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The Role of Commercial Energy Payments in Agricultural Producer Income

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Abstract

A significant portion of energy production in the United States takes place on farmland, which can have substantial economic implications for the farmers who host such developments. This report analyzes energy payments made to farmers for the production of oil, natural gas, and wind energy on their land. The authors used 10 years of data (2011–20) from the USDA's Agricultural Resource Management Survey (ARMS) in their analysis. Results show that 3.5 percent of farm operations received energy payments and that the average annual payment to the operators was more than $30,000 (in 2020 dollars), contributing substantially to farm household income and exceeding government payments to these operations. Energy payments were more common in counties producing oil and natural gas than in those with wind energy development. Larger farms were significantly more likely to receive energy payments and received higher payments on average. Further, Hispanic producers and those with less education were significantly less likely to receive energy payments. Although the average energy payment varied by ethnicity and education status, this report did not find a statistically significant difference after accounting for farm location and size.

Keywords: Energy, oil, natural gas, wind energy, farm income, energy production, wind turbine, leasing income, energy development, farmland use, energy payments

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About the Authors

Justin B. Winikoff is a research agricultural economist in the Rural Economy Branch and Karen Maguire is a research agricultural economist in the Conservation and Environment Branch of the Resources and Rural Economy Division of the USDA, Economic Research Service.

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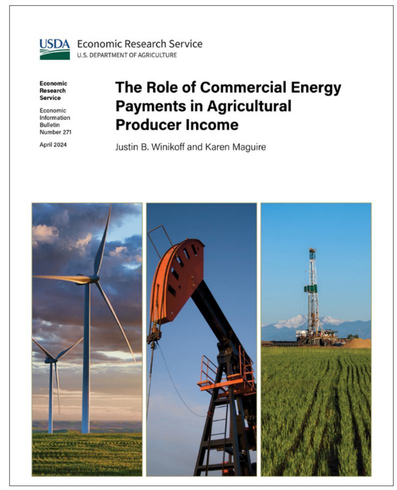

What Is the Issue?

Historically, payments from businesses for energy development, particularly oil and natural gas, have been an important source of income for farmers who hosted energy production on their land. Since the early 2000s, energy markets experienced marked shifts: Price increases and technological improvements led to a dramatic increase in oil and gas production, and wind energy development experienced significant growth, leading to a new source of income for farmers. Information about who has benefited from energy income and how the income was distributed to agricultural producers, regionally and demographically, may help stakeholders understand the costs and benefits of a changing energy mix as leases for new types of energy production become common among farm households.

What Did the Study Find?

High crude oil prices through 2014 led to increases in the size of energy payments to farm operators with oil or natural gas resources. Wind projects were also widespread over this period and continued to expand through 2020, the end of the study's sample period. Wind development provided opportunities for energy payments to producers outside of areas with oil and gas resources. For agricultural producers over the sample period of 2011–20, this report found:

- Approximately 3.5 percent of farm operators reported receiving payments for energy production on their operation between 2011 and 2020. The share of farmers receiving payments did not dramatically differ from year to year.
- For those who received energy payments, the average annual payment (in 2020 dollars) over the period was $30,482, but it varied significantly from year to year. Average annual payments were as high as $62,944 in 2013 and as low as $14,032 in 2020. Payment amounts tracked closely over time with the price of oil.
- Average annual energy payments were the most common (7.4 percent received payments) and largest ($39,087) in the Plains region (Kansas, Nebraska, North Dakota, Oklahoma, South Dakota, and Texas), where energy production is most abundant. They were least common (1.45 percent received payments) in the South (Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, and South Carolina) and smallest ($10,953) in the Midwest (Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin).

- Farm operators were between an estimated 4.5 and 5.6 percent more likely to receive energy payments if located in oil and natural gas-producing counties than in counties with only wind energy production.
- On average, payments were higher in counties with only oil and natural gas production ($32,167) than in those with only wind energy production ($17,303). However, the median payment in wind counties was larger than the median payment in oil and gas counties. This difference is due to an uneven distribution of oil and gas payments, which included a large number of small payments and a small number of very large payments. This report did not find a statistically significant difference in the size of energy payments after accounting for farm size, location, and the asymmetric distribution of oil and gas payments.
- Both the likelihood of and size of energy payments increased with the size of the farm. Midsize family farms (with gross cash farm income between $350,000 and $999,999) were more likely to receive energy payments; nonfamily farms were less likely. Controlling for other factors, payments were larger for midsize and large-scale family farms (with gross cash farm income of $1 million or more).
- Although the average payment size varies by farm operator demographic groups, this report did not find a statistically significant difference in energy payments after accounting for farm size and geography. This suggests that location, farm size, and energy market conditions were the key determinants of payment size. The likelihood of receiving energy payments was lower for Hispanic operators and those with less education, even after accounting for other farm characteristics and location.

How Was the Study Conducted?

This study performed descriptive and regression analyses using data from the USDA's Agricultural Resource Management Survey (ARMS), a national survey of farm operators conducted by the USDA's National Agricultural Statistics Service (NASS) and USDA, Economic Research Service (ERS). Specifically, this report uses data from the Costs and Returns Report (CRR), ARMS Phase III, for 2011 through 2020. In the survey, farm operators were asked how much income they received from "royalties from or leases associated with energy production (e.g., natural gas, oil, and wind turbines)." For this analysis, energy income information was combined with additional ARMS data on farm characteristics, size and type, and farm operator demographics, race/ethnicity, and educational attainment.

This report merges ARMS data with two external sources: the USDA, ERS County-Level Oil and Gas Production in the United States dataset, which includes oil and natural gas production from 2000 to 2011, and the U.S. Wind Turbine Database (USWTD), a quarterly database of all utility-scale wind turbines in the United States (USDA, ERS, 2014; Hoen et al., 2018). These two data sources were used to determine if operators surveyed in ARMS were in counties with oil or natural gas production or wind development.

The Role of Commercial Energy Payments in Agricultural Producer Income

Introduction

The United States is undergoing a dramatic shift in energy production. The U.S. Energy Information Administration (EIA) forecasts that domestic oil production will increase but then taper off and potentially decline over the next 30 years. Although natural gas production is expected to increase, its rate of growth is forecast to slow compared to the late 2000s and 2010s. All remaining growth in domestic energy production is forecast to come from renewable energy sources such as solar and wind (U.S. EIA, 2021).[1] Geographic shifts will likely occur, resulting from a move in energy production from exclusively oil and natural gas-producing regions.

This production shift is of particular interest to rural areas of the United States, where much of the Nation's energy production occurs. Energy production has the potential to transform the economies of the communities where it takes place, both positively and negatively. Oil and gas production has been shown to both enhance and worsen local labor market opportunities.[2] Furthermore, oil and natural gas development can have mixed effects on public finance and education.[3] Similarly, living in close proximity to oil and gas production has been found to both increase and decrease property values.[4] Oil and natural gas production can also have adverse local environmental effects.[5] Although a newer industry, wind energy also can affect public spending and property values. Similar to oil and natural gas, the effects of wind power are also mixed.[6]

[1] This growth is expected to be accelerated by recent Federal legislation, including the Inflation Reduction Act (U.S. EIA, 2023a).

[2] For example, Feyrer et al. (2017) found that new oil and natural gas production from hydraulic fracturing increased local wages and reduced unemployment. Weber (2014) found that expanded natural gas production led to jobs outside of the oil and gas industry. Both Allcott and Kensiton (2018) and Winters et al. (2021) found long-term employment gains from oil and gas development. Jacobsen et al. (2023), however, found that short-term wage benefits from oil and gas booms can be offset by employment effects when production slows in the long term. Furthermore, Cai et al. (2019) demonstrated that benefits may not accrue evenly across demographic groups. Marchand and Weber (2018) provided a summary of the literature.

[3] Oil and gas development has been associated with an increase in both revenues and costs for local governments, although for most governments, revenues were larger (Newell & Raimi, 2018). Weber et al. (2016) found natural gas drilling in Texas led to increased revenue for schools, while James (2017) found schools are relatively well-funded in resource-rich States. Marchand and Weber (2020), however, noted that despite increased educational funding, test scores were worse. Chuan (2017) highlighted how oil and gas production reduced educational attainment for college-aged men, but higher paying jobs compensated for the lack of college degrees.

[4] Boslett et al. (2016) found shale development positively capitalized into property values. Conversely, Balthrop and Hawley (2017) found shale gas wells reduced the value of nearby homes, but conventional wells did not.

[5] Hill and Ma (2017), for example, found shale drilling contaminated drinking water, and Muehlenbachs et al. (2015) found that groundwater-dependent houses saw lower housing prices following the shale boom. Allred et al. (2015) highlighted how oil and gas production has resulted in a loss of ecosystem services.

[6] For example, Kahn (2013) found that rural counties with wind power have lower property tax rates and better school quality. Brunner et al. (2022) found evidence of wind power increasing funding for schools, but no evidence of improved school performance. Heintzelman and Tuttle (2012) and Gibbons (2015) found living near wind turbines can reduce property values, although Hoen et al. (2013) did not. Brunner et al. (2024) found negative effects on property values following the announcement of a wind farm did not persist 5 years following development.

Beyond rural communities, energy production on farms can provide critical income for farm households. Payments generally come in the form of royalties, a predetermined percentage of revenue from oil and natural gas production, lease payments, and/or bonus payments (see box, "Understanding Energy Payments"). High prices from the mid-2000s through 2013 and the development of previously infeasible oil and natural gas resources through the expanded use of hydraulic fracturing (injecting liquid into rocks to create cracks) led to increases in oil and natural gas development and production.[7] This led to payments to additional mineral rights owners and larger leasing and royalty payments (Weber et al., 2013; Brown et al., 2016; Hitaj et al., 2018). Many of these landowners were agricultural producers. In 2014, 67 percent of domestic onshore oil and natural gas production took place on farmland (Hitaj et al., 2018). In the late 2000s, wind energy grew rapidly across the United States, predominantly on farmland. As of 2020, 99 percent of wind generation capacity was in rural areas.[8]

[7] While oil prices declined beginning in 2014 and new oil and gas development slowed, oil and natural gas production continued to increase throughout much of the sample period (U.S. EIA, 2022j, 2022k).

[8] Rural areas were defined using boundaries from the 2019 U.S. Census TIGER/Line Shapefiles. Locations of wind turbines were identified using the U.S. Wind Turbine Database (ver. 4.3, January 14, 2022) (Hoen et al., 2018).

Understanding Energy Payments

Energy payments to farm operators include lease payments for easements, compensation for land used for energy development, and royalty payments, a share of the revenue earned from energy production. Compensation comes from private firms that pay landowners for land access to produce energy. Lease compensation can be one-time or annual payments, while royalty payments are paid at a fixed period (e.g., annually). Landowners can also be compensated through bonus payments, typically paid at the time an energy lease is signed (Fitzgerald, 2012). Furthermore, for wind production, landowners can be paid for easements in which the landowner agrees not to build anything on their property that will impede wind flow to a nearby turbine (Shoemaker, 2007).

Historically, payments for oil and natural gas production were found to differ in part based on the productivity of the well, peaking when production is highest (Hitaj et al., 2018). Royalty rates (the share of revenues paid to the landowner) vary across regions, with 2014 rates as low as 13.4 percent in West Virginia and as high as 21.5 percent in Louisiana (Brown et al., 2016). Wind payments similarly vary based on local considerations, including wind speeds and electricity prices, along with the generating capacity of the turbine(s) (Shoemaker, 2007). They may, however, vary less from year to year as electricity is often sold through Power Purchase Agreements (PPAs) at predetermined rates (Bruck et al., 2018).

Only landowners or those with rights to lease land are expected to benefit from easements. Across the country, many farm operators rent land for agricultural production. Absentee landowners own farmland but do not reside on that land and may live nearby or in another part of the country. Substantial variation exists in the percentage of rented land across States. More than half of farmland was rented in 2017 in high-wind States such as Illinois, Indiana, Iowa, Kansas, and North Dakota. Conversely, almost a third of all farmland is rented in oil and gas producing States such as Colorado, Wyoming, and Pennsylvania (Bawa & Callahan, 2021). Payments from land easements accrue to those who own the land rather than renters, and nonfarming landlords are not surveyed in the USDA's Agricultural Resource Management Survey (ARMS), so they are not considered in the analysis. ARMS includes information on farm operators and the energy income they earn from the farm operation.

Another ownership arrangement is a split estate, where the rights to subsurface minerals, including oil and natural gas, are severed from surface land property rights. Split estates are historically more common in the Western States (Fitzgerald, 2014; Hitaj et al., 2018). Typically, in States where split estates are common, the mineral rights and land rights are not owned by the same individual. Hitaj et al. (2018) found that in 2014, just 19 percent of farm operators owned the oil and gas rights below their farms. The mineral rights owner has a right to develop their resources through the use of the land surface with compensation to the landowner. A farm operator could, therefore, receive energy payments elsewhere if they own the appropriate subsurface rights. Similarly, farmers who own land in energy-rich areas may not receive oil and gas royalty payments due to the split estate ownership structure. Farm operators surveyed in ARMS are asked to provide information on energy income only for the farm operation. Therefore, the authors expect energy income from other off-farm sources would not be included in the survey response about energy payments and instead in "other off-farm sources of income."

Payments from on-farm energy production can provide a supplemental source of income for farm operators and their families. In 2020, more than half (54 percent) of all family farms had negative income from farming, and 51 percent of farm operators and their families sought other opportunities to earn income, such as working off-farm (Whitt et al., 2021). Energy payments provide an additional income stream for farm operators, which may be beneficial given the uncertainty and risks involved in agricultural production (Mishra & Goodwin, 1997; Key et al., 2017).[9] This may be particularly salient as the United States transitions from the historically volatile oil and gas industry to renewable energy, which may provide a steadier stream of leasing income.[10]

This report examined the size, frequency, trends, and relative contribution of energy payments to farm operator income in the United States. Using data from the USDA's Agricultural Resource Management Survey (ARMS) from 2011–20, this study calculated the average annual and total energy payments to farm operations. Additionally, this report compared other sources of farm operator income, including the value of agricultural production, government payments, and off-farm income. This study also highlighted geographic differences in the frequency and size of payments across U.S. regions and across areas specializing in oil and gas or wind energy production. Further, the report examined differences in the likelihood of receiving energy payments based on farm characteristics and farm operator demographics. Finally, a regression analysis was used to explore the relationship between farm and farm operator characteristics and the likelihood of receiving payments, and the amount of the payments received after controlling for geographic and energy resource differences.

This report built on previous studies using data from ARMS to analyze energy payments to farms. Most similar is Hitaj et al. (2018), which used data from the 2014 Tenure, Ownership, and Transition of Agricultural Land (TOTAL) survey to quantify both energy payments and the wealth created from owning oil and gas rights for farm operators and landlords.[11] The authors found that farm operators owned $19.1 billion (about $21.6 billion in 2020 dollars) in oil and gas rights, and nonoperator landlords owned an additional $13.8 billion. Similarly, Hitaj and Suttles (2016) showed that 2014 energy payments comprised less than 1 percent of gross cash farm income nationally, but they found regional variation with the share as high as 6 percent in Oklahoma and Pennsylvania. Other studies estimated the effects of energy payments on farm operator decisions. Weber et al. (2013) used 2011 ARMS data to show energy payments added value to farms and increased farm household consumption, while Groutt et al. (2021) found energy payments had no effect on farm investment in 2014.

This study expanded on the previous work by using multiple years of energy payment information to study variations (or lack thereof) in the likelihood of receiving energy payments and their size over time. Further, this report used information on the county-level distribution of oil and gas production and wind energy capacity to distinguish between payments from oil/natural gas and wind. The sample period 2011–20 extends through a volatile period in the oil and gas market, as high and rising prices through 2014 led to increased development, followed by a drop in prices that potentially reduced energy payments. Finally, wind power significantly expanded between 2011 and 2020. Therefore, this study covered a period of significant transition from the dominance of oil and gas (along with coal) to an era more inclusive of wind and other renewable sources.

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[9] Farmers were also historically willing to accept lower returns in exchange for a lower risk, diversified agricultural portfolio (Katchova, 2005).

[10] The volatility of oil and natural gas markets, discussed later in this report, differs from the day-to-day intermittency of sunshine and wind. Instead, volatility in the oil and gas sector refers to swings in energy prices that affect supply and demand.

[11] In 2014, the Tenure, Ownership, and Transition of Agricultural Lands (TOTAL) survey was conducted instead of ARMS. ARMS includes only farm operators. The TOTAL survey included farm operators and landlords who do not operate their farms.

An important contribution of this study is its analysis of differences in energy payments across farm and farmer characteristics, something not possible with the small sample sizes from 1 year of ARMS data. Socially disadvantaged (SDA) farmers are more common in the southern States, including in oil, natural gas, and wind-rich States such as Texas and Oklahoma, but also States with little energy production in the Southeast.[12] Other energy-abundant States like North Dakota, Kansas, and Pennsylvania (as well as other high-wind States in the Midwest) have relatively low percentages of SDA operators (Callahan & Hellerstein, 2022). This suggests that opportunities to benefit from energy payments from oil and gas or wind may be different for farm operators from different racial or ethnic groups.

Differences in energy payments across farm operator characteristics received limited focus in previous studies using ARMS data. An early exception is Hitaj and Suttles (2016), who analyzed differences in energy payments by farm size using data from the 2014 TOTAL survey. They found that energy payments more commonly accrued to larger farms. Using natural gas leasing data, Timmins and Vissing (2022) found that Hispanic landowners had fewer environmental protections in their natural gas royalty contracts. Similarly, Harleman et al. (2022) found that high-income landowners had the resources to negotiate more favorable oil and gas agreements.

Data and Methodology

The primary data source used for this analysis was the ARMS survey conducted by the USDA's National Agricultural Statistics Service (NASS) and the USDA's Economic Research Service (ERS). ARMS is a nationally representative survey of more than 30,000 farms across the contiguous 48 States and is conducted annually.[13] The survey's final phase, Phase III, included the Costs and Returns Report (CRR) used for this study.[14] The CRR collected farm information including the acreage owned, rented, and harvested, as well as financial information including income, assets, and debt. Furthermore, the CRR provided information on farm operator and spouse characteristics, including race, ethnicity, education, and farm ownership structure.

The key ARMS survey question studied in this report asked farm operators to report the amount of "income from royalties or leases associated with energy production (e.g., natural gas, oil, and wind turbines)."[15] The survey question was first asked in 2011, and this report used responses from every year from 2011–20. This

[12] Although there are many definitions for socially disadvantaged farmers, Callahan and Hellerstein (2022) included both non-White and Hispanic farmers in their definition.

[13] The Agricultural Resource Management Survey (ARMS) is a complex stratified survey designed to represent all farms in the continental United States. To get nationally representative population means and totals, this report used the survey weights provided to analyze ARMS data. For accurate standard errors for statistical tests, this report implemented the jackknife approach outlined in Dubman (2000). The appendix provides more details of the methodology used in estimation.

[14] Phase III consists of a generalized Costs and Returns Report and an expanded version for the producers of the target commodities for the given year's Phase II Production Practices and Costs Report.

[15] Specifically, the survey question asked for the total income earned by the operator and all partners. The text of the survey question was consistent in all ARMS surveys from 2011–20.

question is used to determine the number of farm operations receiving energy payments, as well as the size of the payments.[16]

The ARMS question regarding energy payments notably does not distinguish among energy sources, meaning one cannot determine if the payments came from oil or natural gas production, wind energy, or another energy resource. Because the energy source for the payments cannot be identified, this report used external sources to categorize counties based on the energy produced in that county. To determine oil and natural gas counties, this report used the County-Level Oil and Gas Production in the U.S. dataset (USDA ERS, 2014), which was compiled using State-level and proprietary well-level data sources. Counties with any oil and natural gas production in 2011 were identified as oil and gas counties. The data were maintained only from 2000 to 2011. However, oil prices approached their peak close to 2011, the first year of the sample studied in this report. Therefore, most counties producing oil and natural gas between 2011 and 2020 were likely to have been doing so by 2011 (see box, "Trends in Oil, Natural Gas, and Wind Energy Production").[17] For wind energy, this report used data from the U.S. Wind Turbine Database, which provided the year of construction and location of every wind turbine in the United States (Hoen et al., 2018).[18] Farms in counties with wind turbines in the year they were surveyed were identified as farms within wind counties.[19] Counties with both oil/natural gas and wind development were categorized separately from those with only production in one of the categories.

[16] This report focuses only on wind energy and not solar development for two reasons. First, the relevant ARMS survey question mentions wind turbines as an example, but not solar. Second, wind turbines were much more prevalent during the sample period than solar, other than distributed or rooftop solar, which does not typically generate royalty or leasing income for agricultural producers. Still, it is possible that some payments in the data come from solar power. They may also come from supporting infrastructures, including pipelines and transmission, although this cannot be identified in the data. Moving forward, however, energy payments from solar generation may become more widespread as solar generation can be located throughout the Nation. As of 2021, there were utility-scale solar projects in 48 States (U.S. EIA, 2022c). Furthermore, many States that have not historically had significant oil, natural gas, and wind power, including Florida, Georgia, and North Carolina, are already among the national leaders in solar power.

[17] The sensitivity of the findings to an alternative measure of oil and natural gas counties by including all that overlap an oil or natural gas field is later tested.

[18] USWTD, ver. 4.3, January 14, 2022.

[19] The appendix discusses how the results change with a more restrictive definition of energy counties.

Trends in Oil, Natural Gas, and Wind Energy Production

In the mid-2000s, a technological shift combining horizontal drilling (drilling sideways, rather than vertically, underground) and hydraulic fracturing, also known as fracking (injecting liquid into rocks to create cracks), allowed for a rapid expansion of the development of oil and gas resources in areas with specific geologic features called shale plays. From 2005 through 2020, U.S. natural gas production increased from 18 trillion to 33 trillion cubic feet (U.S. EIA, 2022a). Due to the geologic distribution of shale resources, the boom was concentrated in specific regions of several States, including North Dakota, Pennsylvania, Texas, and Louisiana. In these areas, increases in oil and/or gas prices and the expansion of fracking led to a large increase in the number of oil and gas wells drilled. Although oil and natural gas prices fell after 2014, domestic oil and gas production continued to grow for much of the remainder of the decade (U.S. EIA, 2022d, 2022i, 2022j, 2022k).

Beginning in the early 2000s, wind energy development began expanding across the United States. The wind industry grew due to declines in wind turbine manufacturing costs and policies promoting renewable energy development (Hitaj, 2013; Roach, 2015). Wind-generated electricity grew from less than 1 percent of total U.S. electricity generation in 1990 to more than 8 percent in 2020 (U.S. EIA, 2023b). Wind power occurs in most areas of the country other than the South, where wind speeds are lower. Wind potential, the estimated wind resources available for electricity generation in a given area, is highest across the Plains and Midwest. Consequently, wind development has been highest in States such as Texas, Iowa, and Oklahoma (U.S. EIA, 2022g).

For some States, including Texas and Oklahoma, the growth in oil and gas development and wind development occurred simultaneously and at times in the same parts of the State. This provided unprecedented opportunities for energy income to farmers in some regions of the country.

Trends in Energy Payments

On average, throughout the sample period, 2011–20, only a small fraction of agricultural producers received energy payments. This is in part because many farm operators (40 percent in 2017) did not own their land, and most agricultural producers (81 percent in 2014) did not own the mineral rights associated with their land (Callahan, 2022; Hitaj et al., 2018). The average annual share of producers who received payments across this report's sample years was 3.5 percent. Table 1 presents information on the share of producers who received payments, the average payment received, and the total payment received in each sample year.[20] The share did not vary significantly across the sample years, apart from 2014, the final year before a large drop in oil prices, when 4.7 percent of producers reported receiving energy payments. The average payment was substantial, however, at $30,482. Payments were particularly large during the early years of the sample when oil prices were high and rising (figure 1). Payments averaged $38,788 in 2011, increased to $62,944 in 2013, and then fell to $14,000–$25,000 between 2015 and 2020.[21] The total payments reached a maximum of $4.4 billion in 2014 before declining in subsequent years.

[20] In this table and throughout the report, average energy payments were calculated using only farms that reported receiving payments.

[21] The average payment in 2013 was imprecisely measured due to the presence of outlier values. The influence of outliers was measured using the coefficient of variation (CV). In this case, the CV was greater than 50 indicating that the average was skewed to the right due to the influence of a single or limited number of outlier values. Despite the high CV for this single measure, the overall trend in average payments was clear; average payments were higher prior to the end of the shale boom.

Table 1
Energy payments to U.S. agricultural producers, 2011–20

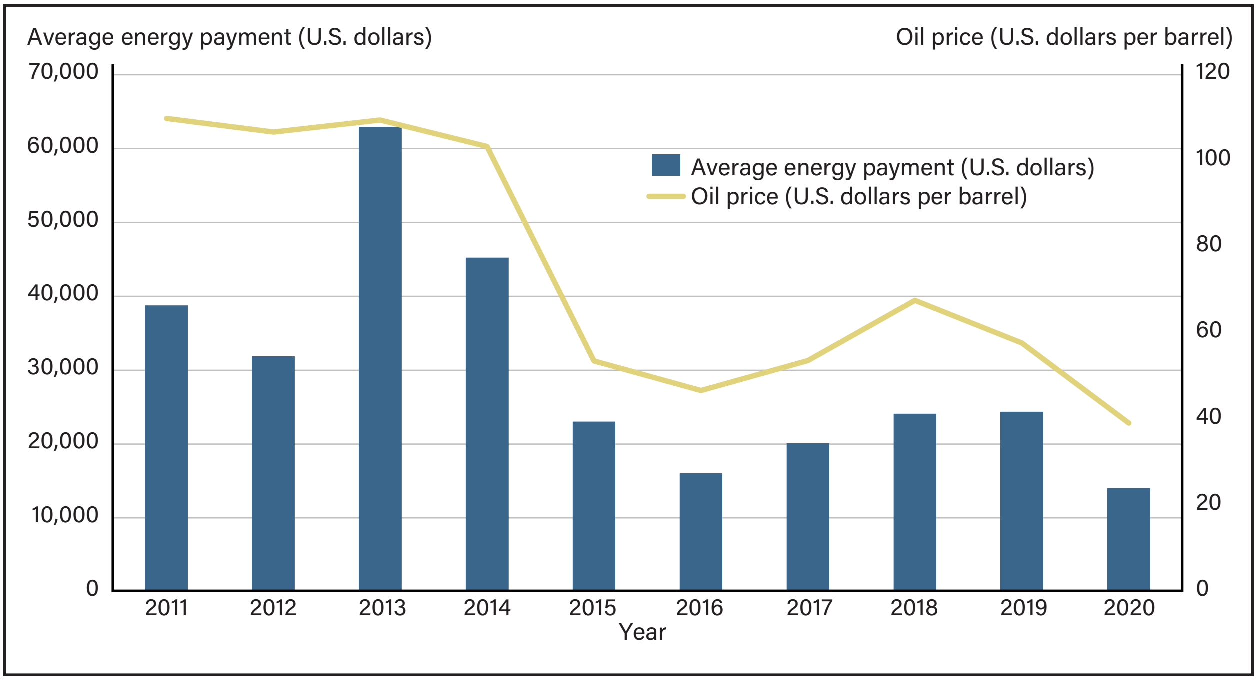
Year	Share receiving energy payments (percent)	Average payment (U.S. dollars)	Total payments (U.S. dollars, million)
2011	3.38	38,788	2,178
2012	3.20	31,874	2,049
2013	3.28	62,944#	4,320#
2014	4.67	45,241	4,383
2015	3.44	23,032	1,633
2016	3.32	16,057	1,093
2017	4.15	20,094	1,696
2018	3.49	24,106	1,703
2019	2.98	24,390	1,465^
2020	3.06	14,032	863
Average	3.50	30,482	2,673

Note: A coefficient of variation (CV) between 25 and 50 is denoted with a ^, and a CV greater than 50 is denoted by a #. All income amounts are in 2020 U.S. dollars using the Consumer Price Index.

Source: USDA, Economic Research Service using data from USDA, National Agricultural Statistics Service and USDA, ERS, Agricultural Resource Management Survey, 2011–20.

The data on average annual energy payments and oil prices in figure 1 demonstrate the strong correlation between the two over the sample period. As prices dropped from their peak of $110/barrel in 2013, energy payments declined, rebounding slightly in 2018 and 2019 as oil prices rose and then dropped to their lowest level in 2020 as the oil price fell to $39/barrel (U.S. EIA, 2022d). Over this period, natural gas prices followed a similar pattern, peaking in 2014 (U.S. EIA, 2022e). Larger payments earlier in the sample period may also partially reflect bonus payments paid when leases were signed during a period of increased drilling early in the decade (Fitzgerald, 2012). The close correlation between oil and natural gas prices and energy payments highlights the key role oil and natural gas, rather than wind, have played in historic energy leases for farmers. Two factors could explain why this is the case. First, oil and gas development is much more common nationally than wind power, which is a younger industry. Second, the payments received from oil and gas leases and royalties may exceed the payments from wind development.

Figure 1
Annual average U.S. energy payments and oil prices, 2011–20



Note: Energy payments to farm operators and West Texas Intermediate (WTI) spot price per barrel both indexed to 2020 dollars using the Consumer Price Index.

Source: USDA, Economic Research Service using data from USDA, National Agricultural Statistics Service, USDA, ERS, Agricultural Resource Management Survey, 2011–20, and U.S. Energy Information Administration.

Table 2 presents information on average energy payments along with average government payments, average off-farm income, and the average total value of production.[22] Each column includes those farms with income from the given source, regardless of whether they received energy payments. Energy payments were, on average, an important income source when compared to other forms of farm income. The average annual payment from energy ($30,482) exceeded that from government payments ($19,858) by 53 percent and was larger in 7 of the 10 sample years.[23] The 3 years when energy payments were lower (2016, 2019, and 2020) were all after oil prices began declining after 2014. In each year, from 2015 through 2019, the difference between the average energy payment and government payment was small. In 2020, government payments included Coronavirus (COVID-19) relief and were higher than energy payments.

[22] Government payments and off-farm income include only positive values in the calculation of the average payments.

[23] Government payments include Federal programs such as the Commodity Credit Corporation (CCC) loans, the Conservation Reserve Program (CRP) and other environmental and conservation programs, Agricultural Risk Coverage, Price Loss Coverage (PLC), and all additional Federal, State, and local programs. In 2020, Coronavirus (COVID-19) pandemic loans and grants were also available. Previous studies find that farm operators typically underreport government payments in ARMS Phase III by about 24 percent, and therefore, the actual size of these payments is most likely larger and more comparable to energy payments (McFadden & Hoppe, 2017).

Table 2
U.S. energy payments compared to other income sources, 2011–20

Year	Average energy payment (U.S. dollars)	Average government payment (U.S. dollars)	Average off-farm income (U.S. dollars)	Average total value of production (U.S. dollars)
2011	38,788	14,114	87,465	150,912
2012	31,874	15,710	101,690	163,900
2013	62,944#	15,078	104,151	153,001
2014	45,241	18,232	118,311	181,908
2015	23,032	17,899	108,188	167,693
2016	16,057	17,557	104,073	175,186
2017	20,094	16,090	102,431	193,090
2018	24,106	19,058	102,999	181,681
2019	24,390	26,176	107,881	176,333
2020	14,032	35,646	97,011	183,467
Average	30,482	19,858	103,372	172,476

Note: A coefficient of variation greater than 50 is denoted by a #. All income amounts are in 2020 U.S. dollars, with both energy payments and off-farm income adjusted using the Consumer Price Index, government payments adjusted using the Government Domestic Product Chain-Type Index, and value of production using the Producer Price Index. Energy payments (N=7,491), government payments (N =92,233), and off-farm income (N=169,383) are limited only to farms with positive values in each category. Total value of production (N=190,540) includes all observations.

Source: USDA, Economic Research Service using data from USDA, National Agricultural Statistics Service and USDA, ERS, Agricultural Resource Management Survey, 2011–20.

The average annual energy payment was approximately 29 percent of the average off-farm income. Off-farm income can come from labor unrelated to the farm and income from nonagricultural investments. More than half of all family farms have a family member with an off-farm job, suggesting that off-farm work is an important source of income (Whitt et al., 2021). In 2013, the average energy payment was 60 percent of the typical value of off-farm income. In 2020, however, during the COVID-19 pandemic when energy payments and off-farm income were lower, energy payments represented just 15 percent of off-farm income.

On average, energy payments comprised about 18 percent of the total value of agricultural production.[24] The share varied from year to year and was as high as 41 percent in 2013 and as low as 8 percent in 2020. Energy payments and the value of production were both volatile from year to year, although not necessarily at the same time. Energy payments peaked in 2013 and were at their lowest value in 2020. The value of agricultural production, however, peaked in 2017 and was at its lowest in 2011.

To further explore the value of energy payments to producers, table 3 includes income information only for producers who received energy payments. For these producers, energy payments exceeded government payments prior to 2015, but in all but 1 subsequent year, average energy payments were lower. Over the sample period, the average annual energy payment of $30,482 was only slightly higher than government payments of $29,164. This is different from the findings in table 2, where the full sample of farms is included, and the average government payments were significantly smaller ($19,858).

Off-farm income and average annual total value of production also differ between the samples. Both were higher for producers with energy payments (table 3) than for the full sample (table 2). The average annual off-farm income for producers with energy income was $121,656, while for all producers, it was $103,372. Further, in 8 of the 10 years of the sample, average off-farm income was higher for producers who had energy

[24] Total value of production includes the value of all agricultural products, including the value from crops and livestock produced in and out of contract.

payments than for the full sample. The average annual total value of production was $225,034 for producers with energy payments and $172,476 for the full sample. The average total value of production was higher in each year for producers who received energy payments as compared to the full sample. The findings indicate that farm operators with energy income may have higher average wealth, potentially from both on-farm and off-farm sources. Therefore, wealthy farm households may not be using energy development as their only source of income diversification.

Table 3

U.S. energy payments compared to other income sources: Energy income households only

Year	Average energy payments (U.S. dollars)	Average government payments (U.S. dollars)	Average off-farm income (U.S. dollars)	Average total value of production (U.S. dollars)
2011	38,788	21,716	82,006	217,119
2012	31,874	22,043	123,175^	191,248
2013	62,944#	25,407	121,019	243,719
2014	45,241	29,792	127,581	204,763
2015	23,032	23,061#	111,217	194,133^
2016	16,057	27,506	189,488^	231,774
2017	20,094	24,904	118,415	231,342
2018	24,106	22,508	131,395	231,172
2019	24,390	37,746	108,714	250,749
2020	14,032	52,956	90,382	266,009
Average	30,482	29,164	121,656	225,034

Note: A coefficient of variation (CV) between 25 and 50 is denoted with a ^, and a CV greater than 50 is denoted by a #. All income amounts are in 2020 U.S. dollars, with both energy payments and off-farm income adjusted using the Consumer Price Index, government payments adjusted using the Government Domestic Product Chain-Type Index, and value of production using the Producer Price Index. Government payments (N=4,634), and off-farm income (N=6,887), and Total Value of Production (7,491) are limited only to farms with positive values. The sample is limited to counties that receive any energy payments (N=7,491).

Source: USDA, Economic Research Service using data from USDA, National Agricultural Statistics Service and USDA, ERS Agricultural Resource Management Survey, 2011–20.

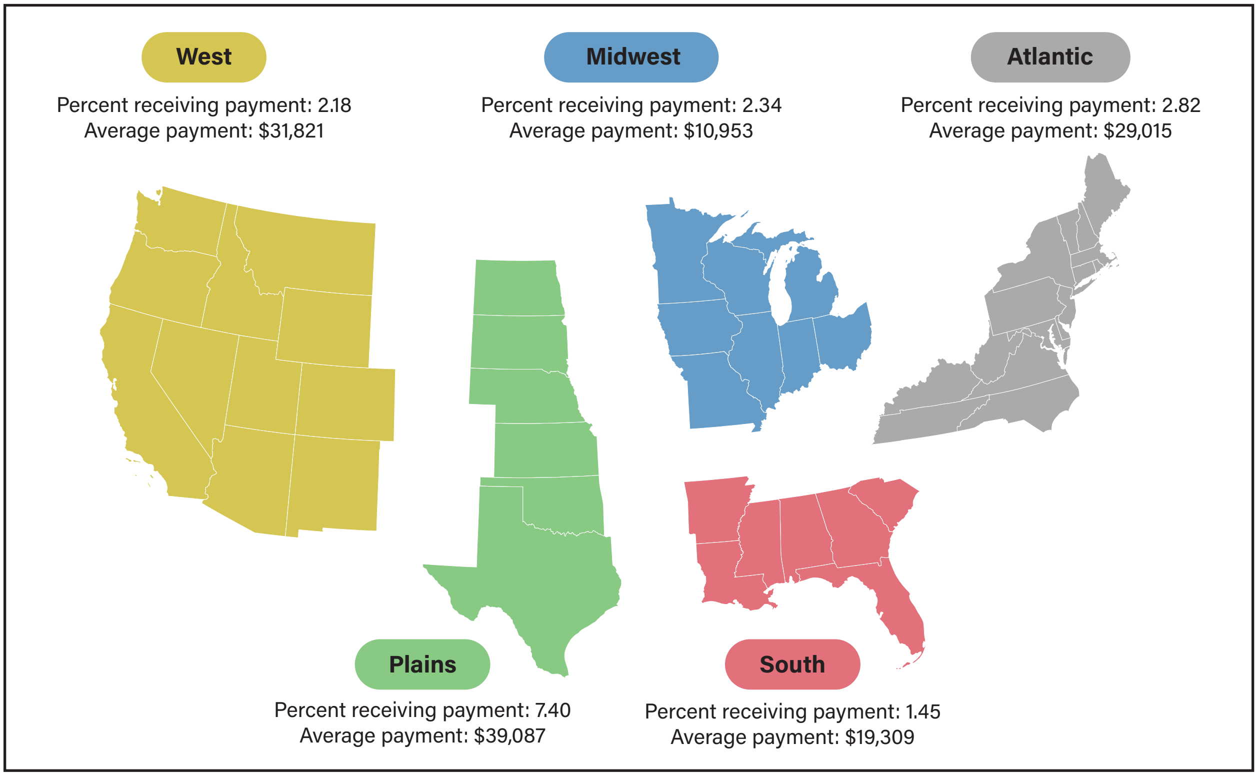
Regional Distribution of Energy Payments: Oil, Natural Gas, and Wind

Oil, natural gas, and wind resources are unevenly distributed across the United States, such that areas with significant oil production may not have natural gas or wind energy. For all three energy types, the uneven distribution of resources and production is reflected in the distribution of energy payments across the ARMS Farm Production Expenditure Regions in figure 2.[25] The Plains region had the largest share of producers receiving energy payments, 7.4 percent, and the largest average payment, $39,087, across the sample years. This region includes States that have significant oil/natural gas and wind production, such as Texas and Oklahoma.

[25] The Atlantic region consists of Connecticut, Delaware, Kentucky, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, Tennessee, Vermont, Virginia, and West Virginia. The South region consists of Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, and South Carolina. The Midwest region consists of Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, and Wisconsin. The Plains region consists of Kansas, Nebraska, North Dakota, Oklahoma, South Dakota, and Texas. The West region consists of Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. The States of Alaska and Hawaii and the District of Columbia are not included in this study.

The West and Atlantic regions had a far lower share of producers who received payments, 2.2 and 2.8 percent, respectively, but for those receiving payments, the average payments across the sample years were near the national average at $31,821 and $29,015, respectively. Although much of the Atlantic region did not have significant oil and gas production during this period, Pennsylvania and West Virginia had substantial development (U.S. EIA, 2022b). In addition, wind development was distributed throughout the region. In the West, there was bountiful oil and gas development, but many landowners did not own the mineral rights and, therefore, could not receive energy payments from on-farm production (Hitaj et al., 2018). This may be a factor in the relatively low share of producers in the West who received energy payments (2.18 percent).

Figure 2
U.S. energy payments (U.S. dollars) by farm production expenditure regions, 2011–20



Note: All income amounts are in 2020 U.S. dollars using the Consumer Price Index. The States of Alaska and Hawaii and the District of Columbia are not included in this study.

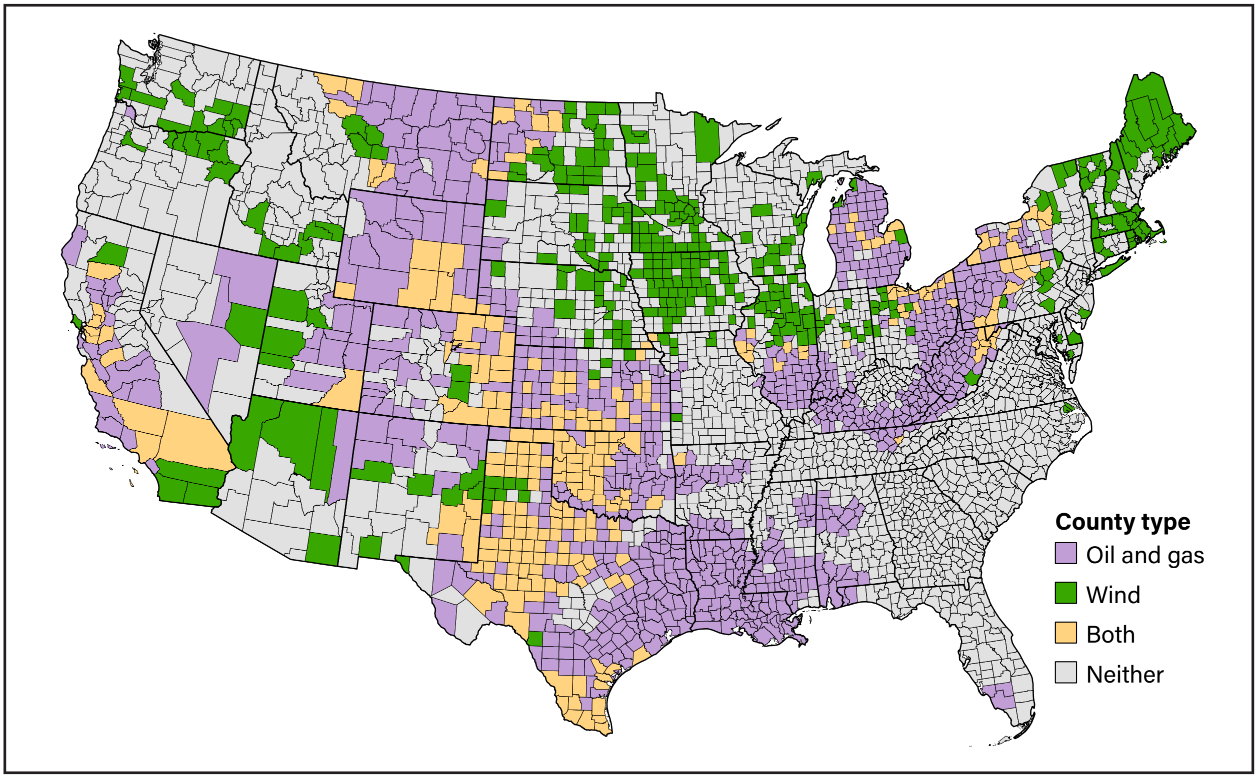
Source: USDA, Economic Research Service using data from USDA, National Agricultural Statistics Service and USDA, ERS, Agricultural Resource Management Survey (ARMS), 2011–20.

The share of producers receiving energy payments in the South was the lowest at 1.5 percent. Most States in the South do not have sufficient wind potential for utility-scale development using current technology (NREL, 2017), and few have substantial oil and natural gas development. Payments to farm operators in the South were likely limited to those along the Gulf Coast where oil and gas production occurs or were from other forms of energy production present. Because ARMS focuses on payments to the relevant farm operation, payments to absentee farm operators should not be captured in the energy income question.

In the Midwest, just 2.3 percent of operations received payments, and producers received the lowest average payment of $10,953, across the sample period. Wind energy development is more common in the Midwest than oil and natural gas. Iowa, Illinois, Minnesota, Indiana, and Michigan have substantial wind energy development. Outside of Ohio, oil and natural gas production in the Midwest is minimal (U.S. EIA, 2022b; U.S. EIA, 2022f).

To examine differences in payments by energy type, this report used geographic variation in oil, gas, and wind resources to construct county-level indicators based on the type of energy production (oil and gas, wind, neither, or both) that occurred within a county.[26] Oil and gas counties included those with any positive production in 2011 according to USDA, ERS (2014). Wind counties were those with positive installed capacity in the sample year according to the U.S. Wind Turbine Database (USWTD) (Hoen et al., 2018).[27] Counties with both oil/natural gas production and wind turbines were categorized as both, and those with neither were categorized as such. Figure 3 shows the distribution by energy county type for 2020.

Figure 3
U.S. energy county definitions, 2020



Note: Oil and gas counties are those with positive production of oil or natural gas in 2011. Wind counties are those with positive installed wind energy capacity in the sample year. “Both” counties have both wind and oil or natural gas. “Neither” counties have no oil, wind, or natural gas installed. The States of Alaska and Hawaii and the District of Columbia are not included in this study.

Source: USDA, Economic Research Service using oil and natural gas production data from USDA, ERS (2014) and wind energy capacity data from the U.S. Wind Turbine Database (Hoen et al., 2018).

Table 4 includes the annual and the annual average frequency of energy payments by the farm operator’s energy county type.[28] There are two important findings from this information. First, large differences existed in the share of producers that received a payment depending on energy county type. Farm operators in oil and natural gas-producing counties received payments 3.8 times more frequently (7.2 percent) than those in counties producing wind power exclusively (1.9 percent). This relationship was consistent over time. Further,

[26] Oil and natural gas development is only feasible where there are proven reserves and wind speeds are highly localized and play a major role in determining where large-scale wind turbines are sited, even at the county level (Hitaj, 2013).

[27] USWTD, ver. 4.3, January 14, 2022 (Hoen et al., 2018).

[28] ARMS provides the county of the operator’s mailing address, which may not necessarily be the county of the farm or ranch. According to the 2017 Census of Agriculture, about 76 percent of primary farm operators lived on farm, suggesting a likely high correlation between mailing address and farm location (USDA NASS, 2019a). Furthermore, as seen in the results of table 4, energy payments are substantially more likely among those with addresses from energy-producing counties, suggesting a reasonable approximation.

10.9 percent of operators in counties with oil/gas and wind production reported receiving energy payments. Conversely, less than 1 percent of farm operators in counties with neither form of energy production received payments, most likely from other sources of energy production.

Second, although some changes occurred in the percentage of energy payments received from year to year, the general pattern and frequency of payments remained relatively consistent. The most volatile category was oil and natural gas, with more than 10 percent of operators receiving payments in 2014 and just under 5 percent in 2019. Although there was a substantial difference, this was in part driven by the number of counties in the "Oil and natural gas" category shrinking as more counties developed wind energy, becoming classified in the "Both" category. Furthermore, production may be reduced if energy prices fell sufficiently, as was the case in 2020.

Table 4

Percent of U.S. agricultural producers receiving energy payments by county production type, 2011–20

Year	Neither	Oil and natural gas	Wind	Both
2011	0.276	7.138	1.336	12.445
2012	0.409	6.606	1.765	8.827
2013	0.451	7.032	1.787	8.504
2014	0.569	10.116	2.585	12.090
2015	0.312	7.45^	1.681#	9.672#
2016	0.378^	6.593	1.453	11.300
2017	0.411	8.921	2.017	11.890
2018	0.253	7.211	1.365	12.352
2019	0.608^	4.942	2.648	11.045
2020	0.186^	5.514	2.089	10.849
Average	0.389	7.180	1.894	10.873

Note: A coefficient of variation (CV) between 25 and 50 is denoted with a ^, and a CV greater than 50 is denoted by a #. All income amounts are in 2020 dollars. Oil and gas counties are those with positive production of oil or natural gas in 2011. Wind counties are those with positive installed wind energy capacity in the sample year. "Both" counties have both wind and oil or natural gas. "Neither" counties have no oil, wind, or natural gas production. "Neither" payments may include those from other energy sources.

Source: USDA, Economic Research Service using information from USDA, National Agricultural Statistics Service, and USDA, ERS, Agricultural Resource Management Survey, 2011–20, oil and natural gas production data from USDA, ERS (2014), and wind energy capacity data from Hoen et al. (2018).

Table 5 shows the size of energy payments by energy county type among those who received payments. The average energy payment across the sample period among those in oil and gas counties was $32,167, almost double the average payment in wind counties, $17,303. Counties with both oil/gas and wind development had a slightly higher average payment of $33,363. Like the correlation between the amount of energy payments and oil prices presented in figure 1, this suggests that energy payments for agricultural producers largely comprised payments for oil and gas rather than wind. Counties lacking oil, gas, or wind production had an average energy payment of $13,702.[29]

Because of the small sample sizes for county types in a given year, the estimates of average payments were imprecisely estimated from year to year, as indicated by the number of estimates with a high coefficient of variation. With fewer observations, the estimates were skewed by outsized influence from a small number of large energy payments. Despite the lack of precision in the annual estimates, there is a clear trend for oil and

[29] The payments may have been for another energy type. Although the ARMS question asks about energy production, it specifically lists only oil and natural gas or wind as examples. Regardless, these estimates are imprecise because, as table 4 indicates, less than 1 percent and in 8 of the 10 years less than 0.5 percent of the operators in these counties received energy payments.

gas payments—they were higher prior to 2015. Further, in 7 of the 10 years, including all sample years from 2011 to 2014, average payments in oil and gas counties exceeded those in wind counties.

Table 5
Average U.S. energy payments by county production type in U.S. dollars, 2011–20

Year	Neither	Oil and natural gas	Wind	Both
2011	35,591#	37,859	15,767^	47,429^
2012	7,871	31,723	8,091^	47,645^
2013	20,003#	77,080#	17,808^	38,149
2014	11,976	48,396	22,796^	51,877
2015	7,167	23,162^	32,307#	23,328^
2016	25,380^	15,128	22,148^	15,100^
2017	12,408^	17,501	14,708	31,526^
2018	6,103^	19,817	13,603	38,109
2019	7,847^	27,145^	12,430	30,094^
2020	7,596	10,678^	13,928	19,887
Average	13,702	32,167	17,303	33,363

Note: A coefficient of variation (CV) between 25 and 50 is denoted with a ^, and a CV greater than 50 is denoted by a #. All income amounts are in 2020 dollars using the Consumer Price Index. County locations represent the mailing address of the farm operator surveyed. Oil and gas counties are those with positive production of oil or natural gas in 2011. Wind counties are those with positive installed wind energy capacity in the sample year. "Both" counties have both wind and oil or natural gas. "Neither" counties have no oil, wind, or natural gas production. "Neither" payments may include those from other energy sources.

Source: USDA, Economic Research Service using information from USDA, National Agricultural Statistics Service, and USDA, ERS, Agricultural Resource Management Survey, 2011–20, oil and natural gas production data from USDA, ERS (2014), and wind energy capacity data from Hoen et al. (2018).

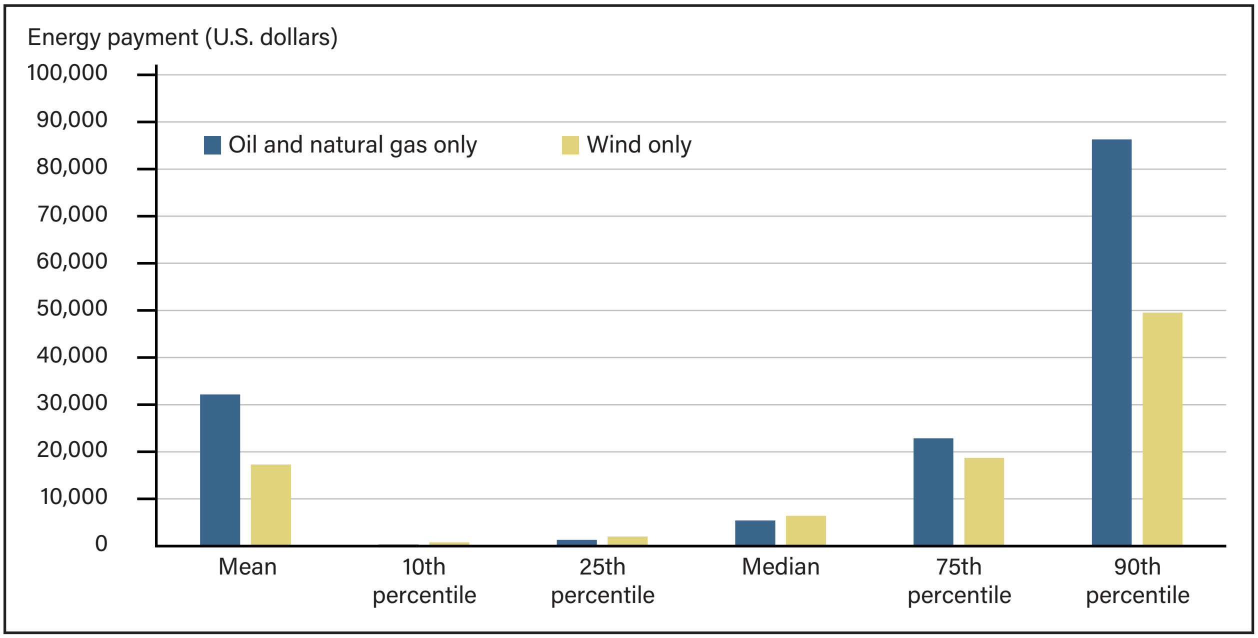
Overall, oil and natural gas payments were relatively volatile, rising as high as $77,080 in 2013, when the price of oil was at its peak over this period, and falling as low as $10,678 in 2020, when oil prices dropped precipitously. Similarly, annual average payments in counties with both oil/gas and wind production were volatile, ranging from $15,100 to $51,877. For counties with only wind development, payments were more consistent, between $8,091 and $22,796, except for 2015, when payments were larger ($32,307) but also more imprecisely estimated. Generally, the findings suggest that although average annual oil and gas payments were typically higher than those from wind, they were also more volatile.

To measure oil and natural gas counties, all counties with positive values of production as of 2011 (the first year of the analysis) were included. Oil prices were at their highest (in the sample) in 2011, and it is unlikely that a county that had zero production in 2011 began producing later in the sample, even though production increased in many areas. Nonetheless, the validity of the results in table 5 was tested with a broader measure of oil and natural gas counties by including all counties that overlapped proven oil/gas reserves (deposits from which oil and gas can be extracted with current technology), using data from U.S. EIA (2022h). Although this measure includes reserves that could be exhausted or not yet produced, the numbers in table A.1 are consistent with those in table 5. The average payment to a landowner in an oil and gas county under the alternative measure was $32,125, just $42 less than using the preferred measure.

As a further test of the sensitivity of the results, table A.2 includes results using a more restrictive measure of energy counties. A county was categorized as an oil and gas county only if 2011 production was greater than or equal to approximately the 40th percentile (for positive values) of oil (70,000 barrels) or natural gas (1 million MCF (thousand cubic feet)) production. For wind counties, the total capacity in a given year had to be greater than or equal to the 40th percentile of wind capacity over the sample period, 40 megawatts. This measure excluded counties with more marginal energy resources from an energy county designation. The findings are similar with this alternative energy county categorization. Payments were nearly identical for the oil/gas and wind categories but larger for the "neither" and "both" categories. This is because more counties with energy production were moved to the "neither" category, and those left in the "both" category were the top-producing counties.

Figure 4 shows the distribution of energy payments made to farmers in oil and gas counties versus those in wind counties.[30] The figure highlights the highly skewed nature of energy payments, particularly for oil and natural gas. The mean payments were much larger than the median, more than double for wind and more than triple for oil and gas. Furthermore, despite a much higher mean oil and gas payment ($32,167) relative to wind ($17,303), the median payment in wind counties was larger. The disparity between the mean and the median was driven by a small number of exceptionally large oil and natural gas payments: the 90th percentile oil and gas payment was about 16 times the median. Comparatively, the 90th percentile payment in a wind county was just seven times as large as the median.

Figure 4
U.S. energy payment distributions, 2011-20



Note: All income amounts are in 2020 dollars using the Consumer Price Index. County locations represent the mailing address of the farm operator surveyed. Oil and gas counties are those with positive production of oil or natural gas in 2011 and no wind development in the sample year. Wind counties are those with positive installed wind energy capacity in the sample year and no oil and natural gas production. Exact values are suppressed to preserve the privacy of the survey takers.

Source: USDA, Economic Research Service (ERS) using data from USDA, National Agricultural Statistics Service and USDA, ERS, Agricultural Resource Management Survey, 2011–20, oil and natural gas production data from USDA, ERS (2014), and wind energy capacity data from Hoen et al. (2018).

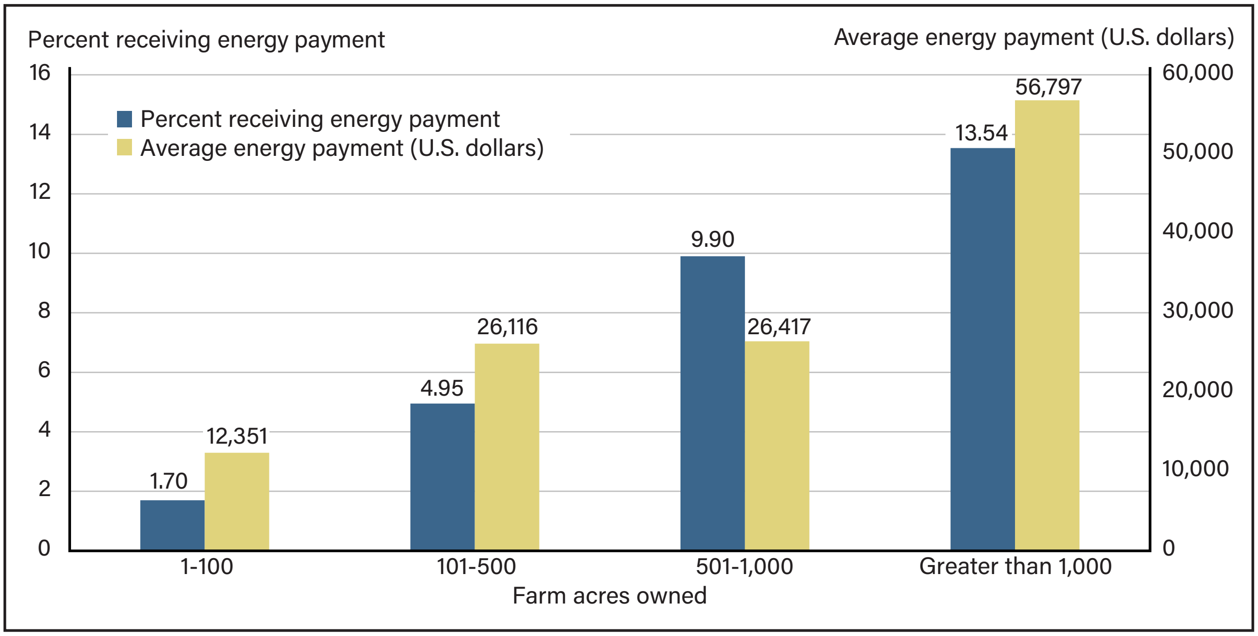
[30] Specific values are suppressed to preserve the privacy of the survey takers.

Energy Payments by Farm and Operator Characteristics

In addition to examining differences in payments by energy county type, the ARMS data allowed for the study of the characteristics of farms and farm operators who received energy payments. In particular, 10 years of ARMS data create a sufficient sample size to evaluate differences in energy payments by demographic characteristics, geographic distribution, and farm and producer characteristics. As wind energy continues to expand, the findings may also provide insight into who will gain (or lose) from future energy development.

Figure 5 includes information on differences in the percentage of farm operators receiving energy payments based on the number of farm acres owned. Acres owned, rather than total acres operated, is used because land and/or mineral rights ownership is required to receive payments from energy production.[31 32 33] The percent of farm operators receiving energy payments grows significantly with the number of acres owned. Less than 2 percent of farm operators owning less than 100 acres received payments, compared to more than 13 percent with greater than 1,000 acres. Energy payment size similarly grows with farm size, although the size of payments does not differ dramatically between the 101–500- and 501–1,000-acre groups, each with average payments of about $26,000. Payments for those owning fewer than 100 acres averaged $12,351 while among farm operators owning more than 1,000 acres, payments were four times that value ($56,797).

Figure 5
U.S. energy payments by farm acres owned, 2011–20



Note: All income amounts are in 2020 U.S. dollars using the Consumer Price Index.

Source: USDA, Economic Research Service (ERS) using data from USDA, National Agricultural Statistics Service and USDA, ERS, Agricultural Resource Management Survey, 2011–20.

[31] It is possible that a farmer could own the mineral rights, but not the land rights, for their farm but this is expected to be an atypical occurrence (Hitaj et al., 2018). Far more likely is that, in areas where mineral rights are severed from land rights, farmers own their land, but not mineral rights. In these cases, the mineral rights owner, rather than the farmer, would receive the payments for oil and gas production.

[32] In 115 observations, producers owned zero acres but had positive energy payments. These observations are dropped as they were likely imputed values or filled out incorrectly.

[33] Figure A.1 shows results in which acres operated, rather than owned, are considered.

Several reasons explain why the size and frequency of energy payments may be smaller for the smallest farms. The smallest farms not only have less room for energy production to take place but also less land area that may contain ideal energy-producing topography. For example, a larger property in a shale area is more likely to overlap with an oil field than a smaller farm. Furthermore, larger farms may host more oil and gas or wind energy development because the per-unit costs of energy development on larger landholdings are lower (Vissing, 2017; Winikoff & Parker, 2023). Larger farms can similarly receive larger payments simply because they can host more energy production.[34] In addition, farm size may be correlated with regional differences in energy potential. For example, larger ranches that have emerged in response to less suitable soil conditions are more common in oil-producing regions such as Texas.

Figure 6 shows differences in payment frequency and size (among those receiving payments) by USDA, ERS Farm Typology categories: small family farms with an annual gross cash farm income (GCFI) less than $350,000; midsize family farms with a GCFI between $350,000 and $999,999; large-scale family farms with a GCFI of $1,000,000 or more; or nonfamily farms (USDA, ERS, 2022).[35] Family farms are defined as those for which the operator and those related to the operator own a majority of the business. Notably, a similar share (about 3.2 percent) of small family farm and nonfamily farm operators received energy payments, compared to more than 6 percent of midsize and large-scale family farm operators. Payments were smallest on small family farms (average of $18,088) and rose to an average of $152,285 on large-scale family farms. This number was nearly three times the value of payments to nonfamily farms ($57,124).

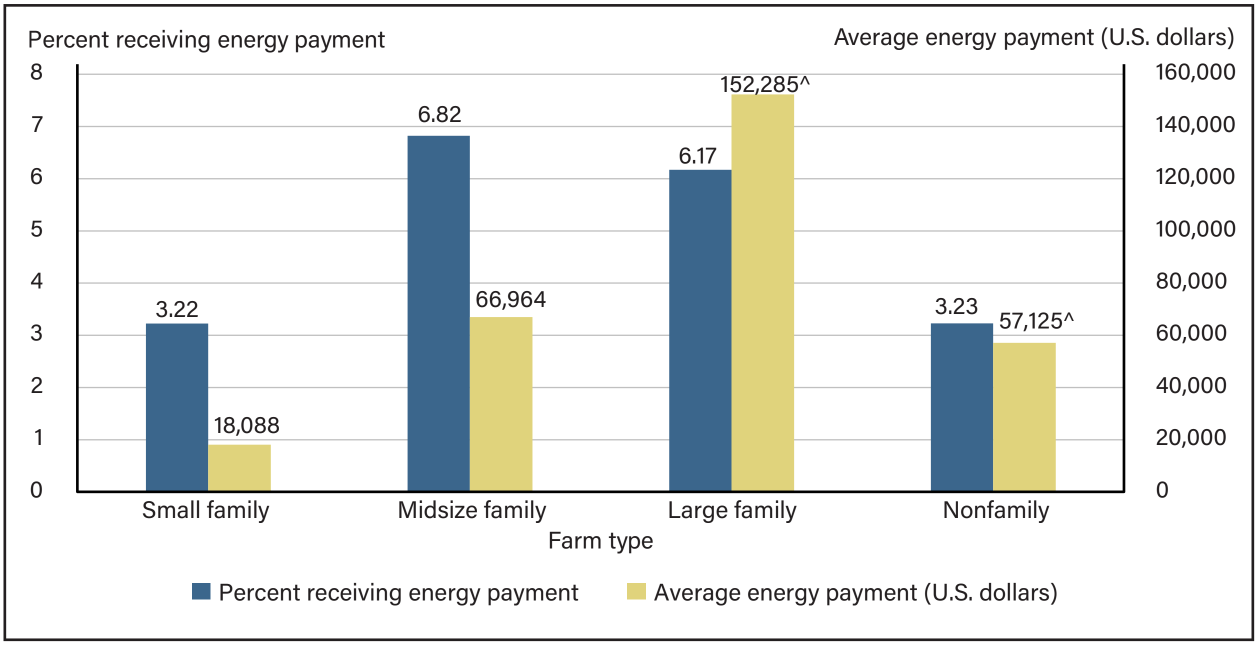
The finding that larger family farms more frequently receive energy payments is consistent with the previous finding that operators who own more land receive larger and more frequent payments. However, the finding for midsize family farms is inconsistent when compared to nonfamily farms. Midsize farms were, on average, smaller than nonfamily farms.[36] This suggests that nonfamily farms, which include corporate farms, may have different objectives and may face different trade-offs when evaluating whether to lease land for energy development. These differences are further explored in the subsequent regression analysis.

[34] This section does not include calculations of per-acre energy payments. This is because ARMS does not include the number of acres leased for energy development. A calculated per-acre payment may incorrectly imply larger payments to smaller farms, even if the payments are identical. For example, suppose 10 acres were leased for energy development at an equivalent rate, $1,000 on two farms—a 40-acre farm, and a 100-acre farm. Although the actual per-acre payment would be identical for the two, $100, using acres owned to calculate the per-acre payment would incorrectly imply a larger per-acre payment to the smaller farm ($25) than the larger farm ($10).

[35] Figure A.2 shows results by the retirement status of the primary farm operator. There do not appear to be substantial differences between retired and nonretired operators, although payments are slightly more frequent among nonretired operators. The researchers additionally examined differences in operator gender. Payments were more common to male operators (3.6 versus 2.7 percent) but slightly larger for female operators ($32,480 versus $30,270). Male operators make up more than 90 percent of the sample.

[36] In the sample, the average midsize family farm was 819 acres, compared to 1,012 acres for nonfamily farms.

Figure 6
U.S. energy payments by farm type, 2011–20



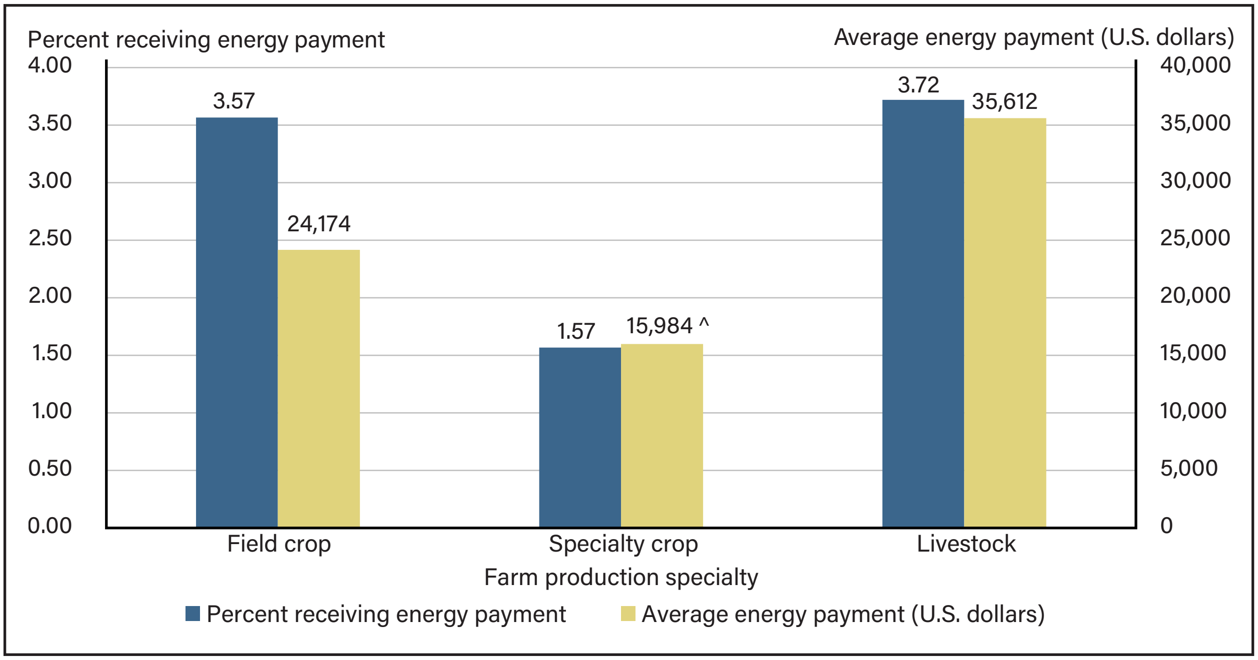
Note: A coefficient of variation between 25 and 50 is denoted with a ^. All income amounts are in 2020 U.S. dollars using the Consumer Price Index.

Source: USDA, Economic Research Service (ERS) using data from USDA, National Agricultural Statistics Service and USDA, ERS, Agricultural Resource Management Survey, 2011–20.

Figure 7 shows differences in energy payment frequency and size by farm production specialty. Energy payments were less common on specialty crop farms than on those primarily producing field crops and livestock. Similarly, energy payments were larger on farms growing field crops and producing livestock. This finding is intuitive, given that many of the areas of the contiguous United States with the largest oil and gas reserves (the Southern Plains and Mountain West) and highest potential for wind development (the Plains and Midwest) specialize in livestock production and field crops such as corn and soybeans. Additionally, specialty crop production typically involves high-value crops. Trading off land use for energy production may be more costly if producers give up specialty crop production. These differences in payments size by production specialty, however, were not statistically significant after controlling for farm characteristics and location.

Figure 7

U.S energy payments by farm production specialty, 2011–20



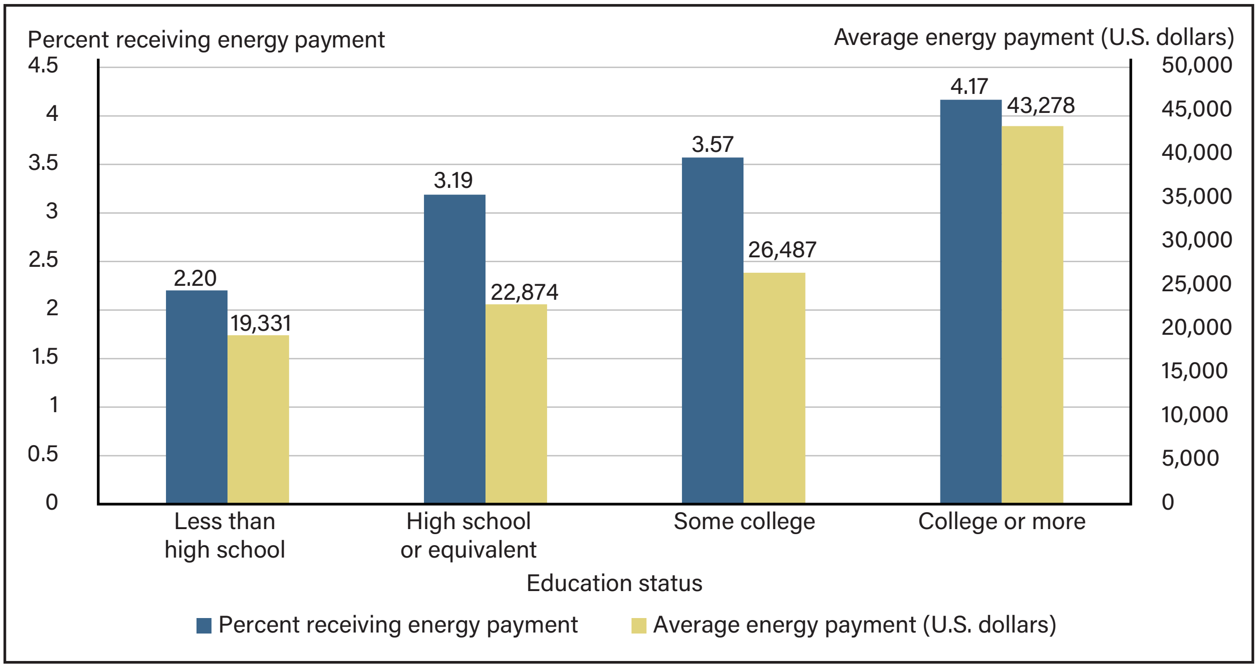
Note: A coefficient of variation between 25 and 50 is denoted with a ^. All income amounts are in 2020 U.S. dollars using the Consumer Price Index. The differences in means do not necessarily represent statistically significant differences. This report did not find statistically significant differences in the likelihood of receiving payments or payment size by production specialty after controlling for farm size, location, and other farm characteristics.

Source: USDA, Economic Research Service (ERS) using data from USDA, National Agricultural Statistics Service and USDA, ERS, Agricultural Resource Management Survey, 2011–20.

Differences in farmer characteristics, focusing first on the relationship between education level and energy payments, are shown in figure 8. The findings indicate that as education increases, so does the likelihood of receiving energy payments and the magnitude of the payments. Only 2.2 percent of farms with an operator with less than a high school diploma received payments, with an average of $19,331. Among those with a college degree or more, 4.2 percent of farmers received a payment, with an average of $43,278. The implication is that those who have more formal education are more likely to benefit from energy production on their farm. Education was positively correlated with income (both on and off-farm) and suggests more educated landowners may have more resources to negotiate energy leases.[37] The regression analysis below shows that a positive correlation between education and payment size exists but was not statistically significant after accounting for farm characteristics and location. The relationship between education level achieved and the likelihood of receiving payments, however, persists and was statistically significant.

[37] Harleman et al. (2022) found that high-income landowners had more resources to negotiate more favorable energy leases. They did not report an education effect.

Figure 8
U.S. energy payments by farm operator educational status, 2011–20



Note: All income amounts are in 2020 U.S. dollars using the Consumer Price Index. The difference in means do not necessarily represent statistically significant differences. This report did not find statistically significant differences in payment size after accounting for location and other farm characteristics. Differences in the likelihood of receiving payments were statistically significant.

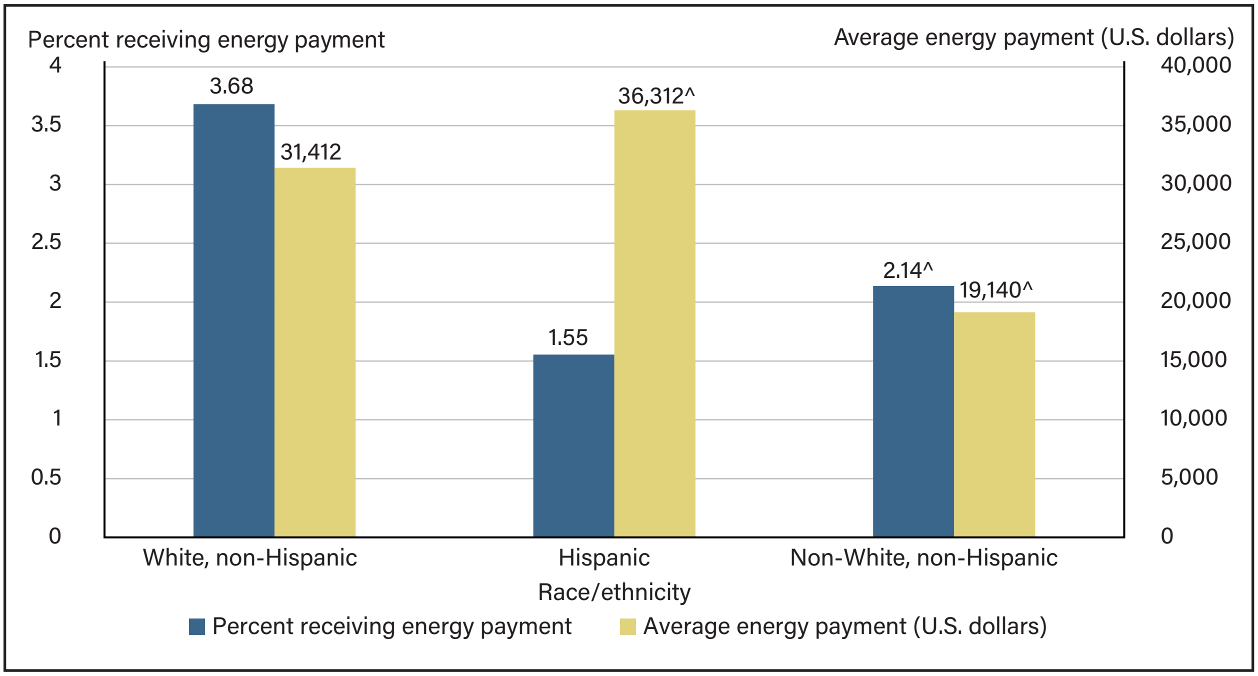
Source: USDA, Economic Research Service (ERS) using data from USDA, National Agricultural Statistics Service and USDA, ERS, Agricultural Resource Management Survey, 2011–20.

Figure 9 reports differences in energy payments among producers by race and ethnicity. Producers were categorized into one of three categories: White non-Hispanics, Hispanics, and non-White non-Hispanics.[38] White, non-Hispanic producers received energy payments at the highest rate, 3.7 percent. Hispanic producers received payments at less than half that rate, 1.6 percent, despite being located predominantly in energy-producing States, such as Texas and New Mexico (USDA, NASS, 2019b).[39] Looking at the size of energy payments, non-White, non-Hispanic operators received the smallest payment, at an average of $19,140, while White and Hispanic farm operators received average payments of $31,412 and $36,312, respectively. The regression analysis below shows that the smaller payments for non-Hispanic operators may be explained by geography or differences in wealth among demographic groups and were not statistically significant. However, differences in the probability of receiving energy payments between Hispanic and White, non-Hispanic operators were statistically significant.

[38] Due to sample size limitations, this report does not include analyses of additional race/ethnicity categories.

[39] Hispanic farm operators are overrepresented in energy counties. They make up 3.3 percent of the sample but about 4.3 percent in energy counties. They are particularly overrepresented in oil and gas only counties (4.3 percent) and oil/gas and wind counties (7.9 percent). They are underrepresented in the wind only counties (1.8 percent) found more commonly in the Midwest.

Figure 9
U.S. energy payments by farm operator race/ethnicity, 2011–20



Note: A coefficient of variation between 25 and 50 is denoted with a ^. All income amounts are in 2020 U.S. dollars using the Consumer Price Index. The differences in means do not necessarily represent statistically significant differences. This report did not find statistically significant differences in average payments by race and ethnicity after accounting for location and other farm characteristics. Differences in the likelihood of receiving payments were statistically lower for Hispanic operators but not for non-White, non-Hispanic operators.

Source: USDA, Economic Research Service (ERS) using data from USDA, National Agricultural Statistics Service and USDA, ERS, Agricultural Resource Management Survey, 2011–20.

Determinants of Energy Payments: Findings From Regression Analyses

Differences in the share of producers receiving energy payments (and the size of payments) across farm and farmer characteristics may be explained by other factors such as geography. This report used linear regression analyses regressing both a binary variable indicating whether the producer received payments and the natural logarithm of the payment amount on a set of farm and operator characteristics while controlling for the State and/or energy county type where the operation is located.[40] Table 6 includes regression results in which the dependent variable equals 1 if a farm received energy payments and zero otherwise. Columns (1)–(3) include all observations, while columns (4)–(6) include only those in oil, natural gas, or wind-producing counties. Full technical details of the model are in the appendix.

[40] Table A.5 in the appendix shows the results are robust to a Probit model specification.

Table 6
Regression results: Probability of energy payments

	All counties			Energy counties only		
	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: Receives energy payment=1, Otherwise 0					
IHS (owned acres)	0.0122***	0.0118***	0.0116***	0.0206***	0.0204***	0.0202***
	(0.0009)	(0.0009)	(0.0008)	(0.0016)	(0.0015)	(0.0015)
IHS (value of farm assets)	0.0020**	0.0018**	0.0020**	0.0035**	0.0030*	0.0035**
	(0.0009)	(0.0009)	(0.0009)	(0.0017)	(0.0016)	(0.0016)
Specialty crop farm	0.0024	-0.0033	0.0041	0.0029	-0.0095	0.0050
	(0.0049)	(0.0044)	(0.0052)	(0.0105)	(0.0086)	(0.0108)
Livestock farm	0.0003	0.0021	-0.0001	-0.0001	0.0044	-0.0006
	(0.0042)	(0.0043)	(0.0042)	(0.0078)	(0.0079)	(0.0078)
Midsize family	0.0202***	0.0191***	0.0206***	0.0344***	0.0301***	0.0351***
	(0.0050)	(0.0048)	(0.0047)	(0.0089)	(0.0088)	(0.0085)
Large family	0.0081	0.0043	0.0081	0.0136	0.0051	0.0135
	(0.0116)	(0.0119)	(0.0116)	(0.0217)	(0.0223)	(0.0218)
Nonfamily	-0.0066	-0.0108	-0.0079	-0.0186*	-0.0284***	-0.0191*
	(0.0066)	(0.0066)	(0.0066)	(0.0104)	(0.0102)	(0.0104)
High school diploma or equivalent	0.0090*	0.0046	0.0090*	0.0174*	0.0062	0.0156*
	(0.0046)	(0.0041)	(0.0047)	(0.0091)	(0.0081)	(0.0086)
Some college	0.0140**	0.0084	0.0142**	0.0257**	0.0118	0.0236**
	(0.0062)	(0.0057)	(0.0061)	(0.0114)	(0.0110)	(0.0107)
College or more	0.0154***	0.0114***	0.0165***	0.0276***	0.0156**	0.0258***
	(0.0037)	(0.0031)	(0.0038)	(0.0068)	(0.0060)	(0.0063)
Hispanic	-0.0161***	-0.0235***	-0.0196***	-0.0211***	-0.0314***	-0.0232***
	(0.0034)	(0.0042)	(0.0039)	(0.0055)	(0.0067)	(0.0060)
Non-White non-Hispanic	-0.0131*	-0.0126*	-0.0155**	-0.0207	-0.0205*	-0.0204
	(0.0075)	(0.0066)	(0.0074)	(0.0140)	(0.0111)	(0.0138)
Operator retired	-0.0015	-0.0029	-0.0015	-0.0012	-0.0045	-0.0013
	(0.0034)	(0.0033)	(0.0033)	(0.0063)	(0.0065)	(0.0061)
Oil and gas county		0.0687***	0.0609***		0.0564***	0.0445***
		(0.0043)	(0.0051)		(0.0062)	(0.0074)
Wind county		0.0129***	0.0141***			
		(0.0022)	(0.0027)			
Oil and gas and wind county		0.1052***	0.0900***		0.0921***	0.0674***
		(0.0133)	(0.0113)		(0.0122)	(0.0115)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
State fixed effects	Yes	No	Yes	Yes	No	Yes
Observations	161,004	161,004	161,004	74,757	74,757	74,757

* p<0.10 ** p<0.05 *** p<0.01; IHS = inverse hyperbolic sine.

Note: Jackknife standard errors in parentheses using procedure outlined from Dubman (2000). All income amounts are in 2020 U.S. dollars. Oil and gas counties are those with positive production of oil or natural gas in 2011. Wind counties are those with positive installed wind energy capacity in the sample year. Energy counties are either oil and gas counties or wind counties.

Source: USDA, Economic Research Service using oil and natural gas production data from USDA, ERS (2014), wind energy capacity data from Hoen et al. (2018), and USDA, National Agricultural Statistics Service, and USDA, ERS, Agricultural Resource Management Survey, 2011–20.

Consistent with the findings in figure 5, owning more farmland was associated with a higher probability of receiving energy payments. A 10-percent increase in owned farm acres corresponded to roughly between a 0.0012 and 0.0021 increase in the probability of receiving payments, depending on model specification. This represented between a 3.4- and 6-percent increase on average, relative to the average share of agricultural producers who received energy payments (3.5 percent). Two explanations exist for why larger farms may be more likely to receive energy payments. First, a larger farm has more space to host energy activities and a greater likelihood that some part of the farm contains land with energy-producing potential. Second, there are potential benefits to contracting with fewer landowners with larger parcels when developing oil and gas or wind energy (Vissing, 2017; Winikoff & Parker, 2023).

Farm household wealth may play a role in the willingness to enter into energy leases. Table 6 shows that wealthier farm households (as measured by total farm assets) were more likely to receive energy payments.[41] The effect, however, was small; a 10-percent increase in farm wealth was associated with about a one-tenth of 1-percent increase in the likelihood of receiving payments relative to the average of 3.5 percent. Nonetheless, the finding suggests that wealthier operators may have more resources to negotiate energy leases (Harleman et al., 2022). The finding also implies that less wealthy farms are not disproportionately entering into energy leases to diversify income, while wealthier farms may be using energy income as one of many sources of diversification.

The analysis found no evidence that the primary form of agriculture (livestock, field crop, or specialty crop) made a difference in the probability of receiving energy payments. Evidence showed, however, that midsize family farms (GCFI between $350,000 and $1 million) were more likely to receive energy payments, and nonfamily farms were less likely, both relative to small family farms, even after controlling for farm size. A midsize family farm had between a 1.9- and 3.5-percent higher probability of receiving energy payments than a small family farm. This finding implies that the farming objectives for nonfamily (often, but not always, corporate) farms may differ from those of family farms. Interestingly, the analysis did not indicate that a statistically significant difference exists in the probability of receiving payments between large-scale family farms and small family farms after controlling for geographic, farm, and farmer characteristics. This suggests that other factors, including farm size, are more strongly associated with differences in the probability of energy payments than farm type. Similarly, objectives and land use for small family farms (often hobby farmers) may differ in ways that make their likelihood of entering into an energy lease less common.

Farm operator characteristics were also correlated with the likelihood of receiving energy payments. A higher level of education increases the probability of receiving an energy payment. A college-educated operator was between 1.1 and 2.8 percent more likely to receive payments than an operator with less than a high school education, depending on the model specification. Additionally, statistical evidence showed that operators with high school or some college education were more likely to receive payments than those without a high school diploma, but the findings are not robust across the model specifications. This echoes findings from figure 8, suggesting education increases the likelihood of benefitting from energy production.

The findings further indicate that ethnicity plays a role in the share of producers who receive payments. A Hispanic operator was between 1.6 and 3.1 percent less likely to receive payments than a White, non-Hispanic operator, depending on the model. This suggests Hispanic producers less frequently entered into energy leases. This may be due to differences in their opportunity to enter into energy leases, differences in preferences, or other factors not accounted for in the model.[42] In some models, there was evidence that non-White, non-

[41] Higher wealth may also, in part, be due to energy payments.

[42] Timmins and Vissing (2022) found fewer contract protections for Hispanic landowners in natural gas leases.

Hispanic farm operators were less likely to receive payments. When the model included controls for the State where the farm was located and limited to only energy-producing counties, however, there was no longer a statistically significant finding for non-White non-Hispanic operators. This suggests that the disparity in payments may be explained by farm location. Farms led by non-White operators were more common in the South, which, with the exception of Louisiana, has limited oil, natural gas, and wind resources.[43]

To further test the finding that Hispanic operators were less likely to receive energy payments, table A.3 in the appendix includes findings for the same model specifications included in table 6 but restricted to operations in the State of Texas. Texas makes a strong candidate for such a test because it is a leader in both energy development and Hispanic farm operators (USDA, NASS, 2019b).[44] Including additional controls for the county of production, results are shown in table A.3. The findings indicate that even when limiting the sample to a disproportionately Hispanic sample with substantial energy production, Hispanic farm operators still were less likely to receive energy payments.

Table 6 also highlights that energy payments were more likely in counties with ongoing energy production compared with counties with neither oil and gas nor wind production. As shown in columns (2) and (3), a farm in an oil and gas county was more than 6 percent more likely to receive an energy payment than a farm with no energy development. A farm in a wind energy county was about 1.3 percent more likely to receive a payment. Farms in counties with both wind and oil and gas production were between 9 and 10 percent more likely to receive a payment. When the sample was limited to just energy-producing counties in columns (5) and (6), the findings indicate that farms in oil-producing counties are between 4.5 and 5.6 percent more likely to receive a payment than a farm in a wind-producing county.

Table 7 shows how the size of energy payments were influenced by the characteristics of farms and farmers.[45] In these regressions, only those producers who received energy payments in at least 1 of the sample years, a total of 6,992 observations, were included. Columns (3) and (4) include observations only from energy counties, 6,319 observations. The dependent variable in each regression was the natural logarithm of energy payments.

Unlike the previous results, no statistically significant differences in energy payments were associated with farmer characteristics in the regression model. When considering the measures of farmer's education, the coefficient on the "college or more" variable remained positive but was not statistically different from zero across all four specifications. Further, no differences in payment size by race or ethnicity were found.

Larger farms, however, received larger energy payments. A 10-percent increase in the number of owned farm acres corresponded to an increase of roughly 2 percent in the payment size. Similarly, midsize and large family farms received larger payments than small family farms, although the same does not hold for nonfamily farms. A midsize family farm was associated with a 66- to 87-percent higher payment than a small family farm, depending on the model specification. These findings are consistent with the literature indicating that wind energy, oil, and natural gas are more common on larger landholdings. Further, while the findings in table 6 do not indicate a significant difference in the probability of payment between large-scale and small-scale family farms, table 7 results indicate that large-scale family farms were associated with payments twice as large as those on small family farms.

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[43] In the sample used for this regression analysis, just 3.8 percent of farm operators identified as non-White (including Hispanics). In the South, this number was 6.6 percent. Hispanics are, however, most common in the West region (8.2 percent).

[44] In the total sample for these regressions, 3.3 percent (when weighting the data) of farm operators are Hispanic. This number was more than 11 percent in Texas, representing more than 700 observations.

[45] Table A.4 tests the robustness of these findings by excluding both the largest and smallest outliers from the regression model. Table A.6 tests the robustness of a Heckman selection model. Both tables are in the appendix, with findings consistent with those in table 7.

Table 7
Regression results: Size of energy payments

	All counties		Energy counties only	
	(1)	(2)	(3)	(4)
	Dependent variable: Log (energy payment in dollars)			
IHS (owned acres)	0.240***	0.228**	0.208**	0.210**
	(0.0794)	(0.0889)	(0.0800)	(0.0934)
IHS (value of farm assets)	0.0152	0.0297	0.0169	0.0276
	(0.0361)	(0.0363)	(0.0306)	(0.0321)
Specialty crop farm	-0.261	-0.233	-0.523	-0.426
	(0.404)	(0.412)	(0.390)	(0.386)
Livestock farm	0.132	-0.194	0.0982	-0.171
	(0.159)	(0.187)	(0.168)	(0.193)
Midsize family farm	0.655***	0.758***	0.790***	0.865***
	(0.171)	(0.170)	(0.155)	(0.146)
Large family farm	1.011*	1.112**	1.107*	1.148*
	(0.552)	(0.536)	(0.577)	(0.587)
Nonfamily farm	0.656	0.641	0.655	0.638
	(0.466)	(0.535)	(0.533)	(0.570)
High school diploma or equivalent	-0.0406	0.0771	-0.0759	0.0274
	(0.270)	(0.303)	(0.272)	(0.307)
Some college	-0.130	-0.143	-0.172	-0.174
	(0.248)	(0.266)	(0.245)	(0.263)
College or more	0.257	0.189	0.196	0.132
	(0.259)	(0.267)	(0.257)	(0.270)
Hispanic	0.146	-0.278	0.0756	-0.314
	(0.372)	(0.312)	(0.360)	(0.316)
Non-White non-Hispanic	-0.681	-0.836	-0.685	-0.809
	(0.578)	(0.603)	(0.572)	(0.586)
Operator retired	0.0791	0.0470	0.103	0.0717
	(0.199)	(0.190)	(0.214)	(0.205)
Oil and gas county			0.0461	-0.395
			(0.211)	(0.499)
Oil and gas and wind county			0.628***	0.109
			(0.219)	(0.501)
Year fixed effects	Yes	Yes	Yes	Yes
State fixed effects	No	Yes	No	Yes
Observations	6,992	6,992	6,319	6,319

* p<0.10 ** p<0.05 *** p<0.01; IHS = inverse hyperbolic sine.

Note: Jackknife standard errors in parentheses using procedure outlined from Dubman (2000). All income amounts are in 2020 dollars. Oil and gas counties are those with positive production of oil or natural gas in 2011. Wind counties are those with positive installed wind energy capacity in the sample year. Energy counties are either oil and gas counties or wind counties.

Source: USDA, Economic Research Service using oil and natural gas production data from USDA, ERS (2014), wind energy capacity data from Hoen et al. (2018), USDA, National Agricultural Statistics Service, and USDA, ERS, Agricultural Resource Management Survey, 2011–20.

Columns (3) and (4) indicate that energy county type did not have a consistent statistically significant effect on the amount of energy payments. The coefficients for "oil and gas county" were not statistically different from zero, and the coefficients for "oil and gas and wind county" were not robustly significant. This is inconsistent with findings in table 5, which indicated that producers in oil and gas counties, on average, received higher payments than those in wind counties. In the regressions, however, measures of farm size and location were included. Furthermore, as presented in figure 4, oil and gas payments were significantly skewed. Oil and gas payments had a larger mean payment size than wind payments but a smaller median payment due to a small number of very large oil and gas payments. Further, taking the natural logarithm of payments placed more weight on the small values and less weight on the large values. Despite the higher mean oil and gas payment after controlling for other farm and farmer characteristics, the findings in table 7 do not indicate a significant difference in the payment amount.

Overall, the findings suggest that many farm and operator characteristics have little influence on the size of energy payments to farmers. Instead, payment size is influenced by farm size, farm income, and location.[46] Although farmer characteristics, race/ethnicity, and education level play a role in the probability of earning energy payments, the findings suggest that they may be relatively less important in influencing the payment size.

Conclusion

Alternative sources of income for farmers beyond traditional agriculture can provide an important revenue stream, particularly considering the volatility of farm revenues. For a small group of farm operators and their families, energy payments provided substantial income, particularly when oil prices were rising dramatically prior to 2013. From 2011 to 2020, for farmers receiving energy payments, average energy payments typically exceeded average government payments ($30,482 vs. $29,164) and comprised about 24 percent of the farm household's off-farm income. Still, payments had a very uneven distribution, varying by region and energy type, with just 3.5 percent of farms receiving payments. Farm operators in the Plains region, which has significant oil, gas, and wind resources, received the highest share of energy payments, although farmers in the West and a subset of Midwest and Atlantic States also received energy payments. Both the likelihood of receiving a payment and the size of the energy payments for farm operators were influenced by whether the farm was in an energy-producing area.

In addition to disparities in payments by region, this report suggests that differences in energy payments were associated with farm size and farm income, and differences in the probability of receiving energy payments were associated with farm operator demographics. Operators on larger farms were more likely to receive energy payments and received larger payments (figure 5). This is not unexpected given that a larger farm has more land area from which energy resources may be found and more land area for the placement of energy development. Further, midsize and large-scale family farms were associated with larger energy payments than smaller farms and midsize farms and had a higher probability of receiving payments than small farms. Additionally, this study finds that Hispanic farm operators, as well as those with less formal education, were less likely to receive energy payments (table 6), even after accounting for other farm characteristics and location. Of note, this disparity exists despite the fact that the largest Hispanic farm operator population is in Texas, which has significant oil and wind resources (USDA, NASS, 2019b). Further, although average payments over the sample period were largest for Hispanic farm operators, the study did not find a significant difference in the energy payment size across racial or ethnic groups after controlling for farm characteristics and location.

[46] Another factor affecting the size of payments is the well or turbine productivity, which was not measured in this analysis, but has been shown to affect payments and royalty rates (Brown et al., 2016; Hitaj et al., 2018).

As energy production in the United States moves increasingly to renewable sources, new regions may be able to capitalize on energy development, presenting opportunities for a wider array of farmer operators to benefit from energy production. Although wind energy development is limited to areas with sufficient wind potential for large-scale development, 43 States generated utility-scale electricity from wind in 2021 (U.S. EIA, 2022f). Wind development and production of wind-generated electricity is expected to expand across the United States, with substantial development in the Plains, Midwest, West, and Atlantic regions. Wind development in some States without major oil and natural gas production, including Iowa, Minnesota, Illinois, Oregon, South Dakota, and Washington, has already provided energy income to farmers. These payments may continue to grow in the future in the wake of Federal and State policies to promote renewable energy, including wind power.

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Appendix

Regression Model Technical Details

In order to determine factors contributing to the likelihood of receiving energy payments, the researchers implemented a linear probability model in which the dependent variable equals 1 if a farm received energy payments and zero otherwise. Results are in table 6.[47] [48] The independent variables of interest are farm and farm operator characteristics that may influence the decision or ability to enter into an energy lease. All models also include controls for the year (or year-fixed effects) in which the farm was surveyed to account for differences over time. Depending on the model specification, the regression may include State fixed effects to account for geographic differences. Some models also include controls for the type of energy county (e.g., oil and gas, wind, both, or neither) in which the farm is located. The reported coefficients can be interpreted as the change in the probability of receiving energy payments from a one-unit change in the independent variable, unless the variable is categorical or transformed as described below. The six models shown in table 6 include some combination of State and energy county fixed effects; columns (4)–(6) include only observations in energy counties.

To determine factors influencing the size of energy payments, the researchers implemented a linear regression model in which the dependent variable is the natural logarithm of energy payments received (table 7).[49] These model specifications include the same sets of independent variables and control variables that are included in the probability of payment regressions. In these models, to interpret the coefficients, multiplying the relevant coefficients by 100 represents the percent change from a unit increase in the independent variables, unless the variable is categorical or transformed as described below. Robustness in these regressions, columns (3)–(4) include only observations in energy counties. The researchers did not include energy county controls in model specifications that include all observations because most farms receiving energy payments are located in energy counties, and energy county controls would account for almost all of the variation in the dependent variable.

Several categorical variables, including farm type, production specialty, education, and race, require the exclusion of a given category for model estimation. The excluded groups are small family farms, field crops, less than a high school education, and White and non-Hispanic farmers, respectively. The relevant coefficients shown for these groups are, therefore, interpretable as the change from the given category to the excluded one. For example, the coefficient for “college or more” is the effect of a change in the given dependent variable for a farm operator who has a college degree or higher compared to a farmer with less than a college degree.

Several variables include a large, skewed range of values that may distort the interpretation of regression results. For these, the researchers adjusted the data using the natural logarithm (log) or inverse hyperbolic sine (IHS). The IHS is similar to the log transformation but allows for the inclusion of observations equal to zero, which the log does not. However, the two types of variables can be interpreted similarly.

[47] In linear probability models, predicted values often appear outside of the unit interval of [0-1]. In this case, approximately 85 percent of observations appear within the range.

[48] All analysis was done using the statistical program Stata.

[49] Two alternative models were considered but ultimately not included. A Poisson model cannot be run because it requires only integer values, which the energy payments do not have. Another potential model is the Tobit, but this requires the marginal effect of whether a farm receives energy payments to have the same sign as the marginal effect on the size of the payments, a restrictive and not necessarily true assumption.

Because of the complex survey design of ARMS, standard linear regression techniques are unable to lead to nationally representative conclusions. In order to correct for this so that the results are nationally representative, the researchers used the methodology outlined in Dubman (2000). This requires reweighting observations to adjust for their sample frequency and using bootstrapped jackknife standard errors, in which every 15th replicate estimate is given zero weight in variance calculation.

Although linear probability models are common in economics literature, it is important to test that results are not driven by the statistical model selected when viable alternatives exist. The marginal effects (the effect on the probability of receiving energy payments of a one-unit change in a given variable) from a Probit model are shown in table A.5. The findings are consistent with those in table 6, suggesting they are not driven by the linear probability specification.

Similarly, table A.6 presents marginal effects from a Heckman selection model testing robustness to the findings in table 7. The findings come from a jointly run two-stage model in which the first stage runs a model for the probability of receiving energy payments (a Probit model), and the second stage determines factors influencing the size of the payments. By running the models jointly, the model corrects for selection into the second stage regression. Results can be interpreted in the same way as from table 7, and the findings are consistent, again suggesting they are not driven by model choice.

Supplementary Descriptive Tables

Table A.1

U.S. average energy payments by county production type: Oil fields measure, 2011–20

		U.S. dollars		
Year	Neither	Oil and natural gas	Wind	Both
2011	5,372^	39,520	19,439^	45,617^
2012	17,428^	30,559	8,691^	46,141^
2013	26,397#	76,120#	19,516^	36,528
2014	14,758^	48,229	27,617^	48,502
2015	6,290^	23,041^	34,538#	22,964^
2016	27,476^	15,234	26,040^	14,840^
2017	7,808#	18,362	15,111	30,983^
2018	12,263#	19,484^	10,249	37,834
2019	8,430^	26,831^	10,239	29,567^
2020	13,545#	10,461^	11,642	20,057
Average	13,624	32,125	17,925	32,458

Note: A coefficient of variation (CV) between 25 and 50 is denoted with a ^, and a CV greater than 50 is denoted by a #. All income amounts are in 2020 dollars. Oil and gas counties are those overlapping a proven oil or natural gas field identified between 2011–20. Wind counties are those with positive installed wind energy capacity in the sample year. “Both” counties have both wind and oil or natural gas. “Neither” counties have no oil, wind, or natural gas installed.

Source: USDA, Economic Research Service using information from USDA, National Agricultural Statistics Service and USDA, ERS, Agricultural Resource Management Survey, 2011–20. Data on oil and natural gas counties from the U.S. EIA (2022h) and wind energy capacity data from Hoen et al. (2018).

Table A.2

U.S. average energy payments by county production type: Strict production measure, 2011–20

	U.S. dollars			
Year	Neither	Oil and natural gas	Wind	Both
2011	44,369#	34,066^	14,008^	67,675^
2012	9,486	33,961	16,559^	59,064#
2013	20,194^	77,964#	22,817^	43,421^
2014	22,486^	50,475	16,597^	67,497
2015	8,867^	24,821^	28,941#	32,885#
2016	19,558#	14,142	15,835^	20,069^
2017	15,997^	17,995	16,248	34,249^
2018	5,613	20,218	13,253	49,848
2019	12,990^	26,797^	13,277	31,089^
2020	23,058#	7,868^	15,445^	20,639^
Average	18,415	32,727	17,052	40,601

Note: A coefficient of variation (CV) between 25 and 50 is denoted with a ^, and a CV greater than 50 is denoted by a #. All income amounts are in 2020 dollars. Oil and gas counties are those with more than 70,000 barrels of oil or 1 million Mcf (1,000 cubic feet) of natural gas produced in 2011. Wind counties are those with more than 40 megawatts (MW) of wind energy in the given sample year. "Both" counties have both wind and oil or natural gas. "Neither" counties have no oil, wind, or natural gas installed.

Source: USDA, Economic Research Service using information from USDA, National Agricultural Statistics Service and USDA, ERS, Agricultural Resource Management Survey, 2011–20. Oil and natural gas production data from USDA, ERS (2014), and wind energy capacity data from Hoen et al. (2018).

Table A.3

Probability of energy payments: Texas, 2011–20

	All counties			Energy counties only		
	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent variable: Receives energy payment =1, Otherwise 0					
Hispanic	-0.0343**	-0.0274***	-0.0346**	-0.0354**	-0.0269***	-0.0356**
	(0.0128)	(0.0079)	(0.0128)	(0.0140)	(0.0085)	(0.0140)
Year-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
County-fixed effects	Yes	No	Yes	Yes	No	Yes
Energy county-fixed effects	No	Yes	Yes	No	Yes	Yes
Observations	11,754	11,754	11,754	10,487	10,487	10,487

* p<0.10 ** p<0.05 *** p<0.01

Note: Jackknife standard errors in parentheses using procedure outlined from Dubman (2000). All income amounts are in 2020 dollars. Oil and gas counties are those with positive production of oil or natural gas in 2011. Wind counties are those with positive installed wind energy capacity in the sample year. Energy counties are either oil and gas or wind counties. All other independent variables included in the analyses from table 7 are included in the analyses.

Source: USDA, Economic Research Service using oil and natural gas production data from USDA, ERS (2014), wind energy capacity data from Hoen et al. (2018), and USDA, National Agricultural Statistics Service and USDA, ERS Agricultural Resource Management Survey, 2011–20.

Table A.4
Size of energy payments regression: Excluding outliers, 2011–20

	All counties		Energy counties only	
	(1)	(2)	(3)	(4)
	Dependent variable: Log (Energy payment in dollars)			
IHS (owned acres)	0.128**	0.121**	0.106**	0.109*
	(0.0513)	(0.0524)	(0.0495)	(0.0547)
IHS (value of farm assets)	0.0108	0.0197	0.0132	0.0209
	(0.0283)	(0.0267)	(0.0246)	(0.0235)
Specialty crop farm	0.0734	0.0317	-0.0840	-0.0876
	(0.251)	(0.221)	(0.267)	(0.227)
Livestock farm	0.159	0.0217	0.160	0.0375
	(0.135)	(0.150)	(0.143)	(0.155)
Midsize family farm	0.123	0.193**	0.185	0.241**
	(0.105)	(0.0874)	(0.116)	(0.0949)
Large family farm	0.238	0.312*	0.261	0.311
	(0.183)	(0.183)	(0.179)	(0.197)
Nonfamily farm	0.359	0.313	0.301	0.269
	(0.290)	(0.316)	(0.354)	(0.352)
High school diploma or equivalent	0.112	0.199	0.0568	0.139
	(0.247)	(0.307)	(0.247)	(0.313)
Some college	0.148	0.173	0.0852	0.126
	(0.252)	(0.293)	(0.241)	(0.293)
College or more	0.306	0.329	0.244	0.273
	(0.257)	(0.308)	(0.253)	(0.316)
Hispanic	0.0395	-0.233	0.00214	-0.245
	(0.401)	(0.379)	(0.399)	(0.352)
Non-White non-Hispanic	-0.280	-0.287	-0.273	-0.251
	(0.465)	(0.490)	(0.471)	(0.508)
Operator retired	0.0223	0.00342	0.0250	0.0149
	(0.173)	(0.158)	(0.168)	(0.137)
Oil and gas county			-0.0593	-0.246
			(0.154)	(0.262)
Oil and gas and wind county			0.292*	0.0874
			(0.151)	(0.246)
Year fixed effects	Yes	Yes	Yes	Yes
State fixed effects	No	Yes	No	Yes
Observations	5,569	5,569	5,025	5,025

* p<0.10 ** p<0.05 *** p<0.01; IHS= inverse hyperbolic sine.

Note: Jackknife standard errors in parentheses using procedure outlined from Dubman (2000). All income amounts are in 2020 dollars. Oil and gas counties are those with positive production of oil or natural gas in 2011. Wind counties are those with positive installed wind energy capacity in the sample year. Energy counties are either oil and gas counties or wind counties. Energy payments in the approximate bottom 10th (less than $450) and top 10th percentile (more than $82,000) are excluded.

Source: USDA, Economic Research Service using oil and natural gas production data from USDA, ERS (2014), wind energy capacity data from Hoen et al. (2018), and USDA, National Agricultural Statistics Service and USDA, ERS Agricultural Resource Management Survey, 2011–20.

Table A.5

Probit marginal effects on the probability of receiving energy payments, 2011–20

	All counties		Energy counties only	
	(1)	(2)	(3)	(4)
	Marginal effects on: Probability (Receiving energy payments)			
IHS (owned acres)	0.0124***	0.0128***	0.0226***	0.0232***
	(0.00102)	(0.00108)	(0.00191)	(0.00205)
IHS (value of farm assets)	0.00172*	0.00193**	0.00280	0.00324*
	(0.000897)	(0.000847)	(0.00171)	(0.00161)
Specialty crop farm	-0.0125*	0.00170	-0.0211	0.00584
	(0.00669)	(0.00639)	(0.0133)	(0.0132)
Livestock farm	-0.0000127	-0.00173	0.00212	-0.00210
	(0.00375)	(0.00346)	(0.00719)	(0.00656)
Midsized family farm	0.00800**	0.00907**	0.0132*	0.0175**
	(0.00356)	(0.00329)	(0.00712)	(0.00673)
Large family farm	-0.00196	0.00181	-0.00447	0.00523
	(0.00888)	(0.00838)	(0.0192)	(0.0183)
Nonfamily farm	-0.0141*	-0.00829	-0.0405***	-0.0274**
	(0.00725)	(0.00611)	(0.0123)	(0.0113)
High school diploma or equivalent	0.00634	0.00998*	0.0114	0.0178*
	(0.00536)	(0.00551)	(0.0104)	(0.0103)
Some college	0.00810	0.0138**	0.0151	0.0259**
	(0.00630)	(0.00610)	(0.0121)	(0.0114)
College or more	0.00985**	0.0141***	0.0169**	0.0244***
	(0.00428)	(0.00446)	(0.00811)	(0.00819)
Hispanic	-0.0273***	-0.0219***	-0.0500***	-0.0391***
	(0.00563)	(0.00494)	(0.0108)	(0.00932)
Non-White non-Hispanic	-0.0159	-0.0116	-0.0288	-0.0201
	(0.00964)	(0.0101)	(0.0184)	(0.0192)
Operator retired	-0.00197	-0.000487	-0.00347	-0.000771
	(0.00332)	(0.00297)	(0.00661)	(0.00564)
Oil and gas county	0.0818***	0.0711***	0.0805***	0.0653***
	(0.00450)	(0.00488)	(0.00902)	(0.0116)
Wind county	0.0362***	0.0328***		
	(0.00278)	(0.00337)		
Oil and gas and wind county	0.0938***	0.0770***	0.102***	0.0756***
	(0.00584)	(0.00531)	(0.0112)	(0.0127)
Year fixed effects	Yes	Yes	Yes	Yes
State fixed effects	No	Yes	No	Yes
N	161,004	161,004	74,757	74,757

* p<0.10 ** p<0.05 *** p<0.01; IHS = inverse hyperbolic sine.

Note: Marginal effects reported are the effect of a one-unit change in the probability of receiving energy payments from the first stage (Probit) of a Heckman selection model. Jackknife standard errors in parentheses using procedure outlined from Dubman (2000). All income amounts are in 2020 dollars. Oil and gas counties are those with positive production of oil or natural gas in 2011. Wind counties are those with positive installed wind energy capacity in the sample year. Energy counties are either oil and gas counties or wind counties.

Source: USDA, Economic Research Service using oil and natural gas production data from USDA, ERS (2014), wind energy capacity data from Hoen et al. (2018), and USDA, National Agricultural Statistics Service and USDA, ERS Agricultural Resource Management Survey, 2011–20.

Table A.6
Marginal effects from the Heckman Selection Model, 2011–20

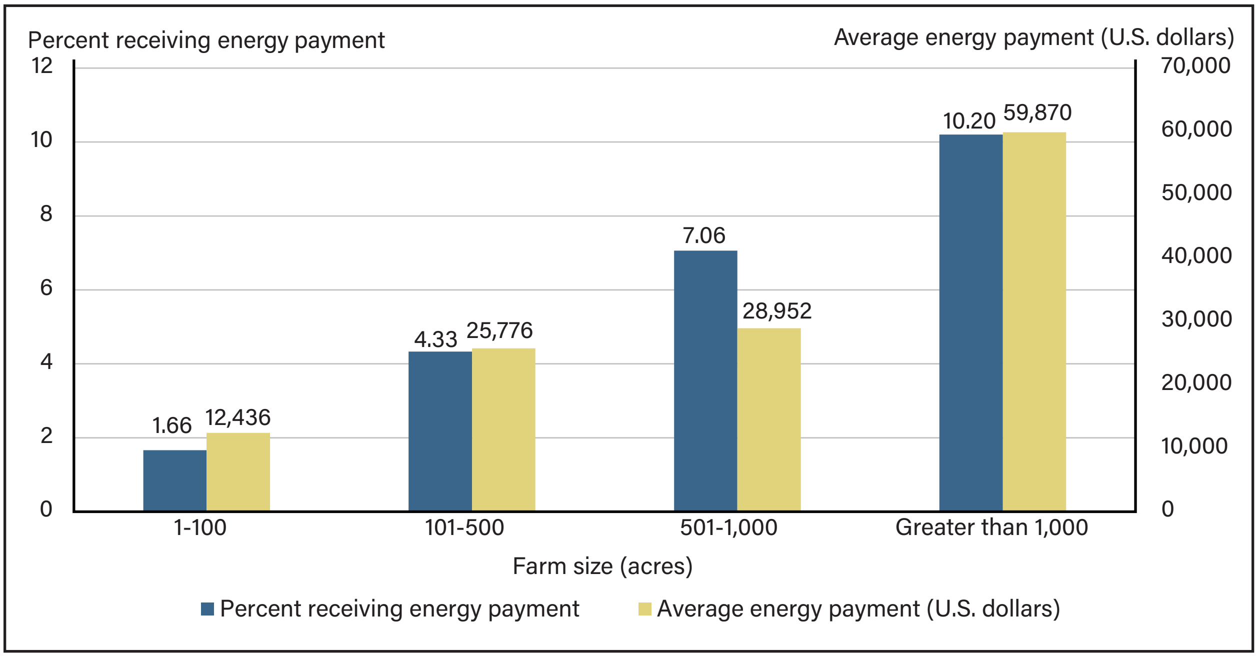
	All counties		Energy counties only	
	(1)	(2)	(3)	(4)
	Marginal effects on: Log (energy payments)			
IHS (owned acres)	0.216***	0.214**	0.206**	0.204**
	(0.0756)	(0.0857)	(0.0800)	(0.0931)
IHS (value of farm assets)	0.0195	0.0288	0.0166	0.0268
	(0.0302)	(0.0311)	(0.0302)	(0.0309)
Specialty crop farm	-0.368	-0.292	-0.522	-0.426
	(0.410)	(0.404)	(0.390)	(0.390)
Livestock farm	0.115	-0.155	0.0971	-0.172
	(0.152)	(0.178)	(0.167)	(0.189)
Midsized family farm	0.679***	0.724***	0.785***	0.849***
	(0.151)	(0.158)	(0.155)	(0.147)
Large family farm	1.067*	1.108**	1.106*	1.142*
	(0.528)	(0.529)	(0.571)	(0.587)
Nonfamily farm	0.790*	0.661	0.658	0.642
	(0.457)	(0.554)	(0.533)	(0.568)
High school diploma or equivalent	-0.0766	0.0369	-0.0772	0.0197
	(0.262)	(0.302)	(0.271)	(0.309)
Some college	-0.165	-0.167	-0.174	-0.186
	(0.237)	(0.263)	(0.245)	(0.264)
College or more	0.206	0.152	0.194	0.121
	(0.243)	(0.258)	(0.257)	(0.271)
Hispanic	0.0513	-0.329	0.0799	-0.305
	(0.351)	(0.307)	(0.361)	(0.317)
Non-White non-Hispanic	-0.640	-0.757	-0.684	-0.805
	(0.568)	(0.592)	(0.566)	(0.590)
Operator retired	0.0879	0.0604	0.104	0.0740
	(0.200)	(0.192)	(0.215)	(0.205)
Oil and gas county	0.731***	0.555*	0.0417	-0.401
	(0.181)	(0.280)	(0.210)	(0.489)
Wind county	0.713**	0.873**		
	(0.261)	(0.399)		
Oil and gas and wind county	1.295***	1.046***	0.620***	0.0972
	(0.206)	(0.258)	(0.220)	(0.490)
Year fixed effects	Yes	Yes	Yes	Yes
State fixed effects	No	Yes	No	Yes
Observations	161,004	161,004	74,757	74,757

* p<0.10 ** p<0.05 *** p<0.01; IHS = inverse hyperbolic sine.

Note: Marginal effects reported are the effect of a one-unit change in the natural logarithm of energy payments from the second stage of a Heckman selection model. Jackknife standard errors in parentheses using procedure outlined from Dubman (2000). All income amounts are in 2020 dollars. Oil and gas counties are those with positive production of oil or natural gas in 2011. Wind counties are those with positive installed wind energy capacity in the sample year. Energy counties are either oil and gas counties or wind counties.

Source: USDA, Economic Research Service using oil and natural gas production data from USDA, ERS (2014), wind energy capacity data from Hoen et al. (2018), and USDA, National Agricultural Statistics Service and USDA, ERS Agricultural Resource Management Survey, 2011–20.

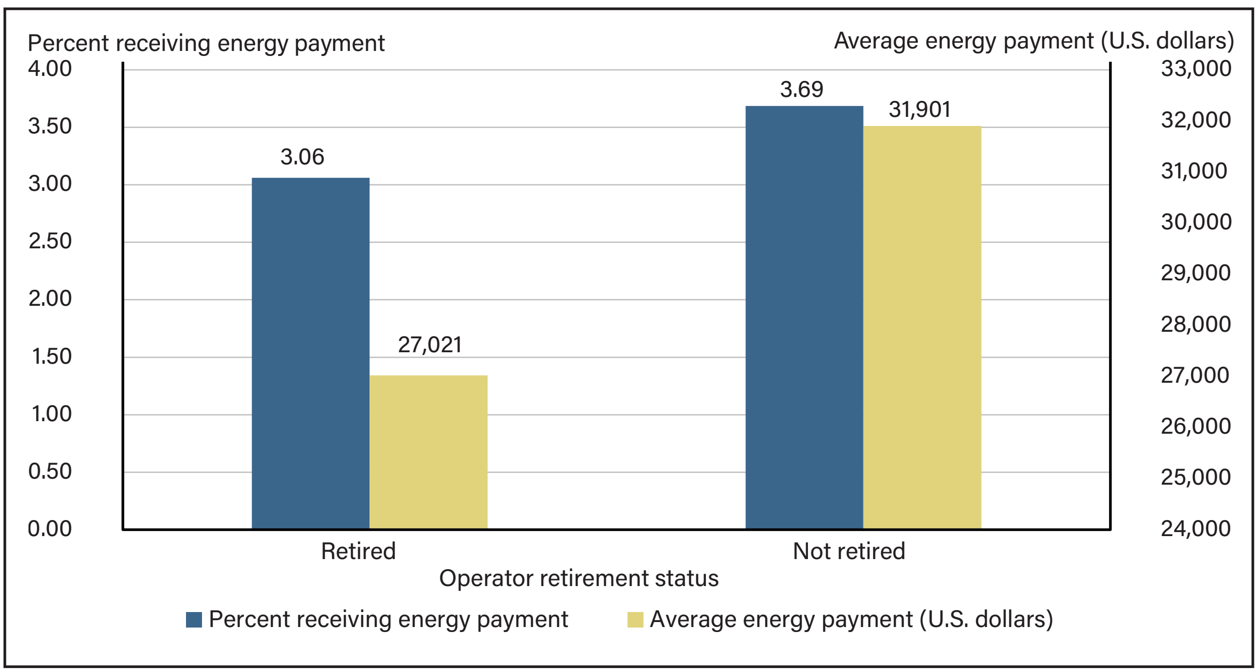
Figure A.1
U.S. energy payments by farm size, 2011–20



Note: All income amounts are in 2020 U.S. dollars using the Consumer Price Index.

Source: USDA, Economic Research Service using data from USDA, National Agricultural Statistics Service and USDA, ERS, Agricultural Resource Management Survey, 2011–20.

Figure A.2
U.S. energy payments by primary farm operator retirement status, 2011–20



Note: All income amounts are in 2020 U.S. dollars, using the Consumer Price Index.

Source: USDA, Economic Research Service using data from USDA, National Agricultural Statistics Service and USDA, ERS, Agricultural Resource Management Survey, 2011–20.