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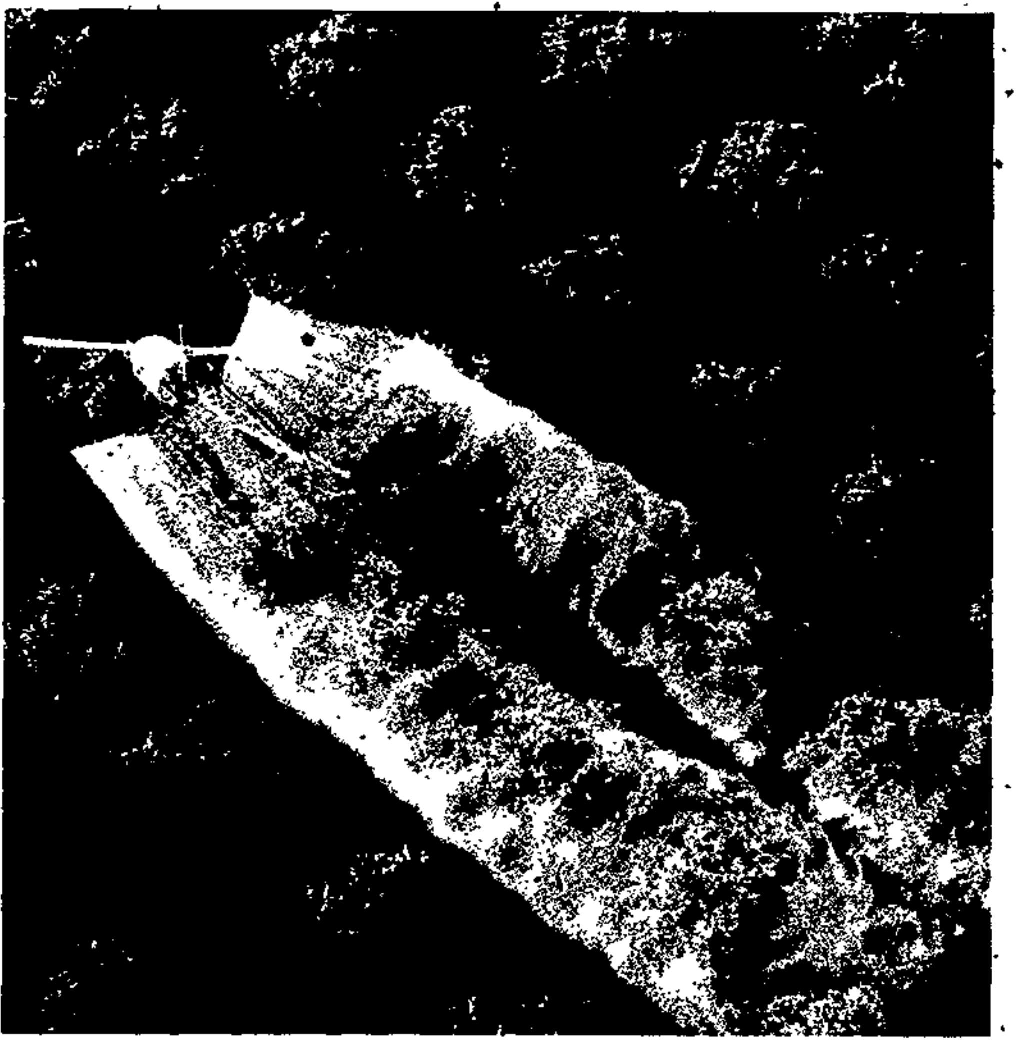
ABSTRACT

This booklet gives a brief overview of energy use in orchard crop production, and gives examples of cutting costs of fertilization, irrigation, weed management, pest management, high density crops, frost protection, and equipment use. (BB)

A GUIDE TO ENERGY SAVINGS

FOR THE ORCHARD GROWER



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 N.A. Wynn, Fruits, Vegetables, Sweeteners, and Tobacco 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, 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 Vegetable Producer, A Guide to Energy Savings for the Livestock Producer, A Guide to Energy Savings for the Poultry Farmer, A Guide to Energy Savings for the Dairy Farmer, and A Guide to Energy Savings for the Field Crop Farmer.

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

Individuals: Stanley S. Johnson, University of California; Glenn A. Zepp and Ernest B. Smith, University of Florida; Thomas A. Burch and William D. Mulkey, Clemson University; R.H. Reed and O.I. Berge, University of Wisconsin; Henry L. Kucera, North Dakota State University; Jim Ballard, Washington, and Richard Norton, New York, Cooperative Extension Service; John L. Baritelle, O.U. Bay, Stephen M. Raleigh, Joseph C. Podany, and Robert A. Wearne, 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, articles, notes and conversations have been extremely helpful. Many of these contributions are directly acknowledged in the text of the report.

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Attach to page i

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.

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INTRODUCTION

The Nation's 2-1/2 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.

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 adopt energy conservation measures irrespective of cost.

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

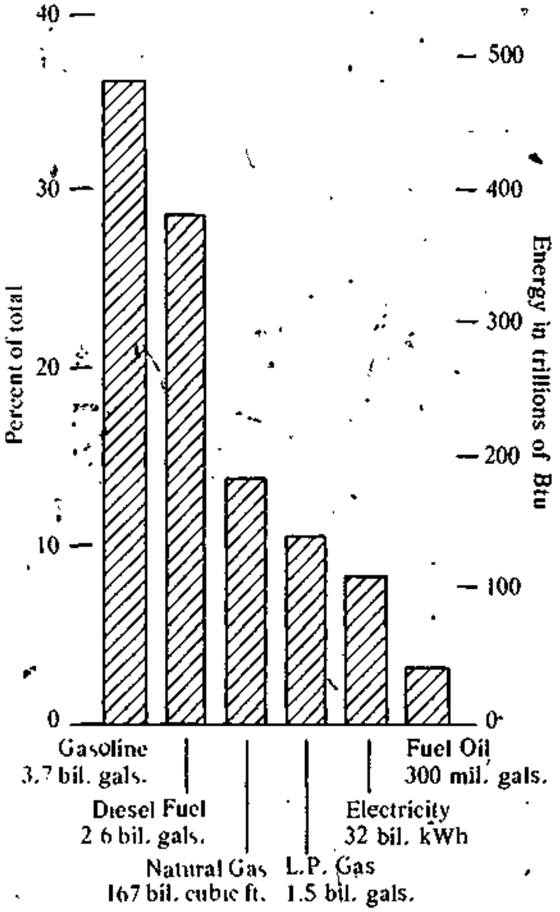

Figure 1. ENERGY USED IN AGRICULTURE (1974)

ENERGY USE IN ORCHARD CROP PRODUCTION

Many forms of energy are used in producing, transporting, and packing or processing orchard crops. Over time, energy use has expanded rapidly, since the relative costs of energy and labor have provided strong incentives for mechanization. Presently, high energy costs are causing orchard crop producers to evaluate carefully their mechanization plans and to scrutinize existing operations to determine possible energy savings.

MAJOR ENERGY USES

Approximately 16 percent of the energy used in orchards, groves, and vineyards goes to bring them into production and to renovate older stands. Other major energy-using orchard crop operations include the following:

Frost Protection--In 1974, almost half of the energy used in producing fruit went for freeze protection (table 2). In the production of citrus more than 60 percent of the energy used was consumed by orchard heaters, wind machines, and sprinkler systems to prevent frost damage. About 80 percent of the California citrus crop has some type of frost protection; in Florida, about 30 percent.

For noncitrus fruit production, about 22 percent of the energy used is for frost protection systems. This is lower than for citrus for several reasons: Deciduous trees are dormant during the winter months; the period when protection may be needed is relatively short; and most noncitrus fruit trees are set on hillsides that provide good cold air drainage or are near large bodies of water that moderate the air temperatures.

Fertilization--Following frost protection in energy usage is fertilization. It accounts for 17 percent of the total. Fuel expended in fertilizer application is nominal, but it takes much energy to produce the fertilizer. Production of 1 ton of nitrogen (actual N), for example, requires more than 500 therms* of natural gas and nearly 1,000 kWh of electricity.

A larger part of fertilizer production energy is used by noncitrus fruits (21 percent) than by citrus fruits (14 percent). The range in fertilization energy use is from 61 percent for pineapples down to about 11 percent for peaches.

Pesticides--The use of pesticides accounts for 11 percent of total energy expended in orchards. Peach production requires much more energy in pesticide application than any other orchard crop. Overall, noncitrus crops require about twice as much pesticide usage as do citrus crops. Lemons require the least use with only 2 percent of the energy requirements for lemon production going to pesticide applications.

Field Operations--These include herbicide and pesticide application, tillage operations, pruning, and other tractor and implement uses. These operations consume about 12 percent of total orchard energy usage. Citrus crops, although produced in semitropical areas where weeds are problems year-round, account for 5 percent of energy usage for field operations. For noncitrus crops, almost 22 percent of energy usage is expended on field operations. Most noncitrus crops require heavier usage of pesticides, fungicides, and pruning than do citrus crops.

Irrigation--About one-half as much energy is used for irrigation as for cultural practices. For grape production, one-eighth of the energy used is for irrigation; for irrigating lemons, about one-ninth. This compares to 6 percent usage on the average for all orchard crops and only 5 percent for all citrus. Irrigating noncitrus orchards takes 7 percent of total energy usage.

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*A therm is 100,000 British thermal units.

Harvest--Although harvest of orchard crops is still mainly a hand operation mechanization is becoming more and more common. Gasoline-and diesel-powered mechanical shakers are extensively used for nuts; shakers are also used for some apples, cherries, prunes, and cling peaches. Commercial harvesting machines are available for juice, wine, and raisin grapes; mechanical harvesters for other orchard crops will likely be in production shortly, increasing the use of fuel for harvest. At present, harvesting fruit crops takes only 1.6 percent of total production energy usage.

FUEL USE BY TYPE

In 1974, orchard crops used about 5.4 percent of total energy expended in crop production, a total of about 96.6 trillion Btu (see tables 3 and 4). The largest source of direct energy used on orchard crops was fuel oil, nearly all of which went for frost protection. This use accounted for over 44 percent of total direct energy use and offers the greatest potential for energy conservation measures.

Diesel fuel accounted for 27 percent of fuel use. For the most part, diesel fuel is used in tillage practices and orchard care, including pest control, but it also has considerable use in fueling wind machines for frost protection.

Gasoline accounted for another 20 percent of fuel usage. It is also used to power wind machines and, of course, the trucks and automobiles used in orchard crop production.

Electricity supplied 6.6 percent of energy used on orchard crops. It, too, goes to power wind machines and multipurpose sprinkler systems which are used for irrigation, frost protection, and pest control.

LP and natural gas are used very little in orchard crop production, accounting respectively for only about 1 and 2 percent of energy usage. Total energy use includes inputs required to produce and deliver fertilizer used on crops. Fertilizer use on orchard crops does not account for as large a proportion of total energy usage as do row crops, but it does account for about 17 percent of all energy used.

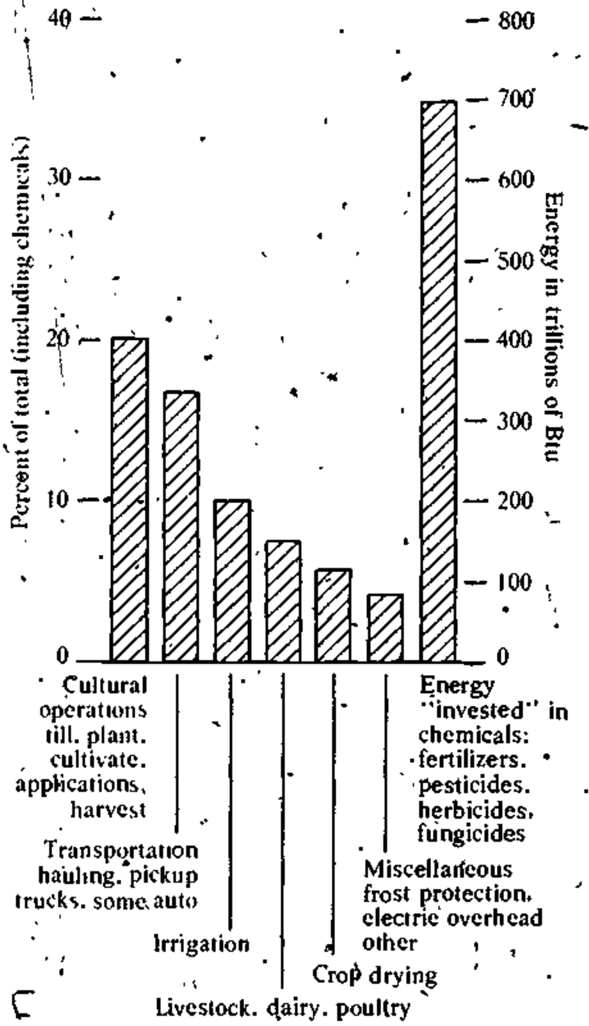

Figure 2. ENERGY USED IN AGRICULTURE. PLUS FERTILIZER AND CHEMICALS (1974)

Table 1--Energy used in agriculture, 1974, U.S. summary by commodity[A/]

Commodity value	Acres B/	Gasoline	Diesel	Fuel oil	LP Gas	Nat. Gas	Electricity	Coal	Invested energy C/	Total energy	Energy per acre
	1,000	Gallons				Cu. ft.	KWH	Tons	Btu		
		Thousand				Million			Billions		1,000
Oranges	881	47,202	41,707	128,029	2,606	533	361		8,785	40,486	45,965
Grapefruit	175	9,123	7,581	22,577	566	281	61		1,789	7,709	44,097
Lemons	63	3,932	1,698	8,293	103	146	60		458	2,714	43,437
Other Citrus	80	3,812	3,886	10,111	255	44	21		832	3,408	42,662
Apples	456	13,775	25,561	17,498	1,294	1	308		4,537	13,461	29,533
Grapes	573	10,204	14,175	3,261	344	70	245		2,445	7,105	12,400
Peaches	231	5,903	9,924	9,230	224	13	65		2,789	6,465	28,036
Pineapples	57	462	536	---	14	---	---		210	345	6,055
Other noncitrus	919	13,657	30,855	18,657	940	28	211		5,396	14,874	16,181
Total crops	340,596	2,881,276	2,286,539	295,112	1,148,657	159,500	22,060		716,452	1,789,930	5,255
Total livestock		817,365	352,416	8,817	332,885	4,625	10,028	32,725		224,291	
Total agriculture		3,698,641	2,638,955	303,929	1,481,542	164,125	32,088	32,725	716,452	2,014,221	

Footnotes: Preliminary data developed by the Economic Research Service, U.S. Department of Agriculture, Washington, D.C. 20250, under a jointly funded cooperative agreement with the Federal Energy Administration. (A) Data include all energy used directly on the farm for crop and livestock production purposes--field operations, irrigation, crop drying, mechanized feeding, space heating, farm business auto use, etc. Numbers may not add up to totals due to rounding. (B) Harvested acreage except for planted acreage in the following: rice, rye, winter wheat, spring wheat oats, barley, cotton, soybeans, peanuts, flaxseed, dry edible beans, dry edible peas, sugar beets, and sweet potatoes. (C) Invested energy includes the energy required to manufacture fertilizers and pesticides (includes carrier solution).

Table 2--Percentage of energy used on orchard crops by function, 1974

Crop	Activity							
	Irrigation	Field operations	Fertilizer	Pesticides	Frost protection	Harvest	Overhead	Total
Oranges	4.7	5.2	13.8	7.9	61.8	1.6	5.1	100
Grapefruit	6.9	5.0	14.6	8.6	57.4	1.6	5.9	100
Lemons	11.9	2.0	14.8	2.1	59.6	0.8	8.8	100
Other citrus	4.0	6.6	15.9	8.6	58.1	2.0	4.8	100
Citrus average	5.3	5.1	14.1	7.7	60.8	1.6	5.4	100
Apples	7.7	24.0	18.4	15.8	23.6	0.4	10.1	100
Grapes	12.6	25.1	15.8	18.6	16.8	1.7	9.4	100
Peaches	3.5	16.0	11.5	31.6	25.9	1.2	10.3	100
Pineapple	--	21.7	60.9	--	--	1.8	15.6	100
Other noncitrus	5.5	21.0	28.5	7.8	22.8	3.2	11.2	100
Noncitrus avg.	7.0	21.9	20.8	15.6	22.4	1.7	10.6	100
Av. all orchards	6.1	12.4	17.0	11.2	44.0	1.6	7.7	100

Table 3--Direct energy use on orchard crops by type of fuel, 1974

Type of fuel	Unit	Amount	Btu	Percent of Btu
		Thousands	Billion	Percent
Gasoline	Gal	127,310	15,914	22.2
Diesel	Gal	131,507	18,411	25.7
Fuel oil	Gal	217,656	30,472	42.6
Liquid Petroleum gas	Gal	7,522	715	1.0
Natural gas	Ft^3	1,404,031	1,404	2.0
Electricity	kWh	1,365,031	4,659	6.5
Total			71,575	100.0

Table 4--Total energy use on orchard crops by type of fuel including fertilizer, 1974

Type of energy	Btu	Percent of Btu
	Billion	Percent
Gasoline	15,914	18.6
Diesel	18,411	21.6
Fuel oil	30,472	35.7
Liquid Petroleum gas	715	.8
Natural gas	1,404	1.6
Electricity	4,659	5.5
Fertilizer	13,791	16.2
Total	85,366	100.0

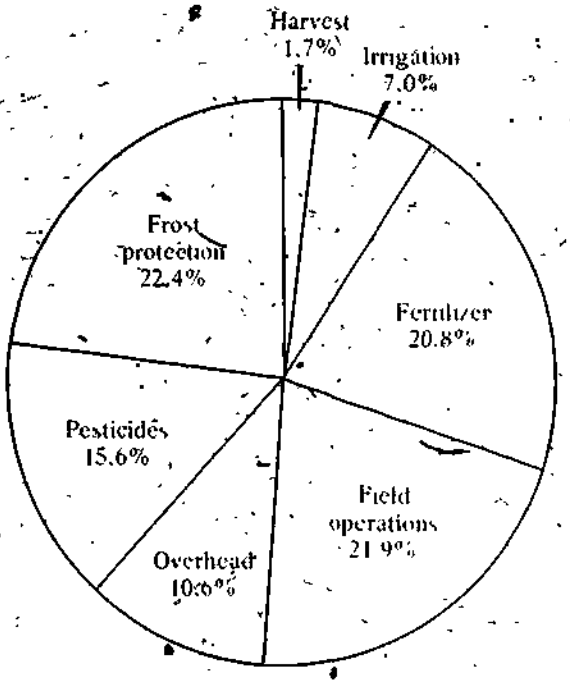

Figure 3. ENERGY USE BY FUNCTIONS, NON-CITRUS ORCHARDS, USA, 1974

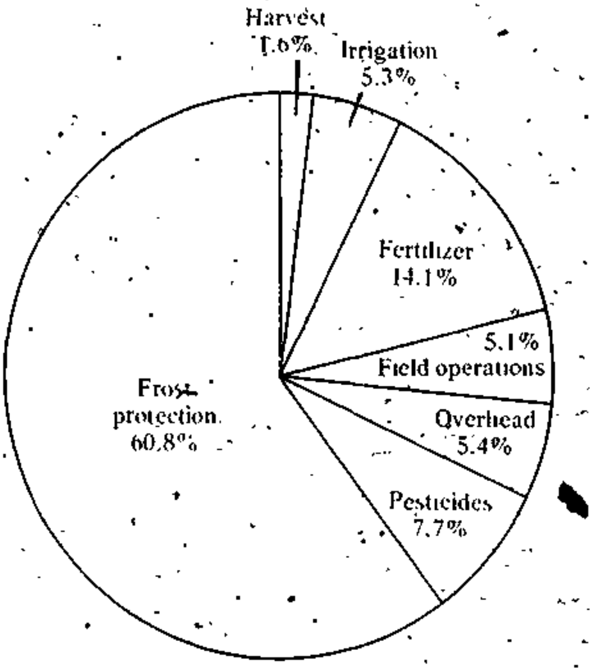

Figure 4. ENERGY USE BY FUNCTIONS, CITRUS GROVES, USA, 1974

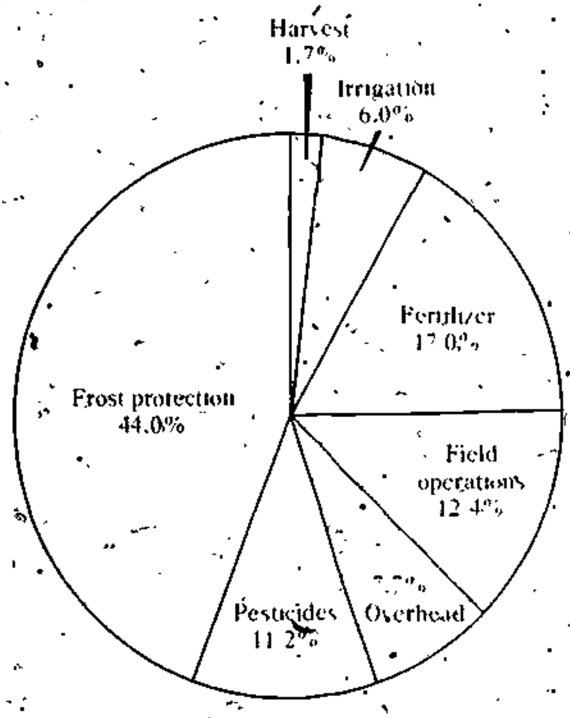

Figure 5, ENERGY USE BY FUNCTIONS, ORCHARD CROPS, USA, 1974

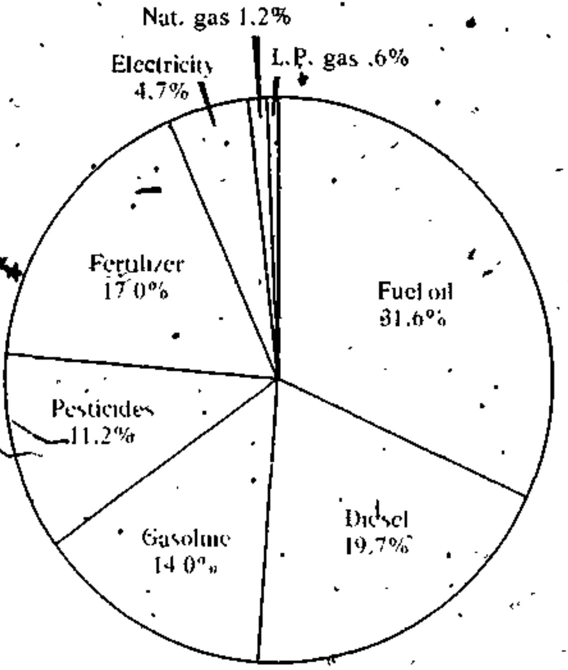

Figure 6 TOTAL ENERGY USE BY TYPE OF FUEL, INCLUDING FERTILIZER, ORCHARD CROPS, 1974

Orchardists who have fertilized extensively in the past have had to pay attention to the precise composition of the soil. Because of the costs of fertilizer and its application, it now pays to take even more careful stock of soil needs. Soil testing discloses nutrient availability and the pH value of the soil.

Leaf analysis reveals element deficiencies, such as zinc, iron, boron, and others that may be hampering production. Where needed, timely application of these minor elements by foliar spraying or ground application can maximize the nutrient value of fertilizer applied to an orchard.

Fertilizing can account for up to 25 percent of the energy used in fruit production. The following suggestions may help to reduce energy consumption in fertilizing orchard crops:

1. Have soil tested and follow recommendations closely. Failure to do so may result in misallocated fertilizer.

2. Calibrate machinery carefully. An applicator applying too much material wastes fertilizer and the excessive amount applied may do more harm than good.

3. If you use an irrigation system, application of supplemental nitrogen with the irrigation water may use less energy than any other method. Consultation with a specialist--USDA Extension or Experiment Station personnel perhaps--is recommended before applying any material through an irrigation system.

4. If possible, combine the fertilizing operation with some other operation, but be sure of compatibility before applying any materials simultaneously. Under most conditions, phosphorus and potassium sources may be applied in one application. However, split applications of fertilizer are often necessary for an effective fertilizing program.

5. Apply fertilizer to the root zone area without damage to the roots either from mechanical operation or fertilizer burn.

6. Establish and maintain contact with Extension Service or Experiment Station agents. They stand ready to serve your needs in developing a "tailor-made" fertilizer program for your orchard.

Cover crops and recycling of crop residues reduce soil erosion, retain moisture, and increase penetration of water; this conserves nutrients and lessens the need for fertilizer, which saves energy on manufacture and application. Cover crops also add organic matter which increases the availability of nutrients, thereby reducing the need for commercial fertilizer.

EXAMPLE OF ENERGY SAVINGS FROM SOIL TEST.

Savings of $12.15 per acre from soil tests.

Recommended fertilization rates are normally based on average soils; therefore, soil test results may change recommended practices. One of several important pieces of information obtained from a soil test is the residual levels of fertilizer nutrients. Indirect energy savings may result from such testing.

Example: A grower has a 10-acre apple orchard. Based on the particular soil type, the recommended fertilization rate is 140 lbs. of N per acre or 3.5 lbs. per tree (40 trees per acre).

If the soil test results in a recommendation of a one-third reduction in the amount of N per acre, the savings would be $12.15 per acre, with N priced at 26 cents per pound.

Fertilizer - Nitrogen

Residual level	Avg.	Med.	High
Fertilizer savings (lb./acre)	0	47	93
Dollar savings/ acre 1/	0	12.15	24.30

1/Nitrogen 26 cents/lb.

EXAMPLE OF ENERGY SAVINGS ON FEEDING YOUNG TREES

Indirect savings of energy may be obtained by economically feeding young trees fully and uniformly month after month for 2 years from a single application of tablets.

Example: "A grower producing 10 acres of apples, with approximately 50 trees per acre, would apply 2 tablets per tree. The tablets' formulation of 28-8-4 (plus iron, zinc, calcium, and sulfur) provides complete nutrients for all kinds and varieties of fruit trees. In a recent study, the cost of conventional fertilization for 1 year was $58.80 for fertilizer and $31.95 for labor and machinery. With the tablets the fertilizer cost would be $50 for 2 years. Because costs for the application of tablets are not available, the cost saving in labor and machinery cannot be computed.

Estimated savings of $6.76 per acre over 2 years in fertilizer cost by applying tablets instead of conventional fertilizers on young trees.

Fertilizer	Year 1	Year 2	Total
33-0-0/10 acres	58.80	58.80	117.60
Tablets/10 acres	50.00	0	50.00
Dollar savings with 10 acres	8.80	58.80	67.60
Dollar saving/acre	.88	5.88	6.76

Cost of supplying water to orchard crops can account for 40 percent or more of the energy used in production. Using water more efficiently and increasing the efficiency of irrigation equipment can conserve energy and reduce the costs of pumping water.

IRRIGATION METHODS

Various irrigation methods have been developed, some of which may be of special benefit under adverse conditions. The usual irrigation methods are flood, furrow, sprinkler, and drip (trickle).

Flood and furrow irrigation require much water but may be low cost if the water can be gravity fed. At some stage, most irrigation water has to be pumped, requiring energy to lift the water or to provide pressure. Sprinkler systems must have high pressure for adequate distribution.

A recent innovation is the drip or emitter method, whereby water is discharged slowly at low pressure through a small opening directly to the root system of the tree or vine, without excess or runoff.

ENERGY SAVING SUGGESTIONS

The following suggestions may help reduce fuel and electricity consumption in irrigating orchard crops. In addition to direct energy savings, some of these practices may increase yields per acre, save labor, water, and fertilizer, and reduce disease problems.

(1) Use drip irrigation. It can double the efficiency of water use, thereby reducing pumping requirements. Less pumping and lower pressure means less energy use and a saving of energy dollars.

(2) Replace open header ditches in sandy soils with plastic pipe. It can reduce water use by 50 percent.

(3) Operate irrigation equipment at maximum efficiency to conserve energy and save on irrigation costs.

(4) Apply only enough water to satisfy crop needs.

(5) Test for soil moisture or check for stress before applying irrigation water.

EXAMPLE OF ENERGY SAVINGS BY CHANGING TO DRIP IRRIGATION FOR STRAWBERRIES

$32 per acre annual energy savings by using drip irrigation.

Drip irrigation is increasing rapidly for strawberries. In one such example, on 50 acres of sandy soil in southern California, a drip system replaced a sprinkler system. Results indicate a 25-percent yield increase, plus other advantages.

The advantages of drip irrigation are that the furrows remain dry, fruit rot is reduced, hand operations can be conducted while irrigating, and water usage and labor costs are reduced.

Calculations

	Drip	Furrow
Investment cost per acre	$620	$400
Overhead cost per acre	100	42
Operating cost per acre:		
Preparation	0	54
Labor	38	81
Water	9	11
Repairs	11	2
Total per acre	158	190

With average costs above, the strawberry producer will have a cost savings of $32 ($190-$158). In general, cost savings can be achieved in situations where labor or water costs are expensive by switching to a drip system.

Source: (9) Underscored numbers in parentheses refer to items in the References.

EXAMPLE OF SAVING FROM OPERATING AN EFFICIENT PUMPING PLANT

$3,432 annual energy savings by increasing pumping efficiency.

Efficiency of a good electric power pumping plant should approach 70 percent. Tests conducted on operating plants indicate that efficiency varied from less than 10 percent to approximately 75 percent. A pump's performance varies with the speed at which it is turned, the amount of wear on the pump from past usage, normal operating friction, and other factors. Your county extension agent, electric company representative, or pump installer can help determine efficiency of your pumping plant. If the overall efficiency is less than 50 percent you may reduce pumping costs and conserve energy by making repairs or adjustments to increase efficiency.

Example:

A grower has 160 acres of vineyard requiring 2 feet of irrigation water per acre with a pumping head of 325 feet. His present electric motor pumping plant is operating at 40-percent efficiency. Repairs and adjustments which would achieve 70-percent efficiency would result in the following energy savings:

Cost per kWh (cents)	40%	70%	Savings (cents)
	(cents/acre-foot/foot of head)		
3	7.8	4.5	3.3
4	10.4	5.9	4.5
5	13.0	7.5	5.5

Total savings with 3¢/kWh electricity would be (3.3¢) x (325 ft head) x (2 acre-feet) x (160 acres) = $3,432.

EXAMPLE OF ENERGY SAVINGS WITH A MULTIPLE-USE OVERHEAD SPRINKLER SYSTEM

$121 annual fuel savings; $178 total savings per year.

Multiple-use overhead sprinklers are being adopted for certain tree and vine crops, such as almonds, grapes, walnuts, pears, apples, and citrus. These are especially effective in areas of possible frost damage. The sprinklers may be used for irrigation, cooling, frost protection, and the application of fertilizer and chemicals. Other advantages of the system: reduced traffic through the orchard, reduced labor, and better control of irrigation.

Calculations

Initial cost:		
Overhead system: (based on costs per 100 acres including well and pump)	$1,900	per acre
Permanent set system:	1,100	per acre
Furrow system:	400	per acre
Operating cost:		
Overhead system:	$ 282.00	per acre
Permanent set system:	219.60	per acre
Furrow system:	189.75	per acre
Water use:		
Overhead and permanent set:	3	acre feet
Furrow system:	3.5	acre feet
Frost protection:		
Overhead system: [1]	$ 55	per acre
Heaters:	325	per acre

($189.75 + $325.00) = $514.75
-($282.00 + $ 55.00) = $337.00

Savings = $177.75 per acre plus less water applied for irrigation needs.

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[1] Taken from cost data presented in Frost Protection section. Net savings of overhead system over furrow with heaters.

EXAMPLE OF ENERGY SAVINGS FROM REPLACING OPEN HEADER DITCHES WITH PLASTIC PIPE ON SANDY SOILS

Using PVC (polyvinyl chloride) pipes to deliver water to field ditches can save 40 to 50 percent of irrigation water in sandy soils. For example, if a grower raises citrus on 200 acres of sandy soil and irrigation water is delivered to field ditches, his water needs are 30 acre-inches per year, which must be lifted 10 feet into open header ditches. If he replaces the system of open header ditches with 4-inch PVC pipe at a cost of $50 per acre, his water needs will be reduced to 15 inches per acre because of reduced percolation losses. Energy savings are substantial.

$150 estimated annual energy per 200 acres by using PVC header pipes.

Estimated direct energy savings from using PVC header pipes in place of open header ditches.

Cents/kWh	Dollars per year
3	112.50
4	150.00
5	187.50

EXAMPLE OF ENERGY SAVINGS BY IRRIGATING ACCORDING TO PLANT NEEDS

Evidence of overwatering is ponding at the lower end of the field and water flowing along the roads. You can improve irrigation efficiency by using such aids as soil augers, evaporation pans, and moisture meters. They help to determine accurately when and how much water to apply. The results: less water used and reduced energy for pumping.

Suppose that overwatering results in a 10-percent waste of water per year. Assume also a medium power requirement of 60 psi and a 200-foot lift on a sprinkler system covering 40 acres with 30 acre-inches applied per year. The extra water pumped requires 12.75 kWh per acre. On a 40-acre field more efficient watering could mean $230 or more a year in saved energy.

$229.50 annual energy savings per year per 40-acre field

Calculations

0.25 acre-ft x 51 gal/acre-ft = 12.75 gal

12.75 gal x 40 acre-ft x $.45/gal = $229.50

Dollars Saved at Various Diesel Fuel Prices

Cents/gal	40¢	45¢	50¢	55¢
Annual savings	$204	$229.50	$255	$280.50

Calculations

0.25 acre-ft x 610 kWh/acre-ft = 152.5 kWh

152.5 kWh x 40 acres x $.03/kWh = $183.00

Dollars Saved at Various Electrical Rates

Cents/kWh	3¢	4¢	5¢	6¢
Annual savings	$183	$244	$305	$366

EXAMPLE OF ENERGY SAVINGS BY MAINTAINING IRRIGATION EQUIPMENT IN EFFICIENT CONDITION

Irrigation lines with squashed pipes, bullet holes, and split seams cannot operate at peak efficiency. Leaking gaskets waste water, causing consumption of extra power. Sprinkler nozzles 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 a pressure drop that increases the droplet size. Clogged perforations or water screens at the water-bearing strata may prevent water flowing freely into the well.

Suppose that inefficiencies in the irrigation system due to lack of maintenance result in a 5-percent increase in the work load 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, better maintenance can result in energy savings of over $100 per year.

$114.75 annual energy savings per year per 40-acre field.

Calculations

2.5 acre-ft x 51 gal/acre-ft = 127.5 gal of diesel

127.5 gal x .05 energy loss x 40 acres x $.45 gal = $114.75

Dollars Saved at Various Diesel Fuel Prices

Cents/ gal	40¢	45¢	50¢	55¢
Annual savings	$102.00	$114.75	$127.40	$140.25

Calculations

2.5 acre-ft x 610 kWh acre-ft = 1525 kWh

1525 kWh x .05 energy loss x 40 acres x $.03/kWh = $91.50

Dollars Saved at Various Electrical Rates

Cents/ kWh	3¢	4¢	5¢	6¢
Annual savings	$91.50	$127	$152.50	$183

Common orchard practice dictates spring and summer cultivation of deciduous crops and continuous cultivation of citrus crops. The principal objective of cultivation is the control of weeds. For deciduous crops, a disk is used to turn the soil at a shallow depth and mulch the vegetation.

The number of times to cultivate an orchard or vineyard floor depends upon soil type, moisture conditions, average daily temperatures, overhead orchard or vineyard cover, and vegetation type. Orchards are generally given special preparation just prior to harvest. They are floated (leveled) and rolled to provide a smooth, firm surface that aids in harvesting.

METHODS OF REDUCING FUEL AND/OR ENERGY COSTS

Proper Horsepower and Equipment Width

If cultivation remains the best and most practical solution in managing an orchard or vineyard floor, it is essential that equipment width and tractor horsepower be well matched to orchard row spacing. Too narrow a disk will require an extra pass between rows, while an excessively wide disk will require more horsepower. When planning a new orchard or the purchase of new equipment, make certain tractor, disk, and orchard are compatible to minimize necessary horsepower.

Clean Cultivation Using Herbicides

Clean cultivation is a long-established practice in citrus groves. An orchard floor is initially prepared by cultivation floating and rolling. Then weeds are sprayed with various selective herbicides at irregular intervals. Initially, spraying is done frequently and uniformly over the entire orchard floor. When reasonable weed control is established, only infrequent and spot spraying may be needed. This method may be costly at first, yet where feasible, it can eliminate cultivation entirely.

Unfortunately, clean cultivation is not practical where irrigation water comes from a common canal or river unless the water is filtered for weed seeds. Also, it is difficult to keep the orchard clean with just chemical sprays if the adjacent grower does not also practice clean cultivation. Where perennial weeds are already well established in an orchard, clean cultivation is difficult. Soil erosion, soil permeability, daytime sun reflection, rapid night radiation, and soil compaction can make clean cultivation impractical. Where feasible, using herbicides on an infrequent basis is unquestionably the best way to reduce fuel and energy costs to growers.

Clean Cultivation and Sod

Where strictly clean cultivation is not practical, growers may strip-spray around trees or along tree rows and grow sod between rows. A 1- or 2-foot strip on each side of a tree row is sprayed with selective herbicides and no vegetation is permitted to grow. Contact sprays are mixed with residual sprays that kill germinating weeds. A late winter or early spring spraying may suffice under certain favorable conditions. Once established, an annual spray with some spot spraying for perennial weeds is usually adequate. The sod established between the tree rows can be maintained by occasional mowing or chopping. This eliminates the need for heavy tillage with a disk. With the exception of the spring mowing or chopping, which may require substantial horsepower because of excessive vegetation, power requirements are considerably below those necessary for disking. Where conditions favor the establishment of low-growing flora, this can substantially reduce the horsepower required and the frequency of mowing.

Furthermore, certain low-growing vegetation may consist of nitrogen-fixing legumes. Two such examples are trefoil and clover. These, of course, can have the added advantage of reducing an orchard's nitrogen requirements. Such low-growing plants may eliminate the need for strip-spraying if they crowd out weed growth.

Initial establishment of sod on an orchard floor requires additional nutrients, particularly nitrogen, until the decaying vegetation from mowing releases enough nutrients for the growing sod. This stable state may require several seasons, even when establishing a legume sod. Additional water may be required with the establishment of sod. Sod, however, can substantially reduce compaction problems and increase soil permeability. Problems frequently encountered with clean cultivation--sun reflection resulting in sunburn and rapid heat radiation--are not problems with sod.

Experimentation

As fuel prices increase, orchardist and vineyardist will seek cost-reducing methods of cultivation. Above are three alternatives to disking. What may prove advantageous to one farm and system of management may not be applicable to another. You may wish to experiment with small blocks of orchard using either sod cultivation or clean herbicide cultivation before making any final decisions.

EXAMPLES OF ENERGY SAVINGS BY CHANGING FROM MAXIMUM TILLAGE TO SOD CULTURE

Sodding the orchard floor may bring savings. Once the sod is established, preferably with low growing legumes, moving and/or chopping three times a year may replace four or five diskings a year. Initially, while the sod is being established, supplemental nitrogen may be needed.

Fuel savings, 100-acre deciduous orchard..........	1,050 gal.
Value of fuel savings......	$472.50
Value of labor saved.......	150.00.
Net savings................	422.50

Calculations

Ownership costs:

Rotary mower, $1,000	
Depreciation, 10-year life	$100
Interest, 1,000 x .08	80
Repairs	20
Taxes	?
	$200

40 hp Tractor

3 mowings	4 diskings
1.5 hrs/ac/yr	
Fuel @ 3.0 gal/hr = 415 gal	

3 mowings

Hrs/ac/yr	1.5	3.0
Fuel/hr	3.0 gal	5.0 gal
Total for year	4.5 gal/ac/yr	15.0 gal/ac/yr

Difference. 10.5 gal/ac/yr

100 acres x 10.5 - 1050 gal/yr

Energy Savings At Various Fuel Costs

Cents/gal	35¢	45¢	55¢
Annual savings	$367.50	$472.50	$577.50

Pest management is perhaps the most complex task growers face. The task is twofold: to maintain vigorous and healthy trees and vines and to produce blemish-free fruit that meets USDA grades and standards and is acceptable to consumers. The task is especially difficult because beneficial predatory insects can be inadvertently destroyed when insecticides are used. Target insects can build resistance over time to various insecticides. One properly timed spray may save four or five expensive ones later in the season.

Material costs aside, spraying can be very expensive when a large volume of water is released under high pressure and thrown high in the air. This requires much horsepower. Depending on spray requirements, 5 to 10 gallons of fuel per acre may be needed to spray one time.

METHODS OF REDUCING FUEL AND/OR ENERGY COSTS

Minimize Spray Frequency

Spray no more than absolutely necessary to maintain fruit quality and tree vigor. Use sprays that are as selective as possible. Work closely with fieldmen and extension service personnel in identifying pest problems. Identify beneficial insects and try to protect them.

Keep Equipment in Proper Working Order

Make certain that spray tanks, filters, and nozzles are clean. Pay careful attention to proper calibration of spraying equipment. Make sure equipment operators are knowledgeable and properly instructed. Make sure that spray applications are effective.

Low-Volume or Concentrate Sprays

Where applicable, use low-volume sprays and concentrate sprays. Hauling large quantities of water within an orchard and blowing it 40 or 50 feet into the air uses enormous amounts of energy.

Aerial Application

Check the cost and effectiveness of aerial application in the area. Often aerial application can be more effective, done more rapidly, and at a lesser cost than applications from ground rigs. Fuel use per acre by aerial application is substantially less than that of a high-volume ground spray rig.

Permanent Overhead Sprinklers

A few orchards and vineyards use permanent or solid set sprinklers. Overhead solid set sprinklers offer the advantage of reducing labor involved in irrigation, provide frost control, and also provide a means of handling pesticides. In some cases, overhead solid set sprinklers are believed to reduce the need for pesticides. This has yet to be scientifically established, but there are some encouraging results. Sprinklers, however, provide an excellent means of distributing pesticides throughout an orchard. The fuel savings can be enormous. Justifying overhead solid set sprinklers on the basis of fuel savings alone would be difficult because of the large capital cost involved. However, where sprinklers can be economically justified because of frost control, every effort should be made to explore their use in pesticide application. A word of caution: Most pesticides receive label clearance on the basis of ground rig or aerial application. Growers should consult with chemical fieldmen and local extension service personnel before giving serious consideration to using sprinklers in pest management programs.

EXAMPLE OF ENERGY SAVINGS BY USING OVERHEAD SPRINKLERS

Overhead orchard and vineyard sprinkler systems may sometimes be used to distribute nutrients and insecticides. At present, only a few chemicals may be applied by overhead spray, but the number is increasing. Developments in this area should be carefully watched.

Fuel savings, 100 acre apple orchard	1,000 gal.
Value of fuel saved	$450
Value of labor saved	400
Net savings (assuming overhead sprinklers already exist in orchard)	850

Calculations

Assume overhead sprinklers already installed for frost protection and irrigation purposes

Assume a 60-hp tractor and 90 hp air fan sprayer

Assume normal spray program for Washington apple orchard includes:

	Fuel use
One delay dormant spray	2.5 gal/acre
One chemical thinning spray	2.5 gal/acre
Two codling moth sprays	5.0 gal/acre
One Growth regulator spray	2.5 gal/acre
Two mite sprays	5.0 gal/acre
Total fuel used	17.5 gal/acre

Assume overhead sprinklers eliminate one codling moth spray and one mite spray and that some of the sprays are given future label clearance for overhead sprinkler application:

Fuel saved per year per acre	10.0 gal
100 acres x 10/gal/acre/year	1000.0 gal/year

Energy Savings at Various Fuel Costs Per Gallon

Cents/gal.	35¢	45¢	55¢
Annual savings	$350	$450	$550

The modern orchardist must examine his fruit farm operation today just as the industrialist must examine his business. Each must determine how to make the most productive use of his capital. For many orchardists, small trees are the most efficient and productive from the standpoint of economics and technology. Not only yield per acre but also production cost per bushel affect income and influence decisions. The small tree reduces requirements for labor and expensive orchard equipment, improves harvest efficiency, and increases mechanization opportunities.

Obviously, the interaction of root stocks, scion varieties, soil, climate, cultural practices, and planting systems is complicated. For each combination of factors there will be different responses and results. However, the economics continue to favor the small tree.

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EXAMPLE OF ENERGY SAVINGS FROM PARTIAL ACREAGE PLANTING

Save $2,190 on producing 10,000 bushels of apples.

Commonly, apples are produced on trees planted 20 feet apart in each direction. Such trees grow large and require large, heavy equipment for spraying, cultivating, and harvesting. New types of dwarf trees do not require such heavy equipment, and production and harvesting costs are reduced. Dwarf trees produce much earlier, require less land, shade more area (reducing weed growth), and cost less to maintain. Since fruit color, size, and quality depend on exposure to sunlight, dwarf trees also allow a grower to harvest, at one picking, over 90 percent of his apple crop in the fancy top grades.

By changing density of trees with dwarf stock, the average growing cost per acre is reduced by $11. On 10,000 bushels, costs are reduced $2,190. Labor productivity per hour is increased by 24 bushels. Because the dwarf trees produce earlier, the break-even year comes 5 years earlier. Yield per acre is increased by 400 bushels, and the 10-year cumulative net return is increased $5,486 on a per acre basis (8).1/

Calculations

Trees per acre	121	792
Yield (bu.)	10,000	10,000
Acres required	18.18	10.53
Growing cost	$4,927.00	$2,737.00

	Density			
Item	Low	Medium	High	Ultra high
Trees/acre	121	218	454	792
Establishment cost/acre	$321	$504	$1,402	$2,329
Nonbearing cost/acre	$856	$1,075	$1,931	$3,159
Avg. growing cost/acre	$271	$281	$302	$260
Cumulative 10-yr profit-acre	$1,805	$2,325	$3,664	$7,291
Yield at full production bu/acre	550	650	750	950
Production labor bu/hour	0.93	0.90	0.87	0.71
Break-even year	11	10	7	6

1/Underscored numbers in parentheses refer to items in the References.

Annually, about 50 percent of the citrus orchards, 10 percent of the deciduous fruit and nut crops, and about 5 percent of the grape acreage require some kind of frost protection.

Producers may use several methods to protect crops, such as heaters, wind machines, water sprinklers, bare soil, hillside planting, or combinations of those methods.

When fuel was inexpensive, most farmers applying frost protection used heaters because they were cheap and easy to move. Higher fuel costs now dictate more careful planning. Wind machines with or without heaters can save money. Sprinklers can save even more money on fuel costs.

Your orchard site may dictate which system is the best investment for frost prevention. For example, with a fairly frost-free site, a good strategy might be to hold stack heaters on hand as insurance against rare Arctic air mass freezes. If you have plentiful water, consider overtree sprinkling. If not, consider overtree wind machines.

PRINCIPLES OF FROST PROTECTION METHODS

Wind Machines

During the daylight hours a layer of warmed air accumulates around and over the orchard or vineyard as the air at ground level warms and rises. At night the process reverses, as the earth's surface loses heat. Air in contact with the earth and trees is cooled and flows to lower areas. This process is called inversion. Frosts caused by these conditions are called radiation frosts and are characterized by cold air at the ground surface building up to various heights with warmer air above.

To work, wind machines must have a low warm air ceiling--not over 40 to 50 feet above the orchard. If this is not available, supplemental heat must be supplied by orchard heaters. Wind machines mix warm air above the orchard with the cold air in the orchard. The difference in air temperature at 5 feet and 40 or 50 feet above ground level is critical for effective protection. By rule of thumb, one-fourth of this temperature difference can be converted to a temperature rise in the orchard by using a wind machine at 10 horsepower per acre.

Wind machines are typically used for frost protection in citrus orchards. LP and natural gas, gasoline, and diesel engines and electric motors are all used as a power source.

Orchard Heaters

Orchard heaters, typically fired by fuel oil or LP gas, provide heat by direct radiation and convection. Hot-stack heaters, like the return-stack types, give out 25 to 30 percent radiant heat. Radiant heat moves along a straight line from the heater to the tree or other surface in the orchard. Convection heat warms the air around the immediate area of the heater and much of this heat is lost by rising above the level of the orchard.

Sprinklers

When water freezes, heat is released to its surroundings. By providing a continuous flow of sprinkled water to the orchard, the mixture of ice and water remains at 32°F until water is all changed to ice or vice versa.

This continuous ice and water mixture maintains a protective temperature of 32°F on the tender bud surfaces or fruit of the orchard.

It is essential to maintain enough precipitation to have water available for freezing on wet crop surfaces. If water is not constantly available to maintain the ice and water mixture, bud surface temperatures may drop to the danger point. On the other hand, excessive water applied may cause excessive ice buildup on limbs and may damage trees or waterlog the soil.

Cultural Practices

During a freeze, a tree radiates its warmth and that of the soil towards its exposed parts. Since the soil is much warmer than the air, it constitutes the major heat reserve supply. Optimum conditions for the conduction of heat out of the soil to replace heat lost from the tree occur when the soil is firm, bare, and moist. Conversely, this provides the best conditions for absorption of heat from the sun during the day. Cover crops interfere with such heat interchange and also provide additional surface to radiate heat. Trees in such groves may be 3 to 6 degrees colder than in groves where the soil is bare, firm, and moist.

Areas planted solid to citrus may become colder after the trees reach 15 to 20 years old. The large leaf area of the older trees causes more radiant heat loss at night and prevents direct heating of the soil by the sun during the day. Large trees also interfere with normal air drainage. Thus, a warm area in the desert may become progressively cooler as more orchards are planted and the trees become large and older.

Least expensive frost protection in the long run is to select planting sites of elevated land free of obstructions to air movement so that cold air drains to lower levels. Good air drainage protects the flowers and young developing fruit from frosts.

MAINTAINING EQUIPMENT FOR FUEL CONSERVATION

Maintenance of the heaters involves refilling with fuel and periodic cleaning. Wind machines should be checked periodically to be sure they are ready and usable when needed. Sprinkler systems should not be allowed to accumulate water in pipes that would freeze and block usage. You can do several other things to keep frost protection units running efficiently and conserve energy.

Hea[illegible]

(1) Clean heaters periodically for efficient heating.

(2) Check heater bottoms, joints, etc., to be sure they are tight with no leaks.

(3) For good draft, regulate hot-stack type of heaters 1 minute after lighting.

(4) Check heaters regularly during the night and adjust to control burning rates and conserve fuel if temperatures can be maintained.

Wind Machines and Sprinkler Irrigation—Petroleum Fuel

(1) Adjust carburetors for best performance, not maximum horsepower.

(2) Clean or replace air cleaners.

(3) Restore lost compression by valve and ring jobs since "blow-by" is a loss of power.

(4) Put in new spark plugs, new distributor cap, and breaker points.

(5) Adjust spark timing.

(6) Adjust timing of diesel injection to correct specifications.

(7) Eliminate wasteful over-fueling on diesel injection to get more power.

(8) Stop leaks in fuel lines and replace leaking carburetor float valves.

(9) Provide optimum fuel storage conditions.

Wind Machines and Sprinkler Irrigation--Electric

(1) Make sure main service box is of recommended size for motor.

(2) Be sure electrical service wires to each unit have adequate capacity.

(3) Check insulation for deterioration, replace when needed.

(4) Clean motors; clogged air ducts retard ventilation and may cause overheating.

(5) Maintain pump for maximum efficiency.

EXAMPLE OF ENERGY SAVINGS BY CHANGING FROST PROTECTION METHODS

$2,014 annual fuel savings, $2,728 net savings for a 10-acre cherry orchard

Frost protection by overtree sprinkling offers considerable savings over other methods. If you are already using sprinklers for irrigation, use the same system with modifications for frost protection. If you do not have a sprinkler system, it may pay for itself in a short time when you consider costs of other methods of frost protection. The sprinkler works on the principle that upon freezing, water gives up heat and as long as water is available to freeze, the temperature cannot go below 32°F.

An overtree sprinkling system that would provide frost protection for a 10-acre orchard would cost about $8,000 (1975) installed. Such a sprinkling system could reduce frost protection cost by $1,200 annually over heaters. In an average year the sprinkler would have to be used 38 hours versus about 26 hours for heaters. Sprinklers have to be started before the temperature reaches freezing and have to operate until the ice starts melting (1).

This excessive "irrigation" at the beginning of the season would cut the need of the normal early irrigation applications.

Calculations (10 acres)

Ownership costs-Overtree sprinklers

Depreciation, $8,176.80 - 817.68/10 year life =	$ 735.91
Interest, $8,176.80/2 x 8 percent	327.07
Insurance, $8,176.80/2 x .8 percent	32.71
Repairs	40.88
Total	$1,136.57

Operating costs (10 acres)

	Heaters	Overtree Sprinklers	Savings
Labor	$ 225.00	$ 95.00	$ 130.00
Equipment	110.00	18.50	91.50
Fuel	2,100.00	86.00	2,014.00
Total	2,435.00	199.50	2,235.5
Investment overhead	842.40	349.60	492.8
Total cost	3,277.40	549.10	2,727.8

EXAMPLE OF ENERGY SAVINGS BY USING A WIND MACHINE FOR FROST PROTECTION

$9,088.50 annual energy savings, $11,901.50 net savings for a 50-acre orchard.

A method which would reduce the amount of energy required in frost protection would result in a significant reduction in overall energy usage on an orchard. Wind machines are one way to reduce the energy required for frost protection. Wind machine frost protection involves the transfer of warm air from a height of 50 feet to the orchard below, thereby raising the temperature in the orchard.

A 50-horsepower electric motor on a wind machine would cost $13,017 installed. Such a machine would reduce the need for one-half the heaters and these would not be operated when warm air was above the orchard. Considering depreciation, interest on the cost of the equipment, etc., the wind machine has an annual ownership cost of about $1,807. For example, if you had a 50-acre orchard and pay 40 cents a gallon for fuel oil, you could reduce your fuel bill by $9,088 with the wind machine; considering the annual ownership cost involved, you would see a net savings of about $11,900 (1).

Calculations

Ownership costs:

Depreciation, ($13,000-$1,300)/10 year life =	$1,170
Interest, $13,017/2 x 8 percent	520
Insurance, $13,017/2 x .8 percent	52
Repairs, $13,017 x .5 percent	65
Total	$1,807

Cost to protect with heaters, $325 per acre.

Cost to protect with wind machines and heaters, $87 per acre.

$325 - $87 = $238/acre savings

50 acres/orchard x $238 = $11,900

It is important to keep the engine in top operating condition to get the most out of tractors and trucks for each gallon of fuel used. But all of the fuel saved through proper maintenance can be lost through inefficient work routines.

Only a thorough work analysis can rid an orchard operation of fuel waste. No grand scheme can be presented for every orchard, grove, or vineyard, because each is different. There are, however, pitfalls common to many operations. Some of the following examples may point out fuel wasters that you may have been too busy to recognize in the course of pressing day-to-day demands on your time. Most are easy to correct.

When fuel savings are the results of reduced operating time, as is usually the case, you will save even more dollars in nonfuel costs, such as repairs, oil, grease, and tires. Reduction in associated labor cost is another benefit.

EXAMPLES OF SAVING ENERGY THROUGH CHOICE OF TRACTOR FUELS

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

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; and LP gas tractor will use 1.2 times as many gallons of fuel as a gasoline tractor. 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. Diesel-powered tractors appear to be the most economical in terms of cost of fuel consumption. If you are using several tractors which use different kinds of fuel, when it is time to trade for newer machines consider moving toward diesel for all tractors.

If you are planning to purchase a new car or pickup, consider those with electronic ignition and radial tires. They provide better fuel economy.

Tractors with all gear power transmission are 25 percent more efficient in use of fuel than hydraulic drives, even at reduced engine speed, and with part load as well as at full, according to Nebraska tests. This consideration partly offsets the greater convenience of hydrostatic transmission.

EXAMPLE OF ENERGY SAVINGS BY USE OF DIESEL TRACTOR

$646.40 saved per year using a 75-hp diesel versus a 75-hp gasoline tractor operating 500 hours at 50-hp output.

A 75-horsepower diesel tractor which is used 500 hours a year and operates at an average output of 50 horsepower will use about 1,833 gallons of diesel fuel per year. The same size gasoline tractor operating under the same conditions will use about 2,675 gallons of fuel annually; a tractor fueled with LP gas will use about 3,210 gallons of LP gas. The difference in total fuel cost on an annual basis can be substantial depending upon the price of the three kinds of fuel. If you now pay $0.45 a gallon for diesel fuel, $0.55 cents for gasoline, and $0.40 for LP gas, the yearly fuel bill would be $825 for diesel, $1,471 for gasoline, or $1,284 for LP gas.

<u>75-hp gasoline tractor</u>: Average 50-hp output at full engine speed 500 hours x 5.35 gallons per hour = 2,675 gallons

<u>75-hp diesel tractor</u>: Average 50-hp output at full engine speed 500 hours 2,675 gallons x .70 = 1,833 gallons.*

<u>75-hp LP gas tractor</u>: Average 50-hp output at full engine speed 500 hours 2,675 gallons x 1.2 = 3,210 gallons.*

* Diesel tractor uses 70% and gas tractor 120% as much fuel as gasoline tractor.

Fuel Costs at Various Prices Per Gallon

Diesel				
Cents/gal.	40c	45¢	50c	55c
Total cost for 500 hours (1,833 gal)	$ 733.20	$ 824.85	$ 916.50	$1,008.15
Gasoline				
Cents/gal	50c	55c	60c	65c
Total cost for 500 hours (2,675 gal)	$1,337.50	$1,471.25	$1,605	$1,738.75
LP Gas				
Cents/gal	35c	40c	45c	50c
Total cost for 500 hours (3,210 gal)	$1,123.50	$1,284	$1,444.50	$1,605

EXAMPLE OF ENERGY SAVINGS BY REDUCING TRACTOR IDLING TIME

You may turn off the tractor engine whenever there are side trips to be made. But chances are you leave it running. An idling engine does not use much fuel and you have probably never given the matter much thought.

Suppose you find that you leave the tractor engine idle for 10 minutes during an average day. During a year this amounts to 61 hours. Sixty-one hours of idling on a 75-horsepower diesel tractor will use about 30 gallons of fuel. This is a sizable amount of fuel, especially when it is accomplishing no useful purpose.

Make it a habit to turn off the tractor engine when you have some other work to do nearby.

$13.50 saved per year for the enterprise.

Present routine: Tractor engine idles unnecessarily an average of 10 minutes a day.

10 minutes x 365 days = 3,650 minutes
3,650 minutes ÷ 60 = 61 hours
61 hours x 0.5 gallon per hour = 30 gallons

Improved routine: Eliminate the unnecessary idling time and save 30 gallons of fuel.

Energy Savings at Various Prices Per Gallon

Cents/gal	40¢	45¢	50¢	55¢
Annual savings	$12	$13.50	$15	$16.50

EXAMPLE OF ENERGY SAVINGS: MATCHING TRACTOR SIZE TO LOAD

$58.50 energy savings per year for a 200-acre orchard or grove.

A tractor working at 75 percent of capacity consumes less fuel per horsepower produced than a tractor working at 50-percent capacity.

A 35-horsepower wheel tractor is required to pull an 8-foot harrow under most conditions. The 35-horsepower tractor will consume approximately 2 gallons of diesel fuel per hour performing this task. A 50-horsepower tractor will consume approximately 3.3 gallons per hour doing the same job.

Assuming the harrow is operated 100 hours per year for 200 acres, use of the larger tractor will require 130 extra gallons of fuel. Therefore, a proper matching of tractor and harrow size could save $58.50 in diesel fuel costs.

Calculations

100 hours x 1.3 gallons/hour = 130 gallons

130 gallons x $.45/gallon = 58.50

Cents/gal	40¢	45¢	50¢	55¢
Annual savings	$52	$58.50	$65	$71.50

EXAMPLE OF ENERGY SAVINGS THROUGH ECONOMIZING ON THE USE OF A PICKUP TRUCK

The pickup truck is one of the orchardist's most useful and necessary machines. Many orchardists commonly drive their pickups 10,000 to 15,000 miles per year.

When gasoline was 25 cents a gallon and considered plentiful, no one gave much thought to fuel conservation. With gasoline now around 60 cents a gallon and rising, some careful consideration should be given to the economy and use of the pickup truck.

Careful planning may result in halving the hours of pickup truck use on most orchards. Even minimal effort could result in a 10-percent reduction. Suppose that you drive your pickup truck 10,000 miles a year. A 10-percent reduction in driving would cut fuel use per year by 100 gallons of gasoline if you average 10 miles per gallon.

To save on fuel, drive slower.

$55.00 energy savings per year for the farm or ranch.

Present pickup truck use: 10,000 miles per year

Planned travel to save 10 percent:
10 percent x 10,000 miles = 1,000 miles
1,000 miles ÷ 10 miles per gallon = 100 gallons

Dollar Savings at Various Prices for Gasoline

Cents/gal	50¢	55¢	60¢	65¢
Annual savings	$50	$55	$60	$65

Tractor tires are not direct-energy users except for the energy used in their manufacture. However, the proper type, size, inflation, and use of tractor tires brings energy savings.

The pneumatic farm tire was introduced in the early 1930's. The bias ply tire is the most familiar type. The bias ply tire consists of layers of cord (plies) set diagonally to the tread and criss-crossed at an angle called bias angle.

In recent years, a new type of tractor tire--the radial--has come to the fore. The radial ply tire consists of plies that run at right angles to the tread, plus a belt of cords around the tire to give strength and stability. It offers many advantages, among them are increased traction, reduced fuel consumption, better field performance, longer wear, and improved ride.

The radial play tractor tire is the most efficient in converting horsepower to drawbar pull. The larger "footprint" made by the radial ply tire results in more area of tire-soil contact, less hole for the tire to climb out of, and more flexing of the sidewall. The result is that a tractor equipped with radial tires uses less energy than one equipped with bias tires.

EXAMPLE OF ENERGY SAVINGS BY USING RADIAL TRACTOR TIRES

$397 estimated fuel savings annually by using radial tractor tires, $632 total annual savings.

Assuming that a tractor equipped with radial tires will do in 623 hours what a tractor equipped with bias tires takes 700 hours to do, fuel per hour would be 5.52 gallons for bias tires, 5.14 gallons for the radials. This amounts to an annual savings of $397 at 60 cents per gallon for fuel. Reduction in labor costs for a tractor driver would be $239 at $3 per hour. Because of the additional tire life of radials, annual tire cost would be reduced $12. Interest on investment would be increased from $13 to $21.

(One 18.4 x 36 radial ply tire sold for $605.00 plus $16.85 Federal excise tax in February 1976 in Galesburg, Ill. A bias ply tire cost $359.50 plus $11.59 excise tax.)

Comparative annual operating cost

Fuel:	Bias ply	Radial ply
700 hr x 5.52 gal/hr x .60/gal	$2,318	
623 hr x 5.14 gal/hr x .60/gal.		$1,921
Labor:		
700 hr @ $3/hr	2,100	
623 hr @ $3 hr.		1,869
Tire cost per year*	94	80
Interest on investment @ 8 percent	14	24
Total annual cost	$4,140	$3,575

*85 percent of tread life.

Field tire tests

	Bias ply	Radial ply
Acres/gallon	.72	.87
Acres/hour	3.98	4.47
Fuel efficiency	100.0	120.8
Acreage efficiency %	100.0	112.6
Tire life %	100.0	165.0
Tire prices %	100.0	167.3

Adapted from material published by and research conducted by B. F. Goodrich Tire Co., 500 South Maine Street, Akron, Ohio 44318 and from (10).

Gasoline and diesel-powered engines used in crop production are the biggest on-farm users of energy. You can have a direct impact on reducing total energy use by conserving fuel.

Fuel-saving begins before you start an engine. The following tips may save you fuel, dollars, and problems:

1. Check tank, lines, fuel pump, and carburetor for leaks.
2. Don't let the tank stand empty, especially in cold weather, condensation may form.
3. Check your usage against your bill.
4. Don't overfill; leave room for expansion.
5. Maintain dispensing records by vehicle and by task performed. This can identify high and wasteful usage.

ENGINE OPERATING TIPS

The way a vehicle is operated can save fuel without changing the amount of work or the way the work is done. Here are some fuel-saving ideas:

1. Avoid excessive warmups in cold weather.
2. Idling can consume 15 to 20 percent of the fuel used. Hold it to a minimum, and avoid excess idle speed.
3. Don't leave the choke out.
4. Let out the clutch slowly; quick starts waste fuel and are hard on equipment.
5. 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.
6. Be sure the thermostat is working properly.

MAINTAINING GAS AND DIESEL ENGINES

You are well aware of the importance of good maintenance of equipment. The following energy-saving maintenance tips may be helpful reminders:

1. One fouled spark plug or one stuck valve lifter can cause a loss of 10 to 15 percent of the fuel used in a vehicle.
2. Too rich a mixture wastes fuel.
3. Too lean a mixture wastes fuel because it prompts excessive choke use.
4. Regularly scheduled tuneups can save up to 10 percent on fuel usage.
5. Keeping the tires of your tractors and other implements properly inflated saves energy.
6. Improper lubrication, loose fan belt, or low oil level will increase fuel consumption.

GASOLINE AND DIESEL ENGINES

EXAMPLE OF ENERGY SAVINGS: REPAIR 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. Suppose the carburetor on one of your tractors starts leaking and you do not find time to fix it for a month. At least 15 gallons of gasoline and $8.25 are wasted.

Calculations

0.5 gallon/day x 30 days x $.55/gallon = $8.25

Dollars Saved at Various Gasoline Prices

Cents/gal	50¢	55¢	60¢	65¢
Annual savings	$7.50	$8.25	$9	$9.75

GASOLINE AND DIESEL ENGINES

EXAMPLE OF ENERGY SAVINGS: CORRECT THERMOSTAT AND ENGINE TEMPERATURE

$9.60 Savings 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 thermostat on your tractor is stuck open during the winter your tractor may operate at 100°F or less no matter how long you use it. Assuming the tractor is used 40 hours during the 3 coldest months of the year, you could save $12.60 by having a properly functioning thermostat. A new thermostat costs about $3 (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

.7 gallon/hour x 40 hours x $.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

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(3) Berge, O. I. Tips on Energy Saving for Wisconsin Farmers, Newsletter of Dept. Agr. Engin., Univ. Wis., Madison, Dec. 1976.

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To conserve energy, you should first know how much electricity, gasoline, diesel, and other fuels you now use in your orchard operations. Some of the orchard operations that use electricity (primarily those involving packing and storage and, in some cases, frost protection) may be hooked up to the same meter as the farm residence. In such instances an amount of electric usage should be subtracted from that of the residence.

Appendix table 1 should help you estimate the number of kilowatt hours you use in your residence. The amount of electrical energy used in a typical home for lighting and appliances is 400-600 kWh per month. This figure includes an electric range but not electric hot water heaters. The amount of electricity required for the water heater varies with family size, composition, habits, and temperature of the water supply. (One long hot shower, 10 minutes, requires about 7 kWh of electricity to heat the water used.) Also excluded from the above figure are kWh estimates for heating and air conditioning. Oil or gas furnaces require approximately 0.6 kWh of electricity for the fan, etc., for each gallon of fuel burned. If your house is heated electrically you already know how that increases your electric use.

The following set of recordkeeping charts should help you in determining your electricity and fuel use for each orchard task. If you keep a careful record, you will be able to identify those parts of your operation where you can save energy and money.

Much of the monthly energy-use information for your farm can be obtained by reading your electric, gas (propane or natural gas), and gasoline or diesel fuel meters each month and subtracting the reading for the previous month from that for the current month. If you don't have a gas, gasoline, or diesel fuel meter, you can use the amounts of energy purchased as shown on your fuel bills. Although these may not be on a monthly basis, they should still provide a basis for estimating monthly and annual energy use.

ENERGY USE

The Energy Use chart, Recorder I, has a column in which you can enter the date of purchase or the date your fuel supplier read the meter. Gasoline or diesel fuel use can also be recorded as you use it. You may already have this data recorded for your gas tax refund claim.

Energy Use Recorder II is to assist you in estimating the number of kilowatt-hours that you use in your orchard or grove operation. The conversion factors needed can be obtained from appendix table 3. The schedule should be used as follows:

(1) First, enter the horsepower of the motor for each piece of electrical equipment used (for example, 5 hp).

(2) Next, select the correct conversion factor for the size motor from appendix table 2 (for example, 6.440 kilowatts are required per hour of use for a 5-hp motor).

(3) Enter the hours of use per unit of time (for example, 40 hours per month).

(4) Multiply together (2) and (3) to get your usage per unit of time (for example, 6.440 x 40 - 257.6 kilowatt-hours of usage per month).

(5) Add the amount used by each motor or piece of equipment per unit of time to get your total electrical usage (this could be 500 to 1,000 kWh below the amount of your

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monthly bill, because the bill usually includes your residential use, too).

Energy Use Recorder III is for logging monthly fuel use (the number of gallons of gasoline each task requires). For example, in orchard spraying for fruit pests, a 45-horsepower diesel wheel tractor pulling a 500-gallon sprayer, operated by the tractor's power take-off, would use 2.6 gallons of fuel per hour (app. table 2). The calculations are as follows: 40 hp x 0.065 gallon per hp hour equals 2.6 gallons (assuming further that 2 acres of fruit trees may be sprayed in 1 hour). The amount of diesel fuel used to spray a 20-acre apple orchard would be 10 x 2.6 or 26 gallons of diesel fuel. Now suppose the 20-acre orchard is sprayed twice in April, twice in May, three times in June, three times in July, and three times in August. The diesel fuel usage will be as follows:

April, 2 x 26 = 52 gallons

May, 2 x 26 = 52 gallons

June, 3 x 26 = 78 gallons

July, 3 x 26 = 78 gallons

August, 3 x 26 = 78 gallons
Total 338 gallons

Energy Use Recorder IV may be helpful in estimating fuel usage by task performed. It could be used in conjunction with your records on refueling to develop data for Energy Use Recorder I. The number of gallons of fuel used by each behicle and each task is valuable information to have for determining which ones are more efficient.

Although keeping energy-use records takes time, if you act upon disclosure of excess use, you will save enough energy dollars to pay you for your trouble. It will also help you to evaluate your equipment and how you use it. If you save only 1 kilowatt-hour per day, you will save $14.60 per year (at $0.04 per kWh)--not bad for the small amount of recordkeeping involved.

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.

Appendix table 1--Annual energy requirements of electric household appliances[1/]

FOOD PREPARATION	Estimated kWh consumed annually
Blender	15
Broiler	100
Carving knife	8
Coffeemaker	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 ft^3)	1,217
Refrigerator/Freezer	
(14 ft^3)	1,137
(Frostless, 14 ft^3)	1,829
LAUNDRY	
Clothes dryer	993
Iron (hand)	144
Washing machine (automatic)	103
Washington machine (nonautomatic)	76
Water heater	4,811

COMFORT CONDITIONING	Estimated kWh consumed annually
Air cleaner	216
Air conditioner (room)	860*
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

*Based on 1,000 hours of operation per year. This figure will vary widely depending on area and specific size of unit. You can approximate the energy used in air conditioning by multiplying tons of capacity (12,000 Btu = 1 ton) times hours used. This will approximate kWh of electricity consumed.

[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.

Source: Electric Energy Association
90 Park Avenue
New York, N. Y. 10016

Appendix table 2--Estimated energy required for various orchard and grove tasks

Orchard or grove task	Size of impl-ment	Size of tractor	Gasoline		Diesel	
			Gallons per acre	Gallons per hour	Gallons per acre	Gallons per hour
Mow	7 ft	35 hp	0.848	2.829	0.670	2.234
Spray	500 gal	45 hp	1.910	3.821	1.303	2.606
Disk offset	10 ft	65 hp	1.690	5.284	1.249	3.905
Land plane	10 ft x 40 ft	65 hp	1.638	5.284	1.210	3.906
Rotary chopper mounted	4 ft	35 hp	1.444	2.829	1.139	2.234
Rotary chopper trailer	6 ft	45 hp	1.299	3.821	.886	2.606
Fruit and nut rake		12.5 hp self-propelled	1.275	.750	--	--
Fruit and nut pickup	7 ft	22.5 hp self-propelled	1.332	1.332	--	--
Fruit and nut pickup	7 ft	45 hp	3.821	3.821	2.606	2.606
Fruit and nut knocker		12.5 hp self-propelled	1.500	.750	--	--

Appendix table 3--Kilowatts required to develop 1 horsepower with electric motors of various sizes for single-and three-phase electric service 1/ 2/

Horsepower rating of the electric motor	Kilowatts required per hour of use	
	With single-phase service	With three-phase service 3/
1/4	0.667	---
1/3	.828	---
1/2	1.127	0.762
3/4	1.587	1.067
1	1.840	1.334
1-1/2	2.300	1.905
2	2.720	2.476
3	3.909	3.531
5	6.440	5.715
7-1/2	9.203	8.376
10	11.500	10.290
40	---	29.640

1/Adapted from (4, p. 53).

2/For motors with normal torque and speed characteristics. These are full load ratings that ignore the power factor (which lowers the kilowatts required per hour of use) plus start-up current demand and other factors which increase the kilowatts demanded. Motors built for especially low speeds or high torque may require more current. If a specific motor is of concern, check the actual name-plate data.

3/Where three-phase service is available.

Energy Use--Recorder I

Date	Electric (kWh)	Gasoline (gal)	Diesel (gal)	Fuel oil (gal)	L.P. gas (gal)	NG 1,000 (ft^3)
Jan.						
Feb.						
Mar.						
Apr.						
May						
June						
July						
Aug.						
Sept.						
Oct.						
Nov.						
Dec.						

Energy Use Recorder II

Type of equipment	Average amount used per month1/												Total per year
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	

1/For example, number of hours per month irrigation for your sprinkler system runs; gallons of gasoline used in plowing.

Energy Use-Recorder, III

Type of equipment	Horsepower of motor	Conversion factor 1/	Use per unit of time	kWh per unit of time

1/Conversion factors are listed in Appendix table 3.

Energy Use-Recorder IV

Task performed	Date	Tractor or engine used	Hours used	Fuel used in performing the task

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.