31	136.44	31.13

MEASURING THE IMPACT OF HIGHER ENERGY PRICES

The structural model provides a solid basis for evaluating a wide range of different energy prices. The way the model is structured, higher energy prices impact fuels, fertilizers, chemicals and custom operations. Interest, seed and other variable costs increase at the rate of inflation and the rate of increase is not impacted by changing energy prices. A further refinement of the model could measure the impact of higher energy prices on inflation and the higher inflation could feed back through the model to impact these non-energy related costs. However, the overall impact on the results would probably be very small.

The EPA study referenced at the beginning of this study found that natural gas prices would be about 35 percent higher in 2020 with the legislation in place than they would have been otherwise in their scenario 2. In scenario 2 the EPA assumed substantial growth in nuclear power and widespread international action. In this scenario, the increase in crude oil prices is around 27 percent according to the study. The energy price changes to the end user include the cost of the carbon content, which is defined by EPA as the product of the physical carbon content of the fuel and the allowance price. The effects of energy price increases of this magnitude are shown in the following set of tables.

The increases in energy prices such as those suggested by the EPA scenario 2 study have significant impacts on per acre production costs. The cost of producing one acre of corn increases about $40, or about 14 percent. Per acre rice production costs go up the most in absolute terms, rising by $79.50 over the baseline, an increase of about 14 percent. The increase for soybeans — which require significantly less fertilizer — is just under 8 percent compared to the baseline by 2020. The total increase in production costs for the eight crops in this scenario is $6 billion, using USDA's forecast of crop acreage in 2017.

TABLE 2: Impacts of EPA Scenario 2 — Crude Oil Prices Increase 27.2% and Natural Gas Prices Rise by 35.2%

CORN

Operating costs:	Baseline 2020	High energy 2020	Change $/acre
Seed	67.19	67.19	0.00
Fertilizer	115.08	140.81	25.73
Chemicals	27.08	28.24	1.16
Custom operations	13.11	15.70	2.60
Fuel, lube, and electricity	39.03	49.87	10.84
Repairs	20.47	20.47	0.00
Other variable expenses	0.17	0.17	0.00
Interest on operating capital	7.62	7.62	0.00
Total, operating costs	289.75	330.08	40.33

SOYBEANS

Operating costs:	Baseline 2020	High energy 2020	Change $/acre
Seed	52.55	52.55	0.00
Fertilizer	16.79	20.03	3.25
Chemicals	16.24	16.93	0.70
Custom operations	8.07	8.72	0.65
Fuel, lube, and electricity	22.16	28.08	5.93
Repairs	16.43	16.43	0.00
Other variable expenses	0.21	0.21	0.00
Interest on operating capital	3.46	3.46	0.00
Total, operating costs	135.90	146.42	10.52

WHEAT

Operating costs:	Baseline 2020	High energy 2020	Change $/acre
Seed	13.06	13.06	0.00
Fertilizer	40.09	47.76	7.66
Chemicals	10.13	10.57	0.43
Custom operations	7.80	8.30	0.50
Fuel, lube, and electricity	25.32	33.05	7.73
Repairs	17.60	17.60	0.00
Other variable expenses	0.47	0.47	0.00
Interest on operating capital	3.16	3.16	0.00
Total, operating costs	117.63	133.96	16.33

COTTON

Operating costs:	Baseline 2020	High energy 2020	Change $/acre
Seed	95.18	95.18	0.00
Fertilizer	61.85	71.90	10.05
Chemicals	72.21	75.31	3.10
Custom operations	32.45	37.99	5.54
Fuel, lube, and electricity	50.54	56.74	6.20
Repairs	31.90	31.90	0.00
Other variable expenses	166.50	166.50	0.00
Interest on operating capital	13.46	13.46	0.00
Total, operating costs	524.09	548.97	24.88

RICE

Operating costs:	Baseline 2020	High energy 2020	Change $/acre
Seed	54.43	54.43	0.00
Fertilizer	104.29	124.98	20.69
Chemicals	66.77	69.64	2.86
Custom operations	97.70	116.20	18.50
Fuel, lube, and electricity	169.51	206.96	37.44
Repairs	33.54	33.54	0.00
Other variable expenses	17.95	17.95	0.00
Interest on operating capital	15.02	15.02	0.00
Total, operating costs	559.21	638.71	79.50

SORGHUM

Operating costs:	Baseline 2020	High energy 2020	Change $/acre
Seed	8.31	8.31	0.00
Fertilizer	36.75	44.47	7.72
Chemicals	20.72	21.61	0.89
Custom operations	12.38	14.99	2.60
Fuel, lube, and electricity	46.69	57.71	11.03
Repairs	25.15	25.15	0.00
Other variable expenses	0.16	0.16	0.00
Interest on operating capital	4.12	4.12	0.00
Total, operating costs	154.28	176.51	22.24

BARLEY

Operating costs:	Baseline 2020	High energy 2020	Change $/acre
Seed	14.20	14.20	0.00
Fertilizer	39.42	46.58	7.16
Chemicals	15.07	15.71	0.65
Custom operations	9.43	11.35	1.93
Fuel, lube, and electricity	25.44	29.06	3.62
Repairs	23.49	23.49	0.00
Other variable expenses	3.42	3.42	0.00
Interest on operating capital	3.63	3.63	0.00
Total, operating costs	134.10	147.45	13.35

OATS

Operating costs:	Baseline 2020	High energy 2020	Change $/acre
Seed	17.14	17.14	0.00
Fertilizer	47.52	59.38	11.86
Chemicals	2.64	2.75	0.11
Custom operations	13.63	16.89	3.26
Fuel, lube, and electricity	28.69	36.14	7.45
Repairs	19.63	19.63	0.00
Other variable expenses	4.67	4.67	0.00
Interest on operating capital	2.53	2.53	0.00
Total, operating costs	136.44	159.12	22.67

SUMMARY

	Baseline 2020	High energy 2020	Change $/acre
Corn	289.75	330.08	40.33
Soybeans	135.90	146.42	10.52
Wheat	117.63	133.96	16.33
Cotton	524.09	548.97	24.88
Rice	559.21	638.71	79.50
Sorghum	154.28	176.51	22.24
Barley	134.10	147.45	13.35
Oats	136.44	159.12	22.67

The second scenario studied to evaluate the impact of higher energy prices on crop production costs, is scenario 6 from the EPA study. This EPA scenario estimates the increase in energy prices based on the assumption that nuclear power and biomass power do not exceed the growth recorded in the base case, scenario 1. Under this scenario, prices for crude oil are up 36.6 percent over the base case by 2020 and natural gas prices are almost 50 percent higher. Such large increases in energy prices would have significant cost implications for U.S. crop producers.

With the large increases in crude oil prices and natural gas prices U.S. crop producers would face much higher production costs. The energy price increases outlined in EPA scenario 6 would add more than $55 to the costs of producing an acre of corn and more than $100 an acre for rice producers. For most crops the per acre production costs increase by around 20 percent compared to the baseline. The increases in energy prices outlined in this scenario would add more than $8 billion to total production costs for the eight crops studied using USDA's 2017 expected crop acres.

TABLE 3: Impacts of EPA Scenario 6 — Crude Oil Prices Increase 36.6% and Natural Gas Prices Rise by 49.4%

CORN

Operating costs:	Baseline 2020	High energy 2020	Change $/acre
Seed	67.19	67.19	0.00
Fertilizer	115.08	150.43	35.35
Chemicals	27.08	28.64	1.56
Custom operations	13.11	16.60	3.49
Fuel, lube, and electricity	39.03	53.87	14.85
Repairs	20.47	20.47	0.00
Other variable expenses	0.17	0.17	0.00
Interest on operating capital	7.62	7.62	0.00
Total, operating costs	289.75	345.00	55.26

SOYBEANS

Operating costs:	Baseline 2020	High energy 2020	Change $/acre
Seed	52.55	52.55	0.00
Fertilizer	16.79	21.25	4.46
Chemicals	16.24	17.17	0.94
Custom operations	8.07	8.94	0.87
Fuel, lube, and electricity	22.16	30.21	8.06
Repairs	16.43	16.43	0.00
Other variable expenses	0.21	0.21	0.00
Interest on operating capital	3.46	3.46	0.00
Total, operating costs	135.90	150.23	14.33

WHEAT

Operating costs:	Baseline 2020	High energy 2020	Change $/acre
Seed	13.06	13.06	0.00
Fertilizer	40.09	50.62	10.53
Chemicals	10.13	10.72	0.58
Custom operations	7.80	8.45	0.65
Fuel, lube, and electricity	25.32	35.92	10.60
Repairs	17.60	17.60	0.00
Other variable expenses	0.47	0.47	0.00
Interest on operating capital	3.16	3.16	0.00
Total, operating costs	117.63	140.00	22.36

COTTON

Operating costs:	Baseline 2020	High energy 2020	Change $/acre
Seed	95.18	95.18	0.00
Fertilizer	61.85	75.66	13.81
Chemicals	72.21	76.38	4.17
Custom operations	32.45	39.90	7.45
Fuel, lube, and electricity	50.54	58.88	8.34
Repairs	31.90	31.90	0.00
Other variable expenses	166.50	166.50	0.00
Interest on operating capital	13.46	13.46	0.00
Total, operating costs	524.09	557.86	33.77

RICE

Operating costs:	Baseline 2020	High energy 2020	Change $/acre
Seed	54.43	54.43	0.00
Fertilizer	104.29	132.72	28.43
Chemicals	66.77	70.63	3.85
Custom operations	97.70	122.60	24.90
Fuel, lube, and electricity	169.51	220.04	50.53
Repairs	33.54	33.54	0.00
Other variable expenses	17.95	17.95	0.00
Interest on operating capital	15.02	15.02	0.00
Total, operating costs	559.21	666.91	107.70

SORGHUM

Operating costs:	Baseline 2020	High energy 2020	Change $/acre
Seed	8.31	8.31	0.00
Fertilizer	36.75	47.36	10.61
Chemicals	20.72	21.92	1.20
Custom operations	12.38	15.89	3.50
Fuel, lube, and electricity	46.69	61.91	15.22
Repairs	25.15	25.15	0.00
Other variable expenses	0.16	0.16	0.00
Interest on operating capital	4.12	4.12	0.00
Total, operating costs	154.28	184.81	30.53

BARLEY

Operating costs:	Baseline 2020	High energy 2020	Change $/acre
Seed	14.20	14.20	0.00
Fertilizer	39.42	49.25	9.84
Chemicals	15.07	15.94	0.87
Custom operations	9.43	12.02	2.59
Fuel, lube, and electricity	25.44	30.31	4.87
Repairs	23.49	23.49	0.00
Other variable expenses	3.42	3.42	0.00
Interest on operating capital	3.63	3.63	0.00
Total, operating costs	134.10	152.26	18.17

OATS

Operating costs:	Baseline 2020	High energy 2020	Change $/acre
Seed	17.14	17.14	0.00
Fertilizer	47.52	63.81	16.29
Chemicals	2.64	2.79	0.15
Custom operations	13.63	18.01	4.39
Fuel, lube, and electricity	28.69	38.71	10.02
Repairs	19.63	19.63	0.00
Other variable expenses	4.67	4.67	0.00
Interest on operating capital	2.53	2.53	0.00
Total, operating costs	136.44	167.29	30.85

SUMMARY

	Baseline 2020	High energy 2020	Change $/acre
Corn	289.75	345.00	55.26
Soybeans	135.90	150.23	14.33
Wheat	117.63	140.00	22.36
Cotton	524.09	557.86	33.77
Rice	559.21	666.91	107.70
Sorghum	154.28	184.81	30.53
Barley	134.10	152.26	18.17
Oats	136.44	167.29	30.85

The final scenario evaluated for this study is scenario 7 in the EPA study of energy price impacts of the Lieberman-Warner Climate Security Act of 2008. This scenario assumes that nuclear power and biomass power do not exceed the growth in the base case and that carbon capture and sequestration technology does not become commercially available until 2030. Without the sequestration and carbon capture technology, prices for crude oil and natural gas are significantly higher than in the base case. Crude oil prices are up 52 percent over those in the base case and natural gas prices are almost 71 percent higher. These price levels would substantially increase production costs for all eight major crops evaluated.

The higher energy prices indicated in scenario 7 would boost per acre corn production costs by almost $80, an increase of more than 27 percent over the baseline. Production costs for all crops would rise significantly with costs to produce an acre of rice up more than $150 compared to the base case. The impact on total crop production expenditures would amount to almost $12 billion, using USDA's acreage estimates.

TABLE 4: Impacts of EPA Scenario 7 — Crude Oil Prices Increase 52.0% and Natural Gas Prices Rise by 70.8%

CORN

Operating costs:	Baseline 2020	High energy 2020	Change $/acre
Seed	67.19	67.19	0.00
Fertilizer	115.08	165.53	50.45
Chemicals	27.08	29.30	2.22
Custom operations	13.11	18.07	4.96
Fuel, lube, and electricity	39.03	60.20	21.17
Repairs	20.47	20.47	0.00
Other variable expenses	0.17	0.17	0.00
Interest on operating capital	7.62	7.62	0.00
Total, operating costs	289.75	368.55	78.80

SOYBEANS

Operating costs:	Baseline 2020	High energy 2020	Change $/acre
Seed	52.55	52.55	0.00
Fertilizer	16.79	23.15	6.37
Chemicals	16.24	17.57	1.33
Custom operations	8.07	9.31	1.24
Fuel, lube, and electricity	22.16	33.63	11.47
Repairs	16.43	16.43	0.00
Other variable expenses	0.21	0.21	0.00
Interest on operating capital	3.46	3.46	0.00
Total, operating costs	135.90	156.31	20.41

WHEAT

Operating costs:	Baseline 2020	High energy 2020	Change $/acre
Seed	13.06	13.06	0.00
Fertilizer	40.09	55.12	15.03
Chemicals	10.13	10.96	0.83
Custom operations	7.80	8.69	0.88
Fuel, lube, and electricity	25.32	40.44	15.13
Repairs	17.60	17.60	0.00
Other variable expenses	0.47	0.47	0.00
Interest on operating capital	3.16	3.16	0.00
Total, operating costs	117.63	149.50	31.87

COTTON

Operating costs:	Baseline 2020	High energy 2020	Change $/acre
Seed	95.18	95.18	0.00
Fertilizer	61.85	81.56	19.71
Chemicals	72.21	78.13	5.92
Custom operations	32.45	43.04	10.59
Fuel, lube, and electricity	50.54	62.39	11.84
Repairs	31.90	31.90	0.00
Other variable expenses	166.50	166.50	0.00
Interest on operating capital	13.46	13.46	0.00
Total, operating costs	524.09	572.15	48.06

RICE

Operating costs:	Baseline 2020	High energy 2020	Change $/acre
Seed	54.43	54.43	0.00
Fertilizer	104.29	144.86	40.56
Chemicals	66.77	72.25	5.47
Custom operations	97.70	133.07	35.37
Fuel, lube, and electricity	169.51	241.34	71.83
Repairs	33.54	33.54	0.00
Other variable expenses	17.95	17.95	0.00
Interest on operating capital	15.02	15.02	0.00
Total, operating costs	559.21	712.45	153.24

SORGHUM

Operating costs:	Baseline 2020	High energy 2020	Change $/acre
Seed	8.31	8.31	0.00
Fertilizer	36.75	51.89	15.14
Chemicals	20.72	22.42	1.70
Custom operations	12.38	17.36	4.98
Fuel, lube, and electricity	46.69	68.44	21.75
Repairs	25.15	25.15	0.00
Other variable expenses	0.16	0.16	0.00
Interest on operating capital	4.12	4.12	0.00
Total, operating costs	154.28	197.84	43.56

BARLEY

Operating costs:	Baseline 2020	High energy 2020	Change $/acre
Seed	14.20	14.20	0.00
Fertilizer	39.42	53.45	14.04
Chemicals	15.07	16.30	1.24
Custom operations	9.43	13.11	3.68
Fuel, lube, and electricity	25.44	32.36	6.92
Repairs	23.49	23.49	0.00
Other variable expenses	3.42	3.42	0.00
Interest on operating capital	3.63	3.63	0.00
Total, operating costs	134.10	159.97	25.87

OATS

Operating costs:	Baseline 2020	High energy 2020	Change $/acre
Seed	17.14	17.14	0.00
Fertilizer	47.52	70.77	23.25
Chemicals	2.64	2.85	0.22
Custom operations	13.63	19.86	6.23
Fuel, lube, and electricity	28.69	42.93	14.24
Repairs	19.63	19.63	0.00
Other variable expenses	4.67	4.67	0.00
Interest on operating capital	2.53	2.53	0.00
Total, operating costs	136.44	180.37	43.93

SUMMARY

	Baseline 2020	High energy 2020	Change $/acre
Corn	289.75	368.55	78.80
Soybeans	135.90	156.31	20.41
Wheat	117.63	149.50	31.87
Cotton	524.09	572.15	48.06
Rice	559.21	712.45	153.24
Sorghum	154.28	197.84	43.56
Barley	134.10	159.97	25.87
Oats	136.44	180.37	43.93

CONCLUSIONS

Based on studies by government agencies, legislation designed to limit carbon dioxide emissions will raise prices for most forms of energy. These higher prices for energy will, in turn, raise production costs for the major U.S. crops. These higher production costs will at least partly offset any economic benefits that may result from the proposed legislation.

Higher energy costs will impact crop production costs in a variety of ways. Farmers use fuels directly to operate equipment and run irrigation wells. These direct energy impacts are most closely related to prices for crude oil. Higher prices for energy in general, and specifically for natural gas and crude oil, will indirectly drive up production costs by boosting prices farmers pay for fertilizers, chemicals and custom operations.

To estimate the impact of higher energy prices on production costs, we estimated structural models that link energy prices to per acre costs for eight major crops. We developed a baseline forecast through 2020 based on energy price forecasts from government sources. With the model in place, we could measure the impact of changes in energy prices on per acre production costs for each of the crops.

The structural model was used to measure the impact of higher energy prices on per acre production costs using the results of three scenarios from an EPA study of the implications of the legislation under consideration. There are clearly a wide range of possible outcomes from the proposed legislation, depending primarily on assumptions about the technology that will be available to deliver clean energy. One scenario indicated energy price increases of around 25 percent to 35 percent by 2020. Another measured the energy impact of the legislation at around 35 percent to 50 percent. The third scenario we used as the basis for analysis indicated a 71 percent increase in natural gas prices and a 52 percent increase in crude oil prices. The impact on crop production costs vary widely depending on which of these energy price outcomes emerges.

The legislation, if passed, will have implications for the energy sector and for agriculture far beyond 2020. Many of the studies see the increase in energy prices continuing through at least 2030, while others see the sector adjusting, with energy prices falling back. The future that far out will depend on technological developments and economic adjustments that are difficult to predict. However, there is no doubt that if the energy price gap between the baseline and the low carbon dioxide emissions scenarios expands beyond 2020, the impact on production costs will also increase.

The higher per acre production costs will add significantly to total expenditures for crop producers. Even the relatively modest changes in energy prices implied by Scenario 2 of the EPA study add $6 billion to total production costs in 2020, using the assumption that the crop acreages projected by USDA for 2017 are still valid for 2020. The EPA scenario study, calling for a 49 percent increase in natural gas prices, combined with a 37 percent increase in crude oil, results in a total increase in expenditures for the eight crops of more than $8 billion in 2020. This is at least a partial estimate of the impact on net cash farm income if we assume that crop yields and prices are not impacted by the higher energy costs.

TABLE 5: SUMMARY OF PRODUCTION COST IMPACTS OF HIGHER ENERGY PRICES IN 2020

Crops	Baseline $/acre	EPA Scenario 2 $/acre	EPA Scenario 6 $/acre	EPA Scenario 7 $/acre
Corn	289.75	330.08	345.00	368.55
Soybeans	135.90	146.42	150.23	156.31
Wheat	117.63	133.96	140.00	149.50
Cotton	524.09	548.97	557.86	572.15
Rice	559.21	638.71	666.91	712.45
Sorghum	154.28	176.51	184.81	197.84
Barley	134.10	147.45	152.26	159.97
Oats	136.44	159.12	167.29	180.37

TABLE 6: CHANGE IN COSTS FROM THE BASELINE

Crops	EPA Scenario 2 $/acre	EPA Scenario 6 $/acre	EPA Scenario 7 $/acre
Corn	40.33	55.25	78.80
Soybeans	10.52	14.33	20.41
Wheat	16.33	22.37	31.87
Cotton	24.88	33.77	48.06
Rice	79.50	107.70	153.24
Sorghum	22.23	30.53	43.56
Barley	13.35	18.16	25.87
Oats	22.68	30.85	43.93

OTHER ISSUES OF INTEREST

The study was designed to evaluate the impact of higher energy prices on per acre production costs for major crops. However, the higher energy prices would affect the agriculture sector and specifically crop producers in other ways as well. One of the biggest impacts on crop producers would be related to the costs of transporting crops to market. Costs for trucking, rail, and barge freight rates would rise, lowering the local basis and the market price for the crops farmers produce. This impact would be smaller for producers with local markets, such as ethanol plants, livestock operations, or processing plants. However, for producers that ship their crops long distances to export terminals or other facilities, the impact of the higher transportation costs could be significant.

The higher energy prices would also affect the cost of producing and transporting other products that are important to farmers. For example, it would cost more to produce and transport farm equipment and those costs would probably be passed on to the buyers. Food processing and distribution costs would rise and some of those costs would probably show up as lower bids to farmers for their products.

Higher production costs for farmers, coupled with lower output prices that may result from the increase in energy prices, would cut into crop production profits. This would tend to have an adverse impact on land prices. The value of land is generally related to the profit-generating potential, and if the profits are reduced farmers should be willing to pay less for the land. Real estate is the largest source of wealth for the agriculture sector.

Higher energy prices would impact the farm sector in many ways, and most of them would have an adverse impact on crop production profits. This study evaluates the impact of energy prices on per acre production costs, but the actual impacts would be much bigger. However, the total magnitude of the impact of higher energy prices is probably impossible to determine.

REFERENCES

EPA Analysis of the *Lieberman-Warner Climate Security Act of 2008*, S. 2191 in the 110th Congress, U.S. Environmental Protection Agency, Office of Atmospheric Programs, March 14, 2008 (updated May 5, 2008).

Energy Information Administration, *Energy Market and Economic Impacts of S. 1766, the Low Carbon Economy Act of 2007*, U.S. Department of Energy, Washington, D.C., January 2008.

Energy Information Administration, *Supplement to: Energy Market and Economic Impacts of S. 280, the Climate Stewardship and Innovation Act of 2007*, U.S. Department of Energy, Washington, D.C., October 2007.

Economic Research Service, USDA, *U.S. and Regional Costs and Returns Estimates.*

Economic Research Service, USDA, *Agricultural Prices.*

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