MINNESOTA AGRICULTURAL ENERGY USE AND THE INCIDENCE OF A CARBON TAX

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ABSTRACT

Annual production, transport, and primary processing of the state's agricultural output consumes 241 million gallons of diesel, 24 million gallons of gasoline, 123 million gallons of LP gas, 23 billion cubic feet of natural gas, and 2.27 billion kilowatt-hours of electricity. A $50 per ton carbon tax on agriculture would raise $107 million in revenues from the agricultural sector. Fifty-five percent of the tax revenue would come from on-farm energy use, 7 percent from transportation fuel use, and 38 percent from primary processors. Minnesota agriculture continues to make energy efficiency gains at both the farm and processor level, despite declines in "real" energy prices.

Keywords: energy, carbon tax, agriculture, food processing, farm production.

INTRODUCTION

This report examines energy use in Minnesota's agricultural economy, and estimates the impact of a $50 per ton carbon tax on fuels purchased for private and commercial use. During the 1998 Minnesota Legislative Session a proposal (H.F. 1190) was offered to levy carbon taxes at this rate in exchange for reductions in property taxes. The sponsors seek to reduce energy use, and promote more efficient energy utilization by all residents, and create "in aggregate" a tax shift instead of an exogenous tax levy. During the 1998 Session the progress of this bill was minimal; however, the objectives of this proposal mirror aspects of energy use proposals evident in President Clinton's " B.T.U. Tax" proposal introduced in his first term, and the Kyoto Accord signed in 1997 which would reduce U.S. greenhouse gas emission to levels seven percent below 1990 levels between the years of 2008 and 2012. While it is uncertain if the U.S. Senate will ratify the Kyoto treaty, "climate change" proposals whether international, national, or local in scope will probably keep appearing. The analysis that follows offers an understanding of energy use by a basic, yet diverse, resource-based economic system. The relationships uncovered and the conclusions reached, extend beyond the proposal offered in the Minnesota Legislature in 1998 and offer insights toward analyzing and crafting alternative energy policy.

Nearly all activities supporting farm production, transportation, and commodity processing in the state require energy. This paper was undertaken to do the following: 1) measure energy consumption and fuel use by individual farm-level enterprises; 2) determine farm-level energy use per unit of production and on a statewide basis; 3) measure energy requirements for transportation and first stage processing of Minnesota grown agricultural production; 4) determine the potential for revenue generation by applying a $50 per ton carbon tax on energy use; 5) consider the potential for energy savings in agricultural production and processing.

ESTIMATION METHODS AND ASSUMPTIONS

Carbon Tax Rates Briefly stated, the purpose of a carbon tax is to change the relative cost of various carbon-based fuels, and in the process, reduce or shift consumption toward more sustainable energy sources. This report makes no effort to address the hypothecation, or assignment, of carbon tax revenues. Since a carbon tax would apply more broadly than just agriculture, the ultimate fiscal impact on agriculture will depend on how these tax revenues are spent. Therefore, the carbon tax is only part of the tax shift equation. While all carbon-based energy sources would be subject to the tax, agriculture primarily uses the six shown in table 1. These are expressed in their common units of measure and based on the rate of $50 per ton of carbon. For example, diesel fuel would be taxed at 15.1 cents per gallon.

Table 1. Rates by Energy Type for a $50 Per Ton Carbon Tax

Energy Source:	Units of Measure	Tax Rate
Diesel (Fuel Oil)	Gallon	$ 0.1510
Gasoline	Gallon	$ 0.1320
LP Gas	Gallon	$ 0.0800
Natural Gas	Mcf	$ 0.8100
Electricity	kWh	$ 0.0123
Coal	Ton	$ 25.180

Modeling Farm-Level Energy Use At the farm-level, it was necessary to estimate energy consumption from expenditure data collected in farm management surveys. For each commodity in the analysis that follows, physical input units are estimated by allocating farm expenditures, based on the price of fuels, and the share each energy source represents in the expenditure item. Tax impacts are then calculated by applying the carbon tax rates (Table 1.) to these physical units. Statewide consumption and tax impacts are calculated by applying farm-level fuel consumption patterns to state aggregate production levels. This method required several analytical decisions. The first element of this approach is to choose a representative set of expenditure data. The primary survey used in this analysis is from the Southwestern Minnesota Farm Business

Management Association (MnFMA). Operators in this group are typical of the state's full-time, modern farm enterprises. The incidence of expenditures in these budgets define the technology of production for the various crops to obtain their respective yields.

A second important element is to identify energy-related budget items. Two energy-related budget items are common to all of the MnFMA enterprise budgets. The first is fuel and lube spending, assumed to represent the diesel and gasoline needed to run farm machines and tractors. Consistent with the fuel use ratios reported by USDA for farms nationally, diesel fuel is assumed to represent an 85 percent share of this budget item. The second budget item is for utility spending, which is interpreted as the cost for heating and electricity. The simplifying assumption here, is that LP gas is used for heating, and represents 20 percent of the budget, while electricity expense represents 80 percent of the utility category. One additional item, special to corn production, is the expense for drying grain at harvest. LP gas is assumed to be the sole energy source for this activity.

A third analytical decision is that of choosing a representative data year. Agriculture is notorious for its wide swings in commodity production and prices from year-to-year; however, 1995 is both recent and fairly typical in terms of crop yield. Energy prices were also taken for the same time period. Fuel prices are reported annually by USDA from farm supplier surveys taken in the spring for bulk delivery. (Table 2.) Naturally, energy prices vary widely across both time and place, but this analysis assumes fuel costs remained constant for all operators throughout the year.

Table 2. Farm Energy Prices - Bulk Delivery 1995.

	Diesel	Gasoline	LPG	Electric
Units	*Gallon*	*Gallon*	*Gallon*	*Kilowatt hour*
1995 price	$ 0.77	$ 1.11	$ 0.73	$ 0.05

Modeling Transportation Energy Use After crops or livestock are produced, farm budgets typically reflect transportation costs of grain to country elevators, local hog-buying stations, or remote sugarbeet dumps. Farmers pay for fuel used in their vehicles for this first trip from farm to market. For other types of production, farmers pay custom haulers with specialized vehicles to transport production from their farms to processors. Examples in this category are milk, peas, sweet corn, cattle, and turkeys.

Once produced, a commodity can take one of several paths to market. Corn represents the most elaborate example. Depending upon its ultimate destination, it may be: 1) consumed by livestock on the farm where produced, 2) delivered to a country elevator, or 3) shipped to another Minnesota farm for consumption by livestock, shipped to a corn processing plant in Minnesota, loaded on a unit train, loaded on a river barge, or loaded on an ocean-going freighter. Each year the proportions of the annual crop and carryover stocks from storage seek these alternate paths with market prices dictating the direction.

To capture the in-state transportation component of energy usage for Minnesota agriculture, it was necessary to consider the proportions of Minnesota production traveling each path and the number of miles traveled utilizing alternate modes of transport. For example, how many truck-miles are required going from farms or country elevators until loaded on a unit train headed for the West Coast? Then, how many train-miles can be assumed on average until the unit train leaves Minnesota? The number of truck-miles before loading a barge headed down the Mississippi River and the barge-miles following must also be estimated. Assumptions on proportions of crop, taking alternative modes were incorporated into an assessment of the diesel fuel requirements per Ton-Mile. The assumptions for gallons of diesel per Ton-Mile for alternative modes of transport are:

fully loaded semi-trailer	75.6 Ton-Miles per gallon
rail unit train	260 Ton-Miles per gallon
river barge	680 Ton-Miles per gallon

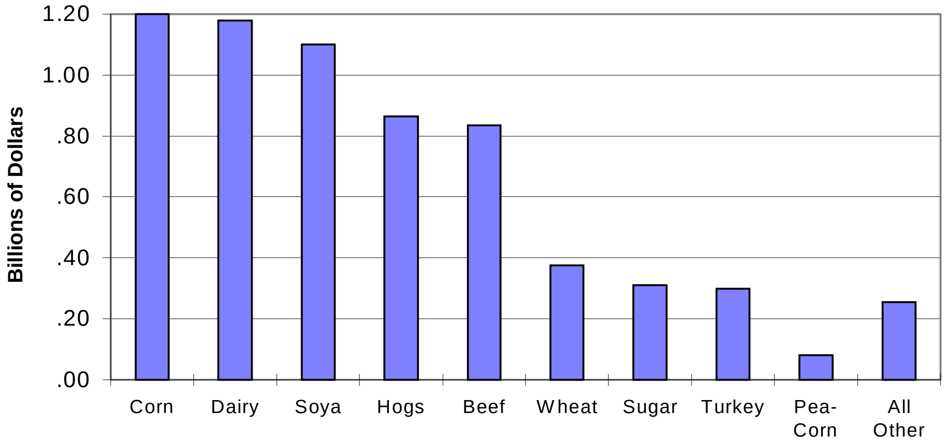
For commodities that "bulk-out" before they weigh-out on the roads, truck capacities were lowered. For example, green peas would be crushed if loaded in a truck deep enough to achieve full loading by weight. The same situation would generally be true for feeder pigs. It is also assumed that pick-up of milk from farms occurs with trucks capable of carrying 20,000 pounds that are only half full on average.

<u>Modeling Processor Energy Use</u> Processing plant engineers and technologists were very helpful in offering their production data relating physical units processed and the amounts of various fuels applied to each. In some cases, plant engineers stated energy requirements in terms of the physical units that were leaving their plants. In order to more clearly identify the incidence of carbon taxes on Minnesota agriculture, it was necessary look at input-output relationships and then recalculate energy requirements in terms of physical energy units. In the instance of canned and frozen vegetables, data was offered in megajoules of energy required per case of final product (18 pounds). These were then allocated in the proportion of megajoules from electricity and from natural gas before determining the kilowatt hours and cubic feet of natural gas necessary to process a raw ton of peas or sweet corn.

MINNESOTA'S AGRICULTURAL SECTOR

Before examining each commodity individually, it is useful to consider the relative importance of these commodities to Minnesota farm production. Figure 2. Represents Minnesota's farm marketing receipts for 1995 of $7 billion and provided guidance on the crop and livestock enterprises to be analyzed. Eighty–eight percent of the receipts were contributed by production of the nine commodities listed. The remaining 12 percent are contained in the "All Other" category, including production of flax, sunflowers, potatoes, sheep, broilers, and eggs.

Figure 2. Minnesota Farm Marketing Reciepts 1995



RESULTS

Farm-Level Table 25 shows that corn at 9.37 gallons of diesel consumed per acre is dwarfed by the 28.92 gallons of diesel used per acre of sugarbeets. The electricity figure of 4.0 kWh/ cwt. of milk translates into 600 kWh for a cow producing 15,000 pound of milk a year. This requirement is twice the electricity required by a sow and each of her "typical" two litters of pigs per year. The shaded area shows the percent energy costs represent of total production value or gross return. Averaging across all commodities, energy accounts for 3.7 percent of total production value. Swine farrowing operations are highest at 5.5 percent, while beef cattle are lowest at 2.6 percent.

Table 25. Summary of On-Farm Energy Use

	Diesel gallons	Gasoline gallons	LP gas gallons	Electric kWh		*Energy Expense / Production Value*
Corn	9.37	1.15	9.58	35.63	acre	***5.3%***
Soybean	7.43	0.91	0.75	27.50	acre	***3.5%***
Spring Wheat	7.24	0.89	0.82	29.88	acre	***5.1%***
Dairy	0.13	0.02	0.11	4.00	cwt	***5.4%***
Swine Farrow	9.05	1.11	4.06	148.25	litter	***5.5%***
Swine Finish	0.91	0.11	0.34	12.38	head	***2.8%***
Beef Calf	6.07	0.74	1.62	59.25	head	***3.3%***
Beef Cattle	3.78	0.46	1.08	39.38	head	***2.6%***
Turkeys	0.09	0.01	0.50	1.24	head	***---***
Sugarbeet	28.92	3.54	2.76	100.75	acre	***4.6%***
Canning Peas	5.19	0.64	0.35	12.75	acre	***3.8%***
Sweet Corn	7.99	0.98	0.49	18.00	acre	***4.0%***
All Other	7.18	0.88	1.87	40.75	----	***3.7%***

Table 26 converts per acre requirements to 1995 statewide totals of the individual fuels required for each commodity. From the table one can see that corn requires 36.3 percent of all the diesel used at the farm-level. Drying requirements makecorn the biggest user of LP gas at 58.3 percent, followed by turkey production with another 18.2 percent. Dairy enterprises are the top farm-level electricity users at 30.8 percent, with corn next at 19.5 percent of total farm-level use.

Table 27 combines the tax rates for the respective fuels and the usage totals derived for farm-level production of the twelve crop and livestock enterprises to determine $59.1 million of tax revenue would be raised by a $50 per ton carbon tax shift. Of this statewide total, 31.4 percent is attributable to corn production. Corn is followed by soybeans at 16.3 percent and dairy at 12.8 percent. It is noteworthy that, in terms of carbon tax, a 15,000 pound per year dairy cow would be responsible for $12.00 per year in carbon taxes, while a typical sow producing two litters per year would be responsible for $7.32 in carbon taxes per year. In terms of carbon tax, a beef steer raised from 500 pounds to 1200 pounds is taxed the same amount as a turkey raised from hatchling to 24 pound bird.

When examining the transportation fuel requirements of the major Minnesota crops in Table 28 , one notes the similar magnitudes of the diesel fuel used to move the state's corn crop and the state's milk supply within the state. Corn requires 10.853 million gallons versus 9.41 million gallons calculated for milk, representing 23.8 percent and 20.6 percent of the state's (agriculturally-related) transportation diesel, respectively. Dairy usage is high due to the many trips at less than full capacity assumed to be made by bulk trucks. Soybeans are the third highest user of diesel used in transportation at 13.3 percent of the total, with sugarbeets and spring wheat each using 10.7 percent.

The total carbon tax impact on all processors is $40.96 million, with 27 percent arising from the coal used by sugarbeet processors. Sugarbeet processors would pay 19.2 percent of the total tax based on natural gas use. On a similar scale soybean processing would pay 21.2 percent. Statewide energy consumption figures are contained in Table 29 while Table 30 shows the carbon tax amounts attributable to each commodity processor and each of their fuels. Sugarbeet processors' total carbon tax transfer would be $15.5 million or 37.9 percent of the total, caused by the usage of coal in sugar refining. Dairy processors have the second highest transfer $7.9 million or 19.3 percent of the total carbon tax bill of processors. Soybean processors would pay $6.4 million or 15.6 percent of the processor total.

Table 26. Summary of Statewide On-Farm Energy Use

Farm-level	Diesel (million gallons)	Gasoline (million gallons)	LP gas (million gallons)	Electric (million kWh)	based on:	
Corn	62.79	7.69	64.18	238.69	731,850,000	bushel
Soybean	43.83	5.37	4.45	162.25	234,900,000	bushel
Spring Wheat	16.29	1.99	1.84	67.22	70,400,000	bushel
Dairy	12.47	1.53	10.31	376.40	94,100,000	cwt
Swine Farrow	9.05	1.11	4.06	148.25	1,000,000	litter
Swine Finish	6.41	0.78	2.40	87.62	7,080,000	head
Beef Calf	2.55	0.31	0.68	24.89	420,000	head
Beef Cattle	2.00	0.24	0.57	20.87	530,000	head
Turkeys	3.69	0.45	20.05	50.14	40,500,000	head
Sugarbeet	12.35	1.51	1.18	43.02	7,434,000	ton
Canning Peas	0.48	0.06	0.03	1.19	107,600	ton
Sweet Corn	1.07	0.13	0.07	2.41	671,630	ton
All Other	20.76	2.54	13.18	146.75	----	
Total Energy	194	24	123	1,370		

Table 27. Summary of On-Farm Carbon Tax Incidence

	Farm Level (dollars)		Statewide (million dollars)	--based on:	
Corn	$ 2.77	*per acre*	$ 18.57	*6.70*	*million acres*
Soybean	$ 1.64	*per acre*	$ 9.68	*5.90*	*million acres*
Spring Wheat	$ 1.64	*per acre*	$ 3.70	*2.25*	*million acres*
Dairy	$ 0.08	*per cwt*	$ 7.54	*94.10*	*million cwt*
Swine Farrow	$ 3.66	*per litter*	$ 3.66	*1.00*	*million litter*
Swine Finish	$ 0.33	*per head*	$ 2.34	*7.08*	*million head*
Beef Calf	$ 1.87	*per head*	$ 0.79	*0.42*	*million head*
Beef Cattle	$ 1.20	*per head*	$ 0.64	*0.53*	*million head*
Turkeys	$ 1.20	*per head*	$ 2.84	*40.50*	*million head*
Sugarbeet	$ 6.29	*per acre*	$ 2.69	*0.43*	*million acres*
Canning Peas	$ 1.05	*per acre*	$ 0.10	*0.09*	*million acres*
Sweet Corn	$ 1.60	*per acre*	$ 0.21	*0.13*	*million acres*
All Other	---		$ 6.33	---------	
			$ 59.1	Total Carbon Tax Impact	

Table 28. Transportation Summary

Commodity	*Gallons*	*Dollars*
Corn	10,853,809	$ 1,638,925
Soybean	6,087,116	$ 919,155
Spring Wheat	4,885,121	$ 737,653
Dairy	9,410,000	$ 1,420,910
Swine Farrow	500,000	$ 75,500
Swine Finish	1,416,000	$ 213,816
Beef Calf	124,320	$ 18,772
Beef Cattle	530,000	$ 80,030
Turkeys	467,107	$ 70,533
Sugarbeet	4,906,440	$ 740,872
Canning Peas	381,980	$ 57,679
Sweet Corn	1,188,785	$ 179,507
All Other	4,890,081	$ 738,402
All Commodities	45,640,759	$ 6,891,755

Table 29. Summary of Processor Energy Use

	Diesel (gallons)	**Coal** (tons)	**NG** (Mcf)	**Electric** (kWh)
All Processors				
Corn	-	-	1,878,610	47,542,000
Soybean	-	-	4,899,750	195,872,500
Spring Wheat	-	-	-	125,242,607
Dairy	-	-	7,316,948	161,789,306
Swine Farrow	-	-	-	-
Swine Finish	-	-	740,000	74,834,000
Beef Calf	-	-	-	-
Beef Cattle	-	-	543,900	55,002,990
Turkeys	-	-	359,681	36,369,365
Sugarbeet	-	440,366	4,431,850	68,361,201
Canning Peas	447,660	-	131,452	13,774,154
Sweet Corn	315,444	-	258,542	27,091,223
All Other			2,467,288	96,705,521
Total Energy Use	763,104	440,366	23,028,021	902,584,866

Table 30. Summary of Processor Carbon Tax

All Processors	Diesel	Coal	NG	Electric
Corn	$ -	$ -	$ 1,521,674	$ 584,767
Soybean	$ -	$ -	$ 3,968,798	$ 2,409,232
Spring Wheat	$ -	$ -	$ -	$ 1,540,484
Dairy	$ -	$ -	$ 5,926,728	$ 1,990,008
Swine Farrow	$ -	$ -	$ -	$ -
Swine Finish	$ -	$ -	$ 599,400	$ 920,458
Beef Calf	$ -	$ -	$ -	$ -
Beef Cattle	$ -	$ -	$ 440,559	$ 676,537
Turkeys	$ -	$ -	$ 291,341	$ 447,343
Sugarbeet	$ -	$ 11,088,427	$ 3,589,799	$ 840,843
Canning Peas	$ 67,597	$ -	$ 106,476	$ 169,422
Sweet Corn	$ 47,632	$ -	$ 209,419	$ 333,222
All Other			$ 1,998,503	$ 1,189,478
SubTotal Taxes	$ 115,229	$ 11,088,427	$ 18,652,697	$ 11,101,794

$ 40,958,147 Total Processor Carbon Tax

CARBON TAX COMBINED ASSESSMENT

Table 31 contains the combined carbon tax revenue collections by crop or species including farm-level, transportation, and processor level in Minnesota. For this aggregation of carbon taxes, corn generates $22.31 million or 20.8 percent of the state total. The collections for corn originate primarily at the farm-level with only 11-12 percent processed in the state. Sugarbeets with associated processing, is second in total carbon tax revenue generation at 17.7 percent of the statewide agricultural total. This is due to heavy energy expenditures and processing as well as the reliance on coal as a fuel. The third highest crop with associated processing is soybeans with 17.0 percent of the state total. Dairy represents 16.9 percent of Minnesota's gross agriculture receipts, and would be less affected by carbon taxes with only 15.8 percent of the state carbon tax bill.

Table 31. Summary of Carbon Tax by Sector and Commodity
(Millions Dollars)

	Farm	Transport	Processor	Total Tax
Corn	$ 18.57	$ 1.64	$ 2.11	$ 22.31
Soybean	$ 9.68	$ 0.92	$ 6.38	$ 16.98
Spring Wheat	$ 3.70	$ 0.74	$ 1.54	$ 5.98
Dairy	$ 7.54	$ 1.42	$ 7.92	$ 16.88
Swine	$ 6.00	$ 0.29	$ 1.52	$ 7.81
Beef	$ 1.42	$ 0.10	$ 1.12	$ 2.64
Turkeys	$ 2.84	$ 0.07	$ 0.74	$ 3.65
Sugarbeet	$ 2.69	$ 0.74	$ 15.52	$ 18.95
Processed Corn/Peas	$ 0.31	$ 0.24	$ 0.34	$ 0.89
All Other Output	$ 6.33	$ 0.74	$ 3.19	$ 10.26
All Commodities	$ 59.07	$ 6.89	$ 40.96	**$ 106.92**

DISCUSSION

Is $106.92 Million a big number? In terms of Minnesota state tax revenues, which totaled $9,990.00 Million in FY1996, this amount would be minor. State collections on Highway Fuels taxes alone totaled $517.00 Million in FY1996. Despite this disparity in scale, this additional tax would be felt by farmers, particularly those producing corn, sugarbeets, milk, and feeder pigs. At the processor level sugarbeets, soybeans, wheat milling, and dairy processing appear the most vulnerable. As a general rule, when livestock do the processing there is less exposure to carbon tax versus modern, industrial processes. In this regard, some of the value-added processors, which heavily process raw, bulk commodities will likely be harmed.

There are certainly responses that will be taken by managers at each stage of the agricultural production-transportation-processing continuum in anticipation and at the onset of a proposal such as the $50 carbon tax. At the farm level one could expect further efforts to reduce tillage operations in crop production. Evidence compiled over the last 15 years have demonstrated that no-till can cut fuel use per acre by 50 percent over convention tillage methods. Computerized moisture and temperature sensors can make grain drying much more efficient than current practices. On dairy farms one might look for spurred interest in use of variable load vacuum pumps, and greater use of milk pan coolers, both with demonstrated high energy efficiency. Improved construction techniques will be sought for livestock enterprises like swine farrowing, and turkeys.

With respect to transportation, one should anticipate introduction of more efficient diesel engines. Greater utilization of barges and railroads would result in fuel savings for bulk, low-value commodities like the grains.

Agricultural processors handling wheat and soybeans are already conducting some of their operations at times to utilize off-peak electrical rates. Wheat millers are already making orderly replacements of older, less efficient electrical motors. Soybean crushers and sugarbeet processors are investigating co-generation of electricity in their facilities when opportunities to sell power back into the power grid are available. Sugarbeet processors might be highly motivated to reduce coal usage, due to the heavy carbon tax levied on that fuel. Probably most processors will be attracted to the lower carbon taxes to be levied against natural gas, due to its relatively lower emissions. Perhaps there will also be greater interest in use of biomass fuels at farm level and by first stage processors because biomass fuels would not be taxed under such a proposal.

REFERENCES

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