PRESERVING THE IOWA CORN CROP: ENERGY USE AND CO_2 RELEASE

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ABSTRACT. *A study was undertaken to estimate energy use and CO_2 release due to postharvest preservation of the 38.8 × 10^6-Mg (1.52 × 10^9-bu) Iowa corn crop. About 87% of the crop is artificially dried. Other preservation methods include cribbing ear corn (7%), oxygen-limiting storage (5%) and chemical preservative treatment (1%). Preservation of the corn crop requires, in total, 18 200 TJ of energy and releases 1614 Gg of CO_2. Combustion of fuel (liquefied petroleum or natural gas) and electricity accounted for 77 and 10% of total energy use, respectively. CO_2 from combustion of fuel and generation of electricity accounted for 57 and 32% of the CO_2 release, respectively. Preservation methods varied in total energy use and CO_2 release from farm natural-air drying at 1020 MJ/Mg corn and 262 kg CO_2/Mg corn to chemical preservative treatment at 116 MJ/Mg corn and 9.3 kg CO_2/Mg corn.*

Keywords. *Corn drying, Energy use, Preservation, Carbon dioxide.*

Corn (*Zea Mays* L.) is Iowa's largest crop, and Iowa's annual corn production, averaging 38.8 × 10^6 Mg (1.52 × 10^9 bu) during 1992 through 1995, ranks first among states and accounts for about 8% of the world's production.

As corn kernels develop, kernel dry matter increases and moisture percentage decreases. At some moisture level between 35 and 25%*, kernels reach physiological maturity, the time when maximum dry matter weight has been attained. Kernel moisture continues to decrease in the field until harvest, most of which takes place at moistures between 25 and 17%. Following harvest, conditions favor rapid growth of storage fungi that can damage or destroy the kernels. Therefore, some preservation process must be initiated quickly.

Prior to World War II, most Iowa corn was harvested on the ear and preserved by storage in cribs designed to allow natural air to circulate freely and dry kernels on the ear. This drying took place soon enough so unacceptable damage by storage fungi was avoided.

During the 1940s, corn producers began shifting to harvesting systems that shell corn at harvest. These new systems allowed earlier harvest at higher moisture levels, reduced field losses, were more convenient, required less labor and storage volume, and were usually lower in dollar cost than the ear corn systems they replaced. This shifting has continued and only about 7% of Iowa's corn crop is preserved on the ear now (Iowa Agricultural Statistics, 1989).

Corn shelled at harvest (the other 93% of the crop) must be preserved by some other means. Methods in use include forced-air drying (the most common), oxygen-limiting storage and subsequent fermentation, and preservative treatment. Forced air drying is an energy-intensive process and commonly uses over one-third of the direct energy (fuel, chemicals, fertilizer, electricity) required for corn production (Hansen et al., 1996). This energy is of particular importance in Iowa because 97% of the state's $5 billion per year energy usage is imported into the state (Beeman, 1994). This energy use also results in release of carbon dioxide into the atmosphere, due to combustion of hydrocarbons. Carbon dioxide, along with water vapor, methane, nitrous oxide, chlorofluorocarbons, and other greenhouse gases are of increasing concern because they absorb part of the infrared radiation emitted from the Earth's surface. An increase in greenhouse gas concentration means that the Earth's surface temperature must increase in order to bring the radiative energy emission to a level adequate to achieve radiative energy balance.

How do the major corn preservation methods being used in Iowa compare, in terms of energy use and carbon dioxide release? What is the energy use and carbon dioxide release associated with preserving the Iowa corn crop using current practices? How much do these values change if corn is harvested or stored at higher or lower moisture levels? The objective of this study was to answer these questions.

PROCEDURE

Estimates were made of the total mass of the Iowa corn crop and of the fraction preserved by each of the methods in wide use. Energy use and carbon dioxide release rates for these methods were estimated. Both energy used during preservation (direct energy) and energy expended for producing electricity, fuel, equipment, and preservatives (indirect energy) were considered. Total energy is the sum of direct energy and indirect energy. A computer

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* All moistures are % wet basis.

spreadsheet was set up to perform calculations for selected preservation scenarios.

IOWA CORN CROP

This study assumes Iowa corn production equal to the average production for 1992 through 1995. This value is 38.7×10^6 Mg (1.52×10^9 bu)* of corn (Iowa Agricultural Statistics, 1995, 1994a,b).

PRESERVATION METHODS

Preservation was assumed to take place in the time period beginning when the corn preservation process starts and ending when the corn is placed in storage in a preserved state. Energy associated with storage is included only if the preservation operation is carried out during storage. Eight principal corn preservation methods were identified (table 1). They will be discussed in turn, and energy requirement assumptions will be stated for each.

OXYGEN-LIMITING STORAGE

When high-moisture shelled corn is sealed in an airtight (or nearly airtight) structure, oxygen is quickly depleted by aerobic organisms, and anaerobic bacteria become active converting sugars to fatty acids. After about 20 days, pH of the mass has decreased to about 3.9 and bacterial activity stops. This ensiled corn remains stable if oxygen is not admitted. It is usually fed to livestock directly out of the silo. Estimates of the fraction of the crop preserved by oxygen-limiting storage range from 6.5% (Iowa Crop and Livestock Reporting Service, 1982) to 4.8% (Iowa Agricultural Statistics, 1989). For this study 5% of the Iowa corn crop was assumed to be preserved this way (table 1). This figure does not include whole-plant corn chopped for silage.

Energy for manufacturing preservation equipment was estimated from the mass of a common glass-lined steel silo. The Harvestore silo, 6.1 m (20 ft) in diameter by 23.5 m (77 ft) high, and associated equipment has a mass of 15 Mg (Landphair, 1996). Concrete for the foundation is estimated at 12 m^3. Pimentel (1992) lists manufacturing energies of 46.8 MJ/kg for steel and 109 MJ/kg for agricultural machinery. Stout (1984) lists the energy resource depletion of 3 GJ/m^3 for concrete. A value of 80 MJ/kg was assumed for this silo. Assuming the silo is filled once per year (631 m^3) with 26% moisture shelled corn and has a 40-year life, an energy rate of 61.9 MJ/Mg corn was used. CO_2 production rate was assumed to be 0.08 kg/MJ, a value that assumes manufacturing energy is derived from coal. For the energy rate assumed, 4.95 kg CO_2/Mg of corn is produced.

A 5% loss of dry matter is typical for a sealed silo (Midwest Plan Service, 1983). A 4% dry matter loss was charged to preservation and modeled as oxidation of glucose. This results in an energy use of 472 MJ/Mg corn and releases 40 kg CO_2/Mg of corn.

CRIB

With the crib system of preservation, corn ears are removed from the stalk by a picker when kernel moisture is about 20 to 22%. Ears, with husks removed, are placed in a crib that allows free circulation of atmospheric air for drying the kernels to a moisture level low enough so that damage by storage fungi is not a problem. The ears can be shelled as they are removed from storage. Estimates of the fraction of the crop cribbed include 3.9% for Ohio (Hansen et al., 1996) and 7.6% for Iowa (Iowa Agricultural Statistics, 1989). A value of 7% was assumed.

Energy for manufacturing the crib was estimated from the weight of a common steel mesh corn crib 5.9 m (18 ft) in diameter by 3.3 m (10 ft) high. With this weight of 750 kg, and assuming a manufacturing energy of 75 MJ/kg for the crib, a capacity of 15.3 Mg, harvest moisture percentage of 21%, and a life of 40 years, an energy rate of 151 MJ/Mg of corn was calculated. CO_2 from manufacturing was estimated assuming manufacturing energy came from combustion of coal (0.08 kg coal/MJ). Then, CO_2 is 12.1 kg/Mg of corn.

ARTIFICIAL DRYING

There are more than 15 distinct artificial drying methods used to dry corn in Iowa. For this study, they were grouped into five categories, selected because reasonable data on the extent of their use and energy requirements are available in the literature. The five consisted of off-farm drying plus four on-farm methods (table 1). All corn was assumed to be dried to 15% moisture. This estimate is made assuming some corn is dried to moistures below 15% and some corn is stored in bins without drying at moistures above 15%. The common recommended maximum moisture level for corn in storage is 15.5% for up to six months storage and 14% for 6 to 12 months storage (MWPS, 1987).

Table 1. Total energy use rate and CO_2 release rate for Iowa corn preservation methods

		Artificial Drying							
		Manufacturing		Fuel		Electricity		Other	
Preservation Method	Portion of Crop (%)	Energy (MJ/Mg corn)	CO_2 (kg/Mg corn)	Energy (MJ/kg H_2O)	CO_2 (kg/kg H_2O)	Energy (MJ/kg H_2O)	CO_2 (kg/kg H_2O)	Energy (MJ/Mg corn)	CO_2 (kg/Mg corn)
O_2-limiting	5	61.9	4.95	0	0	0	0	472	40
Crib	7	151	12.1	0	0	0	0	0	0
Off-farm dry	26	7.5	0.597	6.72	0.44	0.42	0.11	0	0
Farm nat air dry	2	59.9	4.79	0	0	13.7	3.67	0	0
Farm HTDC dry	18	9.0	0.72	6.72	0.44	0.42	0.11	0	0
Farm comb dry	4	68.9	5.51	2.71	0.18	2.77	0.74	0	0
Farm other dry	37	37.0	2.96	5.66	0.37	0.36	0.10	0	0
Preservative	1	0.87	0.070	0	0	0	0	115	9.23
Total	100								

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* 1 Mg corn = 1000 kg at 15.5% moisture; 1 bu corn = 56 lb at 15.5% moisture.

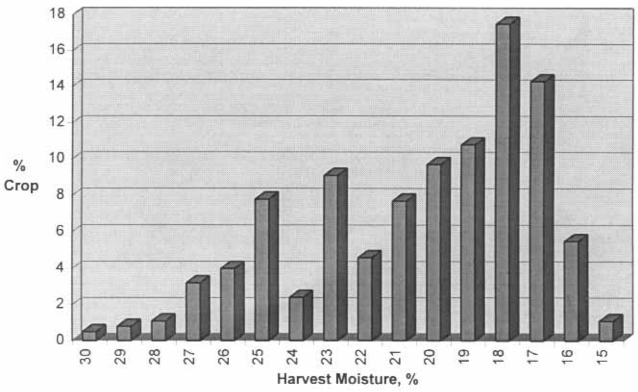

Figure 1–Estimated harvest moisture content of Iowa corn crop, 1992 through 1995 (Wolf, 1996).

HARVEST MOISTURE CONTENT

Because energy use of corn preservation done by artificial drying is dependent on harvest moisture content, an estimate was made of the fraction of the crop harvested at each of 16 moisture levels between 30 and 15% (fig. 1). This figure is an average of data on loads received during harvest at country elevators near Boone in Central Iowa and near Worthington in Northeast Iowa for the harvests of 1992 through 1995 (Wolf, 1996). The weighted average harvest moisture content was 20.5%.

OFF-FARM DRYING

Twenty-six percent of the corn crop was assumed to be dried off farm (table 1). This estimate was made considering estimates of 20.4% for Ohio (Hansen et al., 1996), and 24.2 (Iowa Agricultural Statistics, 1989) and 29.2% for Iowa (Iowa Agricultural Statistics, 1990).

Off-farm drying was assumed to be done at a country elevator or processing plant with a high-temperature cross-flow dryer, with in-dryer cooling. Manufacturing energy was calculated assuming the dryer to be a popular 38 Mg/h (1500 bu/h) cross-flow model, rated for drying corn from 25 to 15% moisture. This dryer has a mass of 23.4 Mg. Assuming a life of 15 years and a yearly throughput of 23,000 Mg of corn, manufacturing energy was calculated at 7.46 MJ/Mg corn with resulting CO_2 at 0.597 kg/Mg corn. This assumes an energy requirement of 109 MJ/kg for farm machinery (Pimentel, 1992) and combustion of coal.

Energy for fuel burned was assumed to be 6.72 MJ/kg of evaporated water and 0.42 MJ/kg of evaporated water for electricity (Hellevang and Morey, 1985). The figures include sequestered energy ratios of 1.179 for liquefied petroleum gas and 3.802 for electricity to account for energy required to produce the usable fuel and electricity (Fluck, 1992). All fuel and electricity values will include these ratios. CO_2 emissions are 0.44 kg/kg evaporated water (calculated from combustion of propane) and 0.11 kg/kg of evaporated water for electrical energy, assuming 964 Mg/GWh for coal-fired electric generating plants (Pilat, 1995). This value was used for all electrical energy.

ON-FARM DRYING

Corn dried on the farm has been estimated at 61.5% of the crop (Iowa Agricultural Statistics, 1989). A value of 61% was assumed here. On-farm drying was divided into four methods: natural air drying (2% of crop), high temperature in-dryer cooling (18% of crop), combination drying (4% of crop), and other (37% of crop). These four methods were chosen because information was found on the extent of their use in the Corn Belt (Hansen et at., 1996) and because their energy requirements are distinguishable (Hellevang and Morey, 1985).

FARM NATURAL AIR DRYING

Natural air drying is done by placing corn in a bin and aerating it until it is dried with an electric motor-driven fan. Hansen et al. (1996) estimated 1.8% of the Ohio corn crop is dried this way. A value of 2% is assumed here. Manufacturing energy was estimated assuming a steel bin with a capacity of 305 Mg corn, filled once per year and having a 20-year life. With a bin mass of 5.3 Mg and assuming manufacturing energy of 46.8 MJ/kg for the mostly steel bin plus 3 GJ/m^3 for 39 m^3 of concrete (Stout 1984), and combustion of coal for the energy, manufacturing energy and CO_2 were calculated at 59.9 MJ/Mg corn and 4.79 kg/Mg corn, respectively. Preservation energy is all electrical and was estimated to be 13.7 MJ/kg water evaporated assuming a 4.6-m corn depth (Wilcke and Bern, 1985) and including a sequestered energy ratio of 3.802, with CO_2 calculated as before.

FARM HIGH-TEMPERATURE, DRYER-COOL DRYING

Farm high-temperature, dryer cool drying consists of using a column continuous flow, a column batch, a batch-in-bin, or a similar dryer, and cooling the corn in the dryer at the completion of drying. The fraction of the crop dried this way has been estimated at 17.7% for Ohio (Hansen et al., 1996). A value of 18% was assumed. Manufacturing energy was estimated considering a 10-point moisture removal in a 13 Mg/h (500 bu/h) continuous cross flow dryer with a mass of 4.7 Mg, a life of 15 years, and a yearly throughput of 3900 Mg of corn. Using 109 MJ/kg of agricultural machinery mass (Pimentel, 1992), this results in an energy use value of 9.0 MJ/Mg of corn and a CO_2 emission of 0.72 kg/Mg of corn. Direct energy use for drying was assumed to be the same as for off-farm drying.

FARM COMBINATION DRYING

Farm combination drying systems use both a high-temperature dryer and a natural-air dryer. Initial drying is done in the high-temperature dryer. When a moisture level of 20 to 22% is reached, corn is unloaded hot into a natural-air drying bin for completion of drying. This procedure saves considerable energy, compared with either natural air or heated air drying (Hellevang and Morey, 1985).

The manufacturing energy estimate is the total of the value assumed for the natural air dryer and the value assumed for the farm high-temperature dryer-cool system, because both are required for combination drying. This total is 68.9 MJ/Mg corn. Manufacturing CO_2 is calculated as before.

Preservation energy is assumed to be 2.71 MJ/kg of water for propane and 2.77 MJ/kg of water for electricity. These values use energy requirements from Hellevang and Morey (1985), with sequestered energy ratios applied as before. Resulting CO_2 emissions are calculated as before.

OTHER ON-FARM DRYING

Other types of on-farm drying are grouped into the "farm other" category. These include in-bin heated-air layer drying, in-bin counterflow drying, column batch and column continuous drying with dryeration or bin cooling, batch-in-bin drying without cooling, and heated-air stir drying. Manufacturing energy (37.0 MJ/Mg) of corn is assumed to be the average of the other three farm drying methods, because equipment is similar for each. CO_2 emission (2.96 kg/Mg corn) is calculated in a similar way.

Preservation energy is figured as the average for heated-air batch-in-bin drying, stir drying, counterflow drying, and layer drying (Hellevang and Morey, 1985). With sequestered energy values added, these come to 5.66 MJ/kg of water in fuel energy and 0.36 MJ/kg of water in electrical energy. CO_2 emission rates are 0.37 and 0.10 kg/kg H_2O for fuel and electricity, respectively.

PRESERVATIVE TREATMENT

High moisture corn can be preserved by treating it with a preservative chemical. Corn preservatives used include organic acids (acetic, propionic, isobutyric, sorbic, and formic, along with mixtures), potassium sorbate, and iprodione (Aljinovic et al., 1995). Buffered propionic acid is the most widely used. In consultation with an industry expert, 1% of the Iowa corn crop was estimated as the crop fraction preserved with chemical preservatives (Schlatter, 1996). Corn treated with preservative is likely to be used for feed on the farm where it is grown.

Manufacturing energy was calculated for a propionic acid application machine. Assuming this machine treats 1000 Mg of wet corn at 25% moisture per year, has a 10-year life, and a mass of 90 kg, and using an energy value of 109 MJ/kg equipment for machinery and maintenance (Pimentel, 1992), an energy value of 0.87 MJ/Mg corn and a CO_2 release of 0.070 kg/Mg of corn were assigned.

A typical propionic acid application rate is 10 kg/Mg of wet corn for 25% moisture corn to be preserved for one year. The manufacturing energy is estimated at 13 000 kJ/kg of propionic acid (Schwaar, 1996). Thus the energy requirement is 115 MJ/Mg of corn. Assuming this energy is derived from burning coal, the CO_2 release is 9.23 kg CO_2/Mg corn.

RESULTS AND DISCUSSION

PRESERVATION ENERGY AND CO_2

Energy use and CO_2 release were calculated using the rates listed in table 1 and assuming the harvest moistures of figure 1 for artificial drying. Assuming preservation was carried out according to the methods and fractions of table 1 and that the artificial drying operations dried the corn to 15% moisture, a total of 2360 Gg of water needed to be evaporated. Table 2 shows the estimated total energy use (18 200 TJ) and CO_2 release (1614 Gg) for preserving the Iowa corn crop. Total energy and total CO_2 is the sum of energy and CO_2 for manufacturing the preservation equipment plus what is used for supplying any fuel or electricity to the site plus fuel and electricity used directly plus any fermentation loss or preservative used. The average total energy use is 470 MJ/Mg corn and the CO_2 mass released amounts to 41.7 kg/Mg corn preserved.

From table 2, note that farm natural air drying is highest in total energy use and CO_2 release at 1020 MJ/Mg corn and 262 kg CO_2/Mg corn, respectively. This occurs because of its extensive use of coal-derived electric energy with its sequestered energy ratio of 3.802. Energies for the other artificial drying methods and oxygen-limiting storage are seen to be about half of that for farm natural air drying. Preservative treatment at 116 MJ/Mg corn and 9.3 kg CO_2/Mg corn is the lowest preservation method in energy use and CO_2 release. The crib system, with energy and CO_2 only for manufacturing equipment, is slightly higher at 151 MJ/Mg corn and 12.1 kg CO_2/Mg corn.

DIRECT ENERGY

Direct energy (energy used during the drying process) for artificial drying is 11 900 TJ for fuel, plus 139 GWh of electricity. Assuming 87% of the crop is artificially dried,

Table 2. Total energy use and total CO_2 release for preserving the 38.8 × 10^6 Mg Iowa corn crop

		Artificial Drying*									
		Manufacturing		Fuel		Electric		Other		Average	
Preservation Method	Portion of Crop (%)	Energy (TJ)	CO_2 (Gg)	Energy (TJ)	CO_2 (Gg)	Energy (TJ)	CO_2 (Gg)	Energy (TJ)	CO_2 (Gg)	Energy (MJ/Mg corn)	CO_2 (kg/Mg corn)
O_2-limiting	5	120	9.6	0	0	0	0	913	77.4	534	45.0
Crib	7	409	32.8	0	0	0	0	0	0	151	12.1
Off-farm dry	26	75	6.00	4730	310	296	77.5	0	0	508	39.1
Farm nat air dry	2	46.4	3.71	0	0	743	199	0	0	1020	262
Farm HTDC dry	18	62.7	5.01	3280	215	205	53.7	0	0	509	39.2
Farm comb dry	4	106	8.53	294	19.5	300	80.2	0	0	453	70.0
Farm other dry	37	530	42.4	5680	371	361	100	0	0	459	35.9
Preservative	1	0.337	0.027	0	0	0	0	44.5	3.57	116	9.3
Total	100	350	108	14000	915	1900	511	958	81.0		
% of tot energy		7.4		76.9		10.5		5.2			
% of tot CO_2			6.7		56.7		31.6		5.0		

Total energy:	18 200TJ and 470 MJ/Mg corn
Total CO_2 release:	1614 Gg and 41.7 kg/Mg corn
Total direct energy for drying:	12 360 TJ and 367 MJ/Mg corn artificially dried
Direct fuel energy for drying:	11 900 TJ and 352 MJ/Mg corn artificially dried
Direct electrical energy for drying:	139 GWh and 4.13 kWh/Mg corn artificially dried

*Assumes corn is dried from moistures of figure 1 (weighted average: 20.5%) to 15%.

these average 352 MJ/Mg of artificially dried corn and 4.13 kWh/Mg of artificially dried corn.

EFFECTS OF CHANGING HARVEST OR FINAL MOISTURE CONTENT

Table 2 assumes that all corn artificially dried was harvested at the moisture content fractions of figure 1 and dried to 15% moisture. Figures 2, 3, and 4 show effects of varying harvest or storage moisture contents on energy use. Total energy, fuel energy (calculated as Liquefied Petroleum Gas volume), and electrical energy increase or decrease at rates of 3.06 PJ/point, 85.9 ML/point, and 26.8 GWh/point, respectively, as harvest moisture of each fraction increases or decreases (right line of figs. 2, 3, 4). Total energy, fuel energy, and electrical energy decrease or increase at rates of 2.61 PJ/point, 73.4 ML/point, and 22.7 GWh/point, respectively, as final moisture increases or decreases (left line of figs. 2, 3, 4).

ENERGY COMPARISONS

The 18 200 TJ total energy is about 1.75% of Iowa's average annual energy consumption during 1992 through 1994 (USDOE, 1994). The 1614 Gg of CO_2 attributable to preservation of the Iowa corn crop is about 2.0% of Iowa's annual CO_2 emission for 1992 through 1994 (IDNR, 1996). The 12 360 TJ of direct energy for corn drying (fuel plus electricity) is about 1.19% of Iowa's average annual energy consumption during 1992 through 1994. The 139 GWh of direct electricity use for corn drying is about 0.44% of Iowa's average annual electricity consumption for 1992 through 1994 (USDOE, 1994).

The 470 MJ/Mg average total preservation energy for corn estimated here is 12% of 3.9 GJ/Mg which Slesser (1984) states as the unweighted modal value of the "gross energy requirement to the farm gate" of U.S. corn production". The 470 MJ/Mg value is 7.9% of the 5.88 GJ/Mg "total energy input to corn production" from Pimentel and Pimentel (1996). Neither reference cited gives a precise definition of one Mg of corn.

DISCUSSION

Results of this study show which approaches to reducing energy and CO_2 emission could be most successful. The crib and preservative methods are seen to use only about one-fourth the energy and to emit one-eighth the CO_2 of all the other methods. A shift to these methods would reduce energy and CO_2 for preserving the crop. Inherent in all the artificial drying methods is the necessity to supply the latent heat of vaporization of the water to be removed (at least 2.5 MJ/kg of water evaporated). Decreasing harvest moisture contents through use of varieties having faster dry-down, and increasing storage moisture contents through use of varieties with better storability could greatly reduce the energy and CO_2 for existing artificial drying methods.

The coal origin of electrical energy in Iowa drives up energy use and CO_2 emissions for artificial drying because of the high sequestered energy ratio (3.802) and because of the CO_2 from combustion of coal. Obtaining electricity from a source with a lower sequestered energy ratio, and one not derived from combustion will lower energy and CO_2 emissions for all artificial drying methods. Such a

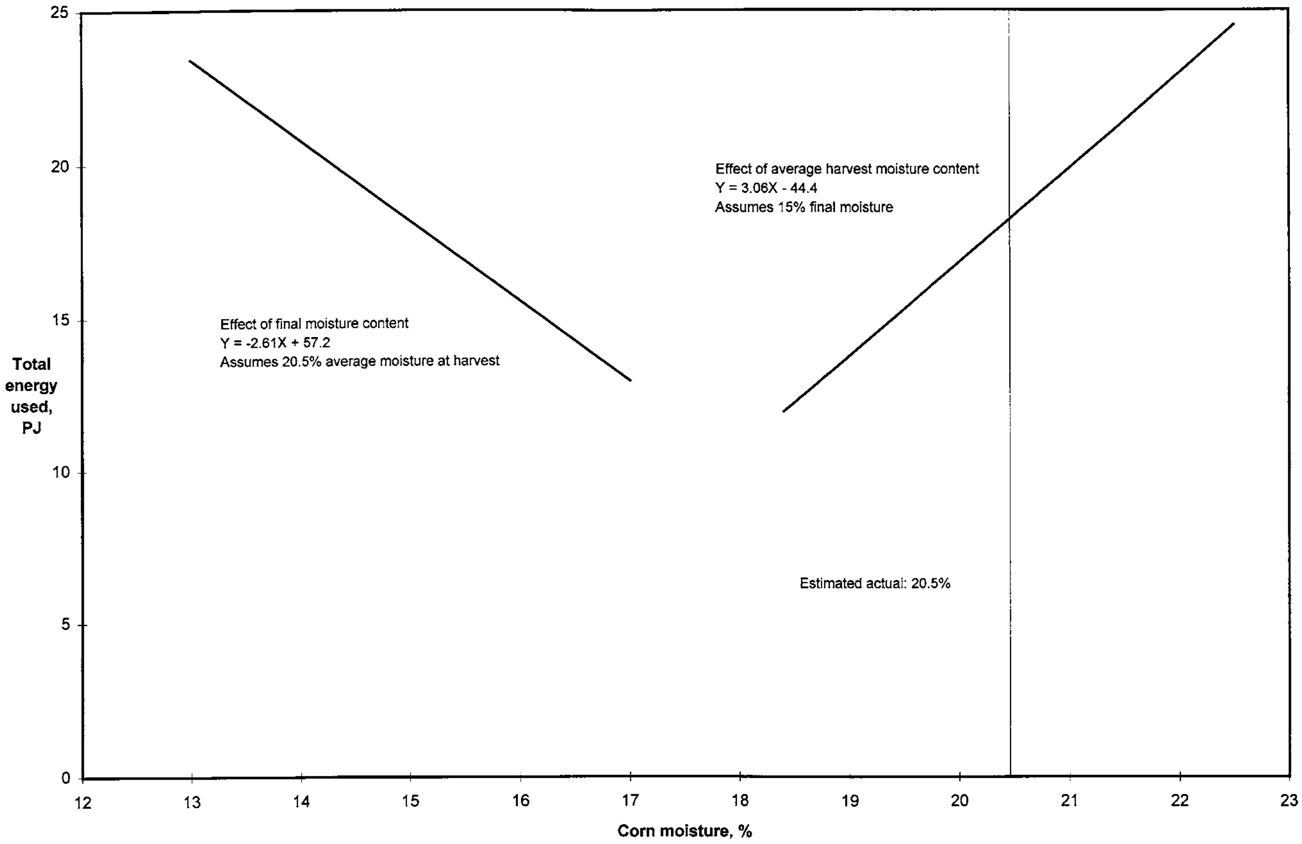

Figure 2–Effect of corn moisture content on total energy used for preservation.

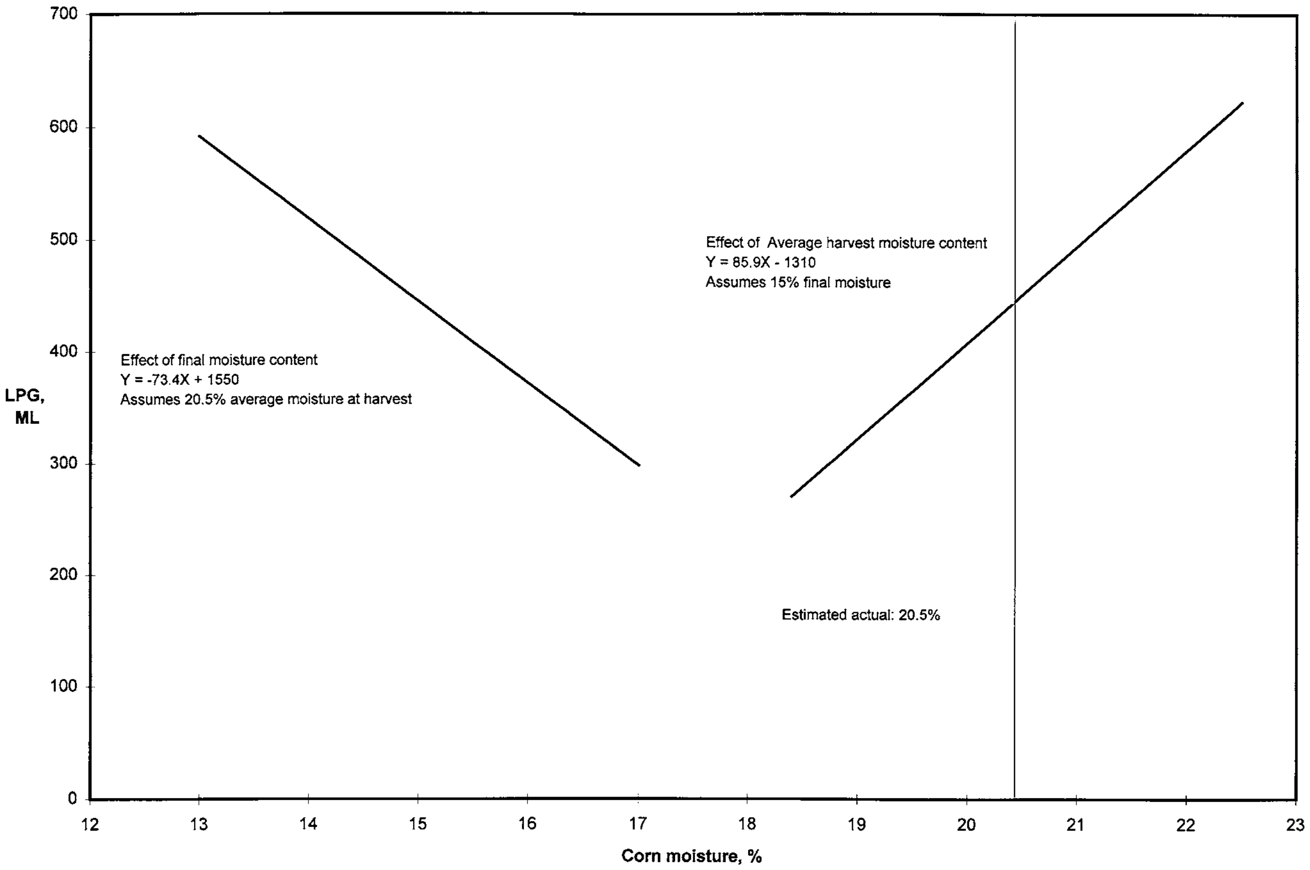

Figure 3–Effect of corn moisture content on liquefied petroleum gas (LPG) used for artificial drying.

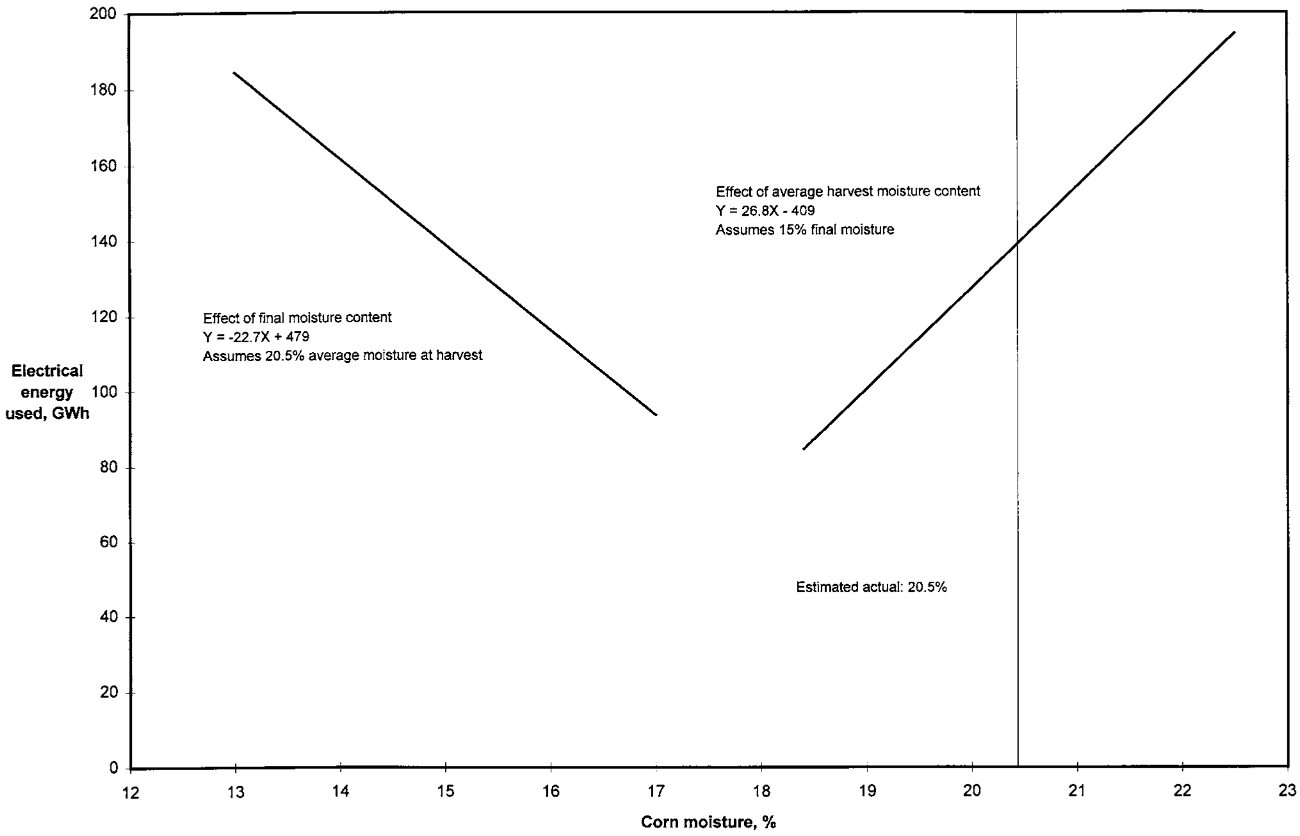

Figure 4–Effect of corn moisture content on electrical energy used for artificial drying.

change in source would lower energy and CO_2 emission most for farm natural air drying and would bring its energy use and CO_2 emissions to within the range of the other artificial drying methods.

CONCLUSIONS

Energy use and CO_2 release associated with preserving the Iowa corn crop are estimated as follows:

- Range of total energy use rates of preservation methods: 1020 MJ/Mg corn (farm natural air) to 116 MJ/Mg (preservative treatment).
- Range of CO_2 release rates of preservation methods: 262 kg CO_2/Mg corn (farm natural air) to 9.3 kg CO_2/Mg corn (preservative treatment)
- Total energy use: 18 200 TJ
- Average total energy use: 470 MJ/Mg corn
- Total CO_2 release: 1614 Gg
- Average CO_2 release: 41.7 kg/Mg corn
- Total direct fuel energy for drying: 11 900 TJ
- Average direct fuel energy for drying: 352 MJ/Mg corn
- Total direct electrical energy use for drying: 139 GWh
- Average direct electrical energy use for drying: 4.13 kWh/Mg corn
- Rate of energy increase as harvest moisture increases: 3.06 PJ/point (total energy), 85.9 ML/point (LPG use), 26.8 GWh/point (electricity)
- Rate of energy decrease as final moisture increases: 2.61 PJ/point (total energy), 73.4 ML/point (LPG use), 22.7 GWh/point (electricity)

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