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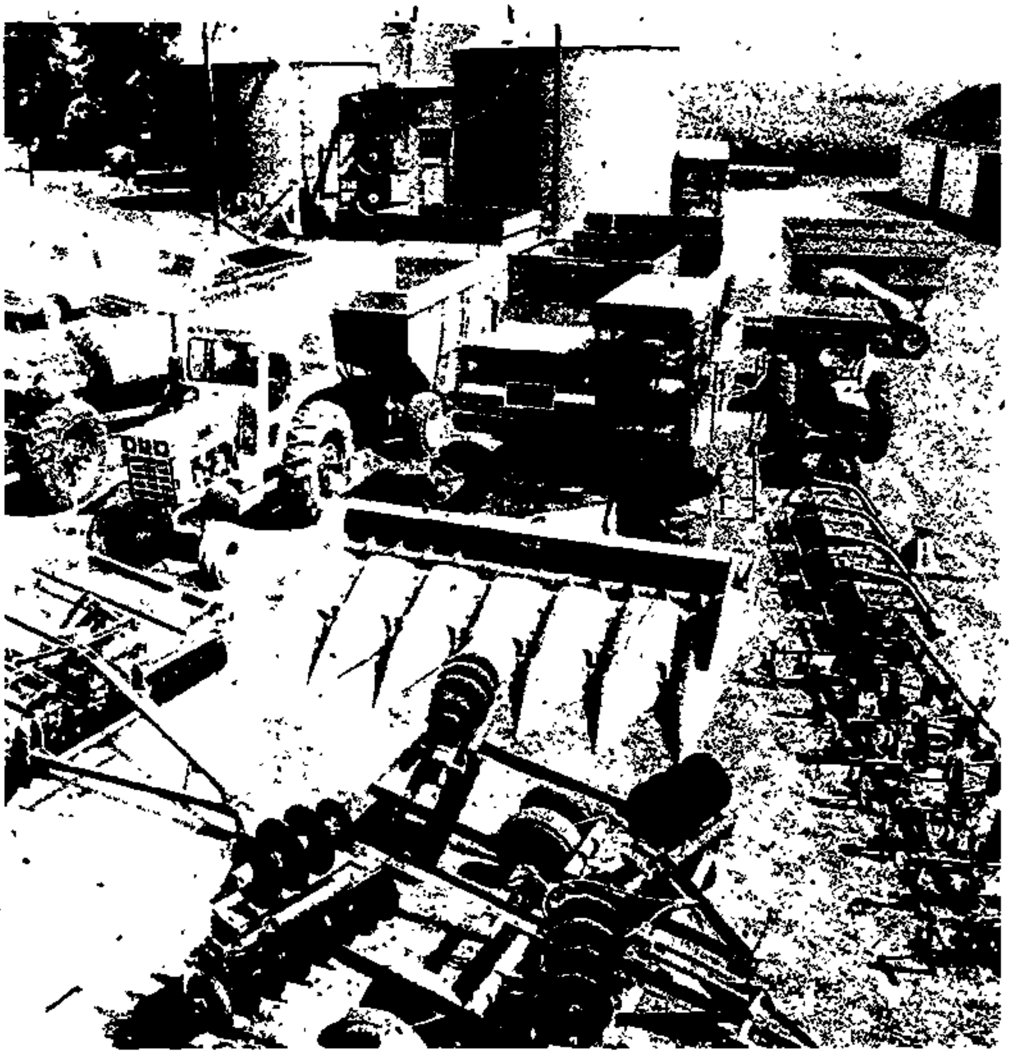
ABSTRACT

This booklet gives a brief overview of energy use in field crop production and gives examples of cutting costs of fertilizer use, irrigation, grain drying, tobacco drying, forate production, and tractor and truck use. Recordkeeping is also discussed. (BB)

A GUIDE TO ENERGY SAVINGS FOR THE FIELD CROPS PRODUCER



UNITED STATES
DEPARTMENT OF
AGRICULTURE

FEDERAL
ENERGY
ADMINISTRATION

ERRATA

ONE PART OF A SERIES OF PUBLICATIONS ON ENERGY AND U.S. AGRICULTURE

This report was prepared by Allen Schienbein, Grains and Feeds Program Area, Commodity Economics Division, Economic Research Service, U. S. Department of Agriculture. It was prepared under the supervision of George B. Rogers, Energy Coordinator, Commodity Economics Division, and Earle E. Gavett, Energy Coordinator, National Economic Analysis Division, Economic Research Service, and Robert C. Marlay, Technical Projects Office, Federal Energy Administration.

Other publications in this series are A Guide to Energy Savings for the Livestock Producer, A Guide to Energy Savings for the Vegetable Producer, A Guide to Energy Savings for the Poultry Farmer, A Guide to Energy Savings for the Orchard Grower, and A Guide to Energy Savings for the Dairy Farmer.

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Organizations: American Farm Bureau Federation, Grain Sorghum Producers Association, National Association of Wheat Growers, National Grange, National Corn Growers Association.

Individuals: Erwin O. Ulrich and William H. Peterson, South Dakota State University; William F. Lagrone and Paul E. Fischbach, University of Nebraska; L. B. Altman, Walter Lovely, James J. Naive, Pat Weisgerber, Shelby Holder, Walter Heid, O. U. Bay, Harold J. Owens, and Robert O. Gilden, U. S. Department of Agriculture.

The contributions of State and Federal extension and research personnel to this guidebook in the form of research bulletins, extension publications, notes, and conversations have been extremely helpful. Many of these contributions are directly acknowledged in the text of the report.

*Listing does not imply official action to endorse the report nor complete agreement with its contents.

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ONE PART OF A SERIES OF PUBLICATIONS ON ENERGY AND U.S. AGRICULTURE

This report was prepared by N. A. Wynn, Fruits, Vegetables, Sweeteners, and Tobacco Program Area, Commodity Economics Division, Economic Research Service, U. S. Department of Agriculture, under the supervision of George B. Rogers, Energy Coordinator, Commodity Economics Division, and Earle E. Gavett, Energy Coordinator, National Economic Analysis Division, Economic Research Service, and Robert C. Marlay, Technical Project Officer, Federal Energy Administration.

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This report has been reviewed by one or more of the organizations and individuals listed below.*

Organizations: American Farm Bureau Federation, Farm and Industrial Equipment Institute, International Apple Institute, National Council of Farmer Cooperatives, National Farmers Organization, National Farmers Union, Florida Fruit and Vegetable Association, National Grange, National Peach Council, Western Growers Association.

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JUNE 1977

CONTENTS

5

The Nation's 2½ million farms consume 6.3 billion gallons of gasoline and diesel fuel, some 173 billion cubic feet of natural gas, 1.5 billion gallons of LP (liquified petroleum) gas, and 32.3 billion kilowatt-hours of electricity in a typical year.

While amounting to only 3 percent of all the energy used in the country, the energy required to keep our farms in operation is a vital and increasingly expensive resource. The cost of energy has nearly doubled in the last 10 years. The largest part of the increase has taken place in the last 3 years alone.

Farmers are coping with higher costs for energy in the same way they deal with other problems that arise. They are adjusting operations to get the last drop of value out of a gallon of fuel, to wring more work out of a kilowatt-hour of electricity.

Beyond the need to save money, farmers may well ask why they should be expected to be more conscientious about conserving energy; cost-consciousness is built into any successful farm operation. But farmers, like the rest of the Nation, are being forced by global energy problems to reassess their use of fossil fuels. The entire Nation is being made increasingly aware of the severe limits of what was once thought of as a limitless resource. For all to prosper, all must conserve, no matter how great the individual priority of use.

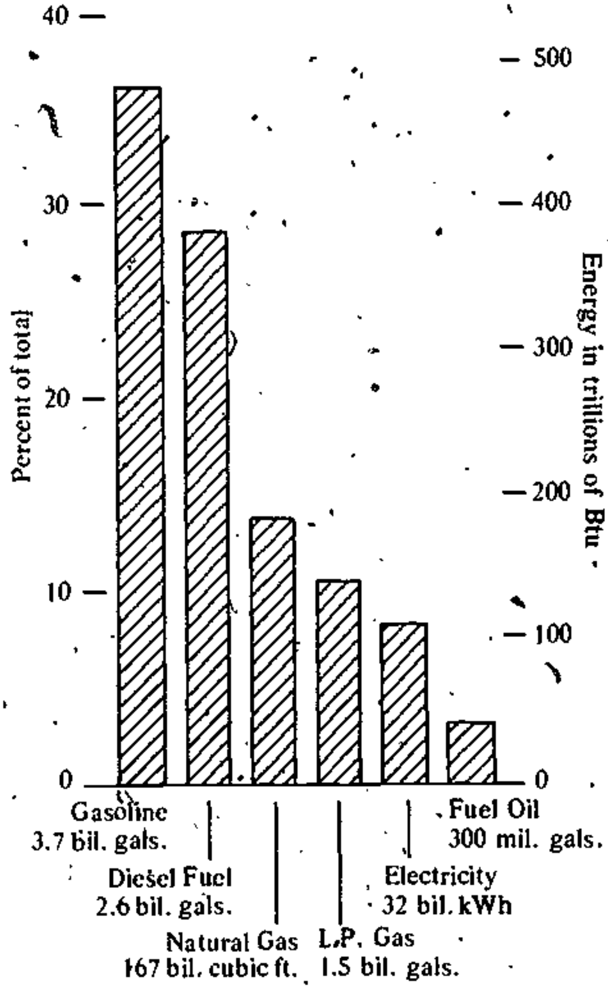

Figure 1. ENERGY USED IN AGRICULTURE (1974)

This guidebook contains a wide spectrum of ideas for operators of many sizes and types of farms, operators whose conception of energy conservation may vary. The ideas range from greater attention to daily details to substantial added investments in facilities and equipment. Not all the ideas will yield large dollar savings. Today energy conservation may seem secondary to other considerations because energy costs remain a small fraction of total costs.

Tomorrow, as available quantities of energy become restricted, producers will have to adope energy conservation measures irrespective of cost.

This effort is to help farmers to use energy resources even more prudently in the future.

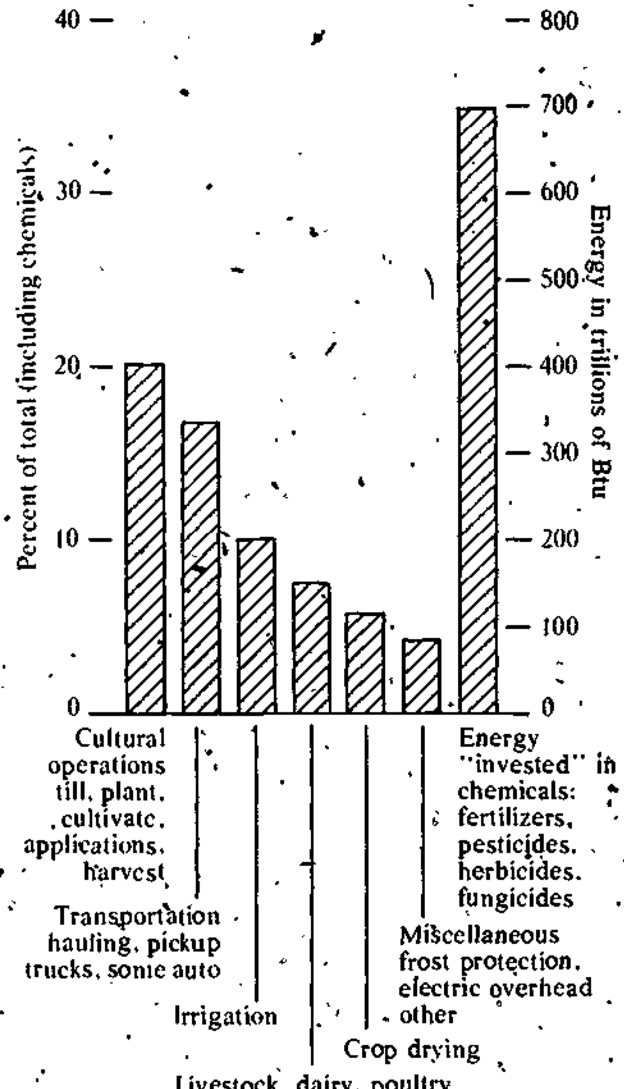

Figure 2. ENERGY USED IN AGRICULTURE, PLUS FERTILIZER AND CHEMICALS (1974)

Table 1--United State Agriculture and Energy - Field Crops - 1974

Crops	Acres 1/	Gals of gasoline	Gals of diesel	Gals of fuel oil	Gals of LP gas	Cu. ft. of nat gas	KWH's of elect	Total BTU's: inv. energy 2/	Total BTU's	BTU per acre
	1,000	1,000	1,000	1,000	1,000	Million	Million	Billion	Billion	
Corn	65,194	685,421	470,688	11,297	585,088	25,869	1,994	256,549	499,256	7,658
Grain Sorghum	13,917	98,397	102,283	92	40,585	29,047	1,022	36,924	101,399	7,286
Barley	9,153	49,693	36,580	---	13,799	1,266	691	11,374	26,757	2,924
Oats	18,136	95,530	43,910	---	8,704	55	212	12,790	32,488	1,792
Winter Wheat	52,407	291,144	195,872	---	32,961	14,215	1,262	72,420	158,600	3,027
Spring Wheat	18,762	117,025	71,980	---	5,498	40	347	16,415	42,868	2,285
Rye	3,200	15,218	12,104	---	1,198	8	17	3,546	7,323	2,289
Rice	2,588	35,251	69,459	414	33,638	14,351	410	11,821	45,673	17,648
Soybeans	53,582	387,501	342,898	---	37,876	1,975	361	23,529	126,875	2,409
Flaxseed	1,787	9,253	4,123	---	291	---	9	305	2,097	1,174
Corn Silage	10,695	98,221	147,798	---	14,807	3,857	366	37,379	77,053	7,205
Sorghum Silage	746	5,012	10,545	---	1,162	837	25	2,076	5,253	7,042
Alfalfa	26,642	377,735	133,262	---	71,361	27,289	3,719	7,476	121,474	4,560
Hay - Other	33,904	120,681	9,853	---	35,610	1,785	2,090	50,616	79,469	2,344
Seed Crops	1,431	22,469	7,967	---	3,564	103	88	673	5,345	3,736
Flue-Cured Tobacco	617	25,705	14,613	64,761	171,342	---	174	5,482	36,680	59,449
Burley Tobacco	340	14,716	1,700	---	8,047	---	2	4,501	7,350	21,618
Shade Tobacco	7	356	366	---	1,531	---	---	70	311	44,429
Peanuts	1,523	16.097	31,814	---	8,893	1,088	46	3,778	12,388	8,134
Cotton	13.731	107,000	202,765	---	28,014	20,393	1,997	76,097	148,750	10,834
Sugar Cane	865	13,779	35,528	---	1,021	---	646	4,248	13,248	15,524
Sugar Beets	1,252	16,330	19,226	---	4,284	1,214	627	6,963	15,518	12,395
Total Field Crops 3/	330,479	2.602,534	1,965,334	76,564	1,099,274	143,392	16,105	645,032	1,566,175	4,739
Total Other Crops 4/	10,117	278,742	321,205	218,548	49,383	16,108	5,955	71,420	223,755	22,119
Total Crops	340.596	2,881,276	2,286,539	295,112	1,148,657	159,500	22,060	716,452	1,789,930	5,256
Total Livestock 5/	---	817,365	352,416	8,817	332,885	4,625	10,028	NA	224,291	
Total Agriculture	---	3.698,641	2,638,955	303,929	1,481,542	164,125	32,088	716,452	2,014,221	

1/ Harvested acreage except for planted acreage in the following: rice, rye, winter and spring wheat, oats, barley, cotton, soybeans, peanuts, flaxseed, and sugar beets.

2/ Invested energy includes energy required to manufacture the fertilizers and pesticides (including carrier solution) used in crop production.

3/ Includes all energy used directly on the farm for crop production purposes--field operations, irrigation, crop drying, farm business auto use, etc.

4/ Includes all energy used directly in the production of vegetables, citrus, and fruit crops--planting, irrigation, pesticide application, harvesting, etc.

5/ Includes all energy used directly in the production of beef cows and calves, feedlot beef, milk cows, hogs, chicken layers and pullets, broilers, turkeys, sheep and lamb, and miscellaneous poultry.

Source: Energy and U.S. Agriculture: 1974 Data Base, USDA/FEA, Vol. 1, FEA/D 76/459, Sept. 1976.

Modern agriculture relies heavily on electricity and all types of fossil fuels. The production of field crops (grains, oilseeds, forage, cotton, and tobacco) uses by far the largest portion of agricultural energy, over 75 percent.

Energy in field crop production is required for soil tilling, planting, fertilizing, cultivating, irrigating, spraying, and harvesting. Energy also is needed to dry or cure some crops after harvest. Table 2 shows the estimated 1974 energy consumption (Btu) for the various production activities by major field crops.

Historically, most forms of energy used in farming have been relatively inexpensive and abundant. Crop production technology was not focused on energy cost or on efficient usage. Recent price increases, however, have fostered a need for efficient energy technologies.

The crop producer now has the opportunity to save money as well as to help conserve energy. Improved application of fertilizers, adoption of minimum and no-till methods, applying alternative crop drying techniques, perfecting pest control techniques, and better scheduling the use of irrigation water are examples of how to reduce energy requirements in field crop production.

Some ideas in this booklet may result in energy and money savings without additional investment. Others may require investments that take several years to pay off. The hope is that some of these ideas will help now or in the future if you are planning to expand or make a major change in your operation. At the very least, you will have some energy data handy to consult in decisionmaking and in planning.

Most field crop farmers know how much their electricity and fuel bills have gone up recently in terms of dollars, but many do not know the gallons of diesel fuel, gasoline, or LP gas their various farming operations consume. The first energy-saving step is to know how much is used in each production operation.

Typical amounts of energy required for various production activities and equipment are shown in the following tables. Figures in these tables are approximations based partly on actual records and partly on engineering computations. They assume all equipment is in good condition, engines are properly tuned, parts are lubricated, and blades are sharp. These typical energy quantities may not coincide with amounts used on a given farm, but they should be helpful for comparison and as a guideline for improving efficiency.

Table 2--Energy use in the production of field crops, 1974

Commodity	Preharvest 1/	Harvest 2/	Irrigation	Drying 3/	Other 4/
			Btu (billion)		
Corn	53,276	42,346	45,733	50,037	51,315
Sorghum	17,430	5,778	36,346	2,121	2,739
Wheat 5/	37,892	18,926	21,321	277	34,218
Oats	6,802	4,325	657	---	7,914
Barley	4,847	2,486	3,954	70	4,026
Flax	582	391	---	---	819
Rye	1,651	945	29	4	1,148
Rice	4,619	3,745	15,084	8,253	2,151
Silage 6/	8,278	17,430	8,192	---	8,950
Forage 7/	6,729	59,992	40,497	15,760	19,874
Soybeans	48,089	14,434	1,750	2,360	36,714
Peanuts	2,543	2,475	1,5[illegible]6	821	1,216
Cotton	24,089	8,912	31,[illegible]	---	8,414
Tobacco 8/	2,800	3,315	384	25,895	1,894
Total	219,627	185,561	206,740	105,598	181,392

1/ Includes preplant preparations, planting, cultivating, fertilizer, defoliant and pesticide application.
2/ Includes harvesting and hauling.
3/ Includes drying on and off the farm.
4/ Allocated general use of pickup, farm auto, and farm electricity.
5/ Winter and spring wheats.
6/ Corn and sorghum silage.
7/ Alfalfa and hay.
8/ Flue-cured, barley, and shade tobacco.

Table 3--Estimates of fuel burned for crop production operations under average conditions--Iowa

Crop production	Gasoline	Diesel fuel	LP gas
		Gal/acre	
Cropping system			
Corn--Conventional methods	9.5	6.85	11.4
Corn--Plowing with minimum tillage planting	7.5	5.40	9.0
Corn--No plowing, minimum tillage planting	6.0	4.30	7.2
Corn harvested and stored as whole plant silage			
Conventional methods	12.0	8.65	14.4
Plowing with minimum tillage	10.0	7.20	12.0
No plowing, minimum tillage	8.5	6.10	10.2
Soybeans--Conventional methods	9.0	6.50	10.8
Small grains--Oats, barley, rye, wheat	4.25	3.00	5.1
Small grains--With plowing	6.50	4.70	7.8
Hay--Dry cured, 3 cuttings, baled	12.0	8.65	14.4
Haylage--3 cuttings or dry chopped	18.0	13.00	21.6
Using combined type cutting with self-propelled cut, crush, windrow			
Hay--3 cuttings	7.2	5.20	8.6
Haylage--3 cuttings	13.2	9.50	15.8
Corn drying--With favorable drying conditions 1 gal propane will dry 7 bu corn			
--With good drying conditions 1 gal propane will dry 6 bu corn			
--With unfavorable drying conditions 1 gal propane will dry 5 bu corn			

Source: (6). Underscored numbers in parentheses refer to items in References.

12

Table 4--Estimated amount of fuel needed for various operations--Kansas

Operation	Gal/acre 1/	Operation	Gal/acre 1/
Plow (8 in. deep)	1.68	Grain drill	.35
Heavy offset disc	.95	Combine small grains	1.00
Chisel (Spike point 8 in deep)	1.10	Combine soybeans	1.10
Tandem disc	.55	Combine corn & grain sorghum	1.60
Field cultivator (12 in sweeps)	.60	Cutterbar mower	.35
Springtooth harrow	.40	Mower conditioner	.60
Spiketooth harrow	.30	Swather	.55
Rod weeder	.30	Rake, single	.25
Sweep plow	.60	Rake, tandem	.15
Cultivate row crops	.45	Baler	.45
Rolling cultivator	.35	Stack wagon	.50
Rotary hoe	.25	Sprayer	.10
Anhydrous application	.65	Haul small grains (gasoline)	.60
Planting row crops	.50	Rotary mower	.80

1/ Figures are in diesel gallons per acre. Multiply by 1.4 to convert to gasoline and 1.7 to convert to LP gallons.

Source: (14)

Table 5--Estimated fuel requirements for wheat after fallow (operations on 2 acres, 1 acre wheat and 1 acre fallow) 1/--Western Nebraska

Field operation	Times over	Fuel required	
		Gal/acre	Fuel
One-way	2.0	1.28	Diesel
Chisel plow	1.0	.92	"
Sweeps	1.0	.72	"
Rod weed	1.5	1.08	"
Drill	1.0	.47	"
S.P. combine 2/	1.0	3.11	Gasoline
Grain truck	1.0	.98	"
Pickup truck 3/	---	4.56	"

1/ Includes estimate of all fuel requirements. For example, fuel used by custom combiners and custom haulers is included.
2/ Based on harvested yield of 33.1 bushels. Some combines have been converted to diesel which would make diesel gallons about 72 percent of gasoline gallons.
3/ Includes overhead jobs such as taking supplies to field.

Table 6--Estimated fuel requirements for grain crop production and harvesting operations--Indiana

Field Operation	Gasoline required 1/	Notes
	Gal/acre	
Soil engaging		
Moldboard plow	2.32	Based on "average" soils. Fuel requirements may be as much as 50 percent greater on heavy clay soils, or as much as 50 percent less on light, sandy soils.
Chisel plow	1.53	
Heavy tandem disc	1.30	
Standard tandem disc	1.04	
Field cultivator	1.04	
Row-crop planter	1.10	
Grain drill	1.10	
Rotary hoe	.78	
Row-crop cultivator	1.10	
Knifedown NH_3 applicator	1.39	
Crop engaging		
Shred-crop stalks	1.04	Based on "average" crop yields of 100 bu/acre for corn; 33 bu, beans; 45 bu wheat; and 60 bu, oats.
Corn picker	1.61	
Corn combine	1.97	
Combining soybeans	1.74	
Combining small grains	1.58	
Other operations		
Row-crop sprayer	.30	
Bulk fertilizer spreader	.30	

1/ Multiply these values by 0.72 for diesel gallons per acre, or by 1.2 for LPG gallons per acre. These values do not include fuel required to move equipment to, from, or between fields, nor to move production supplies (seed, fertilizer, chemicals, water, etc.) to the field, nor to transport the harvested crop from the field.

Table 7--Fuel use estimates in corn production--Iowa 1/

Cropping System	Gasoline	Diesel	LP Gas
	Gallons per acre		
Corn--conventional method	9.5	6.85	11.4
Corn--plowing with minimum tillage planting	7.5	5.40	9.0
Corn--no plowing, minimum tillage planting	6.0	4.30	7.2

1/ Includes various field operations beginning with land preparation, planting, and harvesting.

Source: (6)

Conventional tillage used in field crop production is steadily yielding ground to minimum tillage methods. Minimum tillage, also referred to as no-till, conservation tillage, or stubble mulch tillage, means leaving crop residues on the soil surface and reducing the number of tillage operations. It means that plowing, disking, and harrowing a field prior to planting and cultivating the crop after it comes up often are bypassed. Reduced tillage in 1975 amounted to nearly 35.8 million acres, about 6.4 million acres of no-till and 29.4 million acres of minimum till. This was mostly corn, soybean, and cotton acreage. Conventional tillage still amounted to about 218.2 million acres.

Benefits of reduced tillage include erosion reduction, weed control, increased soil moisture storage, labor and cost savings, better double cropping opportunities, and <u>conservation of energy</u>.

Use of herbicides for weed control instead of tillage and cultivation can cut tractor fuel use because the tractor passes over the field fewer times. There is some disagreement about the trade-off between the fuel consumed and the additional energy required to manufacture the herbicides. However, the consensus is that with proper use of herbicides there is a net savings of energy inputs. Also, reports are mixed as to whether reduced tillage helps or hurts yields.

In terms of direct fuel use, reduced tillage could save as much as 4 gallons per acre. It could cut farm fuel cost by 40 percent. Table 7 illustrates fuel requirements for corn cropping systems in Iowa.

SAVE ENERGY BY REDUCED TILLAGE

Good approximations of the amounts of fuel consumed in various tillage programs for sorghum are shown below: 1/

Conventional till	Gal/acre
Plow	1.53
Tandem disk	.51
Springtooth	.41
Plant	.32
Spray	.10
Cultivate	.35
Combine	1.00
	4.22

Minimum till	
Disk	.51
Spray	.10
Disk	.51
Plant	.32
Cultivate	.35
Combine	1.00
	2.79

No-till	
Chop stalks	.75
Spray	.10
Plant	.32
Combine	1.00
	2.17

1/ Based largely on calculations from data in American Society of Agricultural Engineers Yearbook and (11).

Over $80 savings in diesel fuel using no-tillage program on 100 acres of sorghum

Situation

Plant and harvest 100 acres dryland sorghum in Kansas

Conventional tillage program
100 acres x 4.22 gal/acre =
422 gal/diesel

No-tillage program
100 acres x 2.17 gal/acre =
217 gal/diesel

205 fewer gallons of diesel fuel used with a no-tillage program

Dollars Saved at Various Diesel Fuel Prices

Cents/gal	35¢	40¢	45¢
Annual savings	$72	$82	$92

Note: Some sorghum production research has shown increased yields using reduced tillage practices. For more information about this possible important benefit, contact your county extension agent.

SAVE ENERGY BY USING LIMITED SEEDBED PREPARATION IN PRODUCING COTTON

Adopting limited seedbed practices for producing cotton in the flood plain areas of Louisiana, Arkansas, and Mississippi can help reduce the quantity of fertilizer used. It takes 2.4 million Btu of energy to make 100 pounds of NH_3—equivalent to about 17 gallons of diesel fuel. Thus, using less fertilizer saves considerable fossil fuel.

The limited seedbed practice reduces seedbed preparation operations with yields often equal to or higher than those reported from usual input practices.

Usual production practices for the flood plains cotton farm requires the application of 122 pounds of NH_3 per acre. Limited seedbed practices require about 110 pounds. (9) Further, per acre yield for the minimum seedbed cultural system is at least 5 percent higher.

SAVE $100 or $1.00 per acre in fertilizer costs by using limited seedbed practices

Situation

100 acres cotton on sandy soils, Delta area of Louisiana, Mississippi, and Arkansas.

Usual cotton production practice:
100 acres x 122 lb = 12,200 lb NH_3
122 cwt x $8.25/cwt = $1,006.50

Limited seedbed preparation practice
100 acres x 110 lb = 11,000 lb NH_3
110 cwt x $8.25/cwt = $907.50

Limited seedbed uses 12 pounds per acre less of NH_3 fertilizer than when usual input practices are followed. For 100 acres, this saves about $100.

SAVE TRACTOR FUEL THROUGH USE OF LIMITED SEEDBED PRACTICE IN PRODUCING COTTON

SAVE 242 gallons of fuel or about $1.00 per acre by using 8-row machinery and limited seedbed preparation.

Limiting seedbed tillage for producing cotton in the flood plains of Louisiana, Arkansas and Mississippi can reduce tractor fuel requirement by about 14 percent. (9) Some primary soil tillage passes over the field are eliminated (2 chisel plowings and disking field work) from the usual production practices. This reduces tractor operating time. Weeds still are controlled with herbicides.

Usual cotton production practices for flood plains areas require about 8.35 gallons of diesel fuel per acre for a tractor using 6-row machinery. Limited seedbed practices require about 7.21 gallons per acre.

A tractor fuel savings of 17 percent also results when switching from 6-row to 8-row planting and tillage machinery. Changing from 6-to 8-row machinery with usual cotton production practices could reduce fuel consumption 1.41 gallons per acre.

NOTE: Experimental results and on-the-farm observations over a 3-year period indicate that solid cotton lint yields on sandy soils can be <u>increased at least 5 percent</u> through adoption of limited seedbed practices.

<u>Situation</u>

100 acres cotton on sandy soils, Delta area of Louisiana, Mississippi and Arkansas

Usual cotton production practices
- 100 acres x 8.35 gal/acre w/6-row = 721 gal
- 100 acres x 5.93 gal/acre w/8-row = 694 gal

Limited seedbed preparation practices
- 100 acres x 7.21 gal/acre w/6-row = 721 gal
- 100 acres x 5.93 gal/acre w/8-row = 593 gal

Difference
- Between 6-row usual and limited = 114 gal
- Between 6-row and 8-row usual = 144 gal
- Between 6-row usual and 8-row limited = 242 gal

Dollars Saved at Various Diesel Fuel Prices

Cents/gal	40¢	45¢	50¢
Annual savings	$97	$109	$121

SAVE ENERGY BY USING HERBICIDES INSTEAD OF CONVENTIONAL TILLAGE FOR WEED CONTROL

The conventional way to control weeds in row crops is by rotary hoeing, harrowing, rolling cultivator use, etc. The alternative: Apply a herbicide following seedbed preparation and planting.

Diesel fuel consumption resulting from use of mechanical weed control for dryland row crop production in Kansas varies from 0.7 to 1.45 gallons per acre. Weed control practices, including application of herbicides, vary from 0.10 to 0.45 gallon per acre. The use of herbicides cuts out 1-2 weed cultivating operations, thus conserving 0.6 to 1 gallon of diesel fuel per acre.

Diesel fuel will do more work than the same amount of gasoline or LP gas, so multiply figures for diesel fuel use by 1.39 for gasoline and 1.67 for LP gas. (10)

SAVE $45 in energy costs by controlling weeds with herbicides (100 acres)

Calculations

Mechanical weed control - no herbicide
100 acres x 0.7 or 1.45 gal/acre = 70 - 145 gal

Weed control - herbicide applied
100 acres x 0.1 or 0.45 gal/acre = 10 - 45 gal

The difference ranges from 60 to 100 gallons, or a $27 to $45 savings on weed control by applying herbicide.

Dollars Saved at Various Diesel Fuel Prices

Cents/gal	40¢	45¢	50¢
Annual savings	$40	$45	$50

20

For several decades, inorganic fertilizers have been credited with spectacular increases in the yields of various field crops. The added returns from the use of these fertilizers were worth several times the cost of the added fertilizer. Even with recent increases in fertilizer prices, additional returns from the use of more fertilizer often pay added dividends.

In 1974, farmers applied fertilizer to 94 percent of the corn, 79 percent of the cotton, 66 percent of the wheat, and 30 percent of the soybean acreage harvested. Field crops took over 90 percent of the 19 million tons of primary plant nutrients applied to agricultural crops.

Fertilizer is by far the largest single energy input item in the production of field crops. Over 40 percent of the energy input comes from fertilizer alone. The other sixty percent of this energy is used in preharvest, harvest, irrigation, crop drying, and other production operations. Enormous quantities of energy are embodied in the production of fertilizer. The production of 1 ton of anhydrous ammonia (82 percent nitrogen) requires 38,130 cubic feet of natural gas. The natural gas equivalent of 5 tons of ammonia would heat an average home in central Illinois for a year.

The efficient use of energy in the manufacture and distribution of fertilizer is beyond the scope of this booklet. However, at the farm level, one way to realize significant energy savings is through reduction of total fertilizer use by proper selection and use of fertilizers.

Agronomists and extension agents, as well as local fertilizer dealers, can provide information and recommendations about fertilizers. Their working experience in a local area and their interpretation of up-to-date fertilizer response data can help prevent wasteful use of fertilizers.

Soil tests, when properly done and interpreted, are effective guides to productive and efficient use of fertilizers. The proper timing and method of application also may contribute to fertilizer efficiency.

Soil testing helps assess nutrient deficiencies and prevents wasteful application of plant nutrients. Much of the excess nitrogen (above the needs of the growing crop) is lost by the time the following year's crop is planted, adding to the cost of production.

Optimally, a farmer should soil test every 10 to 20 acres. He may or may not need soil samples each year, depending upon the crop and the specific yield goal in mind. However, based on 1973 cropland statistics, farmers sampled at a rate of every 230 acres. This wide difference raises the question of just how many farmers who use fertilizer actually know the real nutrient requirements of their soil crops. Some could be underfertilizing and failing to get optimum returns. Others could be overfertilizing and wasting energy and money.

ENERGY CHECKLIST

Apply fertilizers in quantities that produce the greatest net return.

Buy only those fertilizers needed for your particular soil and crop combination.

Make use of animal manures and crop residues by returning to the soil when appropriate.

SAVE ENERGY BY PROPER USE OF FERTILIZER ON GRAIN SORGHUM

SAVE $43 per acre by soil testing, to make sure you put on the right amount of fertilizer

Soil testing can lead to more productive and efficient use of fertilizers. A soil analysis tells how much more fertilizer is needed; or, it may recommend less.

Along with helping to obtain better yields for the fertilizer applied, soil tests help make efficient use of an important energy input.

Table 8 illustrates yield response of grain sorghum in Missouri to different levels of fertilizer application. (7, p. 127)

According to the situation, a Missouri farmer could expect about 51 bushels per acre when applying fertilizer at the average 1974 level. He would need to expend an equivalent of 124,300 Btu of energy to produce each bushel.

By adding commercial fertilizer, up to 160 pounds of N, 80.2 pounds of P_2O_5, and 90.3 pounds of K_2O_5, the resulting increased yield (79.2 bushels) would reduce the invested energy to 122,500 Btu per bushel--an energy saving of 1,800 Btu per bushel.

With grain sorghum at $2.25 per bushel, fertilizer applied as above will produce a return of $43 per acre. If more fertilizer is applied, net return per acre will begin to decline.

Table 8--Energy consumption in fertilizer manufacture

Material	Quantity	Energy (Million Btu)
Ammonia	100 lb of N	2.4
Ammonium nitrate	100 lb of N	3.3
Triple superphosphate	100 lb of P_2O_5	.67
Rock phosphate	100 lb of P_2O_5	.19
Muriate of potash	100 lb of K_2O	.27

Table 9--Grain Sorghum: Yield response to fertilizer and Btu per bushel

Fertilizer applied per acre N	P2O5	K2O	Yield per acre 1/	Fertilizer Btu/bu 2/	Total Btu/bu 3/	Return 4/ 2.25 x yield	5/ - cost	Net = benefit
---- Pounds ----			Bushels	---- Thousands ----		---- Dollars ----		
0	0	0	18.0	0	222.2	40.50	0	40.50
40.0	23.0	24.0	50.0	28.74	108.7	112.50	9.00	103.50
80.0	38.3	48.2	67.2	42.43	102.0	151.20	17.20	134.00
120.0	57.3	70.2	75.0	57.00	110.0	168.75	25.67	143.08
160.0	80.2	90.3	79.2	72.00	122.5	178.20	34.47	143.73
200.0	80.2	90.3	80.8	87.00	136.5	181.80	39.80	142.00
6/66.0	32.0	29.1	51.0	46.00	124.3	114.75	13.99	100.76

1/ Derived from (7, p. 127)
2/ N = 33,000 Btu/lb; P = 3,000 Btu/lb; K= 2,000 Btu/lb.
3/ Assumes invested Btu/acre other than from fertilizer (for land preparation, planting, cultivating, and harvesting) approximates 4,000,000 Btu.
4/ Grain sorghum $2.25 per bushel. (19)
5/ Fertilizer price $0.133/lb N; $.107/lb P_2O_5; $0.051/lb K_2O. (18)
6/ 1974 levels of Missouri average fertilizer application, and 1974 yield per acre of grain sorghum in Missouri.

SAVE ENERGY IN FORAGE PRODUCTION BY NITROGEN FIXATION RATHER THAN APPLICATION OF COMMERCIAL NITROGEN

Nitrogen is necessary for abundant pasture growth. While synthetic nitrogen has been relatively cheap, grass pasture has become the answer to forage needs. The present concern toward energy conservation, the high costs of nitrogen fertilizer, and the high prices of purchased hay may warrant more use of legume/grass combinations. The nitrogen fixation ability of legumes would allow for reduced need for synthetic nitrogen. An analysis of the feasibility of growing legumes to generate a supply of nitrogen versus use of synthetic nitrogen on pastures shows a total cost advantage of $5.18 per ton in favor of the legume/grass mixture.

A legume and Ladino clover mix substituted for 360 pounds per acre of nitrogen, 33.5-0-0, equivalent to 120.6 pounds of nitrogen. About 3,445 cubic feet of natural gas is required to manufacture that amount of synthetic nitrogen.

SAVE about $33 per acre or $11 per ton of hay in reduced fertilizer application with a legume/grass combination

Situation

3 hay-ton equivalents per acre

Pasture #1--Orchard grass and no legume 1/

0-10-20	375 lb/acre
33.5-0-0	360 lb/acre
Lime	500 lb/acre

Pasture #2--Ladino clover and orchard grass 2/

0-10-20	500 lb/acre

1975 Costs of Fertilizer Applied/Acre

Pasture #1

0-10-20	$ 5.42/cwt x 3.75	=	$20.32
33.5 N	$10.18/cwt x 3.60	=	36.65
Lime	$15.00/ton x .25	=	3.75
			60.72/ac
			20.24/ton

Pasture #2

0-10-20 $5.42/cwt x 5.00 = $27.10/acre
9.03/ton

Legume/grass pasture saved $33/acre in fertilizer.
Cost-equivalent to saving $11 per ton of hay.

1/ 60 percent digestible--3-ton equivalent equals 225 cow-grazing days.
2/ 65 percent digestible-3-ton equivalent equals 244 cow-grazing days.

Source: (12)

On many irrigated farms, delivering water to the field requires more energy than all other farm operations combined. Although two to three times as much fuel is required for irrigated crops, the energy required per unit of product has been no greater, and in some cases, less than energy used in dryland production. Often, irrigated field crops have a greater net return than dryland farms in the same areas. This is one reason irrigated agriculture has expanded rapidly. Nearly 52 million acres of farmland were irrigated in 1974.

In 1973, some 14 percent of the total electrical energy generated by the Idaho Power Company was used to pump water. At this rate, 6 acres of land under pumped irrigation would use about the same annual electrical energy requirements as a typical American home. In California, about 68 percent of all electricity used in agriculture goes into irrigation.

Natural gas may still be the cheapest source of pumping energy per acre and per acre-foot of irrigation water. Next are electricity, diesel fuel, liquid propane gas, and gasoline, in that order (4). However, measured in Btu of energy consumed per acre irrigated, natural gas is easily the leader in energy expended. Electricity (not including Btu used to generate the electricity) consumes the least Btu per acre in irrigation pumping, followed by diesel fuel, liquid propane gas, gasoline, and natural gas.

Crop production on irrigated lands can compete better with nonirrigated agriculture in the production of food and the priority for energy inputs when there is better knowledge of all irrigation energy inputs, direct and indirect. A detailed comparison of energy inputs to various types of irrigation systems is shown in table 10. This is an attempt to account

Table 10--Energy inputs to irrigation systems

Irrigation system	Installation 1/	Pumping	Labor	Total
	1,000 kilocalories of energy 2/			
Surface (gravity without irrigation runoff recovery system)	103.2	35.2	0.50	139.9
Surface with irrigation runoff recovery system	179.9	48.0	.30	228.2
Trickle	530.5	468.0	.10	998.6
Solid-set sprinkle	614.1	770.0	.40	1,384.5
Permanent sprinkle	493.6	770.0	.10	1,263.7
Hand-moved sprinkle	159.7	804.0	4.80	968.5
Side-roll sprinkle	200.3	804.0	2.40	1,006.7
Center-pivot sprinkle	388.5	864.0	.10	1,252.6
Traveler sprinkle	288.9	1,569.0	.40	1,858.3

1/ Includes energy used in manufacturing (1) all materials installed (pipes, etc.), (2) machinery installed; (3) a pro rata share of excavation machinery used, and the energy required to operate excavation machinery. No energy required to transport any materials, machinery, or labor was included.

2/ One kilocalorie = 3.97 Btu.

for the energy inputs in installing and operating several different irrigation systems for an actual 160-acre farm (2). This data may be helpful in evaluating contemplated changes and new irrigation installation.

Irrigation engineers feel that if available irrigation technology is used wisely, the total energy requirements could be reduced nearly one-half. This would require many changes in irrigation procedures and the installation of newer types of irrigation systems. But it is well within current technological capability to reduce energy consumption by 10 to 20 percent. This can be done in several ways. Some are common to all widely used irrigation methods; others are specific to a given method or general climatic zone. The suggested steps include:

Increasing Irrigation Pumping Plant Efficiency

A typical field situation is shown in a study which tested 376 pumping plants in Nebraska. Fewer than 9 percent of them met standard pumping performance levels. Neglect, maladjustment, few checkups, and minimal maintenance were the primary causes. Most are easily correctable and could mean substantial fuel savings and lower costs to the irrigator.

Reduced Water Application

Correct irrigation scheduling can save water without hurting the crop. Determination of "when" and "how much," correlated to weekly monitoring of soil moisture level in the field, often will result in pumping less water. Commercial irrigation scheduling services are available to farmers.

Controlled depletion of soil moisture is useful on sprinkler irrigation fields where maximum water control can be exercised. "Programmed Soil Moisture Depletion" is used on certain soils to accomplish effective use of rainfall and utilize stored soil moisture.

Reuse of Irrigation Runoff Water

Surface irrigation systems may have runoff losses averaging 25 to 30 percent of all water applied. Installation of a reuse system for this lost water could reduce total power consumption by 10 to 25 percent where substantial pumping lift is necessary.

Improve Irrigation System Design

Recently developed equipment and design procedures can modernize irrigation systems. Automatic surface irrigation systems often provide greater than 90 percent water application efficiency. Various irrigation procedures which pay off in energy saving and irrigation efficiency are: reducing row lengths on light soils, shortening application times, using "cutback" furrow stream, and irrigating every other furrow.

SAVE ENERGY BY IMPROVING EFFICIENCY OF PUMPING UNITS

SAVE from $200-500 on irrigation energy costs by making sure your pumping plant is operating efficiently.

A basic problem, after an irrigation system has been installed, is that it is not maintained properly. Just like any other mechanical equipment, pumping plants need periodic adjustment to maintain operation at peak performance.

An estimated 10-percent energy savings could result by increasing the performance of the plants from 80 to 100 percent of the pumping standard (expressed in water horsepower and gallons of fuel used per hour, whp-hr/gal).

These savings justify periodic performance testing of pumps so that proper adjustments and repairs can be made. The Pacific Gas and Electric Company of California provides regular testing of electrically powered plants. The 1974 cost of the test averaged $41 and varied from $23 to $108. Subsequent repairs and adjustments reduced energy requirements and costs. A similar service is likely to be introduced in Colorado and perhaps other Great Plains States.

Savings through adjustment, repair, or replacement of pumping plants with efficiencies of less than 80 percent would be significantly greater than indicated in the following irrigation tables. About one-half of irrigation pumping plants now in service would be hard pressed to attain 75 percent of performance standards.

ENERGY SAVED on 130-acre field

Diesel
130 x 5.4 gal = 702 gal

LP Gas
130 x 8.4 gal = 1,092 gal

Natural Gas
130 x 871.0 = 113,230 ft^3

Electricity
130 x 66.0 = 8,580 kWh

Dollars Saved at Various Diesel Prices

Cents/gal	40¢	45¢	50¢
Annual savings	$281	$316	$351

Dollars Saved at Various LP Gas Prices

Cents/gal	35¢	40¢	45¢
Annual savings	$382	$437	$491

Dollars Saved at Various Natural Gas Prices

Dollars (per 1,000 ft^3)	$1	$2	$4
Annual savings	$113	$226	$452

Dollars Saved at Various Electricity Prices

Cents/kWh	3¢	4¢	5¢
Annual Savings	$257	$343	$429

Table 11--Fuel requirements--Center pivot sprinkler irrigation per acre 1/

Energy Source	80% performance standard	100% performance standard	Fuel savings
Diesel fuel (gal)	54.0	48.6	5.4
LP gas (gal)	84.3	75.9	8.4
Natural gas (100 ft^3)	8,709.0	7,838.0	871.0
Electricity (kWh)	656.0	590.0	66.0

1/ Fischbach assumes total lift of 273 feet, 900 gallons per minute applying 15 acre-inches.

Table 12--Comparison of energy requirements of surface irrigation system with automated reuse system

Water and energy requirement	Gated pipe and siphon tubes	Automated with reuse system	Savings per acre
Usual water applied:	30 inches	20 inches	10 inches
Energy operating requirements:			
Electricity	572 kWh	381 kWh	191 kWh
Diesel fuel	46.4 gal	30.9 gal	15.5 gal
LP gas	73.3 gal	48.9 gal	24.4 gal
Natural gas	7,593 ft^3	5,062 ft^3	2,531 ft^3

SAVE ENERGY BY INSTALLING AUTOMATED GATED PIPE WITH REUSE IRRIGATION SYSTEM

A reduction in irrigation energy requirements can be attained when a surface irrigation system using gated pipe and siphon tubes is converted to automation with a reuse system. Gated pipe delivers water to the furrows. A reuse system returns runoff water to the head of the field and pneumatic valves shift from set to set at whatever time interval is dictated by soil conditions.

This conversion would cost about $5,000 for a 130-acre field. Assuming a 15-year life and 9 percent interest on borrowed capital, a fuel saving of $558.50 would offset these fixed costs. Calculations show that the autosurface system with reuse can save this amount of fuel when 30 inches of water is applied for the season. Natural gas power pumping and application is the only exception.

In addition to fuel saving, the reuse irrigation system reduces water use to about one-third of the gated pipe and siphon tube system. This can be very important in areas with limited water supplies.

A $550 SAVINGS in irrigation energy will pay for added annual fixed costs when converting to autosurface irrigation with reuse system

ENERGY SAVED on 130-acre field

<u>Electricity</u>
130 x 191 kWh = 24,830 kWh

<u>Diesel</u>
130 x 15.5 gal = 2,015 gal

<u>LP Gas</u>
130 x 24.4 gal = 2,172 gal

<u>Natural Gas</u>
130 x 2,531 ft^3 = 329,030 ft^3

<u>Dollars Saved at Various Electrical Rates</u>

Cents/kWh	3	4	5
Annual savings	$744.90	$993.20	$1,241.50

<u>Dollars Saved at Various Diesel Fuel Prices</u>

Cents/gal	40¢	45¢	50¢
Annual savings	$806.00	$906.75	$1,007.50

<u>Dollars Saved at Various LP Gas Prices</u>

Cents/gal	35¢	40¢	45¢
Annual savings	$1,110.20	$1,268.80	$1,427.40

<u>Dollars Saved at Various Natural Gas Prices</u>

Dollars (per 1,000 ft^3)	$1	$2	$4
Annual savings	$329.03	$658.06	$1,316.12

SAVE ENERGY BY IRRIGATING EVERY OTHER FURROW

SAVE about $150 of electrical or diesel energy by irrigating every other furrow instead of every furrow

Irrigating every other furrow rather than every furrow supplies water to one side of each row and waters more acres quicker. Less water pumped means less energy expended--a dual savings.

Wasteful overirrigation is prevented, and the system applies more nearly the correct amount of water.

Water seepage on only one side of each row leaves more storage space in root zones to soak up rainfall that otherwise might run off.

Watering every other furrow reduces by one-half the number of valves needed in an automatic system--another cost cut.

Research in Nebraska shows that irrigating every other furrow can save more than 4 inches of water per acre each season--a 30-percent reduction. It may reduce corn yields 5 percent, not significant compared with the savings.

Various irrigation treatments using automated gated pipe system with a reuse system--Nebraska (Sharpsburg silty clay loam) 1/

Item	Irrigating: Every furrow	Irrigating: Every other furrow (same)
Number of irrigations	6	6
Time of irrigations (hr)	2.0-3.5	2.3-5.0
Water irrigation (in)	2.1-3.8	1.4-2.9
Total water/season	14.9	10.7
Yield bu/acre 2/	170	161

1/ Total lift of 120 feet, 900 gal/min, 80 percent of Nebraska Performance Standards.

2/ Check plot nonirrigated--123 bu/acre.

Table 13--Irrigation energy used and cost per acre

Item	Irrigating		Savings per 100 acres
	Every furrow	Every other furrow (same)	
			Dollars
Electricity			
Kilowatt hours	142.3	102.2	120
@3¢	$4.27	$3.07	161
4¢	5.70	4.09	201
5¢	7.12	5.11	
Diesel			
Gallons	11.6	8.4	
@40¢	$4.64	$3.36	128
45¢	5.22	3.78	144
50¢	5.80	4.20	160
LP gas			
Gallons	18.2	13.1	
@35¢	$6.37	$4.59	178
40¢	7.28	5.24	204
45¢	8.19	5.90	229
Natural gas			
Cubic feet	1,884.9	1,353.6	
@1.00/ 1,000 ft^3	$1.88	$1.36	52
$2.00	3.77	2.71	106
$4.00	7.54	4.00	212

Rainfall 11.8 inches June 4-September 20.
Length of run 1,250 feet.

SAVE ENERGY BY USING AUTOMATIC TIMERS ON IRRIGATION PUMPS

SAVE $53 to $56 per year with automatic timers on irrigation pumps

Install timers to automatically switch off pumps and save considerable energy. Not only does it eliminate the need to get up and turn off a pump during inconvenient nighttime hours, but it also guards against overapplication of water, which can result in plant and soil damage and wasted energy.

Consider a situation where the pumps run unnecessarily 25 hours a year because there is no one to attend the cut-off switches. On a medium pressure well (60 psi) and a 200-foot lift with a system delivering 500 gallons per minute, $53 in energy savings could be realized annually with a diesel pump; $56 with an electric pump.

Automatic timers range in cost from $9 to $31 plus installation.

Calculations

25 hrs x 60 min x 500 gal/min = 750,000 gal pumped ÷ 326,000 gal/acre-feet = 2.3 acre-feet of water pumped

2.3 acre-feet x 51 gal diesel/acre-feet = 117.3 gallons diesel/fuel used

2.3 acre-feet x 610 kWh/acre-feet = 1,403 kilowatts used

<u>Dollars Saved at Various Diesel Prices</u>

Cents/gal	40¢	45¢	50¢
Annual savings	$47	$53	$59

<u>Dollars Saved at Various Electrical Rates</u>

Cents/kWh	3¢	4¢	5¢
Annual savings	$42	$56	$70

SAVE ENERGY BY PROPERLY MAINTAINING IRRIGATION EQUIPMENT

SAVE $115 to $122 per year on 40 acres of irrigated cropland

Keep irrigation equipment in top shape by repairing leaks in valves, pipes, and risers. There is no way that irrigation lines with squashed pipes, bullet holes, and split seams can operate at peak efficiency. Check gaskets in the sprinkler lines for leaks. Water-wasting leaky gaskets are easily replaced. Inspect sprinkler nozzles. They enlarge after being used a period of time and may apply water at a greater rate than the soil can accept it. Enlarged sprinkler nozzles also shorten the distance water is thrown, overload the pump, and cause pressure to drop, increasing the droplet size. Investigate the efficiency of the well. Clogged perforations or water screens at the water-bearing strata may inhibit water flow.

Inefficiencies in the irrigation system due to lack of maintenance may result in a 5-percent increase in the workload of the pump unit. On a 40-acre field using a medium power system (60 psi) and a 200-foot lift delivering 30 acre-inches per crop year, this can cause losses of $100 per year, or more.

Although costs of materials used in maintenance may well exceed energy cost savings, other benefits may accrue in better water distribution and increased equipment life.

Calculations

Pump 2.5 acre-feet of water x 51 gallons diesel/acre-feet = 127.5 gallons of diesel fuel per acre

127.5 x 5% pumping efficiency loss = 6.4 gal x 40 acres = 256 gallons diesel energy lost

Pump 2.5 acre-feet x 610 kWh/acre-feet = 1,525 kilowatts per acre

1,525 x 5% pumping efficiency loss = 3,050 kilowatt-hours lost

<u>Dollars Saved at Various Diesel Prices</u>

Cents/gal	40¢	45¢	50¢
Annual savings	$102	$115	$128

<u>Dollars Saved at Various Electrical Rates</u>

Cents/gal	3¢	4¢	5¢
Annual savings	$92	$122	$153

Over half of the U.S. field shelled corn crop is now dried with heated air, upping energy usage sharply compared with the natural air-drying of ear corn. Fuel consumption for tillage, planting, cultivation, and harvesting typically will use about 9-10 gallons of gasoline or diesel fuel per acre; drying 100 bushels of corn from 25- to 15-percent moisture requires 17 to 18 gallons of LP gas. With food and feed grain production increasing, and fossil fuels in even more critical supply, all energy used for drying grain has to be utilized to its best advantage.

There are several ways to reduce grain drying fuel requirements. Some options may involve more in-the-field drying, changing the type of fuel, changing the drying system, better management of the existing system, and the use of new technical developments such as solar heat.

Operation, Maintenance, and Planning

Because of varying drying conditions, different systems have evolved which can produce optimal drying energy (air temperature and air flow). Four major systems, ranked from high to low supplemental energy inputs, are: (1) high temperature-high air flow dryers; (2) medium temperature-air flow in-storage-bin drying; (3) low temperature in-bin drying; and (4) natural air drying.

Careful maintenance of drying equipment is important. The automation and design of high temperature dryers ease operation, but adjustments and housekeeping tasks need to be done. Not reviewing the dryer manufacturer's instruction book and following suggested maintenance practices can cause grain to be damaged, machinery ruined, and fuel wasted.

Any plan to expand or change a grain drying operation should be related to the harvesting rate. Selecting drying equipment with the capacity to meet the harvesting rate requires knowing the amount of moisture to be removed, the airflow rate, heat energy requirements, size of dryer or drying bin, and horsepower requirements. Compare drying alternatives because it is possible to satisfy the harvesting rate and the pocketbook while still saving on fuel consumption. A new drying operation will be of little use unless the system gets all the fuel it needs.

ENERGY CHECKLIST

Keep the dryer fan belts tight and replace those that are worn.

Adjust the dryer burner regularly for the best air-fuel mixture.

Periodically clean out all dryer air tunnels and perforated floors for maximum airflow.

Keep accurate records of fuel consumption and the maintenance routine to pinpoint areas where dryer management can be improved.

SAVE ENERGY BY BETTER PLANNING OF CORN HARVESTING SCHEDULE

SAVE about $200 by field drying 5,000 bushels of corn an additional 5 points before harvest.

The longer matured corn stands in the field, the greater the loss to bad weather. The natural impulse is to combine the field as fast and as soon as possible and get the crop into storage.

However, many corn producers could delay harvest a few days in the early fall when temperature and field drying often are ideal. Delaying harvest for a week or 10 days may mean harvesting 25- instead of 30-percent moisture corn. The farmer with large corn acreage may have to use every available day to harvest the crop and still do fall plowing. But a smaller producer may wait awhile and still get the crop into storage before bad weather occurs.

Harvesting the first 5,000 bushels at an average of 23- instead of 28-percent moisture can save over 400 gallons of LP gas. Also, the 23-percent corn will combine with less kernel damage and less loss than 30-percent corn. The cost of waiting may cause a little anxiety while the combine sits in the shed, but better corn and reduced fuel costs may be worthwhile.

It takes about 1.84 gallons of LP gas and 1.40 kilowatt-hours of electricity to remove 1 percent of the moisture from 100 bushels of corn, using a high-temperature farm dryer.

Situation

--Harvest 5,000 bushels corn
--Normal harvest moisture 28 percent
--Delay harvest to 23-percent moisture
--Use high-temperature batch dryer
--Energy per point removed
  LP gas - 0.0184 gal/bu
  Electricity - .0140 kWh/bu

Calculations

28 to 23% (5 points) x .0184 gal/bu = .092 x 5,000 bu = 460 gal LP gas.

5 points x .0140 kWh/bu = .07 kWh x 5,000 bu = 350 kWh

Energy dollars saved

Cents per kWh	Dollars	Cents per gallon	Dollars
3	11	35	161
4	14	40	184
5	18	45	207

SAVE ENERGY BY UTILIZING THE RIGHT COMBINATION OF GRAIN STORAGE BINS

A large storage bin costs less per bushel of capacity than a smaller one. For example, a 20,000-bushel bin with perforated floor and aeration fan presently costs about $12,000. Three 7,000-bushel bins similarly equipped cost about $15,000, or $3,000 more.

Buying a large grain bin can save money but it may cost more in extra drying expense. By using three small capacity bins and staggering grain drying requirements, energy and dollars can be saved.

When all the corn intended for feed goes into one bin, it all must be dried to the safe storage level of 13 or 14 percent. But corn can be stored satisfactorily at much higher moisture levels without spoilage if it can be kept cool. For example, 20-percent moisture corn can be stored about 60 days if it is cooled to 45°F. This can be accomplished by aerating with cool night air of the typical harvest season. Then it can be kept and fed out before warm weather comes.

Drying 20,000 bushels of corn in one large bin from 23.5 to 14 percent moisture for year-round storage requires about 3,881 gallons of LP gas and 3,164 kilowatt-hours of electricity.

Consider using three 7,000-bushel bins instead of one. Corn harvested early at 25 percent moisture is dried to 14 percent and put in one bin for summer feeding. Midharvest corn at 23 percent is dried to 18 percent, cooled in a bin and kept for spring feeding. Late harvest corn, with 20 percent moisture, is put directly from the combine into the third bin and cooled with natural air and fed during winter. Aeration is necessary for all corn regardless f moisture or bin size.

SAVE $500 by using a three-bin storage system	for corn to be fed on the farm

Calculations

Harvest 20,000 bu of 23.5% moisture corn
Dry to 14.0% moisture for safe storage
Use high-temperature batch or continuous flow dryer
Energy required to dry 100 bushels
1.84 gal of LP gas per moisture point removed
1.40 kWh of electrical energy per point removed

One-Bin System

Moisture removed 23.5 - 14.0 = 9.5 points
9.5 x 1.84 gal x 200.0 = 3,496 gal of LP
9.5 x 1.40 kWh x 200.0 = 2,660 kWh

Three-Bin Grain Storage System

Summer-fed corn--6,670 bu harvested at 25% moisture
Spring-fed corn--6,670 bu harvested at 23% moisture
Winter-fed corn--6,670 bu harvested at 20% moisture

Summer: 25- 14 = 11 points
11.0 x 1.84 gal x 67.7 = 1,370
11.0 x 1.40 kWh x 67.7 = 1,042

Spring: 23 - 18 = 5 points
5.0 x 1.84 gal x 67.7 = 623
5.0 x 1.40 kWh x 67.7 = 474

Winter: No drying

Total energy use: 1,993 gal LP gas and 1,516 kWh electricity
Energy saved three-bin system over one bin system: 1,503 gal LP and 1,144 kWh

continued next page

continued from page 30

Dollars Saved by Various Prices for LP Gas and Electricity

Cents/kWh	3	4	5
Annual savings (electricity)	34	46	57
Cents/gal (LP gas)	35	40	45
Annual savings (LP gas)	526	601	676

SAVE ENERGY BY FEEDING HIGH MOISTURE CORN

Drying corn is not necessary if it is to be fed to livestock, particularly beef cattle. Corn containing 20- to 25-percent moisture is just as good if not better in a beef cattle feed ration. But wet corn eventually will spoil and be no good as feed so corn drying prolongs the storable time.

High-moisture corn can be placed in an airtight storage structure and preserved through fermentation. Even a horizontal silo will work when air is totally excluded. Tight walls, coarse grinding to allow firm packing, a plastic cover, and perhaps a surface preservative such as sodium metabisulfide are necessary to exclude all air.

Propionic acid allows preservation of high-moisture corn without fermentation. The acid is sprayed on high-moisture corn as it goes into the storage bin. Bins need not be airtight, so existing dry corn storage structures can be used.

Ensiling is another way of keeping wet corn from spoiling. New investments and other costs may be involved, and there is a possible increase of loss through careless management. Weigh the options carefully before making a change.

Limit the use of the high-temperature batch dryer. Place a good share of the corn intended for feed into wet grain storage facilities and see the energy saving. Suppose 150 steer calves are finished to slaughter weight with 8,430 bushels of No. 2 dry corn, equivalent to 9,660 bushels of 26-percent moisture corn. To dry this corn to 15.5-percent moisture would require about 1,738 gallons of LP gas and 1,352 kilowatt-hours of electricity using a medium capacity high-temperature batch or continuous flow dryer.

SAVE $649 by not drying 9,660 bushels of corn to be fed to 150 beef cattle

Calculations

Drying grain with high-temperature batch or continuous flow dryer.
Corn harvested--9,660 bushels, 25.5% moisture.
Water removed--25.5% to 15.5% = 7.9 lb/bu.
Energy required--2,050 Btu per lb of water removed.
Energy in LP gas--90,000 Btu per gallon

Dryer Fuel

2,050 Btu x 7.9 lb/bu = 16,195 Btu/bu to remove 10 points moisture
16,195 x 9,600 = 156,443,700 Btu to obtain 8,430 bu No. 2 dried corn
156,443,700 ÷ 90,000 = 1,738 gal LP gas

Fan Operation

9,660 bu x 0.14 kWh per bushel to remove 10 points = 1,352 kWh

Dollars Saved at Various LP Gas Prices

Cents/gal	35¢	40¢	45¢	50¢
Annual savings	$608	$695	$782	$869

Dollars Saved at Various Electricity Rates

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$41	$54	$68	$81

SAVE ENERGY BY PARTIAL GRAIN DRYING

SAVE $706 (3.5 cents per bushel) by partial drying of corn rather than complete drying

Grain does not have to be dried completely as soon as it is harvested: Half the fuel needed to dry grain all the way can be saved by using partially heated air followed by natural air drying. Fast drying with high temperature and high air flows, to make dryers keep up with harvesters may waste energy.

This system works by removing the first 5 moisture points at high-energy expenditures and then running aeration fans continuously to remove additional moisture and to cool the grain to a safe storage level.

Dryers have to be carefully managed with all pertinent factors taken into consideration, i.e., grain moisture content, foreign material content, proper cfm/bu the ambient air temperature, and humidity.

Table 14 illustrates fuel savings with partial drying but also shows that partial drying takes longer.

Situation

20,000 bushels corn, 26% moisture
Dry to 15.5% = 0.21 gal LP gas and 0.14 kWh per bushel
Dry to 21.0% = 0.10 gal LP gas and 0.22 kWh per bushel

Energy to dry to 15.5%

LP gas: 20,000 bu x .21 = 4,200 gal
Electricity: 20,000 bu x .14 = 2,800 kWh

Energy to dry to 21.0%

LP gas: 20,000 x .10 = 2,000 gal
Electricity: 20,000 bu x .22 = 4,400 kWh

Energy Dollars Saved

4,200 - 2,000 = 2,200 gal x $.35/gal = $770 reduced LP gas cost

4,400 - 2,800 = 1,600 kWh x $.04/kWh = $64 increased electrical cost

40

Table 14--Fuel comparison for complete and partial dry at high temperatures

Moisture reduction pct. wet basis	Heat energy Btu/bu	Drying time hours	Gallon of LP gas per bushel 4/
26 - 15.5 1/	19,200	2.8	.21
26 - 21.0 1/	8,900	1.2	.10
Savings of partial over complete drying	+54%	-57%	
26 - 15.2 2/	13,900	10.6	.15
26 - 21.0 2/	7,100	5.4	.08
Savings of partial over complete drying	+49%	-49%	
26 - 15.5 3/	12,400	19.0	.14
26 - 21.0 3/	6,150	9.3	.07
Savings of partial over complete drying	+50%	-51%	

1/ Column batch or continuous flow dryer with 50 cfm/bu at 180°.
2/ Batch-in-bin, 3-foot-deep batch, 10 cfm/bu at 180°.
3/ Batch-in-bin, 3-foot-deep batch, 10 cfm/bu at 120°.
4/ About 90,000 Btu per gallon of LP gas.

Source: (17).

The amount and type of energy used to produce, harvest, and cure tobacco varies considerably by type of tobacco. Essentially, the curing process (gradual drying of fresh leaves under controlled conditions of temperature, humidity, and air supply) for flue-cured tobacco is by far the greatest energy user. More than 80 percent of the fuel used in flue-cured tobacco production is for curing.

Both LP gas and fuel oil are used as the heat sources for curing. About 70 percent of the production is cured with LP gas and the remainder with oil. About 390 gallons of LP gas or 328 gallons of fuel oil are required to cure the amount of tobacco produced on an acre. This translates into 165 million gallons of LP and 65 million gallons of fuel oil for curing the national flue-cured tobacco crop. In addition, about 100 million kWh of electricity are used.

Can fuel consumption for tobacco curing be reduced? Yes. More concern with the operation and temperature control in both conventional and bulk barns may save 20 to 30 percent of curing fuel.

Before buying or building a new curing barn, ask the manufacturer about heat conversion efficiencies of various makes and models. Also check with neighbors who own the type being considered. In general, the newer bulk barns are more efficient if manufacturers' operating and maintenance suggestions are followed.

Excessive use of fuel while curing flue-cured tobacco arises primarily because of improper damper control and ventilation, low heat conversion efficiency, and inadequate barn insulation. Improper barn damper and ventilation control may add as much as $40 per acre to the production costs. Investment in a good hydrometer (wet bulb thermometer) will help achieve proper ventilation at the right time.

ENERGY CHECKLIST

Firing Up.

Close intake dampers before heat is turned on.

Raise heater temperature to yellowing range gradually.

Do not raise temperature more than 5 degrees at any one time.

Allow about 30 minutes between temperature rises for curing air to become humid.

Yellowing

Yellow at 95 to 105 degrees and high humidity.

Adjust dampers so they are almost closed to prevent color setting before desired.

Crack dampers open to the maximum extent short of color setting for fuel economy and the best cure.

Extend the yellowing period in down-draft barns (hot air enters at the top of the curing compartment and moves downward through the tobacco) 6 to 12 hours longer than in up-draft barns.

Leaf Drying

Raise temperatures slowly, two degrees per hour to the critical drying temperature (110-135°F).

Keep dampers open enough to hold the wet bulb temperature below 105 degrees throughout leaf drying.

Consider a wet bulb reading of 110 degrees--it would require less fuel but there is a greater chance of sponging or scalding.

Stem Drying

Raise temperature gradually (2 to 3 degrees per hour) to 170 degrees after leaf is dry.

Close dampers enough to hold wet bulb temperature down to 110 degrees during first 12 to 18 hours.

Gradually close dampers as drying proceeds until temperature reaches 170 degrees. (22)

SAVE ENERGY THROUGH PROPER VENTILATION WHEN STEM DRYING BULK-CURED TOBACCO

Correct curing of flue-cured tobacco is essential if maximum returns are to be obtained. However, the correct cure may take less fuel.

When dampers are left wide open during the stem drying stage of curing, heat loss may add $20 per acre to production costs. Much of the hot air that is blasted out during this curing stage could be retained without affecting the cure. The dampers should be open only enough to hold the wet bulb temperature at 110 degrees during the first 12 to 18 hours of stem drying. Then they should be completely closed.

Improper damper control throughout an operation could waste several hundred dollars' worth of energy. Install a hydrometer to assure correct relative humidity so that ventilation can be regulated to assure minimum use of fuel. Use barely enough fuel to prevent scalding and sponging.

Over $200 saved with proper damper control during tobacco stem drying

Situation

Harvest 30,000 pounds of flue-cured tobacco.

Cured in bulk-curing barns.

Fuel required

Inadequate damper control
18 gallons per 100 pounds

Adequate damper control
16 gallons per 100 pounds

300 cwt x 2 gallons = 600 gallons

600 gallons x 40¢ = $240 savings

Dollars Saved at Various LP Gas Prices

Cents/gal	35¢	40¢	45¢
Annual savings	$210	$240	$270

Forage--grassland pasture, hay, green crop silage, and stover--is the mainstay of the U.S. livestock industry. Forage accounts for about 70 percent of all livestock feed. Dairy cattle alone consume about 60 percent of their feed ration as forage. Livestock producers, facing increased supplemental feed costs, have come to more fully appreciate the economies of excellent pasture and high-quality hay crops.

While nearly 700 million acres of U.S. land area is grassland pasture or range, about 60 million acres are used to produce hay and 11 million, crop silage. About 130 million tons of hay are harvested from the 60 million acres.

Forage production requires considerable energy input (table 3). Harvesting operations lead the list. Much fuel is used for alfalfa irrigation systems and even more energy goes into applying fertilizer to hay cropland. Manufacturing 100 pounds of nitrogen (ammonium nitrate) requires about 3,000 cubic feet of natural gas.

Fuel requirements for producing baled hay from 3 cuttings under average conditions are estimated at 12 gallons of gasoline per acre. If all the Nation's 60 million acres of hay croplands were cut and harvested an average of only 1½ times, a year's hay crop would require the equivalent of 360 million gallons of gasoline. This haying energy can be used more wisely. There are a number of different haying technologies available. Hay can be put up in conventional bales, in large rolls, put in stacks, or be chopped. Each method has a unique set of equipment with differing energy requirements ranging from 1 to 3 gallons of gasoline equivalent per hay ton. It is important therefore to heed the manufacturers' suggestions on the best ways to use and maintain the machinery.

ENERGY CHECKLIST

Use of mower-conditioner-windrower will eliminate two trips and save at least 50 percent of fuel compared to separate trips for cutting, conditioning, and raking.

Sharpen forage harvester knives regularly and turn shear bar as needed to save 20 to 30 percent of fuel and do better work.

Keep knife to shear bar setting as close as possible and check often.

Run forage harvester at rated pto speed only. Overspeeding can increase power used per ton chopped by 25 percent or more.

Run silo blower at rated pto speed. Overspeeding wastes power here, too.

Keep blowers in good condition. Blade tip clearance should be adjusted to about 0.06 inch, or so they will move a nickel but leave a dime.

Add some water at the blower when putting up haylage. This can reduce power needs by 10 to 20 percent and improve elevation under some conditions.

Consider using an electric motor when replacing a tractor-powered blower. Check with power supplier for proper size.

Use proper size tires, correctly inflated, on wagons to reduce rolling resistance.

Keep road speeds under 15 mph for safety and to save fuel.

Maintain belt tension to eliminate slippage.

FUEL CONSUMPTION--HAY HARVESTING, NORTHERN GREAT PLAINS

Because sizable amounts of energy are used in harvesting forage crops, efforts should be made to conserve fuels. The checklist covers energy-saving tips for equipment and maintenance.

In addition, what about the various ways to package hay? Comparison of hay harvesting methods shows quite a variation in fuel consumption. However, it is difficult to say that one particular system is a greater fuel saver because of the variety of ways to handle hay and the many machinery types and capacities.

The advent of large hay packaging systems, rolls and stacks, reduces labor needs and helps shorten hay harvesting time. These cost savers make hay harvesting more economical than haying with conventional bales. However, they take more fuel.

Accompanying examples of harvesting systems illustrate average fuel consumption rates for different machinery operations. It may not be justifiable to promote the adoption of one system over another solely on the basis of fuel conservation. But, be aware that some fuel savings can result when hay harvesting procedures are changed.

Notice that a self-propelled swather (systems 3 and 4) will reduce fuel use per ton by more than one-half over the two separate operations of mowing and raking in systems 1 and 2.

Remember that, although the newer large hay packaging machines use more gallons of fuel, they can cut fuel costs per ton produced because they work faster.

Put up low-moisture silage to 55- to 65-percent moisture so feed value is not wasted in heating or in seepage. (3)

Hay harvesting is a heavy fuel consumer on the farm. Do something about better fuel utilization and save money.

43

Examples based upon hay cutting $1\frac{1}{4}$ tons per acre. Hay hauling not included, except haylage.

	Gallons of gasoline per:		
	Hour	Acre	Ton
System 1--hay baling			
Mow 7'	1.38	0.46	0.368
Rake	3.20	0.40	0.320
Bale pto, standard	4.67	0.73	0.584
Total gallons	9.27	1.59	1.272
System 2--hay baling			
Mow 7'	1.38	0.46	0.368
Rake	3.20	0.40	0.320
Bale pto, large roll	6.00	0.80	0.640
Total gallons	10.58	1.66	1.328
System 3--hay baling			
Swath 14' SP	3.20	0.40	0.320
Bale pto, standard	4.67	0.73	0.584
Total gallons	7.87	1.13	0.904
System 4--hay baling			
Swath 14' SP	3.20	0.40	0.320
Bale pto, large roll	6.00	0.80	0.640
Total gallons	9.20	1.20	0.960
System 5--haylage			
Swath 14' SP	3.20	0.40	0.320
Forage harvester	24.00	3.00	2.400
Total gallons	27.20	3.40	2.720
System 6--loose hay			
Mow 7'	1.38	0.46	0.368
Rake	3.20	0.40	0.320
Loose hay stacker--3 ton	7.80	1.50	1.200
Total gallons	12.38	2.36	1.888
System 7--loose hay			
Swath 14' SP	3.20	0.40	0.320
Loose hay stacker--3 ton	7.80	1.50	1.200
Total gallons	11.00	1.90	1.520

To get the most out of tractors and trucks for each gallon of fuel used, maintain engines properly. Equally important, manage work routines that involve tractors and trucks.

Only a thorough work analysis can help rid a farming operation of fuel waste. There are pitfalls common to many operations. Some of the following examples may point out fuel wasters that may not have occurred to you. Most are easy to correct once discovered.

When fuel saving is the result of reduced operating time, as is usually the case, more dollar savings are likely in nonfuel costs such as labor, repairs, oil, grease, and tires. These savings may be greater than those through fuel use reduction.

TRACTOR AND TRUCK USE

SAVE ENERGY BY REVAMPING THE FARM TRUCK BED TO HAUL MORE HAY

SAVE $13 worth of gasoline transporting hay

It may be necessary to haul baled hay a considerable distance to the barn or stack lot. It will pay to increase the load per haul, not by overloading, which can be dangerous, but by increasing the truck's capacity.

Suppose a feeding operation consumes 225 tons of hay per year, of which 68 tons must be transported 30 miles. The standard farm truck can be loaded to carry 112 bales weighing 70 pounds or a load of 3.9 tons. Total distance traveled to move the hay is 1,080 miles at 9 miles per gallon. Gasoline use is 120 gallons.

By adding an overshot on the cab and a three-foot extension on the truck bed rear, the load can be increased to 154 bales or 5.4 tons. An overshot and bed extension may cost $100 to $200. Total hay moving mileage drops to 780 miles and gasoline to about 98 gallons.

Calculations

Flatbed truck only:

112 bales x 70 lb = 3.9 tons/load
68 tons to move ÷ 3.9 = 18 loads
18 loads x 60 miles = 1,080 miles
1,080 miles ÷ 8 mpg = 135 gallons

Flatbed truck with expanded hauling bed:

154 bales x 70 lb = 5.4 tons/load
68 tons to move ÷ 5.4 = 13 loads
13 loads x 60 miles = 780 miles
780 miles ÷ 7 mpg = 24 gallons

135 gal - 111 gal = 24 gallons saved

Dollars Saved at Various Gasoline Prices

Cents/gal	55¢	60¢	65¢
Annual savings	$13	$14	$16

SAVE ENERGY THROUGH CHOICE OF TRACTOR FUELS

SAVE $600 per year using a 75-hp diesel tractor versus a gasoline tractor

Every farmer and rancher should be familiar with the efficiency of the various kinds of tractor fuels, including diesel, gasoline, and LP gas. Most tractors now on the market, even many of the smaller sized units, use diesel fuel, but a rather wide selection of gasoline-powered tractors and some tractors that operate on LP gas are available.

A rule of thumb: Given the horsepower and running time, a diesel tractor will use 0.7 as many gallons of fuel as a gasoline tractor; an LP gas tractor will use 1.2 times as many gallons. Not only are there differences in fuel requirements for a given power output, but there are differences in the cost and relative availability of the three different kinds of fuels. All advantages point toward the diesel-powered tractors. When it is time to trade for newer machines give strong consideration to moving toward diesel for all tractors.

The following example shows the difference in fuel requirements and costs using similar farm tractors but different fuel types.

<u>Calculations</u>

75-hp gasoline, diesel, and LP gas tractor.

Average 50-hp output--full engine speed

500 hours running time

<u>Gasoline tractor</u>

500 hrs x 5.35 gal/hr = 2,675 gal

2,675 x $.50/gal = $1,338

2,675 x $.55/gal = $1,471

<u>Diesel tractor</u>

2,675 gal x .70 = 1,870 gal

1,870 x $.40/gal = $748

1,870 x $.45/gal = $842

<u>LP gas tractor</u>

2,675 gal x 1.2 = 3,210 gal

3,210 x $.35/gal = $1,124

3,210 x $.40/gal = $1,284

SAVE ENERGY THROUGH ECONOMICAL USE OF A PICKUP TRUCK

Farmers and ranchers usually drive their pickup trucks 5,000 to 15,000 miles per year. Such a vehicle is both a necessity and a luxury. But its speed often compensates for lack of planning and judgment.

When gasoline was cheap and plentiful, little thought or question was given to the pickup's use. Now, with energy conservation an important national policy and gasoline costs rising, some careful thought should be given to using it more wisely.

The best energy conservation measure is to use common sense in applying work simplification principles. Asking whether each trip is necessary can result in the most productive method of conserving fuel. How many times is one job done on each of several trips when a little thought could have combined all jobs into one trip? How often has it been necessary to return to the machine shop from a field miles away for an inexpensive wrench or tool when proper planning would have had the tool in the pickup or on the machine needing adjustment? How many times have you driven around town in search of a part when a few phone calls would have directed you to the right place at the outset?

Careful planning of work probably could cut in half the miles a pickup truck is used on most farms and ranches. Even minimal planning easily could result in 10 percent reduced travel.

Modest speeds also are recommended to minimize fuel use. Driving around the farm at 20 or 25 mph will get many more miles per gallon than 50 or 60 mph.

SAVE $55 of gasoline by wise use of farm pickup truck

<u>Situation</u>

Drive pickup 10,000 miles per year. Try to do same jobs driving 9,000 miles.

<u>Calculations</u>

10,000 miles x 10% = 1,000 miles
1,000 miles ÷ 10 mpg = 100 gallons saved

<u>Dollars Saved at Various Gasoline Prices</u>

Cents/gal	50¢	55¢	60¢
Annual savings	$50	$55	$60

50

SAVE ENERGY BY REDUCING TRACTOR IDLING TIME

SAVE $15 of diesel fuel per year; eliminate unnecessary tractor idling

The typical farmer does many jobs with the tractor in his daily routine. He must be a jack-of-all trades and continually look for problems that may arise.

Turn off the tractor engine when side trips are to be made. An idling engine does not use much fuel, but even this much shouldn't be wasted.

How much time is the tractor engine left idling during the course of an average day? Five minutes? Ten minutes? Fifteen minutes?

Suppose the tractor engine is left idling for 10 minutes during an average day. That is not much time, but during the course of a year it amounts to 61 hours. Sixty-one hours of idling on a 75-horsepower diesel tractor will use about 30 gallons of fuel.

The remedy is simple. Become conscious of the fuel that is wasted by an idling engine. Make it a habit to turn off the tractor engine when attending to other nearby work. Some things will occur unexpectedly and it will not be possible to turn off the tractor engine without making a special trip to do so. On routine matters, however, try to turn the engine off when it is certain that you will work a few minutes away from the tractor.

Situation

Unnecessary tractor idling average 10 minutes per day

Calculations

10 min x 365 = 3,650 min

3,650 min ÷ 60 = 61 hrs

61 hrs x 0.5 gal/hr = 30 gal

Dollars Saved at Various Diesel Fuel Prices

Cents/gal	40¢	45¢	50¢
Annual savings	$12	$13.50	$15

SAVE ENERGY BY MATCHING TRACTOR SIZE TO LOAD

Using a larger tractor than necessary wastes fuel, especially for mobile operations. It takes more horsepower and more fuel just for the larger tractor to move its own weight over a field. Also, engines may have to be operated at "standard" speed to generate the necessary rpm for pto operation even if the extra power is not needed.

Suppose the job is spreading manure. It takes 100 hours a year. A 75-horsepower tractor could do the job, but a 125-horsepower tractor is used. It will take 24-horsepower to roll the 75-horsepower tractor at 6 mph over a fair surface; the 125-horsepower tractor will use 34-horsepower just to roll its own weight--10-horsepower more than the smaller tractor. Rolling the extra weight and operating the bigger engine will take 1.0 to 1.5 more gallons of fuel per hour, depending on the engine speed. This could waste $50 or more a year.

SAVE $56.25 per year for 100 hours of tractor use

Calculations

100 hours x average 1.25 gal/hr = 125 gal

125 gal x $.45/gal = $56.25

Dollars Saved at Various Diesel Fuel Prices

Cents/gal	40¢	45¢	50¢	55¢
Annual savings	$50.00	$56.25	$62.50	$68.75

52

SAVE ENERGY BY USING THE MOST EFFICIENT VEHICLE FOR GENERAL FARM TRAVEL

Fuel can be saved by using the vehicle which accomplishes the job with the greatest gasoline efficiency. For example, a trip to town may not require the transportation of any commodity. So use the family car which gets better gas mileage than the pickup. Many such opportunities to save fuel may occur throughout the year.

SAVE $14.30 per 1,000 miles driven by changing from a vehicle that gets 14 miles per gallon to one that gets 22 miles per gallon

Gasoline consumption/1,000 miles driven at different levels of fuel efficiency

Fuel consumption in miles/gallon	10	14	18	22	24
Gallons consumed/1,000 miles driven	100	71	56	45	42

Gasoline price	Energy cost dollars/1000 miles				
$.50/gal	50.00	35.50	28.00	22.50	21.00
$.55/gal	55.00	39.05	30.80	24.75	23.10
$.60/gal	60.00	42.60	33.60	27.00	25.20
$.65/gal	65.00	46.15	36.40	29.25	27.30

The amount of gasoline and diesel fuel used directly in the production of field crops varies widely. Land preparation may be the same for different crops in one region and still different for the same crops in another region. So it is with tilling and harvesting systems. Generally it is hard to pinpoint which system or method of doing things is more energy efficient in "total."

Simple savings of fuel begin even before you start your tractor, truck, or car, with pre-operational checks. The way a vehicle is operated also can save fuel without changing the amount of work or the way it is done. Finally, periodic examinations and check-ups will increase the life of your machinery as well as save energy.

There are several ways to save energy consumed in gasoline and diesel engines.

ENERGY CHECKLIST

Check tank, lines, fuel pump, and carburetor for leaks.

Allowing the tank to stand empty, especially in winter, causes moisture condensation.

When filling the tank, leave room for expansion.

Maintain dispensing records by vehicle and by task performed. This can identify high and wasteful usage.

Avoid excessive warmups in winter.

Minimize idling; it can consume 15 to 20 percent of the fuel used.

Don't leave the choke out.

Let out the clutch slowly; quick starts waste fuel and are hard on equipment.

Run tractors in the proper gear for the load and condition. Improper shifting and use of the wrong gear can result in a 5-percent fuel loss.

Be sure the thermostat works properly.

Maintain proper fuel mixture; too rich a mixture wastes fuel, as does too lean a mixture, prompting excessive choke use.

Have regularly scheduled tuneups, a practice which can save up to 10 percent on fuel usage.

Keep the tires of tractors and other implements properly inflated for the task being performed.

Check for improper lubrication, loose fan belt, or low oil-level--all three increase fuel consumption.

Consider the purchase of a diesel unit when shopping for a new tractor or truck. Diesel engines use approximately one-fourth fewer Btu per horsepower generated, which means roughly one-fourth fewer gallons of fuel.

Consider electronic ignition and radial tires when buying a new car or pickup because they provide 15 to 20 percent better fuel economy. Nebraska tests have shown that tractors with all gear power transmissions are 25 percent more efficient on fuel than hydraulic drives even at reduced engine speed and part load as well as at full load. This consideration partly offsets the greater convenience of hydrostatic transmission.

SAVE ENERGY BY CHECKING THERMOSTAT AND ENGINE TEMPERATURE

$9.60 energy saving per winter season per operating tractor

Be sure the thermostat is functioning properly so the engine warms up quickly, especially in winter. Fuel consumption increases by approximately 25 percent when the engine is operating at 100°F instead of 180°F.

If the tractor thermostat is stuck open during the winter, the tractor may operate at 100°F or less no matter how long it is used. Assuming the tractor is used 40 hours during the 3 coldest months of the year, a properly functioning thermostat could save $12.60. A new thermostat costs about $3.

Engine operating temperature	Gallons of fuel consumed per hour
100°F	3.5
140°F	3.2
160°F	2.9
180°F	2.8

Calculations

0.7 gallons/hour x 40 hours x $0.45/gallon = $12.60/season

$12.60 - $3.00 (thermostat) = $9.60 (savings)

Dollars Saved at Various Diesel Fuel Prices

Cents/gal	40¢	45¢	50¢	55¢
Annual savings	$8.20	$9.60	$11.00	$12.40

SAVE ENERGY BY FIXING A LEAKING CARBURETOR.

$8.25 energy savings per month

A slowly dripping carburetor can waste 0.5 to 1.5 gallons of gas per day. This is considerably less than a dripping water faucet under pressure. This kind of leak is much less noticeable, but even moderate amounts of leakage are costly.

Suppose the carburetor on a tractor starts leaking and it is not fixed for a month. This wastes at least 15 gallons of gasoline.

Calculations

0.5 gallons/day x 30 days x $0.55/gal = $8.25

Dollars Saved at Various Gasoline Prices

Cents/gal	50	55	60	65
Monthly savings	$7.50	$8.25	$9.00	$9.75

GASOLINE AND DIESEL ENGINES

SAVE ENERGY BY FIXING MISFIRING GASOLINE TRACTOR ENGINE

$24.75 energy saving per year for 100 hours of tractor use

One fouled spark plug can cause 10 to 15 percent more fuel to be used during a given task. Using a 50-horsepower gasoline tractor at full load and full engine speed, with the engine "missing," could cost an extra 45 or more gallons of fuel in 100 hours. This would mean $22.50 to $29.25 wasted, perhaps more.

If this same tractor is used for most cropping tasks, savings from correcting the misfiring engine will be much greater.

Calculations

4.5 gallons/hour x 100 hours = 450 gallons.
10 percent x 450 gallons = 45 gallons

Dollars Saved at Various Gasoline Prices

Cents/gal	50¢	55¢	60¢	65¢
Annual saving	$22.50	$24.50	$27.00	$29.25

To conserve energy, first know how much electricity, gasoline, and other fuels are used on the farm. The following set of energy recorders can help keep track of total energy used and also help determine the amount of energy used by each machine.

ELECTRICITY -- RECORDER NO. 1

Each year more farm production operations are switching from tractor to electric power. Electric motors already power many livestock and dairy operations. In field crop production, electrical energy use is small compared to all the fossil fuel energy input. Irrigation and crop drying, storing, and handling probably consume the largest share of electrical energy used in crop production.

On Recorder No. 1, record the kilowatt hours (kWh) from the monthly utility bill. If any farming activity (livestock facility, crop dryer, farmstead, etc.) has a separate meter, enter that kWh amount directly to the proper column.

Next, make an allowance for home use and enter the kWh in the second column. Typically, farm home lights and appliances use 500-600 kWh per month. This includes an electric range but not an electric water heater, home heater, or air conditioning. A hot shower may require about 10 kWh to heat the water and an oil or gas furnace about 0.6 kWh for each gallon of fuel burned. If further estimates are necessary, consult the average values for specific appliance use in table 15.

After deducting electricity used in the home, assign the remaining kWh to farming operations. In dividing the kWh use between various farming activities (last two columns of Recorder No. 1), estimate the electricity use for the most definitive activity, i.e., a motor(s) or heater(s) or power source(s) can be charged to a specific activity. For example, the horsepower of fan motors, estimated operating hours, and the kWh usage table can be used to calculate electricity used in grain drying. Account for all the electricity used in farming operations.

LP OR NATURAL GAS -- RECORDER NO. 2

More and more gas is being used to heat livestock buildings, dry crops, and pump irrigation water. Recorder No. 2 is set up to handle one type of gas (LP or natural). Two record sheets could be used if both types of gas are used. If all gas comes from one tank and meter, estimate the gas used in the home and deduct from the total to obtain the quantity used for farming. A separate supply and meter often are used for livestock, grain drying, and irrigation. Recording the gas used in these operations helps to understand fuel consumption per unit of output and can help pinpoint excessive energy use.

RECORDER NO. 1

Electricity Use Record 197_

Month and year	Total kWh 1/	kWh for home use 2/	kWh for livestock 3/	kWh for other farm work 3/
Jan.				
Feb.				
Mar.				
Apr.				
May				
June				
July				
Aug.				
Sept.				
Oct.				
Nov.				
Dec.				
Year				

1/ Record from monthly utility bill. Only column 3 will be necessary if livestock are served through a separate meter.

2/ Record an allowance for home use, typically 500 to 600 kWh per month excluding air conditioning and electric heat. See table 15 for guides on selected home equipment.

3/ Estimate kWh of electricity either for livestock or other farm purposes, whichever is the easiest, and assign the remainder to the use not estimated. For example, much electric power often is used in grain drying where both motor size and hours of operation are known. After deducting electricity for home use, the remainder (minus that for grain drying, a little for the shop and a yard light), would be chargeable to livestock.

RECORDER NO. 2

LP or Natural Gas Use Record 197_

Month and year	Total gallons (or cubic feet) 1/	Gallons for livestock (or cubic feet) 2/	Gallons for other farm work (or cubic feet) 2/
Jan.			
Feb.			
Mar.			
Apr.			
May			
June			
July			
Aug.			
Sept.			
Oct.			
Nov.			
Dec.			
Year			

1/ Read tank guage or meter. Deduct amount for home use if both farm and home use are from the same supply.

2/ Estimate the use for which evidence is clearest and leave the remainder for the other. For example, other farmwork may be grain drying for which both hours of use and gas consumption per hour are easily figured. Charge the remainder to livestock.

TRACTOR FUEL - RECORDER NO. 3

The tractor warrants diligent record-keeping of the fuel it consumes. A record on each tractor shows the fuel used on each job and serves as a reminder of periodic maintenance needs.

The record: List each tractor by type of fuel. Record the date, the hour, and gallons added at each fuel filling. Then note the estimated hours driven since the last fueling and compute the fuel used per hour. Keep Recorder No. 3 in a notebook stored at the fuel supply point. The routine of keeping this record takes little time and really can help make energy-saving decisions.

TRUCK AND AUTOMOBILE FUEL-RECORDER NO. 4

A record of fuel used by each truck and automobile can be useful for the same reasons that apply to tractors. Keep a record for each vehicle; record the date, odometer reading, and gallons of fuel at each filling. Recollect and note the primary use of the vehicle since the last filling, such as a pleasure trip, hauling livestock, or hauling grain. Over a period of time, this record indicates which vehicle uses the most fuel per mile and points the way to savings.

RECORDER NO. 3

RECORDKEEPING SAMPLE

ctor Fuel Use Record 197_

Date filled	Tractor No. 1 (D or G) 1/				Tractor No. 2 (D or G) 1/			
			Fuel				Fuel	
	Hour reading 2/	Hours use	Total	Per hour	Hour reading	Hours use	Total	Per hour
		(hr)	(gal)	(gal)		(hr)	(gal)	(gal)
Jan. 3	1680	10.0	35.0	3.5				
Jan. 6	1690							
Jan. 10								
–								
–								
–								
Year								

1/ Record fuel used--diesel, gasoline, or LP gas.

2/ At first filling, record hour reading and gallons of fuel added. At next filling, record new hour reading, figure operating time and fuel use per hour. Continue as running record and compute totals and averages the year.

RECORDER NO. 4

Truck and Auto Fuel Use Record 197_

Date filled	Truck No. 1 (D or G)				Truck No. 2 (D or G)			
	Odometer reading	Miles	Fuel Total	Fuel Miles per gal	Odometer reading	Miles	Fuel Total	Fuel Miles per gal
		(No)	(gal)	(No)		(No)	(gal)	(No)
Jan. 7	8200	160	20.0	8.0				
Jan. 12	8360							
Year								

1/ Record fuel used--gasoline, diesel, or LP gas.

2/ At first filling, record odometer reading and gallons of fuel added. At next filling, record new odometer reading, figure miles traveled and miles per gallon of fuel. Continue a running record and compute totals and averages for the year.

BTU ACCOUNTING

The producer can convert the quantities of different types of fuel used on his farm to a common measure, the Btu of energy used with the aid of the conversion factors in the tabulation below. The producer may find this measure useful when comparing total energy use from year to year or month to month or when comparing alternative equipment or practices in terms of energy use where more than one type of fuel is involved. For example, if one used 4,000 gallons of propane, 500 gallons of regular gasoline, and 25,000 kilowatt hours of electricity last year, the total energy use in Btu would be 515.3 million Btu. The calculations follow:

4,000 gallons propane x 92,000 Btu/gal	= 368,000,000
500 gallons reg. gasoline x 124,000 Btu/gal	= 62,000,000
25,000 kWh x 3,412 Btu/kWh	= 85,300,000
Total Btu	515,300,000

Btu Conversion Factors

Gasoline (regular)	6.12 lb/gal	124,000 Btu/gal
Diesel fuel (no. 2)	7.07 lb/gal	140,000 Btu/gal
Propane	4.25 lb/gal	92,000 Btu/gal
Natural gas		1,067.5 Btu/gal
Natural gas		100,000 Btu/therm
Fuel oil (no. 2)	7.2 lb/gal	138,500 Btu/gal
Coal (anthracite)		25,894,000 Btu/ton
Coal (high-volatile bituminous)		23,734,000 Btu/ton
Coal (lignite)		13,894,000 Btu/ton
Electricity		3,412 Btu/kWh

Sources: Environmental Engineering Analysis and Practice, Burgess H. Jennings, International Textbook Company, Scranton, PA, 1970 and Tractors and Their Power Units, by Barger, Liljedahl, Carleton and McKibbon, 2nd ed., Wiley and Sons, N.Y., 1963.

Since farmers may have their household electricity on the same meter as the electricity used in farming, we are including the following table so the reader may estimate the electric power used in the home.

Table 15--Annual energy requirements of electric household appliances

	Est. kWh consumed annually 1/
FOOD PREPARATION	
Blender	15
Broiler	100
Carving knife	8
Coffee maker	106
Deep fryer	83
Dishwasher	363
Egg cooker	14
Frying pan	186
Hot plate	90
Mixer	13
Oven, microwave (only)	190
Range	
with oven	1,175
with self-cleaning oven	1,205
Roaster	205
Sandwich grill	33
Toaster	39
Trash compactor	50
Waffle iron	22
Waste disposer	30
FOOD PRESERVATION	
Freezer (15 ft^3)	1,195
Freezer (frostless 15 ft^3)	1,761
Refrigerator (12 ft^3)	728
Refrigerator (frostless 12 ft3)	1,217
Refrigerator/freezer (14 ft^3)	1,137
(Frostless 14 ft3)	1,829
LAUNDRY	
Clothes dryer	993
Iron (hand)	144
Washing machine (automatic)	103
Washing machine (nonautomatic)	76
Water heater	4,811

	Est. kWh consumed annually 1/
COMFORT CONDITIONING	
Air cleaner	216
Air conditioner (room)	860 2/
Bed covering	147
Dehumidifier	377
Fan (attic)	291
Fan (circulating)	43
Fan (rollaway)	138
Fan (window)	170
Heater (portable)	176
Heating pad	10
Humidifier	163
HOME ENTERTAINMENT	
Radio	86
Radio/record player	109
Television	
black & white	
tube type	350
solid state	120
color	
tube type	660
solid state	440
HOUSEWARES	
Clock	17
Floor polisher	15
Sewing machine	11
Vacuum cleaner	46

1/ When using these figures for projections, such factors as the size of the specific appliance, the geographic area of use, and individual usage should be taken into consideration.

2/ Based on 1,000 hours of operation per year. This figure will vary widely depending on area and specific size of unit.

Source: Electric Energy Association, 90 Park Ave., New York, New York

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61

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