Potential Cost Savings from Investments in Energy-Conserving Irrigation Systems

October 1982

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POTENTIAL COST SAVINGS FROM INVESTMENTS
IN ENERGY-CONSERVING IRRIGATION SYSTEMS

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PREFACE

The Agriculture and Food Processes Branch is a research, development, and demonstration program office within the Office of Industrial Programs, U.S. Department of Energy (DOE). In accordance with DOE goals, the Agriculture and Food Processes Branch is promoting both increased use of existing energy-saving irrigation technologies and the development of new technologies in the Energy Conservation in Irrigation Systems Program. This program has involved sharing with industry the development costs of projects having the potential to significantly reduce energy usage in irrigation systems.

Since 1977, the Pacific Northwest Laboratory (PNL), operated by the Battelle Memorial Institute, has been supporting the Agriculture and Food Processes Branch in its efforts to issue a program opportunity notice for the design and development of irrigation systems that reduce energy consumption without sacrificing agricultural productivity. Toward this end, PNL has technically and administratively monitored the contracts under the program opportunity notice. This report, which provides an assessment of the market potential and economics of the energy-saving irrigation systems, is intended to be of interest to farmers, irrigation equipment vendors, and irrigation equipment manufacturers.

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EXECUTIVE SUMMARY

INTRODUCTION

The Agriculture and Food Processes Branch of the U.S. Department of Energy in 1977 began sponsorship of ten research projects designed to develop energy-conserving irrigation systems. These energy-conserving irrigation systems were designed to save energy through a wide variety of methods, ranging from improved well development to computerized water scheduling. Each of these systems offered energy cost savings relative to conventional irrigation systems; however, in most cases, these energy cost savings were realized at the expense of increased capital costs or increased operating and maintenance costs.

The purpose of this report is to analyze, within a consistent framework, the potential for energy-conserving irrigation systems to reduce total irrigation costs. This task is accomplished by comparing the levelized or annualized costs of energy-conserving irrigation systems with those of conventional systems of similar technology. Energy-conserving irrigation systems reduce total irrigation costs relative to conventional systems as long as the value of energy saved is great enough to offset any additional capital, operating and maintenance costs.

In this study, generic conventional and energy-conserving irrigation systems designed for a 160-acre field are compared on the basis of energy use and energy, capital, operating and maintenance costs. Energy use for each system is calculated from energy-use equations that relate the amount of energy used by the generic irrigation systems to parameters such as well, pump, and prime-mover efficiencies, application system operating pressures, volume of water applied, and the amount of lift necessary to move water from its source to the field. Since the values of parameters such as well draw-down, surface-water and groundwater lift, and water application rates vary substantially across regions, average state-level values for these parameters are used to estimate energy use in the 17 states that use the largest amounts of energy in crop irrigation. The 17 states are (in alphabetical order): Arizona, Arkansas, California, Colorado, Florida, Idaho, Kansas, Montana,

Nebraska, Nevada, New Mexico, Oklahoma, Oregon, Texas, Utah, Washington and Wyoming. These 17 states contain 91% of the irrigated cropland in the United States.

Energy cost is calculated for each generic system by multiplying energy use times average state-level energy prices. The calculated energy cost, capital cost and operating and maintenance costs are then levelized and adjusted for inflation, real fuel price escalation, and taxes. The levelized after-tax costs of energy-conserving irrigation systems are compared to those of conventional irrigation systems of similar technology to determine whether conserving systems offer cost advantages over the systems they would most likely replace. Several energy-conserving technologies are analyzed in this study: 1) well improvements through surging and jetting techniques, 2) a redesigned column and pump, 3) variable-speed pumping, 4) a reduced-pressure center pivot system, 5) Low Energy Precision Application (LEPA) lateral-move and center-pivot systems, 6) a radio-controlled automated gated-pipe system, 7) a computer-assisted water scheduling system, and 8) an instrumented water scheduling system. Two other energy-conserving technologies, an irrigation system optimization computer program and a system pipeline optimization computer program, which were computer program upgrades made with the help of funding from the Agriculture and Food Processes Branch, are not analyzed in this study because both Projects focused on computer model design modifications to existing models. These model improvements could not be represented by a generic irrigation system.

The conclusions reached in this report are formulated from the results of a comparative analysis based on the following economic assumptions: 1) 10% real discount rate, 2) 6% general inflation rate, 3) 2% real fuel price escalation rate, 4) 25% tax rate, 5) 10% real salvage value for irrigation equipment (except well equipment, which has no salvage value), 6) 15-year equipment life (20 years for wells), and 7) straight line depreciation. Another critical assumption in the comparative analysis is that crop yields and nonirrigation production costs are unaffected by the choice of irrigation system if the two systems compared perform the same functions. Conclusions reached as a result of the comparative analysis are presented below by energy-conserving

technology. All after-tax costs are based on a 160-acre generic irrigation system (center pivot is based on 130 acres).

CONCLUSIONS

Improved Well Development

Wells developed by surging and jetting reduce the amount of energy used to pump groundwater by reducing water drawdown in the well. The comparative analysis indicates that when bentonite is used as a drilling fluid, surging wells in unconsolidated aquifers reduces after-tax costs in all states except Idaho, where costs are increased by \$40 per year for a 160-acre operation. Annual after-tax cost reductions in the other states range from \$25 to \$2522. Jetting wells in unconsolidated aquifers where bentonite is used as a drilling fluid reduces after-tax costs in all states except Arkansas, Kansas, Florida and Idaho, where costs are increased from \$11 to \$137 per year. Costs are reduced slightly in Colorado, Wyoming, and Montana, and are reduced by more than \$100 per year in the remaining states.

This analysis indicates that improved wells could reduce irrigation costs in many parts of the U.S. Surged wells may have a slightly better potential for market penetration than jetted wells, since surged wells are less expensive and provide only marginally lower energy savings than jetted wells. Both surging and jetting are limited to use on new wells only, so market penetration may be relatively slow.

Column and Pump Redesign

Improvements through improved column and pump (impeller and housing) redesign can reduce energy losses by reducing friction losses in pumping. When combined with either conventional gated-pipe or center-pivot systems using groundwater, the redesigned column and pump identified in this program reduces the leveled after-tax cost of irrigation in all 17 states considered in the analysis. This technology reduces annual after-tax costs for a 160-acre gated-pipe system between \$56 and \$1663, depending on the state. Reduction in the after-tax cost of a center-pivot system ranges from \$118 to \$1636 per year.

The advantage of the redesigned pump over a conventional pump is that it is able to reduce energy costs with a negligible increase in capital costs. Some questions have arisen, however, regarding the ability of the redesigned column and pump to maintain high performance under harsh conditions. If superior performance can be maintained over the life of the pump, the technology has the potential to save irrigators both energy and money in all major irrigation regions of the country.

Variable-Speed Pumping

Variable-speed pumping reduces energy use by matching pump speed with the required water delivery rate. However (except in extreme circumstances), the energy cost savings from varying the speed of an electric motor is insufficient to offset the substantially higher capital costs. Variable-speed pumping using electrical motors was found to increase after-tax costs of irrigation in all states, except Arizona, for both gravity flow and sprinkler irrigation systems using groundwater. Although no comparative analysis is performed for systems using surface water, the comparative economics for variable-speed electrically driven pump using surface water clearly would show even greater increases in after-tax costs. This analysis indicates that under the assumptions of this study, variable-speed electric prime movers have a limited potential for reducing energy costs enough to make the conversion cost effective. The potential market for variable-speed motors is limited to regions facing extremely high irrigation costs attributable to deep groundwater, large well drawdown, high water application rates, and high energy prices.

Reduced-Pressure Center-Pivot Systems

The reduced-pressure center-pivot sprinkler system decreases energy use by lowering system operating pressure and improving water use efficiency. This system uses reduced-pressure impact sprinklers, rather than drop tubes, to distribute water and is, therefore, not significantly different from conventional center-pivots that use high-pressure impact sprinklers. The capital, operating and maintenance costs for this system are, in fact, virtually identical to those for conventional center-pivot systems. Field testing has demonstrated that few adverse side effects, such as increased soil erosion, are likely to result from the use of reduced-pressure impact sprinklers.

Reduced-pressure center pivots reduce after-tax irrigation costs in all 17 states in the comparative analysis. Costs are reduced by \$861 to \$5626 per year for both surface-water and groundwater irrigation for a 130-acre circle. This system appears to have excellent potential for market penetration and irrigation cost savings in all major irrigation regions of the United States.

LEPA Lateral-Move Systems

Low-Energy Precision Application (LEPA) lateral-move systems reduce application pressure and improve water application efficiency relative to conventional lateral-move systems. Yet they have only slightly higher capital, operating and maintenance costs. Consequently, LEPA lateral-move systems reduce irrigation costs in all states for both surface-water and groundwater applications. Annual after-tax cost reductions for a 160-acre operation range from \$412 to \$11,027 for groundwater and \$250 to \$7431 for surface-water applications. Because this system offers significant potential for cost savings in all major irrigation states, and because it uses a type of irrigation system already familiar to irrigators, it has a high potential for row crop application.

LEPA Center-Pivot Systems

LEPA center-pivot systems reduce energy use through reduced application pressure and improved water application efficiency, as compared to conventional center-pivot systems. The capital costs for LEPA center-pivot systems are slightly higher than those for conventional systems, but are readily offset by energy cost reductions, so that these systems reduce after-tax irrigation costs in all states for both surface-water and groundwater applications. After-tax cost reductions ranged from \$220 to \$688 per year for surface water and from \$351 to \$9709 per year for groundwater for a 130-acre irrigated field. This system offers potential cost savings in all major irrigation regions, and uses a familiar type of irrigation system. For these reasons it should have a good potential for row crop application. One factor that could slow its penetration potential is that drop tubes used by this system could force farmers to change cultivation patterns. However, a few Texas farmers have converted to LEPA center-pivot operations and have not found circular cultivation to be a problem.

Automated Gated-Pipe Systems

Automating the operation of a gated-pipe system improves water application efficiency and thus reduces energy use by allowing greater control over the timing and application of water. The automated gated-pipe system analyzed in this study requires large additions to system capital costs, relative to conventional gated-pipe systems, to cover the expense of radio-controlled equipment and additional field piping. This system also requires an increase in operating and maintenance costs because of the possibility of more frequent system failure and the need for highly skilled repairmen. The value of energy saved by this system is not great enough to cover increased capital, operating and maintenance costs, except in very high-cost irrigation situations. The comparative analysis shows that, for groundwater applications, using the automated gated-pipe system rather than conventional gated-pipe would result in an increase in after-tax irrigation costs of more than \$1903 per year for a 160-acre farm in all states except Arizona, where it would potentially reduce costs by \$1815 per year. For surface-water applications, automated gated-pipe would increase after-tax costs by more than \$3000 per year in every state. Analysis indicates that radio-controlled automated gated pipe, in the configuration analyzed in this study, has little potential for reducing irrigation costs for groundwater applications, and virtually no potential for surface-water applications. This system does have some potential as a labor-saving device, if its reliability is improved and its capital costs are reduced. Although not analyzed in this assessment, a hard-wired automated gated-pipe system may have the potential for greatly reducing capital costs and improving reliability.

Computerized Irrigation Scheduling

Computerized irrigation scheduling saves energy by reducing the amount of water applied to grow crops. Scheduling is accomplished through scientific control and timing of irrigation water to improve water application efficiency. Although computerized irrigation scheduling theoretically can be used with any application system, it is able to improve water application efficiency more effectively for sprinkler systems and automated gated-pipe systems because these systems give a greater degree of control over water application than

conventional gravity flow systems. When used with a center-pivot system, computerized scheduling lowers annual after-tax costs for surface-water applications in all states but Kansas and Colorado, where costs increase slightly. For groundwater applications, implementing computerized scheduling with a center-pivot system offers after-tax cost savings of \$19 to \$5492 per year for a 160-acre operation in all 17 states. The comparative analysis shows that using a computerized irrigation scheduling system with conventional gated-pipe application increases after-tax irrigation costs in all states except Arizona, for groundwater applications, and in every state for surface-water applications.

Computerized scheduling does appear to have high potential for cost savings when combined with high-pressure sprinkler systems. The possible cost savings from computerized scheduling are further enhanced by the value of water savings. Computerized scheduling does not appear to have much potential for use with gravity flow irrigation systems unless systems can be designed so that the amount of water applied can be precisely controlled. One factor that could inhibit the acceptability of a computerized scheduling system is the perception of its effect on crop yields. The results of J. M. Lord's field tests showed no significant differences in grain and tomato yields between computerized and noncomputerized scheduled fields. Cotton yields actually increased when irrigations were scheduled with the computer system. Despite these results, more evidence may be required to convince farmers of the accuracy of computerized scheduling because the risks of lower yields from underwatering appear to be significantly greater than the risks of lower yields from overwatering.

Instrumented Irrigation Scheduling

Instrumented irrigation scheduling employed tensiometers to measure soil moisture. This system reduces water use and energy use by watering only when soil moisture is low. Problems with the instrumented system evaluated in this study include high capital costs of instrumentation, and system reliability and accuracy. The energy cost savings generated by this system are generally insufficient to cover increased capital, operating and maintenance costs. The comparative analysis indicates that for both surface-water and groundwater

applications, instrumented irrigation scheduling, when combined with a gated-pipe application system, increases after-tax irrigation costs in all 17 states. In fact, disregarding Arizona, these costs are increased everywhere by over \$1500 per year for a 160-acre operation. When instrumented scheduling is combined with a high-pressure center-pivot system, after-tax irrigation costs are increased in every state for surface-water applications, and in all states except Arizona for groundwater applications.

Although this system does generate water savings, it is questionable whether the value of water saved is great enough to make it economically viable in most states. Instrumented scheduling has limited potential for cost savings, except in very high water cost irrigation regions. The market penetration potential is negligible unless capital costs can be lowered significantly and system reliability improved. The economic performance of this system could be further eroded if crop yields are reduced by its use.

RECOMMENDATIONS

Several of the energy-conserving irrigation systems analyzed in this study offer potential for saving energy and money when used in irrigated agriculture. For these systems to save energy, however, they must be accepted in the market. Ultimately, market acceptance of these systems depends on their ability to reduce irrigation costs. The rate at which cost-effective, energy-conserving irrigation systems penetrate the market is partially affected by the farmer's exposure to information about the technical and economic performances of those systems. The PNL assessment staff recommends that DOE select several energy-conserving irrigation systems that appear to be economically attractive and disseminate information about them to farmers, irrigation equipment manufacturers, extension agents, and other interested parties. This information could be distributed either through second-hand information sources such as print and broadcast media, or through first-hand sources such as seminars and on-farm demonstration programs. On-farm demonstration projects are particularly valuable for systems like computerized irrigation scheduling, where some uncertainty about impact on crop yield exists.

Based on the results of the economic comparisons made in this study, the assessment staff recommends that information dissemination and commercialization efforts be concentrated on the following energy-conserving irrigation technologies:

- well development techniques
- redesigned pump impeller and housing
- LEPA center-pivot and lateral-move systems
- computerized irrigation scheduling.

Efforts on the part of the Agriculture and Food Processes Branch to further the commercialization of reduced-pressure center-pivot systems do not seem warranted because these systems are already being marketed by the private sector. Agriculture and Food Processes could, however, distribute information about the benefits of reduced-pressure center-pivot irrigation to facilitate the adoption rate of these systems by farmers.

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1.0 INTRODUCTION

In response to the increasing prices and decreasing supplies of fossil fuel resources, national energy policy emphasizes the conservation of nonrenewable energy resources. Conservation efforts are focused on two basic strategies: 1) to advance the displacement of scarce, nonrenewable energy sources with renewable or more plentiful sources of energy, and 2) to promote more efficient use of all energy resources. The Agriculture and Food Processes Branch of the Department of Energy has been responsible for expending these conservation goals to the agricultural sector. Using the equivalent of 46 million barrels of oil each year, crop irrigation is one of the most fossil-fuel-intensive activities in agriculture. If oil costs \$35 per barrel, the oil equivalent cost of the energy used for agricultural irrigation exceeds \$1.6 million annually. Conserving energy in irrigation is therefore important to the national policy goal of reducing oil imports and to the farmer in terms of minimizing production costs.

To facilitate development of energy-saving irrigation system technologies, the Agriculture and Food Processes Branch has undertaken the Energy Conservation in Irrigated Agriculture Program. This program matches public funds to private research funds for ten development projects, each of which advances a specific irrigation energy conservation technology. Pacific Northwest Laboratory's responsibilities in the program have been to manage and perform cross-cut research related to the ten projects. In addition to having the potential to significantly reduce energy use, the projects chosen to receive funding were required to have a high probability of economic viability in the relatively near term. When evaluating the energy-saving systems, it is important to remember that if energy prices continue to rise, technologies that are not economically feasible at the present time may become so at some future date.

The central issues of energy conservation in irrigation involve identifying the technologies that reduce energy consumption and determining the amount and economic value of energy saved. Results of previous research suggest that substantial energy savings are possible through technological

improvements to irrigation system equipment and through more precise management or system operations. Because irrigation depends heavily upon fossil fuel stocks, the reduction of energy use retards the depletion of nonrenewable fossil fuel supplies. The economic value of energy savings to the farmer, which is the difference between lower energy expenditures and the higher capital and operation costs connected with the energy-saving technology, is the major factor determining commercial acceptance of the energy-conserving irrigation system.

This report contains a comparative analysis of the levelized costs of selected irrigation systems with an emphasis on the costs and benefits of energy savings. The purpose of the report is to evaluate the net economic benefits, measured as energy cost savings minus additional capital and operating costs, of some of the energy-conserving systems developed through Agriculture and Food Processes Branch sponsored research.^(a) Energy use in irrigation and descriptions of both the conventional and the energy-saving technologies involved in the analysis are discussed in Chapters 2 and 3. In Chapter 4 the approach used in the analysis is outlined, and in Chapter 5 the comparative analysis results are discussed. Detailed cost information is presented by state in the Appendix.

(a) The comparisons made do not necessarily depict the conditions faced by any particular farmer. The methods of comparison employed, however, can be used to evaluate any farm operation.

2.0 ENERGY USE IN IRRIGATION

Crop irrigation is practiced in all 50 states on a total of 61 million acres, according to recent published data (Brantwood Publications 1981). Irrigated acreage is concentrated in the arid West, where seventeen states, listed in Table 1, contain 91% of all irrigated land. These same seventeen states consume 95% of the 0.27 quadrillion Btu of energy expended annually for crop irrigation. Total energy consumption in irrigated agriculture has risen steadily over time, reflecting increases in both total acres irrigated and in the proportion of acreage that is sprinkler irrigated. From the standpoint of energy use, the increasing proportion of sprinkler-irrigated acres is important because sprinkler systems use considerably more energy per unit of water delivered than gravity flow systems.

The amount and type of energy used for irrigation purposes vary widely across the United States. In general, the amount of energy demanded by an irrigation system depends on a variety of factors including the water source, the amount of water pumped, the method of water application, and the types of crops grown. The amount of energy expended to apply a given amount of water to a field is positively related to the lift and operating pressure required by the irrigation system. Systems that use groundwater or high-pressure sprinkler equipment consume more energy per unit of water delivered than systems that use surface water or gravity flow application. Energy use is also positively related to the amount of water used. Thus, decreasing the volume of water pumped with a given system will result in the consumption of less energy. Several of the energy-saving technologies discussed later in this paper reduce energy consumption by conserving water.

Most of the energy used by an irrigation system is used to lift water and pressurize application systems. An estimated two-thirds of the total irrigation energy is expended lifting water from its source to the field. The amount of energy used to lift water is affected by factors that include well efficiency, well depth, prime mover efficiency, and pump efficiency. Pump and prime mover efficiency are significantly affected by the type of fuel used, because electric prime movers (motors) have much higher efficiencies at the prime mover than gas or fossil-fuel-powered prime movers (engines).

TABLE 1. Total Irrigated Cropland Acres and Energy Use Per Acre in the Seventeen States Having the Most Irrigated Acreage

<u>State</u>	<u>Total Irrigated Acres^(a)</u>	<u>Energy Use per Acre (Btu)</u>
Arizona	1,147,500	13,785,600
Arkansas	1,648,500	3,141,600
California	9,899,000	2,245,500
Colorado	3,030,000	1,306,900
Florida	2,285,800	2,901,000
Idaho	3,987,500	3,219,300
Kansas	3,588,000	10,038,200
Montana	3,100,000	1,359,700
Nebraska	7,445,200	5,813,800
Nevada	1,304,100	2,910,800
New Mexico	1,239,700	13,237,900
Oklahoma	935,200	12,078,700
Oregon	1,978,300	2,455,600
Texas	9,000,000	6,296,800
Utah	1,203,228	1,893,200
Washington	1,838,000	5,115,900
Wyoming	1,937,700	1,054,900
17 state total	55,567,728	---
U.S. total	61,148,376	---

(a) Brantwood Publications 1981.

Excessive energy use occurs when irrigation system efficiencies are low and when crops are overirrigated. From 1974 to 1977, 85% of the growth in irrigation water supply came from groundwater sources, adding considerably to increased demand for pumping energy (Sloggett 1979, p.5).

The other major user of irrigation energy is the application system, in which the amount of energy consumed essentially depends on the required operating pressure, friction losses, the amount of water applied, and pump and prime mover efficiencies. While sprinkler irrigation methods are more energy intensive per unit of water applied than surface methods, they have higher application efficiencies and, thus, often use less water. Application efficiency becomes increasingly important as the amount of lift increases and as energy used for pumping becomes greater compared to that used for pressurization. The trend of proportionally more sprinkler irrigation and less surface irrigation is primarily related to the lower labor costs of sprinkler irrigation. Other irrigation-related uses of energy (not assessed here) include the energy used to propel mobile irrigation systems, manufacture of irrigation equipment and system installation.

3.0 IRRIGATION TECHNOLOGY

In this chapter the conventional irrigation systems and the energy-conserving systems analyzed in this report are described briefly. Descriptions of irrigation system equipment and practices surrounding its use are included for conventional systems because many of the energy-saving technologies offer improvements to specific components of conventional systems. To help the reader compare the hardware of the energy-conserving systems to the hardware of the conventional systems, both conventional and energy-conserving systems discussed in the following sections include application systems, pumps, wells, and scheduling.

3.1 CONVENTIONAL IRRIGATION SYSTEMS

Most of the conventional, mechanically automated irrigation systems used today were developed when energy was relatively cheap and readily available to farmers. At that time, labor costs were a key factor in determining the economic feasibility of irrigation. Consequently, the systems that emerged in the market were designed primarily to reduce the labor required to irrigate, and less attention was given to the amount of energy used by the systems. Throughout the remainder of this report, the term "conventional irrigation system" refers to irrigation systems developed and used with low emphasis placed on energy-conserving features. Three conventional application systems (gated-pipe, center-pivot, and linear-move) and conventional wells, pumps, and irrigation scheduling were assessed and are described below.

3.1.1 Irrigation Wells

Conventional well-drilling techniques involve various types of drilling machines, uses of different drilling muds, and the possible addition of a screen and gravel pack. How a well is drilled depends on the depth of groundwater, the amount of water needed, the material being penetrated, and the type of aquifer.

Well drilling is commonly done with rotary, cable tool, and bucket auger techniques. Drilling fluid, referred to as mud, is used to bring the loosened

material to the surface. This mud also stabilizes the well walls, but it can reduce the capacity of the well unless it is removed through well development. After the drilling is completed, a screen and gravel pack may be added to the well. These devices permit the flow of water but retard the movement of sand and rock into the well. Selection of the proper screen and gravel pack material can also contribute to a well's efficiency.

During pumping periods, a well attains a new depth of water that is below the static, or nonpumping, water level. The difference between the static water level and the pumping water level is referred to as the well drawdown. Drawdown is directly related to well efficiency. A large drawdown increases the pumping depth, which means that more energy will be expended to lift water to the surface.

3.1.2 Irrigation Pumping Plants

An irrigation pump takes stationary water and imparts force to lift it to a desired height and distribute it through an application system. The impeller is the apparatus that transfers force to water. Different impeller designs and sizes result in pumps with varying flow rates and varying lift capabilities. Gravity flow irrigation application systems typically use pumps with high flow rates and low heads (pressures), whereas center-pivot and other sprinkler application systems use pumps with lower flow rates and higher heads. Other pump components include the diffuser, which is used with the impeller to pressurize irrigation water, and the pump housing.

The ability of the pumping plant to translate pumping energy to the water (via the impeller) is a measure of the pump's efficiency. Every pump is designed to operate at a specific flow rate and head; major deviations from the design flow rate and head can reduce pump efficiency, resulting in excess energy consumption. For example, if the operating pressure of an irrigation system is reduced from 80 psi to 40 psi, and the pump used with the system was designed to deliver 80 psi, the system loses efficiency because the pump is no longer operating at its intended level. Matching the pump to the system requirements is important in obtaining maximum pump efficiency. Pump efficiency tests for existing wells indicate wire-to-water pump efficiencies

of around 50%. Off-the-shelf pumps are designed to have efficiencies of up to 75%. Depending on the reasons for the low efficiency, there may be considerable potential for improving a pump's efficiency.

3.1.3 Center-Pivot Irrigation

Center-pivot irrigation is the fastest growing type of automated sprinkler system. Center-pivots presently account for about 42% of sprinkler-irrigated acreage and 11% of total irrigated acreage in the 17 states having the most irrigation acreage. The basic center-pivot system, without the corner-catching device, irrigates a 130-acre circle and is composed of a series of towers (average length about 125 feet) coupled together. An alignment system is used to keep the system straight. Each tower includes a water supply pipe with a 4- to 8-inch diameter, supported by A-frame trusses mounted on wheels that roll the pipe around the circle. The clearance between the water supply pipe and the ground ranges from 5 to 12 feet. The system is powered by motor driven (electric, hydraulic, or water powered) gearboxes, which drive the wheels, causing the pipe system to pivot around a point in the center of the field. Rotational times range from 8 to 300 hours.

Water is supplied to the center-pivot system through a mainline pipe attached at the pivot point. Center-pivots apply water efficiently but require large amounts of energy to pressurize water and to overcome friction losses resulting from distribution of water through the pipe. Operating pressures at the pivot point of about 85 psi are required to deliver the water to the impact sprinklers mounted along the water supply pipe. These high-pressure systems are herein considered the conventional form of center-pivot; however, some lower-pressure impact sprinklers center-pivot systems are currently available.

3.1.4 Lateral-Move Irrigation

A newer form of sprinkler application is the linear- or lateral-move system. This system is basically a center-pivot machine without the pivot point. Instead the system moves linearly along the field at rates of up to 6.5 feet per minute. To facilitate automatic irrigation, the system has both tower-to-tower alignment and alignment up and down the field.

Water is supplied at the end or middle of the lateral-move system, either through a long flexible drag hose, which must be moved periodically, or from a ditch, which allows extraction via an on-board pump. Lateral systems allow for complete field irrigation and use less energy than pivots because less water is carried to the far end of the system. The actual application of water is similar for lateral-move and center-pivot systems, as both impact sprinklers and spray nozzles are used. Lateral-move systems are relatively new and are being sold by all the major center-pivot manufacturers.

3.1.5 Gated-Pipe Irrigation

Gated-pipe is a type of gravity flow irrigation that applies water to the crop at low pressures of approximately 2 psi. A gated-pipe system is basically composed of 30-foot sections of aluminum or pvc pipe, available in several different diameter sizes, although six inches is the diameter size most commonly used. Each section of pipe has regularly spaced openings that have gates that are opened and closed manually. When the gates are open, water flows from the pipe into the furrows between crop rows and infiltrates the soil adjacent to plants.

The low-pressure gated-pipe application system is very efficient in its use of energy per unit of water applied. This system, however, typically involves high labor costs and water application inefficiencies that, in some cases, have limited its market share. A field may have enough sections of pipe to irrigate without moving the pipe. More commonly, the pipe system is moved one or more times during an irrigation, resulting in the need for less pipe but more labor. Gated-pipe irrigation is fairly common, accounting for about 20% of the irrigated acres in the 17 states.

3.1.6 Irrigation Scheduling

Irrigation scheduling is the term used to describe the amount and timing of water applications. Water is applied according to crop needs, soil type, climatic conditions, and other factors. Generally, conventional scheduling is the farmer's decision, based on past experience and knowledge of current

conditions, as to when and how much to irrigate. At present, some computer scheduling models are in use. However, for the purposes of this study, conventional irrigation scheduling is defined as scheduling without the aid of a computer.

3.2 ENERGY-CONSERVING IRRIGATION SYSTEMS

Increases in the cost of energy and potential shortages of nonrenewable energy resources have heightened the need to reduce the energy-use inefficiencies of conventional irrigation systems. In response to this need, ten energy-saving technologies were developed as part of the Energy Conservation in Irrigated Agriculture Program sponsored by the Agriculture and Food Processes Branch of the Department of Energy. Each involves the development of an improvement or innovation designed to reduce a targeted source of energy use inefficiency in irrigation technology. A list of the ten energy-conserving projects is shown in Table 2.

TABLE 2. Technologies Addressed in the Energy Conservation
in Irrigated Agriculture Program

<u>Technology</u>	<u>Sponsor</u>
Well Design and Development	University of Minnesota Irrigation Center, Staples
Column and Pump Redesign	Aerospace Research Corporation
Variable-Speed Pumping	Foster-Miller Associates
Reduced-Pressure Center-Pivot Systems	University of Nebraska
Low-Energy Precision Application (LEPA)	Texas A&M Research Foundation
Automated Gated-Pipe Systems	Kansas State University
Computerized Scheduling	J. M. Lord, Inc.
Instrumented Scheduling	Prossen Industries
Optimal Pipe Network Design	Keller Engineering
Groundwater System Optimization	University of California at Davis

3.2.1 Well Design and Development

The University of Minnesota's Irrigation Center at Staples researched the effects of well design and development practices on energy used by an irrigation system (Werner 1980). The effects of several components of well design, including screen design, drilling fluid, and well development method, were studied in this project. The two development methods of primary interest in this report are surging and jetting. Both techniques facilitate the movement of water from the aquifer into the well. Surging involves the rapid raising and lowering of a piston-like device in the well, which creates a back-and-forth surging action through the well screen. Mud and fine particles move into the well and are then removed. In jetting, a tool with several nozzles is lowered into the well and inside the screen. Water is forced through the nozzles as the tool is rotated slowly and moved up and down. At the same time, compressed air is pumped into the well at a rate approximately 1.5 times greater than the flow through the nozzles. The jetting and pumping combine to produce a flushing action that loosens and removes fine particles from the well.

Development of a well with surging or jetting techniques can result in reductions in drawdown of as much as 50% for a well drilled with a bentonite drilling mud in an unconsolidated aquifer. This increase in well efficiency translates into energy savings through reduction in the pumping energy necessary to lift water to field level. Although this technology is not easily applied to existing wells, it is readily applicable to new wells.

3.2.2 Column and Pump Redesign

Losses in pumping plant efficiency and energy occur in the column, the line shaft, the pump impeller, and the diffuser apparatus. Aerospace Research Corporation modified the design of a conventional column and pump to reduce the friction losses that result in efficiency loss and increased energy use (Hamrick 1980). The column and redesigned pump differed from conventional columns and pumps in four respects: 1) a packer was used to seal the well casing just above the pump so it could be used as a supplementary water conduit; 2) a smaller, high-strength line shaft was installed; 3) the impeller and diffuser design was modified, and 4) the impeller blades were mechanically polished. This technology saves energy by reducing friction losses.

3.2.3 Variable-Speed Pumping

Irrigation pumping systems powered by electric motors are designed and installed to deliver water at constant rates and pressures that meet or exceed peak demand requirements. Because operating delivery rates often fall below peak requirements, energy may be wasted in the form of excess capacity. Foster-Miller Associates analyzed variable-speed electric prime movers which could pump irrigation water at flow rates and pressures compatible with crop and application system needs (Foster-Miller 1981). A computer simulation model was developed to compare the costs of variable-speed to the costs of constant-speed electric prime mover pumping. Because the model uses parameters of any designated irrigation system as inputs, it can model any farm operation.

3.2.4 Reduced-Pressure Center-Pivot Systems

The energy-conserving irrigation system evaluated at the University of Nebraska focused on reduced-pressure center-pivot operations (Gilley and Mielke 1981). The standard impact sprinkler heads, requiring high operating pressures, were replaced with heads that operate effectively at lower pressures. Generally, as system pressures fall, water applied per unit of time to an area increase because the effective area over which water is being applied decreases. Traditionally, it has been believed that lower operating pressures increase water runoff and soil erosion. To prevent the additional runoff and erosion associated with reduced operating pressures and to increase water application efficiency, water-conserving tillage techniques were implemented with the reduced-pressure system. Two types of application equipment, reduced-pressure impact sprinklers and spray nozzles, were tested. The primary focus of this project was to compare the performance of reduced-pressure versus high-pressure systems in relation to energy use, water application efficiency, crop yield, water use, and soil erosion.

3.2.5 Low-Energy Precision Application (LEPA)

The LEPA system developed by Texas A&M Research Foundation addresses energy use and water application efficiency (Lyle and Bardovsky 1981). The purpose of this project was to develop and evaluate an irrigation application

system that is both energy conserving and water efficient. Designed to use existing pipe networks, (especially those of center-pivot and linear-move systems), the newly developed mobile system uses drop-tube irrigation technology that applies water closer to the crop root zone and operates at pressures as low as 5 psi at the pivot point.

Unlike conventional drip systems that have many small stationary orifices, the LEPA system is mobile and has fewer large orifices, which reduces system capital costs compared to conventional drip systems. The LEPA system has the ability to handle a wide range of flow rates, so it can be used with either low- or high-capacity wells. Energy savings are realized from lower operating pressures and water-use savings resulting from precise water application.

3.2.6 Automated Gated-Pipe Systems

The high labor costs and water application inefficiencies of gated-pipe irrigation systems were targeted by Kansas State University in its development of an automated gated-pipe system (Manges and Bloom 1981). Because considerable amounts of labor are needed to open and close the gates of conventional systems, farmers tend to change water application from one part of the field to another according to labor availability instead of crop needs. Regulating the flow of water with radio-controlled valves and programmed timers that automatically open and close the gates can reduce labor costs and water consumption. The reduced water use reduces pumping requirements and saves energy.

3.2.7 Computerized Irrigation Scheduling

Conventional scheduling practices are subjective, and they often lack precision in the timing and quantity of irrigation water applied to the field. Typically, 20% of irrigation water is lost because of the tendency of farmers to overirrigate crops. J. M. Lord, Inc., developed a computer-predictive model that schedules irrigation according to measured input parameters such as soil moisture content, crop water requirements, and weather patterns (Lord and Gartung 1981). Preliminary results suggest that computerized scheduling can reduce the amount of water used by an irrigation

system by up to 15%. Reducing the amount of water expended in overirrigation translates into a reduction in energy used to pump and apply irrigation water.

3.2.8 Instrumented Irrigation Scheduling

Another system aimed at the problem of overirrigation is the fully instrumented water scheduling system developed by Prossen Industries (Prossen 1981). This system makes computer scheduling more effective by reducing the inconvenience of gathering input parameter data. With an instrumented scheduling system, data-gathering instruments (such as soil moisture tensiometers) are physically connected to a host terminal, so that crop needs for water can be quickly determined. Energy savings result from increased precision in water application, which reduces pump and application system energy consumption. Unusually high capital costs are associated with fully instrumented systems.

3.2.9 Pipe Network Optimization

A trade-off between the higher capital costs of large-diameter irrigation system pipe and increased operating energy costs of small-diameter pipe suggests an optimal pipe size, depending on lifting and application system requirements. Currently, pipes for most irrigation systems are sized manually, which is both time consuming and likely to ignore the relationship between energy costs and capital costs. Keller Engineering improved a life-cycle cost computer program for optimizing irrigation pipe network design and developed a program user's manual aimed at irrigation system designers (Watters and Keller 1980). The potential for energy savings comes through reductions in friction losses and excess capacity that often result from using improperly sized pipe.

3.2.10 Groundwater Supply System Optimization

The University of California at Davis reviewed the factors that influence groundwater supply energy use (Helweg 1981). An optimization model for pumping and well performance was expanded to diagnose causes of energy-use inefficiencies and to evaluate the effect of inefficiency on the amount of energy used. An algorithm was included to optimally design, replace, or repair wells and pumping equipment. The model's contribution to the

conservation of energy lies in its ability to help decision makers analyze tradeoffs between capital and operating costs in designing and maintaining an irrigation system.

4.0 ANALYSIS PROCEDURE

To evaluate the energy-saving performance and cost effectiveness of the energy-saving irrigation systems described in Chapter 3.0, measures of energy use and system costs need to be developed. In this chapter, the approach and data used to evaluate the energy-conserving irrigation systems are described. The comparative analysis methodology, outlined in the first section, involves computer modeling and mathematical techniques. The data and assumptions actually used in the comparative analysis are discussed in the second section.

4.1 COMPARATIVE ANALYSIS METHODOLOGY

The following comparative analysis relates the costs and energy use of energy-conserving irrigation systems to those of conventional irrigation systems. The results of this analysis are useful in identifying conservation technologies that deserve further support. The energy use of each of the systems being evaluated is calculated using equations that describe energy use as a function of various factors. Energy-use data and state average energy-cost data are used to compute the value of energy consumed by each irrigation system. Since the useful service of an irrigation system is spread over several years, system costs and benefits are discounted to a comparable basis through levelized cost calculations.

4.1.1 Energy Use Equations

The first step in the comparative analysis involves estimating the amount of energy used by both conventional and energy-conserving irrigation systems. The amount of energy used by a system depends on the volume of water pumped, the lift required to deliver water from its source to the field, the operating pressure required by the application system, friction losses in the system, and the efficiencies of the pump, power unit, and well. The equation used to calculate energy use accounts for all of these factors. In general, the amount of energy required to move a specified quantity of water can be calculated by the following formula:

$$E = \frac{V \times H \times 2.718 \times 10^6 \text{ lb/acre-ft}}{PE \times PUE \times 777.9 \text{ ft-lb/Btu}} \quad (1)$$

where E = quantity of energy used (Btu)
 V = volume of water pumped (acre-ft)
 H = total operating head (ft)
 PE = pump efficiency
 PUE = power unit efficiency.

Total operating head (H) is the sum of well head (H_w), pumping head (H_p), and application head (H_a). Well head is the amount of head required to overcome drawdown in a well and is equal to actual drawdown (DDA) in the well. This can be calculated by dividing the theoretical drawdown (DDT) by the well efficiency (WE):

$$H_w = DDA = DDT/WE. \quad (2)$$

The amount of pumping head is equal to the vertical distance (D), in feet, between the static water level and the field level:

$$H_p = D. \quad (3)$$

Application head is the amount of head required to pressurize an application system and can be calculated by converting the system operating pressure (OP) from psi to feet. This is accomplished by multiplying the operating pressure by the factor 2.31 ft/psi:

$$H_a = OP \times 2.31 \text{ ft/psi}. \quad (4)$$

The amount of energy consumed by an irrigation system is related to the amount of total operating head, the efficiency of energy use, and the amount of water applied. High heads, low energy efficiencies and high water use translate into high levels of energy use. The relationships among variables in Equations 1 through 4 show how energy use is related to head, efficiencies and water use. For example, energy can be saved by pumping less water or by increasing the efficiencies of pump and power units. Lowering the amount of

head by improving well efficiency or reducing application system pressure requirements also conserves energy. These and other options for reducing energy consumption in an irrigation system are addressed in the energy-saving technologies analyzed in this study.

4.1.2 Levelized Cost Analysis

Net present value analysis is the standard method used to compare the value of investments over time. With this method, the value of a business over time is reflected by the net present value (NPV), or discounted value, of future cost and income streams. Organizing production and investment activities so that future income streams are maximized will maximize the value of the business. When deciding whether to invest in a conventional irrigation or in an energy-conserving system, a wealth-maximizing farmer would compare the expected NPV associated with both systems and choose the system offering the highest expected NPV.

The NPV associated with a particular irrigation system is the discounted sum of revenues and expenditures for a farm operation using that system. The revenue of a farm in a given year is equal to the price received times the quantity sold for all crops grown on the farm that year. Farm expenditures include the costs of all resources used in the production process and any tax liabilities incurred. An irrigation system can affect the NPV of a farm operation in two ways: it can increase or decrease revenues by changing the quantity of crops produced, or it can impact the cost of maintaining a given level of crop production. The NPV of the irrigation system alone is represented mathematically as follows:

$$\begin{aligned}
 NPV_i = & \sum_{t=1}^n \frac{B_{it} (1-T)}{(1+d)^t} - \sum_{t=1}^n \frac{(EC_{it} + OM_{it}) (1-T)}{(1+d)^t} \\
 & + \sum_{t=1}^n \frac{D_{it} \times T}{(1+d)^t} - I_i + \frac{SV_{in}}{(1+d)^n}
 \end{aligned} \tag{5}$$

where NPV_i = net present value associated with irrigation system i
 B_{it} = change in revenues minus nonirrigation expenditures associated
with irrigation system i , in year t
 EC_{it} = energy cost for irrigation using irrigation system i in year t
 OM_{it} = nonenergy operating and maintenance cost of irrigation system
 i , in year t
 D_{it} = depreciation expense for irrigation system i , in year t
 T = tax rate
 d = discount rate (minimal acceptable rate of return)
 I_i = initial cost of irrigation system i
 SV_{in} = salvage value of irrigation system i , in terminal year
 t = time index
 n = life span of irrigation system
 i = subscript value for irrigation system i .

The first ratio on the right hand side of Equation 5 represents the discounted after-tax value of annual benefits associated with using the irrigation system. These benefits are equal to the prices of crops grown, times the change in production attributable to irrigation, minus any changes in expenditures for nonirrigation activities. When multiplied by one minus the tax rate, these benefits reflect after-tax benefits. Because the benefits accrue over a period of years, they must be divided by a discounting factor, $(1 + d)^t$, to reflect the present value of future benefits.

The second ratio in Equation 5 represents the discounted after-tax costs of operating and maintaining the irrigation system. Energy costs are separated from other operation and maintenance costs to highlight their important role in the analysis of energy-conserving systems. These costs are multiplied by one minus the tax rate to adjust for after-tax costs and then are divided by the discounting factor to reflect the present value of future costs. The third ratio in Equation 5 is the discounted value of tax credits for depreciation on the irrigation system. The last two terms in Equation 5 represent the initial cost (I_i) and the discounted salvage value of the irrigation system.

A positive NPV for an irrigation system indicates that the present value of benefits exceeds the present value of costs, and that the system yields a rate of return on investment of at least d . The larger the NPV for an irrigation system, the greater the increase in a farmer's wealth from an investment in the system. When choosing between systems, a wealth-maximizing farmer invests in the irrigation system offering the highest NPV when costs and benefits are discounted at his minimum acceptable rate of return. When comparing two systems, Equation 5 can be rewritten in the following form:

$$\begin{aligned} \Delta NPV = & \sum_{t=1}^n \frac{\Delta B_t (1-T)}{(1+d)^t} - \sum_{t=1}^n \frac{(\Delta EC_t + \Delta OM_t)(1-T)}{(1+d)^t} \\ & + \sum_{t=1}^n \frac{\Delta D_t T}{(1+d)^t} - \Delta I + \frac{\Delta SV_n}{(1+d)^n} \end{aligned} \quad (6)$$

where $\Delta NPV = NPV_j - NPV_k$

$$\Delta B_t = B_{jt} - B_{kt}$$

$$\Delta EC_t = EC_{jt} - EC_{kt}$$

$$\Delta OM_t = OM_{jt} - OM_{kt}$$

$$\Delta D_t = D_{jt} - D_{kt}$$

$$\Delta I = I_j - I_k$$

$$\Delta SV_n = SV_{jn} - SV_{kn}$$

j = subscript value for irrigation system j

k = subscript value for irrigation system k

n = terminal year for irrigation system

t, d = same as in Equation 5.

In Equation 6, NPV represents the difference between the net present values for irrigation system j and for irrigation system k . If the value of ΔNPV is positive, a wealth-maximizing farmer would invest in system j ; if ΔNPV is negative, he would invest in system k ; and if it is zero, he would be impartial to either system.

When the farmer's investment decision criteria are expressed in terms of differences in costs and benefits between two systems, those cost or benefit components that are common to two systems can be ignored. Ignoring these components is very convenient in the case of irrigated agriculture, since it can be argued that, as long as crop yields and nonirrigation costs of production do not differ between two irrigation systems, the first term in Equation 6 can be ignored. If this term can be ignored for two irrigation systems, the NPV between the two systems can be expressed simply as the difference between the life-cycle costs for each system. The life-cycle cost (LCC_i) for any irrigation system i is the discounted cost of owning, operating, and maintaining the system. Thus, the change in NPV between two irrigation systems j and k can be represented mathematically by the change in LCC as follows:

$$\Delta NPV = \Delta LCC = LCC_k - LCC_j \quad (7)$$

where LCC for any irrigation system i is

$$LCC_i = \sum_{t=1}^n \frac{(E_{it} + OM_{it})(1-T)}{(1+d)^t} - \sum_{t=1}^n \frac{D_{it} T}{(1+d)^t} \quad (8)$$

$$+ I_i - \frac{SV_{in}}{(1+d)^t}.$$

Equation 7 indicates that when benefit streams for two irrigation systems are equal, comparison of the life-cycle costs can determine which system offers the higher NPV. Equations 7 and 8 show that NPV will be positive if LCC_k exceeds LCC_j , negative if LCC_j exceeds LCC_k , and zero if LCC_j equals LCC_k . On the basis of life-cycle costs, a farmer would choose system j over system k only if its life-cycle cost was less than that for system k .

It should be emphasized that comparing irrigation systems on the basis of life-cycle costs, as in Equation 7, is only valid if the systems have functionally comparable technologies. For example, the life-cycle costs of a gravity flow irrigation system could not be meaningfully compared here to those of a center-pivot sprinkler system, since the latter employs a different level of technology. Comparisons can be made, however, between high-pressure and low-pressure center pivots, where the level of technology is comparable.

In general, the present value analysis discussed above is an appropriate way to compare the economic value of irrigation systems because it shows the effect of system choice on the investor's wealth. Life-cycle cost analysis does, however, have one drawback that makes it difficult to use in the comparative analysis of this study; it does not easily accommodate the comparison of systems having different life spans. Life-cycle cost analysis assumes that reinvestment in each system occurs at regular intervals. If the irrigation systems being compared have different life spans, life-cycle costs must be calculated on the basis of a life span equal to the least common multiple of the different systems' life spans. This analysis can get somewhat complicated.

Levelized or annualized cost analysis is an alternative to life-cycle cost analysis that does not require that irrigation systems have equal lifespans to be comparable. Levelized cost analysis converts the present value of each system's cost to a uniform annual cost stream. The annual, or levelized, costs for systems can be compared directly to determine which system is least expensive for a given level of benefits.

The levelized cost for an irrigation system i can be calculated using the formula

$$LEV_i = I_i - \left[\frac{SV_i}{(1+d)^n} \right] \left[\frac{d(1+d)^n}{(1+d)^n - 1} \right] + [(EC_i + OM_i) \times (1-T)] - (D_i T). \quad (9)$$

The comparative analysis of two irrigation systems with different life spans is performed by calculating the difference between the levelized costs of each system:

$$\begin{aligned}
LEV &= LEV_k - LEV_j \quad (10) \\
&= \left[I_k - \frac{SV_k}{(1+d)^n} \right] \left[\frac{d(1+d)^n}{(1+d)^n - 1} \right] - \left[I_j - \frac{SV_j}{(1+d)^m} \right] \left[\frac{d(1+d)^m}{(1+d)^m - 1} \right] \\
&\quad + \left[(\Delta EC + \Delta OM) \times (1-T) - (\Delta D \times T) \right]
\end{aligned}$$

where n is the life span of system k and m is the life span of system j .

The results obtained by comparing levelized costs between two systems are the same as those obtained by comparing life-cycle costs of systems with similar life spans. If ΔLEV is positive then ΔLCC is positive, if ΔLEV is negative then ΔLCC is negative, and if ΔLEV is zero then ΔLCC is zero. The magnitudes of ΔLEV and ΔLCC , however, will be different because ΔLEV measures an annual cost stream and ΔLCC measures the cost of the system over its entire life.

The formula for levelized costs, Equation 9, must be modified slightly to account for the effects of inflation and real energy price escalation. For this analysis, salvage value is assumed to be stated in real terms. Operating and maintenance costs increase at the same rate as general price inflation, energy prices increase at a rate faster than general price inflation, and annual depreciation is constant in nominal terms. With these assumptions, no adjustments are necessary in Equation 9 for initial investment, salvage value, operating and maintenance costs. However, energy costs and depreciation must be adjusted to account for the effects of real energy price escalation and general price inflation.

To adjust energy costs for real energy price escalation, it is necessary to: 1) escalate annual energy costs by the real energy price escalation rate, r ; 2) convert those escalated costs to present value; and 3) levelize the present value costs. Levelized energy costs (EC_j) can be found by multiplying energy costs in the initial year (EC_j^0) times an adjustment factor as follows:

$$EC_i = EC_i^0 \times \left[\sum_{t=1}^n \frac{(1+r)^t}{(1+d)^t} \right] \times \left[\frac{d(1+d)^n}{(1+d)^n - 1} \right]. \quad (11)$$

To adjust depreciation for inflation, it is necessary to 1) deflate annual depreciation by the rate of inflation, p ; 2) convert real depreciation into present value terms; and 3) levelize depreciation cost. Levelized depreciation (D_i) is found by multiplying depreciation in the initial year (D_i^0) by an adjustment factor:

$$D_i = D_i^0 \times \sum_{t=1}^n \left[\frac{1}{(1+d)^n (1+p)^n} \right] \left[\frac{d(1+d)^n}{(1+d)^n - 1} \right]. \quad (12)$$

The formula for levelized cost is adjusted for real energy price escalation and inflation by substituting EC_i and D_i from Equations 11 and 12 for EC_i and D_i in Equation 9. Equation 10 is then used, as before, to perform the comparative analysis calculations.

4.2 DATA AND ASSUMPTIONS

Equations 1-4 and 9-12 above are the basis for the computer model used to do the comparative analysis. To actually perform the comparisons, inputs are needed for the variables contained in these eight equations. Specifically, the following data are required:

- volume of water pumped
- efficiencies of pumps, wells, and power units
- theoretical and actual drawdowns
- pumping lift (well depth)
- system operating pressures
- initial capital costs for all systems components
- salvage value
- fuel costs
- operating and maintenance costs for all system components

- depreciation expense
- life spans of system components
- tax rate, rate of inflation, and fuel price escalation rate
- discount rate (minimal acceptable rate of return).

The data inputs and assumptions used to generate the results of this report are described in this section.

4.2.1 Irrigation Parameters

To standardize the costs analyzed, the concept of generic irrigation systems is used. All the systems compared in the analysis are assumed to irrigate 160 acres, except for center-pivot systems, which are assumed to irrigate 130 acres. All system costs are based on the equipment needed by each type of system to cover the 160 (130) acres. Additionally, the cost, life span, and efficiency of each system component is assumed to be constant across all states, and the yields and nonirrigation production costs are assumed to be the same for each system and state. When an energy-conserving technology is aimed at a specific system component, such as an improved pump, only the cost changes associated with that particular system component are analyzed, the parameters of the other components are assumed to remain constant.

4.2.1.1 Wells

The efficiencies, costs, and life spans of conventional, surged, and jetted wells are shown in Table 3. The capital costs of both the surged and jetted wells include an additional \$4 charge per foot for exploration and predrilling operations. The total costs for wells are calculated by multiplying the capital costs in Table 3 times the well depth, (pumping lift) in Table 4. Development costs, given as \$400 for a surged well and \$1600 for a jetted well, represent one-time development costs. Operating and maintenance costs are assumed to be the same for all wells, and are set equal to zero in the model to show that well operating and maintenance costs have no impact on the comparative analysis. Salvage values of wells are assumed to be zero.

TABLE 3. Well Parameters: Efficiencies, Costs, and Life Spans

<u>Well Type</u>	<u>Well Efficiency</u>	<u>Capital Costs (dollars per foot)</u>	<u>Development Cost (dollars)</u>	<u>Life (years)</u>
Conventional	0.242	40	0	20
Surged	0.369	44 ^(a)	400	20
Jetted	0.426	44 ^(a)	1600	20

(a) Includes \$4/ft charge for exploration and test drilling.

TABLE 4. Pumping Lifts in Feet by State

<u>State</u>	<u>Groundwater</u>	<u>Surface Water</u>
Arizona	375	0
Arkansas	60	15
California	110	10
Colorado	120	10
Florida	95	6
Idaho	266	11
Kansas	180	15
Montana	100	60
Nebraska	100	20
Nevada	100	20
New Mexico	250	5
Oklahoma	200	16
Oregon	266	11
Texas	200	40
Utah	225	15
Washington	287	26
Wyoming	150	25

Source: Sloggett 1979.

The theoretical and actual drawdowns are given in feet for the 17 states having the largest irrigation acreages (see Table 5). The actual drawdowns shown for conventional wells were obtained from unpublished data from the Irrigation Research Center at Staples, Minnesota. Theoretical drawdowns were computed by multiplying the actual drawdowns by an assumed well efficiency of 0.242 for conventional wells. Actual drawdowns for surged and jetted wells were calculated by dividing theoretical drawdowns by well efficiencies of 0.369 and 0.426, respectively. All well efficiency numbers were obtained from the results of well field tests performed at the Irrigation Research Center.

TABLE 5. Well Drawdowns in Feet by State

<u>State</u>	<u>Theoretical Drawdown</u>	<u>Actual Drawdown</u>		
		<u>Conventional</u>	<u>Surged</u>	<u>Jetted</u>
Arizona	29.04	120	79	68
Arkansas	6.05	25	16	14
California	12.10	50	33	28
Colorado	14.52	60	39	34
Florida	4.84	20	13	11
Idaho	4.84	20	13	11
Kansas	12.10	50	33	28
Montana	8.47	35	23	20
Nebraska	7.26	30	20	17
Nevada	12.10	50	33	28
New Mexico	16.94	70	46	40
Oklahoma	21.87	90	59	51
Oregon	19.36	80	53	45
Texas	19.36	80	52	45
Utah	19.36	80	53	45
Washington	19.36	80	53	45
Wyoming	12.10	50	33	28

Source: Unpublished data obtained from the Irrigation Research Center, Staples, Minnesota.

4.2.1.2 Pumps

For this report, conventional new pump efficiencies were assumed to be 70% for all states. For the redesigned pump and the variable-speed pump, efficiency estimates were calculated by adding the incremental improvement in pump efficiency that was obtained in the testing of these two technologies to the 70% base efficiency of new pumps. Redesign of the pump column and pump impeller increased pump efficiency by approximately 5 percentage points in field testing performed by Aerospace Research Corporation (Hamrick 1980), whereas variable-speed characteristics will increase pump efficiency by 4.2 percentage points, according to Foster-Miller's evaluations (Foster Miller 1981). Thus, a pump with a redesigned impeller and column is assumed to have an efficiency of 75%, whereas the efficiency of a variable-speed electric powered pump is assumed to be 74.2%.

The cost of impeller redesign was assumed to be all R&D costs with little or no extra cost per unit at point of sale. Aerospace's research indicates that the pump packer cost would be compensated in large measure by a reduction in line and column pipe costs. Thus, the change in capital costs for the redesigned pump was assumed to be only \$200. For variable-speed pumping, capital costs were estimated by Foster-Miller to be \$8000, and the technical complexity of variable-speed pumping was assumed to require \$400 a year for additional operating and maintenance costs.

The power unit, or prime mover, efficiencies used in this analysis were electricity, 90%, natural gas, 19%; and diesel, 24%. Estimates were developed for every major type of fuel used for pumping in a particular state; however, to limit the length of this analysis, only estimates for the predominant fuel are presented in the Economic Analysis section of Chapter 5.0. Predominant fuel use was determined from published data (Brantwood Publications 1981) on types of power units used within a particular state. The predominant fuel used for irrigation pumping in each state and fuel costs in dollars per million Btu are given in Table 6.

TABLE 6. 1980 Fuel Costs by State (Dollars per Million Btu)

<u>State</u>	<u>Predominant Fuel^(a)</u>	<u>Electricity^(b)</u>	<u>Natural Gas^(c)</u>	<u>Diesel^(d)</u>
Arizona	E	16.12	2.64	5.14
Arkansas	E	13.19	1.34	5.00
California	E	12.90	2.69	5.07
Colorado	E	11.72	2.26	5.00
Florida	D	14.65	2.78	6.01
Idaho	E	7.62	3.46	5.00
Kansas	NG	14.07	1.65	5.21
Montana	E	8.79	1.97	5.07
Nebraska	D	11.72	2.02	5.21
Nevada	E	11.72	2.68	5.14
New Mexico	NG	14.65	2.35	5.07
Oklahoma	NG	12.60	3.44	5.58
Oregon	E	7.03	3.66	4.85
Texas	NG	13.48	2.86	5.07
Utah	E	12.31	2.29	5.14
Washington	E	4.69	3.42	4.71
Wyoming	E	9.96	2.30	5.21

(a) NG = natural gas
D = diesel
E = electricity

(b) Edison Electric Institute 1980.

(c) Energy Information Administration 1980.

(d) United States Department of Agriculture, prices paid by farmer 1980.

4.2.1.3 Application Systems

Table 7 shows the operating pressures, capital costs, operating and maintenance costs, and life spans used to generate the comparative results. The real salvage value of the application systems was assumed to be 10% of the original capital cost for all systems. Costs and operating pressures for conventional systems are manufacturers' estimates. Costs and operating pressures for energy-saving systems were taken from contractor reports.

TABLE 7. Application System Parameters: Operating Pressures, Costs, and Life Spans

	Operating Pressure (ft)	Capital Costs (dollars)	Annual O&M Costs (dollars)	Useful Life (years)
<u>Conventional Systems</u> ^(a)				
Lateral-Move	180	51,000	1,530	15
Center-Pivot	200	38,000	1,140	15
Gated-Pipe	5	14,850	1,481	15
<u>Energy-Conserving Systems</u> ^(b)				
Automated Gated-Pipe	5	36,760	2,369	15
Center-Pivot LEPA	25	45,000	1,350	15
Lateral-Move LEPA	25	58,600	1,758	15
Reduced-Pressure Center-Pivot	70	38,000	1,140	15

(a) Manufacturer's estimates.

(b) Contractor reports.

Table 8 shows the average water volume applied by state. Increased water application efficiency is an important factor in producing energy savings for the automated gated-pipe and LEPA systems. Higher water application efficiency causes a decrease in water use. Thus, average water volume applied in each state was reduced by 20% for the automated gated-pipe system, and by 18% for the LEPA systems. These reductions were computed from field tests at Kansas State and Texas A&M.

4.2.1.4 Scheduling Systems

The costs and reductions in water usage associated with computerized and instrumented scheduling systems are shown in Table 9. The estimates of reductions in water use are presented for both gravity and sprinkler systems. Sprinkler water use reduction estimates were obtained directly from the field test results of J. M. Lord and Prossen (Lord and Gartung 1981, Prossen 1981). Water use reductions for gravity flow irrigation were shown to be very small in the field testing of energy-conserving scheduling systems because of a lack

TABLE 8. Average Irrigation Water Volume Applied
by State^(a) (acre-ft/acre)

<u>State</u>	<u>Gravity-Flow Systems</u>	<u>Sprinkler Systems</u>
Arizona	5.46	4.37
Arkansas	1.85	1.48
California	3.30	2.64
Colorado	1.15	0.92
Florida	1.08	0.86
Idaho	3.51	2.81
Kansas	1.82	1.46
Montana	2.74	2.19
Nebraska	1.40	1.52
Nevada	5.05	5.04
New Mexico	1.83	2.26
Oklahoma	2.05	1.64
Oregon	3.35	2.68
Texas	1.58	1.26
Utah	3.13	2.50
Washington	4.89	3.91
Wyoming	1.86	1.49

(a) Sloggett 1979.

TABLE 9. Costs and Water Usage Reductions for Scheduling Systems

<u>System</u>	<u>Reduction in Water Use</u>	<u>Annual Operating Cost/Acre</u>	<u>Capital Investment</u>
<u>Computerized</u>			
Gravity Flow	5%	\$5.00	\$ 0
Sprinkler	24%	\$5.00	\$ 0
<u>Instrumented</u>			
Gravity Flow	4%	\$6.25	\$10,000
Sprinkler	20%	\$6.25	\$10,000

of control over the amount of water applied by gravity flow methods. Thus, a small number was arbitrarily assigned to represent these reductions. Note that the computerized system has no initial investment costs because the system is offered to farmers as a service. The instrumented irrigation scheduling does, however, involve hardware that is purchased and installed.

4.2.1.5 Economic Parameters

The economic variables in the modeling equations are assumed to be as follows:

- discount rate = 10%
- real fuel price escalation rate = 2%
- general inflation rate = 6%
- tax rate = 25%

The impact of the assumptions of real fuel price escalation rate and discount rate (minimum acceptable rate of return) are examined in a sensitivity analysis, included in Chapter 5.0. Depreciation expense is assumed to be calculated with straight-line methods and is equal to capital costs less the discounted real salvage value, divided by the life span of the component.

5.0 COMPARATIVE ANALYSIS RESULTS

In this chapter, the comparative analysis of the energy- and cost-saving performance of selected irrigation systems is summarized. The comparative analysis results are presented in two sections. The first section discusses the economic comparisons between each energy-conserving system and a conventional system of similar technology. The second section contains a sensitivity analysis of the interest and fuel escalation rates assumed in the study.

Results from the comparative analysis are presented in several tables included in this chapter. In the tables, energy-use and cost-comparison numbers will be negative whenever the energy-conserving systems outperform the conventional systems. This is because the energy and cost measures of the conventional systems are subtracted from the corresponding measures of energy-saving systems (i.e., substitution of energy-conserving systems for conventional ones lowers cost). The important relationship between energy cost savings and any additional capital or operating and maintenance costs associated with a conserving technology is summarized in the after-tax cost columns in the comparison tables. If the value of the energy savings generated by an energy-conserving irrigation system more than offsets additional equipment and operating costs, the after-tax total cost difference will be negative, reflecting net reduction economic cost. A positive after-tax cost difference indicates that an additional economic cost is associated with the energy-saving system. Additional detail on the economic comparisons is shown by state in the Appendix.

5.1 ECONOMIC ANALYSIS

Representative comparisons among energy-conserving irrigation systems and conventional systems were performed for cases where systems with comparable technologies would compete with each other in the irrigation equipment market. Three measures of energy-saving performance--energy use, energy cost, and after-tax total cost--were used to evaluate the energy-conserving systems' performance relative to conventional systems. The two scheduling projects, computerized and instrumented, were also evaluated on the basis of water

savings for surface-water irrigation systems because if farmers are assessed variable water user fees, they may reduce costs by saving water. All comparisons made in this section are based on data for newly installed systems.

The economic comparisons are organized by the energy-conserving system being analyzed. For each energy-conserving system, the comparative analysis results and an assessment of market penetration potential are given. The conclusions that can be drawn from the results of the economic comparisons are subject to limitations, which differ across technologies. Particular limitations are discussed, as they apply, with the results of the comparisons for each technology.

5.1.1 Well Development

The energy use, energy cost, and total after-tax cost differences for two well development techniques are shown in Table 10. The energy-saving performance measures for two types of well improvement, surging and jetting, were compared to those of unimproved wells. In general, the surged wells offered slightly lower savings in energy than did jetted wells. However, surged wells generally offered greater overall cost savings than jetted wells due to lower capital costs.

The lower capital costs of surged wells were large enough, compared to jetting, to result in greater after-tax total cost savings benefits for surged wells in most states. However, the cost effectiveness of jetting compared to surging depends on a well's drawdown and the volume of water pumped. The data in Table 10 show that for states with high drawdowns or large volumes of applied irrigation water (like Arizona, Oklahoma, and Utah), the jetted wells offer higher benefits than surged wells. Based on statewide average data, surged wells offered cost savings in all states except Idaho, and jetted wells offered cost savings in all but four states.

The economic benefits shown by the comparative analysis of the well development techniques are subject to qualifications according to the type of well and the drilling methods used. The results in Table 10 would not be representative of cases in which bentonite drilling fluid is not used, or in which wells are drilled into aquifers where few particles are present (e.g., consolidated aquifers).

TABLE 10. Change in Energy Use, Energy Cost, and After-Tax Cost for Conventional Versus Surged and Jetted Wells^(a)

State	Fuel ^(b)	Surged			Jetted		
		Energy Use ^(c)	Energy Cost ^(d)	After-Tax Cost ^(d)	Energy Use ^(c)	Energy Cost ^(d)	After-Tax Cost ^(d)
Arizona	E	-198	-3722	-2522	-248	-4672	-3103
Arkansas	E	-14	-215	-78	-18	-270	11
California	E	-48	-729	-429	-61	-914	-437
Colorado	E	-20	-276	-79	-25	-346	-1
Florida	D	-23	-161	-25	-29	-202	75
Idaho	E	-20	-174	40	-25	-218	137
Kansas	NG	-123	-237	-29	-154	-297	56
Montana	E	-29	-296	-116	-36	-371	-42
Nebraska	D	-60	-366	-171	-75	-459	-110
Nevada	E	-76	-1044	-670	-96	-1310	-739
New Mexico	NG	-278	-764	-383	-349	-958	-399
Oklahoma	NG	-239	-960	-542	-300	-1205	-437
Oregon	E	-73	-601	-249	-92	-755	-234
Texas	NG	-174	-579	-262	-218	-727	-242
Utah	E	-73	-1053	-606	-92	-1321	-677
Washington	E	-103	-562	-211	-129	-705	-187
Wyoming	E	-28	-325	-108	-35	-408	-40

(a) Based on a 160-acre operation, the change is calculated by subtracting the energy use, energy cost, and after-tax cost of an unimproved well from those of surged or jetted wells. Negative numbers mean a reduction in energy use or cost from the unimproved well case.

(b) NG = natural gas

D = diesel

E = electricity

(c) Million Btu/yr (negative numbers indicate decrease in use).

(d) In dollars/yr (negative numbers indicate decrease in cost).

5.1.2 Column and Pump Redesign

Evaluation of the column and pump impeller redesign was based on comparisons of both gravity flow and sprinkler irrigation systems; operation of the redesigned pump was evaluated with a gated-pipe application system and with a center-pivot system. The energy use, energy cost, and after-tax costs of the systems with redesigned pumps were compared to similar systems with conventional pumps. The results of the comparisons between the two gated-pipe systems and the two center-pivot systems are shown by state and primary fuel in Table 11.

According to the data in Table 11, the column and pump redesign reduces economic costs to the farmer in all of the states listed. The total annualized after-tax cost differences between the conventional and improved systems are negative for all states, indicating that redesigned pumps lower annual costs compared to conventional pumps. Cost savings ranged from \$56 to \$1663 per year for gated-pipe systems and between \$118 and \$1636 per year for center-pivots. The cost savings attributed to the redesigned pump are comparatively greater for center-pivot systems than for gated-pipe because center-pivots generally use more energy than do gated pipes.

The after-tax benefits of the redesigned pump are primarily related to the small capital cost increase reported by Aerospace for the redesign of the impeller and diffuser and the installation of the casing packer and new drive line shaft, described in Chapter 3.0. When annualized, these technological changes increased pump capital costs by only \$26 per year, an amount that was easily offset by the value of the realized energy savings. Although the comparative analysis suggests that the redesigned column and pump is an economically sound technology, concern has been expressed by some equipment manufacturers regarding the technical feasibility of some aspects, especially the ability of the packer to support the pump's hanging weight over the long term. The potential viability of this column and pump design in the market and its contribution to energy conservation in irrigation will depend upon technical, instead of economic, considerations.

TABLE 11. Change in Energy Use, Energy Cost, and After-Tax Cost for Redesigned Column and Pump Using Groundwater^(a)

State	Fuel ^(b)	Gated Pipe (160 acres)			Center-Pivot (130 acres)		
		Energy Use ^(c)	Energy Cost ^(d)	After-Tax Cost ^(d)	Energy Use ^(c)	Energy Cost ^(d)	After-Tax Cost ^(d)
Arizona	E	-123	-2248	-1663	-121	-2212	-1636
Arkansas	E	-7	-107	-56	-18	-277	-184
California	E	-22	-329	-223	-39	-577	-409
Colorado	E	-9	-113	-61	-14	-188	-118
Florida	D	-24	-164	-99	-46	-312	-211
Idaho	E	-56	-487	-342	-63	-545	-385
Kansas	NG	-94	-177	-109	-126	-237	-154
Montana	E	-17	-170	-104	-32	-315	-213
Nebraska	D	-44	-262	-173	-82	-487	-341
Nevada	E	-31	-418	-290	-58	-776	-558
New Mexico	NG	-202	-540	-381	-232	-618	-440
Oklahoma	NG	-118	-460	-322	-149	-584	-414
Oregon	E	-54	-429	-298	-60	-479	-336
Texas	NG	-91	-295	-198	-115	-373	-256
Utah	E	-43	-596	-423	-51	-714	-512
Washington	E	-84	-450	-314	-92	-488	-342
Wyoming	E	-17	-193	-121	-25	-284	-189

(a) The change is calculated by subtracting the energy use, energy cost, and after-tax cost of systems using conventional pumps from those of systems using the redesigned impeller. Thus, negative numbers mean a reduction in use or cost.

(b) NG = natural gas
D = diesel
E = electricity

(c) Million Btu/yr (negative numbers indicate decrease in use).

(d) In dollars/yr (negative numbers indicate decrease in cost).

5.1.3 Variable-Speed Pumping

Energy savings and after-tax costs associated with variable-speed pumping were calculated for both gated-pipe and center-pivot application systems. Results from the groundwater analysis are shown in Table 12. The higher energy savings realized for center-pivot systems are related to the higher energy use required by the pressurized sprinklers, in relation to the smaller energy demands of a gravity flow system like gated pipe.

The positive after-tax total cost figures of Table 12 imply that the 5% increase in pump efficiency effected by variable-speed pumping does not result in sufficient energy cost savings to offset the \$8000 in additional capital costs required to purchase the variable speed electric prime movers. When annualized, total costs of variable-speed pumping are equal to \$1027 of capital costs plus \$400 of additional operating and maintenance costs. As seen in Table 12, the capital and operating costs of electrically driven variable-speed pumping generally outweigh the benefits of increased energy cost savings. These results suggest that electrically driven variable-speed pumping is not cost effective, except in regions like Arizona where the pumping depth and the volume of water applied are uncommonly high. Excluding the results for Arizona, the economic losses associated with variable-speed pumping range from \$862 to \$1173 annually for a gated-pipe system and from \$747 to \$1121 for a center-pivot system.

5.1.4 Reduced-Pressure Center-Pivot Systems

Table 13 contains the calculations resulting from a comparative evaluation of a reduced-pressure center-pivot and a conventional high-pressure pivot system. The results for surface-water and groundwater sources were identical, since the only variable operating element in the comparison was the system operating pressure. Significant energy use and energy cost savings were realized with the reduced-pressure system for all states.

Because the capital and operating and maintenance costs were assumed to be the same for both the high- and the reduced-pressure systems, the after-tax cost numbers in Table 13 are simply tax adjusted energy cost savings. The greatest economic savings were realized in those states where energy use or

TABLE 12. Change in Energy Use, Energy Cost, and After-Tax Cost for Variable-Speed Pumping^(a) Using Groundwater

State	Fuel ^(b)	Gated Pipe			Center Pivot		
		Energy Use ^(c)	Energy Cost ^(d)	After-Tax Cost ^(d)	Energy Use ^(c)	Energy Cost ^(d)	After-Tax Cost ^(d)
Arizona	E	-104	-1909	-190	-103	-1878	-168
Arkansas	E	-6	-91	1173	-16	-235	1065
California	E	-19	-279	1032	-33	-490	874
Colorado	E	-7	-96	1169	-12	-160	1121
Florida	D	-20	-139	1137	-39	-265	1042
Idaho	E	-48	-414	931	-53	-463	894
Kansas	NG	-80	-150	1128	-107	-201	1090
Montana	E	-14	-144	1133	-27	-268	1040
Nebraska	D	-38	-222	1074	-70	-413	931
Nevada	E	-27	-355	975	-49	-659	747
New Mexico	NG	-172	458	897	-197	-525	847
Oklahoma	NG	-100	-391	948	-127	-496	869
Oregon	E	-46	-364	968	-51	-407	936
Texas	NG	-77	-250	1053	-97	-317	1004
Utah	E	-36	-506	862	-43	-606	786
Washington	E	-72	-382	954	-78	-414	930
Wyoming	E	-14	-164	1118	-21	-241	1060

(a) Based on 160-acre operation, the change is calculated by subtracting the energy use, energy cost, and after-tax cost of systems using conventional pumps from those of systems using a variable-speed pump.

(b) NG = natural gas
D = diesel
E = electricity

(c) Million Btu/yr (negative numbers indicate decrease in use).

(d) In dollars/yr (negative numbers indicate decrease in cost).

TABLE 13. Change in Energy Use, Energy Cost, and After-Tax Cost for Center-Pivot Versus Reduced-Pressure Center-Pivot Systems

State	Fuel ^(b)	Surface-Water/Groundwater		
		Energy Use ^(c)	Energy Cost ^(d)	After-Tax Cost ^(d)
Arizona	E	-410	-7502	-5626
Arkansas	E	-139	-2079	-1559
California	E	-247	-3627	-2720
Colorado	E	-86	-1148	-861
Florida	D	-302	-2064	-1548
Idaho	E	-263	-2280	-1710
Kansas	NG	-648	-1215	-911
Montana	E	-205	-2050	-1538
Nebraska	D	-534	-3163	-2372
Nevada	E	-379	-5042	-3782
New Mexico	NG	-1003	-2679	-2009
Oklahoma	NG	-728	-2846	-2134
Oregon	E	-251	-2006	-1505
Texas	NG	-559	-1818	-1363
Utah	E	-234	-3277	-2458
Washington	E	-366	-1953	-1465
Wyoming	E	-140	-1580	-1185

(a) Based on 130-acre operation, the change is calculated by subtracting the energy use, energy cost, and after-tax cost of conventional high-pressure center-pivot systems from those of reduced-pressure center-pivot systems.

(b) NG = natural gas
D = diesel
E = electricity

(c) Million Btu/yr (negative numbers indicate decrease in use).

(d) In dollars/yr (negative numbers indicate decrease in cost).

energy costs are highest. The economic benefits of the reduced-pressure system support the expanded use of this technology.

The use of reduced-pressure center-pivot sprinklers may increase water runoff and soil erosion. The results of the University of Nebraska's study (Gilley 1981) indicate that with proper soil management, runoff and erosion are not significantly increased by reduced-pressure water application.

5.1.5. Low-Energy Precision Application (LEPA) Lateral-Move System

The Low-Energy Precision Application (LEPA) irrigation method was evaluated for both lateral-move and center-pivot systems using both groundwater and surface-water sources. The comparative analysis calculations for the lateral-move LEPA technology are shown in Table 14 and imply that significant benefits are connected with use of the LEPA system.

The total after-tax cost advantage of the LEPA lateral-move system over a conventional lateral-move irrigation system is more than \$1000 per year in almost every state for both surface-water and groundwater sources. Energy cost savings realized by the LEPA system result from two effects: 1) a reduction in system operating pressure, and 2) a reduction in the water volume applied. A \$975 annual increase in capital costs and a \$228 annual increase in operating and maintenance costs are more than offset by energy cost savings. According to the results shown in Table 14, if the crops grown can use the mobile LEPA lateral-move system (it is possible that this system may not be effectively used on non-row crops), cost savings can be realized by using the LEPA system instead of a conventional lateral-move system.

5.1.6 LEPA Center-Pivot System

The energy-saving performance comparisons for LEPA and conventional center-pivot systems are presented in Table 15. These results differ little from those for the LEPA lateral-move system because the capital and operating and maintenance cost differences between the lateral-move and center-pivot LEPA irrigation systems and their corresponding conventional systems were nearly identical. The economic benefits of the center-pivot LEPA are slightly lower than the lateral-move benefits because center-pivot systems were assumed to irrigate 130 acres, whereas lateral-move systems were assumed to irrigate

TABLE 14. Change in Energy Use, Energy Cost, and After-Tax Cost for Conventional Lateral-Move Versus LEPA Lateral-Move Systems^(a)

State	Fuel ^(b)	Groundwater			Surface Water		
		Energy Use ^(c)	Energy Cost ^(d)	After-Tax Cost ^(d)	Energy Use ^(c)	Energy Cost ^(d)	After-Tax Cost ^(d)
Arizona	E	-880	-16123	-11027	-619	-11328	-7431
Arkansas	E	-224	-3352	-1449	-213	-3192	-1329
California	E	-420	-6157	-3552	-378	-5538	-3089
Colorado	E	-148	-1969	-412	-132	-1754	-250
Florida	D	-505	-3451	-1523	-460	-3138	-1289
Idaho	E	-517	-4477	-2293	-403	-3486	-1550
Kansas	NG	-1178	-2208	-591	-995	-1866	-335
Montana	E	-345	-3445	-1519	-331	-3305	-1414
Nebraska	D	-898	-5315	-2921	-825	-4883	-2598
Nevada	E	-636	-8474	-5290	-585	-7786	-4775
New Mexico	NG	-1943	-5187	-2825	-1524	-4068	-1986
Oklahoma	NG	-1348	-5267	-2886	-1119	-4375	-2216
Oregon	E	-493	-3939	-1889	-384	-3067	-1236
Texas	NG	-1035	-3365	-1458	-883	-2869	-1087
Utah	E	-444	-6206	-3589	-360	-5033	-2710
Washington	E	-733	-3904	-1863	-570	-3036	-1212
Wyoming	E	-247	-2791	-1028	-217	-2454	-775

(a) Based on 160-acre operation, the change is calculated by subtracting the energy use, energy cost, and after-tax cost of conventional high-pressure lateral-move systems from those of LEPA lateral-move systems from those of LEPA lateral-move systems.

(b) NG = natural gas

D = diesel

E = electricity

(c) Million Btu/yr (negative numbers indicate decrease in use).

(d) In dollars/yr (negative numbers indicate decrease in cost).

TABLE 15. Change in Energy Use, Energy Cost, and After-Tax Cost for Conventional Center-Pivot Versus LEPA Center-Pivot Systems^(a)

State	Fuel ^(b)	Groundwater			Surface Water		
		Energy Use ^(c)	Energy Cost ^(d)	After-Tax Cost ^(d)	Energy Use ^(c)	Energy Cost ^(d)	After-Tax Cost ^(d)
Arizona	E	-778	-14254	-9709	-410	-7502	-5626
Arkansas	E	-203	-3043	-1301	-194	-2914	-1204
California	E	-379	-5560	-3189	-345	-5058	-2813
Colorado	E	-133	-1776	-351	-120	-1601	-220
Florida	D	-457	-3122	-1360	-420	-2867	-1169
Idaho	E	-461	-3988	-2010	-368	-3183	-1407
Kansas	NG	-1057	-1981	-505	-908	-1703	-296
Montana	E	-312	-3114	-1355	-300	-3001	-1270
Nebraska	D	-812	-4805	-2623	-752	-4445	-2360
Nevada	E	-575	-7661	-4765	-533	-7102	-4346
New Mexico	NG	-1733	-4627	-2489	-1392	-3718	-1807
Oklahoma	NG	-1207	-4718	-2557	-1022	-3993	-2014
Oregon	E	-439	-3509	-1651	-351	-2801	-1120
Texas	NG	-927	-3013	-1279	-803	-2611	-977
Utah	E	-397	-5546	-3179	-328	-4593	-2464
Washington	E	-652	-3473	-1623	-519	-2767	-1094
Wyoming	E	-222	-2510	-902	-198	-2237	-697

(a) Based on 130-acre operation, the change is calculated by subtracting the energy use, energy cost, and after-tax cost of conventional high-pressure center-pivot systems from those of LEPA center-pivot systems.

(b) NG = natural gas

D = diesel

E = electricity

(c) Million Btu/yr (negative numbers indicate decrease in use).

(d) In dollars/yr (negative numbers indicate decrease in cost).

160 acres. Nevertheless, the comparative after-tax benefits of the LEPA center-pivot range from \$351 to \$9709 per year for groundwater systems and from \$220 to \$6788 per year for surface-water systems.

The method by which LEPA center-pivots apply water directly to irrigation furrows may constrain the use of the system. Precise furrows are necessary for this method of water application if it is to be effective, cultivating furrows in a circular pattern requires a change in cultivation practices and may increase labor costs somewhat. However, farmers in Texas have demonstrated that circular furrows can be successfully plowed by using the center-pivot wheel tracks as a guide.

5.1.7 Automated Gated-Pipe System

The results of the comparison of the energy use, energy costs, and after-tax costs of a conventional gated-pipe irrigation system and the automated gated-pipe system are given in Table 16 for both groundwater and surface-water sources. Energy savings from the automated gated-pipe system result from a 20% reduction in water use because of higher application efficiency. Energy savings double from groundwater to surface water because of the larger amount of lifting energy required for groundwater irrigation.

The annualized cost differences between automated and conventional gated-pipe systems are positive in all of the cases analyzed, except for groundwater systems in Arizona. Economic losses ranged from \$1903 to \$3003 per year for groundwater systems and from \$3007 to \$3213 per year for surface-water systems. In Arizona, after-tax cost savings for groundwater systems were \$1815 per year. This poor economic performance is attributable to the high capital costs of the radio transmitters and receivers and to labor-related increases in operating and maintenance costs resulting from reduced system reliability. Although the automation of gated-pipe systems reduces the amount of labor needed, it requires labor with a higher level of technical skill, which causes the per-hour costs of labor to increase. Continued development of automated gated-pipe irrigation could eventually reduce the operating, maintenance, and capital costs for these systems. However, considering the technical problems of the system tested by Kansas State, the use of radio-controlled automated gated-pipe operation is not ready for widespread use.

TABLE 16. Change in Energy Use, Energy Cost, and After-Tax Cost for Gated-Pipe Versus Automated Gated-Pipe Systems^(a)

State	Fuel ^(b)	Groundwater			Surface Water		
		Energy Use ^(c)	Energy Cost ^(d)	After-Tax Cost ^(d)	Energy Use ^(c)	Energy Cost ^(d)	After-Tax Cost ^(d)
Arizona	E	-368	-6744	-1815	-5	-89	3177
Arkansas	E	-21	-320	3003	-7	-98	3170
California	E	-67	-987	2503	-9	-129	3147
Colorado	E	-26	-340	2989	-3	-41	3213
Florida	D	-72	-491	2875	-8	-54	3203
Idaho	E	-169	-1462	2147	-10	-86	3179
Kansas	NG	-283	-531	2845	-31	-57	3200
Montana	E	-51	-510	2861	-32	-316	3007
Nebraska	D	-133	-786	2654	-32	-187	3103
Nevada	E	-94	-1253	2303	-22	-298	3020
New Mexico	NG	-607	-1620	2028	-24	-64	3196
Oklahoma	NG	-353	-1381	2208	-36	-141	3137
Oregon	E	-161	-1287	2278	-10	-76	3186
Texas	NG	-272	-885	2580	-60	-194	3098
Utah	E	-128	-1787	1903	-11	-155	3127
Washington	E	-253	-1350	2231	-27	-143	3136
Wyoming	E	-51	-579	2809	-10	-112	3159

(a) Based on 160-acre operation, the change is calculated by subtracting the energy use, energy cost, and after-tax cost of conventional gated-pipe systems from those of an automated gated-pipe system.

(b) NG = natural gas

D = diesel

E = electricity

(c) Million Btu/yr (negative numbers indicate decrease in use).

(d) In dollars/yr (negative numbers indicate decrease in cost).

5.1.8 Computerized Irrigation Scheduling

A computerized irrigation scheduling system was evaluated in comparison to conventional, noncomputerized scheduling for gated-pipe and center-pivot irrigation systems. The results of the comparisons are presented for groundwater in Table 17, and for surface water in Table 18. The change in water use is added to the list of system performance measures in the surface-water table because water user charges may be levied against farmers irrigating with surface water. If water-user charges are assessed at a fixed rate, water savings have no impact on farm costs. If, however, charges are levied at a variable rate according to the amount of water used, every unit of water saved reduces irrigation costs.

The significantly different results of the comparative analyses of gated-pipe scheduling and center-pivot performance with and without computerized scheduling are explained by two factors. First, as discussed earlier, only a small reduction in water volume applied to the field was assumed for the gravity flow gated-pipe system as a result of computerized scheduling, while a large reduction in water use was assumed for the center-pivot sprinkler system. The second factor is the higher energy use per unit of water applied for center-pivot systems compared to gated-pipe, which causes the relative energy savings of computerized center-pivot scheduling to be higher.

The comparative calculations for the system imply that, for groundwater, at a cost of \$5 per acre, computerized scheduling would result in cost savings in every state for center-pivot systems. At the same cost per acre, use of the system would increase costs in every state except Arizona when used with gated-pipe systems. The high energy use and costs in Arizona cause even the slight drop in water volume associated with computerized scheduling on gated-pipe systems to be economically beneficial.

Based on energy cost comparisons, computerized scheduling performs more favorably on groundwater systems than on surface-water systems. This is related to the smaller amounts of energy required per unit of water by surface-water systems. However, variable-charge water-use fees, if high

TABLE 17. Change in Energy Use, Energy Cost, and After-Tax Cost for Conventional Irrigation Scheduling Versus Computerized Irrigation Scheduling Using Groundwater^(a)

State	Fuel ^(b)	Gated-Pipe System			Center-Pivot System		
		Energy Use ^(c)	Energy Cost ^(d)	After-Tax Cost ^(d)	Energy Use ^(c)	Energy Cost ^(d)	After-Tax Cost ^(d)
Arizona	E	-91	-1668	-651	-435	-7973	-5492
Arkansas	E	-5	-78	542	-67	-1011	-271
California	E	-16	-239	421	-141	-2064	-1060
Colorado	E	-7	-89	534	-51	-676	-19
Florida	D	-17	-114	515	-167	-1144	-370
Idaho	E	-43	-375	319	-225	-1949	-974
Kansas	NG	-70	-131	502	-454	-852	-151
Montana	E	-13	-130	502	-115	-1145	-371
Nebraska	D	-35	-207	445	-292	-1729	-809
Nevada	E	-23	-310	367	-210	-2794	-1608
New Mexico	NG	-150	-401	299	-830	-2216	-1174
Oklahoma	NG	-86	-337	347	-533	-2082	-1074
Oregon	E	-41	-327	355	-215	-1718	-801
Texas	NG	-69	-224	432	-410	-1332	-511
Utah	E	-33	-457	257	-184	-2571	-1441
Washington	E	-62	-331	351	-330	-1759	-832
Wyoming	E	-12	-140	495	-91	-1028	-284

(a) Based on 160-acre operation, the change is calculated by subtracting the energy use, energy cost, and after-tax cost of irrigation systems using conventional scheduling practices from those of the same systems using computerized scheduling.

(b) NG = natural gas

D = diesel

E = electricity

(c) Million Btu/yr (negative numbers indicate decrease in use).

(d) In dollars/yr (negative numbers indicate decrease in cost).

TABLE 18. Change in Energy Use, Energy Cost, After-Tax Cost, and Water Use for Conventional Irrigation Scheduling Versus Computerized Irrigation Scheduling Using Surface Water^(a)

State	Fuel ^(b)	Gated-Pipe System				Center-Pivot System			
		Energy Use ^(c)	Water Use ^(d)	Energy Cost ^(e)	After-Tax Cost ^(e)	Energy Use ^(c)	Water Use ^(d)	Energy Cost ^(e)	After-Tax Cost ^(e)
Arizona	E	-1	-43.2	-22	584	-151	-136.5	-2773	-1592
Arkansas	E	-2	-14.4	-24	582	-56	-46.8	-836	-140
California	E	-2	-25.6	-31	577	-95	-81.9	-1398	-561
Colorado	E	-1	-9.6	-11	592	-33	-28.6	-444	155
Florida	D	-2	-8.0	-12	591	-117	-27.3	-799	-112
Idaho	E	-3	-28.8	-22	583	-102	-87.1	-882	-174
Kansas	NG	-8	-14.4	-14	589	-257	-45.5	-482	126
Montana	E	-8	-22.4	-81	540	-99	-68.9	-992	-257
Nebraska	D	-8	-16.0	-49	563	-214	-46.8	-1268	-463
Nevada	E	-6	-40.0	-74	545	-154	-126.1	-2049	-1049
New Mexico	NG	-6	-22.4	-16	588	-378	-70.2	-1009	-270
Oklahoma	NG	-9	-16.0	-35	574	-288	-50.7	-1124	-356
Oregon	E	-2	-27.2	-19	586	-97	-83.2	-778	-96
Texas	NG	-15	-12.8	-49	563	-246	-39.0	-799	-112
Utah	E	-3	-25.6	-40	570	-93	-78.0	-1301	-488
Washington	E	-7	-38.4	-35	574	-153	-122.2	-816	-125
Wyoming	E	-2	-14.4	-27	580	-58	-46.8	-661	-8

(a) The change is calculated by subtracting the energy use, energy cost, and after-tax cost of systems using conventional scheduling from those of systems using computerized scheduling.

(b) NG = natural gas

D = diesel

E = electricity

(c) Million Btu/yr.

(d) In acre/inches per year.

(e) In dollars/yr.

enough, could affect the results significantly. In Kansas, for example, use of the computerized system with a center-pivot system would save 45.5 acre-inches of water per year. Variable water-user charges of \$2.77 or more per acre-inch would make use of the computerized scheduling system economically beneficial.

5.1.9 Instrumented Irrigation Scheduling

Results for the instrumented irrigation scheduling system are presented in Tables 19 and 20, which follow the same formats as Tables 17 and 18. The changes in the estimated water volume applied between center-pivot and gated-pipe systems scheduled with the instrumented system and the corresponding conventional systems are only slightly different from comparable estimates made for the computerized scheduling system. Therefore, the differences in after-tax cost numbers between the computerized and instrumented scheduling systems will be primarily determined by differences in their respective capital and operating costs.

For almost all states, the increased costs generated by the instrumented system, in comparison to conventional scheduling, result from large capital and operating and maintenance costs. The fully instrumented system has annualized capital costs of \$1283 and additional annualized operating and maintenance costs of \$1000. Even for center-pivot systems, these costs are offset by reductions in energy costs in only a few cases. On the basis of the results shown in Tables 19 and 20, use of the instrumented system is generally not economically feasible. Variable water-user fees might be able to reduce or negate the economic losses of instrumented scheduling of center-pivot systems in certain states, but losses are so high for gated-pipe systems that water fees most likely would not make instrumented scheduling an attractive option for gravity flow irrigation systems.

5.2 SENSITIVITY ANALYSIS

A sensitivity analysis was performed to test the impact of two important economic parameters, the discounted rate and the real fuel price escalation rate, on the results of the comparative analysis. Sensitivity of the results to these factors was analyzed for Arizona, Texas, and Washington, which

TABLE 19. Change in Energy Use, Energy Cost, and After-Tax Cost for Conventional Irrigation Scheduling Versus Instrumented Irrigation Scheduling Using Groundwater^(a)

State	Fuel ^(b)	Gated-Pipe System			Center-Pivot System		
		Energy Use ^(c)	Energy Cost ^(d)	After-Tax Cost ^(d)	Energy Use ^(c)	Energy Cost ^(d)	After-Tax Cost ^(d)
Arizona	E	-74	-1359	907	-361	-6606	-3169
Arkansas	E	-4	-61	1881	-56	-843	1154
California	E	-13	-194	1780	-118	-1736	484
Colorado	E	-6	-74	1871	-42	-553	1371
Florida	D	-13	-91	1858	-136	-926	1091
Idaho	E	-34	-291	1708	-188	-1629	564
Kansas	NG	-54	-102	1850	-376	-706	1257
Montana	E	-10	-102	1850	-95	-950	1073
Nebraska	D	-28	-165	1802	-243	-1440	705
Nevada	E	-19	-248	1740	-175	-2333	36
New Mexico	NG	-118	-315	1690	-692	-1847	401
Oklahoma	NG	-69	-269	1724	-451	-1762	464
Oregon	E	-31	-250	1739	-181	-1449	699
Texas	NG	-52	-168	1800	-342	-1110	953
Utah	E	-27	-371	1648	-153	-2143	-179
Washington	E	-52	-276	1719	-274	-1459	691
Wyoming	E	-10	-109	1845	-76	-857	1143

(a) Based on 160-acre operation, the change is calculated by subtracting the energy use, energy cost, and after-tax cost of irrigation systems using conventional scheduling practices from those of the same systems using instrumented scheduling.

(b) NG = natural gas

D = diesel

E = electricity

(c) Million Btu/yr (negative numbers indicate decrease in use).

(d) In dollars/yr (negative numbers indicate decrease in cost).

TABLE 20. Change in Energy Use, Energy Cost, After-Tax Cost, and Water Use for Conventional Irrigation Scheduling Versus Instrumented Irrigation Scheduling Using Surface Water^(a)

State	Fuel ^(b)	Gated-Pipe System				Center-Pivot System			
		Energy Use ^(c)	Water Use ^(d)	Energy Cost ^(e)	After-Tax Cost ^(e)	Energy Use ^(c)	Water Use ^(d)	Energy Cost ^(e)	After-Tax Cost ^(e)
Arizona	E	-1	-35.2	-18	1913	-125	-113.1	-2298	62
Arkansas	E	-1	-11.2	-19	1912	-47	-39.0	-697	1263
California	E	-2	-20.8	-25	1907	-80	-68.9	-1176	904
Colorado	E	-1	-8.0	-9	1920	-27	-23.4	-363	1514
Florida	D	-1	-6.4	-10	1919	-95	-22.1	-647	1301
Idaho	E	-2	-22.4	-17	1913	-85	-72.8	-738	1233
Kansas	NG	-6	-11.2	-11	1918	-213	-37.7	-399	1486
Montana	E	-6	-17.6	-63	1879	-82	-57.2	-824	1168
Nebraska	D	-7	-12.8	-39	1897	-178	-39.0	-1056	993
Nevada	E	-4	-32.0	-59	1882	-128	-105.3	-1711	503
New Mexico	NG	-5	-17.6	-12	1917	-315	-58.5	-841	1155
Oklahoma	NG	-7	-12.8	-28	1906	-243	-42.9	-951	1072
Oregon	E	-2	-20.8	-15	1915	-80	-70.2	-656	1294
Texas	NG	-11	-9.6	-37	1899	-205	-32.5	-666	1286
Utah	E	-2	-20.8	-32	1902	-78	-65.0	-1084	973
Washington	E	-6	-32.0	-29	1904	-127	-101.4	-677	1278
Wyoming	E	-2	-11.2	-21	1911	-49	-39.0	-551	1373

(a) The change is calculated by subtracting the energy use, energy cost, and after-tax cost of conventional scheduling systems from those of an instrumented scheduling system.

(b) NG = natural gas

D = diesel

E = electricity

(c) Million Btu/yr.

(d) In acre/inches per year.

(e) In dollars/yr.

represent, respectively, high, medium, and low cost irrigation regions. In each state, sensitivity was performed on the predominant fuel used for irrigation (i.e., electricity in Arizona and Washington, and natural gas in Texas).

The sensitivity analysis was run for eight of the energy-conserving systems evaluated in this study: surged wells, jetted wells, automated gated-pipe, LEPA linear-move, LEPA center-pivot, reduced-pressure center pivot, computerized water scheduling, and instrumented water scheduling. Except for the wells, cases run for each system included both surface-water and groundwater conditions. Wells were analyzed only for groundwater. Each hardware technology was compared to its nearest competitor. For example, improved wells were compared with conventional wells. Each scheduling system was combined with conventional automated gated-pipe and center-pivot systems and compared to the same systems with conventional scheduling. No sensitivity analysis was performed on the redesigned column and pump or variable-speed pumping because the comparative analysis results for these systems were unlikely to be affected by changes in required rate of return or fuel price escalation rate over the range considered in the sensitivity analysis.

5.2.1 Discount Rate

The discount rate assumed in the comparative analysis was 10%. In the sensitivity analysis, the discount rate was changed to 5% and to 15% to test its impact on the change in annual after-tax cost associated with substituting energy-conserving irrigation systems for conventional systems.

The results of the sensitivity analysis on the discount rate are summarized in Table 21. As in the comparative analysis, a negative number indicates that annual after-tax costs of irrigation would be lowered by switching from a conventional irrigation system to an energy-conserving system. A positive number indicates that annual after-tax cost would be increased by such an investment. If a number changes from positive to negative or negative to positive as the discount rate changes, the conclusions of the comparative analysis would be altered by such a change in the discount rate.

TABLE 21. Sensitivity of After-Tax Costs to Discount Rate Changes

Comparison	Water ^(a) Source	Texas (NG) ^(b)		Arizona (E) ^(c)		Washington (E)	
		5%	15%	5%	15%	5%	15%
Conv. Well vs. Surged Well	G	-262	-186	-2693	-2354	-293	-120
Conv. Well vs. Jetted Well	G	-242	-113	-3338	-2868	-317	-44
Gated Pipe vs. Automated Gated	G	2580	3469	-2691	-862	1422	3125
Gated Pipe vs. Automated Gated	S	3098	3980	2384	4058	2342	4017
Conv.-LM ^(d) vs. LEPA-LM	G	-1458	-1117	-11502	-10548	-2186	-1516
Conv.-LM vs. LEPA-LM	S	-1087	-751	-7847	-7004	-1524	-874
Conv.-CP ^(e) vs. LEPA-CP	G	-1279	-965	-1140	-9275	-1920	-1305
Conv.-CP vs. LEPA-CP	S	-977	-668	-7170	-6395	-1382	-783
Conv.-CP vs. Reduced-Pres. CP	G	-1363	-1344	-5720	-5546	-1489	-1444
Conv.-CP vs. Reduced-Pres. CP	S	-1363	-1344	-5720	-5546	-1489	-1444
Gated Pipe with Computerized Sched.	G	432	434	-671	-633	347	355
Gated Pipe with Computerized Sched.	S	563	564	583	584	573	574
CP with Computer- ized Sched.	G	-511	-497	-5591	-5406	-853	-813
CP with Computer- ized Sched.	S	-112	-103	-1627	-1562	-135	-116
Gated Pipe with Instrumented Sched.	G	1800	2204	529	1324	1354	2124
Gated Pipe with Instrumented Sched.	S	1899	3301	1551	2315	1543	2306
CP with Instru- mented Sched.	G	953	1367	-3612	-2696	312	1109
CP with Instru- mented Sched.	S	1286	1695	-328	489	908	1687

(a) G = groundwater, S = surface water

(b) NG = natural gas

(c) E = electricity

(d) LM = lateral move

(e) CP = center pivot

Table 21 indicates that increasing the discount rate lowers the annualized benefits from energy savings that occur in future years. However, in only one of the comparisons considered for the three test states in the sensitivity analysis (instrumented scheduling on center pivots using surface water in Arizona) did the conclusions regarding the relative cost effectiveness of the energy-saving technology change as the discount rate went from 5% to 15%.

5.2.2 Fuel Prices

The results of the sensitivity analysis on the real fuel price escalation rate are contained in Table 22. The fuel price escalation rate is varied from 0% to 4% (baseline is 2%) to determine its impact on the change in after-tax irrigation costs of switching from a conventional irrigation system to an energy-conserving system. The results of the sensitivity analysis on fuel price escalation rate are interpreted in the same way as those for the discount rate.

In general, as the fuel price escalation rate increases, the value of energy savings from energy-conserving systems increases, making them more economical relative to conventional systems. However, in only one of the cases considered (instrumented scheduling on center-pivots in Arizona) were the comparative analysis conclusions altered by varying the fuel price escalation rate between 0 and 4%.

TABLE 22. Sensitivity of After-Tax Costs to Fuel Price Changes

Comparison	Water ^(a) Source	Texas (NG) ^(b)		Arizona (E) ^(c)		Washington (E)	
		0%	4%	0%	4%	0%	4%
Conv. Well vs. Surged Well	G	-200	-339	-2123	-3015	-150	-285
Conv. Well vs. Jetted Well	G	-164	-338	-2602	-3722	-112	-280
Gated Pipe vs. Automated Gated	G	2659	2486	-1208	-2528	2352	2088
Gated Pipe vs. Automated Gated	S	3115	3077	3185	3167	3149	3121
Conv.-LM ^(d) vs. LEPA-LM	G	-1156	-1814	-9577	-12732	1512	-2276
Conv.-LM vs. LEPA-LM	S	-829	-1390	-6413	-8629	-939	-1533
Conv.-CP ^(e) vs. LEPA-CP	G	-1008	-1598	-8428	-8481	-1311	-1991
Conv.-CP vs. LEPA-CP	S	-742	-1253	-5857	-7883	-845	-1387
Conv.-CP vs. Reduced-Pres. CP	G	-1200	-1556	-4952	-6420	-1289	-1671
Conv.-CP vs. Reduced-Pres. CP	S	-1200	-1556	-4952	-6420	-1289	-1671
Gated Pipe with Computerized Sched.	G	452	408	-501	-827	381	316
Gated Pipe with Computerized Sched.	S	568	558	586	581	577	570
CP with Computerized Sched.	G	-392	-652	-4775	-6335	-673	-1018
CP with Computerized Sched.	S	-40	-196	-1343	-1886	-51	-211
Gated Pipe with Instrumented Sched.	G	1815	-1783	1029	764	1744	1690
Gated Pipe with Instrumented Sched.	S	1902	1895	1915	1911	1907	1901
CP with Instrumented Sched.	G	1053	836	-2575	-3867	822	537
CP with Instrumented Sched.	S	1346	1216	269	-181	1339	1206

(a) G = groundwater, S = surface water

(b) NG = natural gas

(c) E = electricity

(d) LM = lateral move

(e) CP = center pivot

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APPENDIX

STATE LEVEL DATA

TABLE A-1. Change in Energy Use and Levelized Costs for Arizona

Systems: Surged and Jetted Wells

Water Source: Groundwater

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
CONVENTIONAL WELL VS SURGED WELL						
ELECTRIC	-198	291	0	-3722	-3432	-2522
NATURAL GAS	-937	291	0	-2888	-2597	-1896
CONVENTIONAL WELL VS JETTED WELL						
ELECTRIC	-240	432	0	-4672	-4240	-3103
NATURAL GAS	-1176	432	0	-3624	-3192	-2317

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-2. Change in Energy Use and Levelized Costs for Arizona

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, Reduced-Pressure Center Pivot, Redesigned Pump and Variable Speed Pump

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE VS AUTOMATED GATED PIPE						
ELECTRIC	-368	2812	888	-6744	-3045	-1815
NATURAL GAS	-1744	2812	888	-5232	-1532	-681
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-880	975	228	-16123	-14919	-11027
NATURAL GAS	-4170	975	228	-12507	-11304	-8315
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-778	898	210	-14254	-13145	-9709
NATURAL GAS	-3686	898	210	-11057	-9949	-7312
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-410	0	0	-7502	-7502	-5626
NATURAL GAS	-1940	0	0	-5820	-5820	-4365
GATED PIPE VS GATED PIPE WITH REDESIGNED PUMP						
ELECTRIC	-123	26	0	-2248	-2222	-1663
NATURAL GAS	-581	26	0	-1744	-1718	-1284
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH REDESIGNED PUMP						
ELECTRIC	-121	26	0	-2212	-2186	-1636
NATURAL GAS	-572	26	0	-1716	-1690	-1264
GATED PIPE VS GATED PIPE WITH VARIABLE SPEED PUMP						
ELECTRIC	-104	1027	400	-1909	-482	-190
NATURAL GAS	-494	1027	400	-1481	-54	131
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH VARIABLE SPEED PUMP						
ELECTRIC	-103	1027	400	-1878	-452	-168
NATURAL GAS	-486	1027	400	-1457	-30	148

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-3. Change in Energy Use and Levelized Costs for Arizona

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, and Reduced-Pressure Center Pivot

Water Source: Surface Water

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
GATED PIPE VS AUTOMATED GATED						
ELECTRIC	-5	2812	888	-89	3611	3177
NATURAL GAS	-23	2812	888	-69	3631	3192
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-619	975	228	-11328	-10125	-7431
NATURAL GAS	-2930	975	228	-8788	-7585	-5526
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-566	898	210	-10358	-9250	-6788
NATURAL GAS	-2679	898	210	-8036	-6927	-5046
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-410	0	0	-7502	-7502	-5626
NATURAL GAS	-1940	0	0	-5820	-5820	-4365

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-4. Change in Energy Use and Levelized Costs for Arizona

System: Computerized Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE						
ELECTRIC	-91	0	800	-1668	-868	-651
NATURAL GAS	-431	0	800	-1294	-494	-370
CENTER PIVOT						
ELECTRIC	-435	0	650	-7973	-7323	-5492
NATURAL GAS	-2062	0	650	-6185	-5535	-4151
HAND MOVED						
ELECTRIC	-494	0	800	-9045	-8245	-6183
NATURAL GAS	-2339	0	800	-7016	-6216	-4662
AUTOMATED GATED PIPE						
ELECTRIC	-73	0	800	-1334	-534	-401
NATURAL GAS	-345	0	800	-1035	-235	-176
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-248	0	650	-4548	-3898	-2923
NATURAL GAS	-1176	0	650	-3528	-2878	-2159
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-337	0	650	-6170	-5520	-4140
NATURAL GAS	-1596	0	650	-4787	-4137	-3102
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-306	0	800	-5597	-4797	-35982
NATURAL GAS	-1448	0	800	-4342	-3542	-2657
LATERAL MOVE						
ELECTRIC	-517	0	800	-9471	-8671	-6503
NATURAL GAS	-2449	0	800	-7347	-6547	-4911

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-5. Change in Energy Use, Levelized Costs and Water Use for Arizona

Systems: Computerized Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE							
ELECTRIC	-1	0	800	-22	778	584	-43.20
NATURAL GAS	-6	0	800	-17	783	587	-43.20
CENTER PIVOT							
ELECTRIC	-151	0	650	-2773	-2123	-1592	-136.50
NATURAL GAS	-717	0	650	-2151	-1501	-1126	-136.50
HAND MOVED							
ELECTRIC	-144	0	800	-2645	-1845	-1384	-168.00
NATURAL GAS	-684	0	800	-2052	-1252	-939	-168.00
AUTOMATED GATED PIPE							
ELECTRIC	-1	0	800	-18	782	587	-34.56
NATURAL GAS	-5	0	800	-14	786	590	-34.56
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-16	0	650	-284	366	274	-111.93
NATURAL GAS	-74	0	650	-221	429	322	-111.93
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-53	0	650	-971	-321	-240	-136.50
NATURAL GAS	-251	0	650	-753	-103	-77	-136.50
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-19	0	800	-350	450	338	-137.76
NATURAL GAS	-90	0	800	-271	529	396	-137.76
LATERAL MOVE							
ELECTRIC	-168	0	800	-3072	-2272	-1704	-168.00
NATURAL GAS	-794	0	800	-2383	-1583	-1187	-168.00

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-6. Change in Energy Use and Levelized Costs for Arizona

Systems: Instrumented Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE						
ELECTRIC	-74	1283	1000	-1359	925	907
NATURAL GAS	-351	1283	1000	-1054	1229	1136
CENTER PIVOT						
ELECTRIC	-361	1283	813	-6606	-4510	-3169
NATURAL GAS	-1708	1283	813	-5125	-3029	-2058
HAND MOVED						
ELECTRIC	-409	1283	1000	-7494	-5211	-3694
NATURAL GAS	-1938	1283	1000	-5014	-3530	-2434
AUTOMATED GATED PIPE						
ELECTRIC	-59	1283	1000	-1087	1196	1111
NATURAL GAS	-281	1283	1000	-843	1440	1294
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-206	1283	813	-3768	-1673	-1041
NATURAL GAS	-975	1283	813	-2923	-828	-407
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-279	1283	813	-5112	-3017	-2049
NATURAL GAS	-1322	1283	813	-3966	-1870	-1189
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-253	1283	1000	-4638	-2355	-1552
NATURAL GAS	-1199	1283	1000	-3598	-1315	-772
LATERAL MOVE						
ELECTRIC	-428	1283	1000	-7848	-5564	-3959
NATURAL GAS	-2030	1283	1000	-6088	-3805	-2640

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-7. Change in Energy Use, Levelized Costs and Water Use for Arizona

System: Instrumented Scheduling

Water Source: Surface Water

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>	<u>Water Use^(c)</u>
GATED PIPE							
ELECTRIC	-1	1283	1000	-18	2265	1913	-35.20
NATURAL GAS	-5	1283	1000	-14	2269	1916	-35.20
CENTER PIVOT							
ELECTRIC	-125	1283	813	-2298	-202	62	-113.10
NATURAL GAS	-594	1283	813	-1782	313	449	-113.10
HAND MOVED							
ELECTRIC	-120	1283	1000	-2192	92	283	-139.20
NATURAL GAS	-567	1283	1000	-1700	583	651	-139.20
AUTOMATED GATED PIPE							
ELECTRIC	-1	1283	1000	-14	2269	1916	-28.16
NATURAL GAS	-4	1283	1000	-11	2272	1918	-28.16
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-13	1283	813	-236	1860	1609	-92.74
NATURAL GAS	-61	1283	813	-183	1913	1649	-92.74
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-44	1283	813	-804	1292	1183	-113.10
NATURAL GAS	-208	1283	813	-624	1472	1318	-113.10
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-16	1283	1000	-290	1993	1709	-114.14
NATURAL GAS	-75	1283	1000	-225	2058	1758	-114.14
LATERAL MOVE							
ELECTRIC	-139	1283	1000	-2545	-262	17	-139.20
NATURAL GAS	-658	1283	1000	-1974	309	445	-139.20

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-8. Change in Energy Use and Levelized Costs for Arkansas

Systems: Surged and Jetted Wells

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
CONVENTIONAL WELL VS SURGED WELL						
ELECTRIC	-14	89	0	-215	-126	478
NATURAL GAS	-66	89	0	-103	-14	5
DIESEL	-52	89	0	-306	-216	-146
CONVENTIONAL WELL VS JETTED WELL						
ELECTRIC	-18	230	0	-270	-40	11
NATURAL GAS	-83	230	0	-130	100	116
DIESEL	-66	230	0	-384	-153	-74

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-9. Change in Energy Use and Levelized Costs for Arkansas

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, Reduced-Pressure Center Pivot, Redesigned Pump and Variable Speed Pump

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE VS AUTOMATED GATED						
ELECTRIC	-21	2812	888	-320	3380	3003
NATURAL GAS	-101	2812	888	-154	3546	3128
DIESEL	-80	2812	888	-455	3245	2902
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-224	975	228	-3352	-2149	-1449
NATURAL GAS	-1059	975	228	-1613	-410	-145
DIESEL	-839	975	228	-4765	-3561	-2509
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-203	898	210	-3043	-1935	-1301
NATURAL GAS	-962	898	210	-1464	-356	-117
DIESEL	-761	898	210	-4326	-3218	-2264
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-139	0	0	-2079	-2079	-1559
NATURAL GAS	-657	0	0	-1000	-1000	-750
DIESEL	-520	0	0	-2955	-2955	-2216
GATED PIPE VS GATED PIPE WITH REDESIGNED PUMP						
ELECTRIC	-7	26	0	-107	-81	-56
NATURAL GAS	-34	26	0	-51	-26	-15
DIESEL	-27	26	0	-152	-126	-90
CONVENTIONAL CENTER PIVOT VS CENTER PUMP WITH REDESIGNED PUMP						
ELECTRIC	-18	26	0	-277	-252	-184
NATURAL GAS	-88	26	0	-133	-108	-77
DIESEL	-69	26	0	-394	-368	-272
GATED PIPE VS GATED PIPE WITH VARIABLE SPEED PUMP						
ELECTRIC	-6	1027	400	-91	1336	1173
NATURAL GAS	-29	1027	400	-44	1383	1208
DIESEL	-23	1027	400	-129	1298	1145
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH VARIABLE SPEED PUMP						
ELECTRIC	-16	1027	400	-235	1191	1065
NATURAL GAS	-74	1027	400	-113	1313	1156
DIESEL	-59	1027	400	-335	1092	990

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-10. Change in Energy Use and Levelized Costs for Arkansas

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, and Reduced-Pressure Center Pivot

Water Source: Surface Water

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
GATED PIPE VS AUTOMATED GATED						
ELECTRIC	-7	2812	888	-98	3601	3170
NATURAL GAS	-31	2812	888	-47	3652	3208
DIESEL	-25	2812	888	-140	3560	3138
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-213	975	228	-3192	-1989	-1329
NATURAL GAS	-1009	975	228	-1536	-333	-87
DIESEL	-799	975	228	-4538	-3335	-2339
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-194	898	210	-2914	-1805	-1204
NATURAL GAS	-921	898	210	-1402	-294	-71
DIESEL	-729	898	210	-4142	-3034	-2125
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-139	0	0	-2079	-2079	-1559
NATURAL GAS	-657	0	0	-1000	-1000	-750
DIESEL	-520	0	0	-2955	-2955	-2216

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-11. Change in Energy Use and Levelized Costs for Arkansas

Systems: Computerized Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE						
ELECTRIC	-5	0	800	-78	722	542
NATURAL GAS	-25	0	800	-37	763	572
DIESEL	-19	0	800	-111	689	517
CENTER PIVOT						
ELECTRIC	-67	0	650	-1011	-361	-271
NATURAL GAS	-320	0	650	-487	163	122
DIESEL	-253	0	650	-1438	-788	-591
AUTOMATED GATED PIPE						
ELECTRIC	-4	0	800	-62	738	553
NATURAL GAS	-20	0	800	-30	770	578
DIESEL	-16	0	800	-88	712	534
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-18	0	650	-271	379	284
NATURAL GAS	-86	0	650	-130	520	390
DIESEL	-68	0	650	-385	265	198
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-34	0	650	-506	144	108
NATURAL GAS	-160	0	650	-243	407	305
DIESEL	-127	0	650	-719	-69	-52
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-22	0	800	-334	466	350
NATURAL GAS	-105	0	800	-161	639	480
DIESEL	-83	0	800	-474	326	244
LATERAL MOVE						
ELECTRIC	-77	0	800	-1149	-349	-262
NATURAL GAS	-363	0	800	-553	247	185
DIESEL	-288	0	800	-1633	-833	-625

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-12. Change in Energy Use, Levelized Costs and Water Use for Arkansas

Systems: Computerized Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE							
ELECTRIC	-2	0	800	-24	776	582	-14.40
NATURAL GAS	-8	0	800	-12	788	591	-14.40
DIESEL	-6	0	800	-34	766	574	-14.40
CENTER PIVOT							
ELECTRIC	-56	0	650	-836	-186	-140	-46.80
NATURAL GAS	-264	0	650	-402	248	186	-46.80
DIESEL	-209	0	650	-1189	-539	-404	-46.80
AUTOMATED GATED PIPE							
ELECTRIC	-1	0	800	-19	781	586	-11.52
NATURAL GAS	-6	0	800	-9	791	593	-11.52
DIESEL	-5	0	800	-27	773	580	-11.52
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-9	0	650	-128	522	392	-38.38
NATURAL GAS	-40	0	650	-61	589	441	-38.38
DIESEL	-32	0	650	-181	469	351	-38.38
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-22	0	650	-331	319	240	-46.80
NATURAL GAS	-105	0	650	-159	491	368	-46.80
DIESEL	-83	0	650	-470	180	135	-46.80
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-10	0	800	-157	643	482	-47.23
NATURAL GAS	-50	0	800	-76	724	543	-47.23
DIESEL	-39	0	800	-223	577	433	-47.23
LATERAL MOVE							
ELECTRIC	-62	0	800	-934	-134	-100	-57.60
NATURAL GAS	-295	0	800	-449	351	263	-57.60
DIESEL	-234	0	800	-1327	-527	-395	-57.60

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-13. Change in Energy Use and Levelized Costs for Arkansas

Systems: Instrumented Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE						
ELECTRIC	-4	1283	1000	-61	2223	1881
NATURAL GAS	-19	1283	1000	-29	2254	1904
DIESEL	-15	1283	1000	-86	2197	1862
CENTER PIVOT						
ELECTRIC	-56	1283	813	-843	1253	1154
NATURAL GAS	-266	1283	813	-406	1690	1482
DIESEL	-211	1283	813	-1198	898	887
AUTOMATED GATED PIPE						
ELECTRIC	-3	1283	1000	-48	2235	1890
NATURAL GAS	-15	1283	1000	-23	2260	1909
DIESEL	-12	1283	1000	-69	2214	1875
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-15	1283	813	-226	1870	1616
NATURAL GAS	-71	1283	813	-109	1987	1704
DIESEL	-57	1283	813	-321	1775	1545
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-28	1283	813	-421	1674	1470
NATURAL GAS	-133	1283	813	-203	1893	1634
DIESEL	-105	1283	813	-599	1497	1336
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-19	1283	1000	-278	2005	1718
NATURAL GAS	-88	1283	1000	-134	2149	1826
DIESEL	-70	1283	1000	-395	1888	1630
LATERAL MOVE						
ELECTRIC	-64	1283	1000	-958	1326	1208
NATURAL GAS	-303	1283	1000	-461	1822	1581
DIESEL	-240	1283	1000	-1361	922	905

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-14. Change in Energy Use, Levelized Costs and Water Use for Arkansas

Systems: Instrumented Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE							
ELECTRIC	-1	1283	1000	-19	2265	1912	-11.20
NATURAL GAS	-6	1283	1000	-9	2274	1920	-11.20
DIESEL	-5	1283	1000	-26	2257	1906	-11.20
CENTER PIVOT							
ELECTRIC	-47	1283	813	-697	1399	1263	-39.00
NATURAL GAS	-220	1283	813	-335	1760	1534	-39.00
DIESEL	-174	1283	813	-991	1105	1043	-39.00
AUTOMATED GATED PIPE							
ELECTRIC	-1	1283	1000	-15	2268	1915	-8.96
NATURAL GAS	-5	1283	1000	-7	2276	1921	-8.96
DIESEL	-4	1283	1000	-21	2262	1910	-8.96
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-7	1283	813	-106	1989	1706	-31.98
NATURAL GAS	-34	1283	813	-51	2045	1747	-31.98
DIESEL	-27	1283	813	-151	1945	1672	-31.98
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-18	1283	813	-276	1820	1579	-39.00
NATURAL GAS	-87	1283	813	-133	1963	1686	-39.00
DIESEL	-69	1283	813	-392	1704	1492	-39.00
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-9	1283	1000	-131	2152	1828	-39.36
NATURAL GAS	-41	1283	1000	-63	2220	1879	-39.36
DIESEL	-33	1283	1000	-186	2097	1787	-39.36
LATERAL MOVE							
ELECTRIC	-52	1283	1000	-778	1505	1343	-48.00
NATURAL GAS	-246	1283	1000	-374	1909	1646	-48.00
DIESEL	-195	1283	1000	-1106	1177	1097	-48.00

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-15. Change in Energy Use and Levelized Costs for California

Systems: Surged and Jetted Wells

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
CONVENTIONAL WELL VS SURGED WELL						
ELECTRIC	-48	127	0	-729	-602	-429
NATURAL GAS	-229	127	0	-720	-593	-422
DIESEL	-182	127	0	-1074	-947	-688
CONVENTIONAL WELL VS JETTED WELL						
ELECTRIC	-61	268	0	-914	-647	-437
NATURAL GAS	-288	268	0	-903	-635	-429
DIESEL	-228	268	0	-1348	-1080	-762

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-16. Change in Energy Use and Levelized Costs for California

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, Reduced-Pressure Center Pivot, Redesign Pump and Variable Speed Pump

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE VS AUTOMATED GATED PIPE						
ELECTRIC	-67	2812	888	-987	2712	2503
NATURAL GAS	-319	2812	888	-975	2725	2512
DIESEL	-253	2812	888	-1455	2245	2152
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-420	975	228	-6157	-4953	-3552
NATURAL GAS	-1990	975	228	-6081	-4878	-3496
DIESEL	-1575	975	228	-9074	-7870	-5740
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-379	898	210	-5560	-4452	-3189
NATURAL GAS	-1797	898	210	-5492	-4384	-3138
DIESEL	-1423	898	210	-8195	-7086	-5165
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-247	0	0	-3627	-3627	-2720
NATURAL GAS	-1172	0	0	-3582	-3582	-2687
DIESEL	-928	0	0	-5345	-5345	-4009
GATED PIPE VS GATED PIPE WITH REDESIGNED PUMP						
ELECTRIC	-22	26	0	-329	-303	-223
NATURAL GAS	-106	26	0	-325	-299	-220
DIESEL	-84	26	0	-485	-459	-340
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH REDESIGNED PUMP						
ELECTRIC	-39	26	0	-577	-551	-409
NATURAL GAS	-186	26	0	-570	-544	-404
DIESEL	-148	26	0	-850	-824	-614
GATED PIPE VS GATED PIPE WITH VARIABLE SPEED PUMP						
ELECTRIC	-19	1027	400	-279	1147	1032
NATURAL GAS	-90	1027	400	-276	1151	1034
DIESEL	-71	1027	400	-412	1015	932
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH VARIABLE SPEED PUMP						
ELECTRIC	-33	1027	400	-490	937	874
NATURAL GAS	-168	1027	400	-484	943	878
DIESEL	-125	1027	400	-721	705	700

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-17. Change in Energy Use and Levelized Costs for California

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, and Reduced-Pressure Center Pivot

Water Source: Surface Water

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
GATED PIPE VS AUTOMATED GATED PIPE						
ELECTRIC	-9	2812	886	-129	3571	3147
NATURAL GAS	-42	2812	888	-127	3572	3148
DIESEL	-33	2812	888	-190	3510	3101
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-378	975	228	-5538	-4335	-3089
NATURAL GAS	-1790	975	228	-5471	-4267	-3038
DIESEL	-1417	975	228	-8163	-6960	-5057
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-345	898	210	-5058	-3950	-2813
NATURAL GAS	-1635	898	210	-4996	-3888	-2766
DIESEL	-1294	898	210	-7455	-6346	-4610
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-247	0	0	-3627	-3627	-2720
NATURAL GAS	-1172	0	0	-3582	-3582	-2687
DIESEL	-928	0	0	-5345	-5345	-4009

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-18. Change in Energy Use and Levelized Costs for California

Systems: Computerized Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE						
ELECTRIC	-16	0	800	-239	561	421
NATURAL GAS	-77	0	800	-236	564	423
DIESEL	-61	0	800	-353	447	335
CENTER PIVOT						
ELECTRIC	-141	0	650	-2064	-1414	-1060
NATURAL GAS	-667	0	650	-2039	-1389	-1041
DIESEL	-520	0	650	-3042	-2392	-1794
TOWLINE, SIDE ROLL						
ELECTRIC	-151	0	800	-2212	-1412	-1059
NATURAL GAS	-715	0	800	-2185	-1385	-1039
DIESEL	-566	0	800	-3261	-2461	-1845
HAND MOVED						
ELECTRIC	-148	0	800	-2171	-1371	-1029
NATURAL GAS	-702	0	800	-2145	-1345	-1009
DIESEL	-556	0	800	-3200	-2400	-1800
TRICKLE						
ELECTRIC	-89	0	800	-1311	-511	-383
NATURAL GAS	-424	0	800	-1295	-495	-371
DIESEL	-335	0	800	-1932	-1132	-849
AUTOMATED GATED PIPE						
ELECTRIC	-13	0	800	-191	609	456
NATURAL GAS	-62	0	800	-189	611	458
DIESEL	-49	0	800	-282	518	388
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-50	0	650	-737	-87	-65
NATURAL GAS	-238	0	650	-728	-78	-58
DIESEL	-189	0	650	-1086	-436	-327
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-82	0	650	-1198	-548	-411
NATURAL GAS	-387	0	650	-1184	-534	-400
DIESEL	-307	0	650	-1766	-1116	-837
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-62	0	800	-907	-107	-80
NATURAL GAS	-293	0	800	-896	-96	-72
DIESEL	-232	0	800	-1337	-537	-403
LATERAL MOVE						
ELECTRIC	-162	0	800	-2376	-1576	-1182
NATURAL GAS	-768	0	800	-2347	-1547	-1160
DIESEL	-608	0	800	-3502	-2702	-2027

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-19. Change in Energy Use, Levelized Costs, and Water Use for California

Systems: Computerized Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE							
ELECTRIC	-2	0	800	-31	769	577	-25.60
NATURAL GAS	-10	0	800	-31	769	577	-25.60
DIESEL	-8	0	800	-46	754	565	-25.60
CENTER PIVOT							
ELECTRIC	-95	0	650	-1398	-748	-561	-81.90
NATURAL GAS	-452	0	650	-1381	-731	-548	-81.90
DIESEL	-358	0	650	-2061	-1411	-1058	-81.90
TOWLINE, SIDE ROLL							
ELECTRIC	-95	0	800	-1393	-593	-445	-100.80
NATURAL GAS	-450	0	800	-1376	-576	-432	-100.80
DIESEL	-356	0	800	-2053	-1253	-940	-100.80
HAND MOVED							
ELECTRIC	-92	0	800	-1352	-552	-414	-100.80
NATURAL GAS	-437	0	800	-1335	-535	-402	-100.80
DIESEL	-346	0	800	-1993	-1193	-894	-100.80
TRICKLE							
ELECTRIC	-34	0	800	-492	308	231	-100.80
NATURAL GAS	-159	0	800	-486	314	236	-100.80
DIESEL	-126	0	800	-725	75	57	-100.80
AUTOMATED GATED PIPE							
ELECTRIC	-2	0	800	-25	775	581	-20.48
NATURAL GAS	-8	0	800	-25	775	582	-20.48
DIESEL	-6	0	800	-37	763	572	-20.48
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-13	0	650	-191	459	344	-67.16
NATURAL GAS	-62	0	650	-189	461	346	-67.16
DIESEL	-49	0	650	-282	368	276	-67.16
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-36	0	650	-533	117	88	-81.90
NATURAL GAS	-172	0	650	-526	124	93	-81.90
DIESEL	-136	0	650	-785	-135	-101	-81.90
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-16	0	800	-235	565	424	-82.66
NATURAL GAS	-76	0	800	-232	568	426	-82.66
DIESEL	-60	0	800	-347	453	340	-82.66
LATERAL MOVE							
ELECTRIC	-106	0	800	-1557	-757	-568	-100.80
NATURAL GAS	-503	0	800	-1538	-738	-553	-100.80
DIESEL	-398	0	800	-2295	-1495	-1121	-100.80

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-20. Change in Energy Use and Levelized Costs for California

Systems: Instrumented Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE						
ELECTRIC	-13	1283	1000	-194	2089	1780
NATURAL GAS	-63	1283	1000	-192	2091	1782
DIESEL	-50	1283	1000	-287	1997	1711
CENTER PIVOT						
ELECTRIC	-118	1283	813	-1736	360	484
NATURAL GAS	-561	1283	813	-1715	381	499
DIESEL	-444	1283	813	-2559	-463	-134
TOWLINE, SIDE ROLL						
ELECTRIC	-127	1283	1000	-1861	422	530
NATURAL GAS	-601	1283	1000	-1838	445	548
DIESEL	-476	1283	1000	-2743	-460	-131
HAND MOVED						
ELECTRIC	-125	1283	1000	-1827	457	556
NATURAL GAS	-590	1283	1000	-1804	479	573
DIESEL	-467	1283	1000	-2692	-409	-93
TRICKLE						
ELECTRIC	-75	1283	1000	-1103	1180	1099
NATURAL GAS	-356	1283	1000	-1089	1194	1109
DIESEL	-282	1283	1000	-1626	658	707
AUTOMATED GATED PIPE						
ELECTRIC	-11	1283	1000	-156	2128	1810
NATURAL GAS	-50	1283	1000	-154	2130	1811
DIESEL	-40	1283	1000	-229	2054	1754
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-42	1283	813	-620	1476	1321
NATURAL GAS	-200	1283	813	-612	1483	1326
DIESEL	-159	1283	813	-914	1182	1100
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-69	1283	813	-1008	1088	1030
NATURAL GAS	-326	1283	813	-996	1100	1039
DIESEL	-258	1283	813	-1486	610	671
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-52	1283	1000	-763	1520	1354
NATURAL GAS	-247	1283	1000	-754	1530	1361
DIESEL	-195	1283	1000	-1125	1159	1083
LATERAL MOVE						
ELECTRIC	-136	1283	1000	-1999	284	427
NATURAL GAS	-646	1283	1000	-1975	309	445
DIESEL	-511	1283	1000	-2946	-663	-283

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-21. Change in Energy Use, Levelized, Costs and Water Use for California

Systems: Instrumented Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE							
ELECTRIC	-2	1283	1000	-25	2258	1907	-20.80
NATURAL GAS	-8	1283	1000	-25	2258	1908	-20.80
DIESEL	-6	1283	1000	-37	2246	1898	-20.80
CENTER PIVOT							
ELECTRIC	-80	1283	813	-1176	920	904	-68.90
NATURAL GAS	-380	1283	813	-1162	934	914	-68.90
DIESEL	-301	1283	813	-1733	362	486	-68.90
TOWLINE, SIDE ROLL							
ELECTRIC	-80	1283	1000	-1172	1111	1047	-84.80
NATURAL GAS	-379	1283	1000	-1158	1126	1058	-84.80
DIESEL	-300	1283	1000	-1727	556	631	-84.80
HAND MOVED							
ELECTRIC	-78	1283	1000	-1137	1146	1073	-84.80
NATURAL GAS	-368	1283	1000	-1123	1160	1084	-84.80
DIESEL	-291	1283	1000	-1676	607	669	-84.80
TRICKLE							
ELECTRIC	-28	1283	1000	-414	1870	1616	-84.80
NATURAL GAS	-134	1283	1000	-409	1875	1620	-84.80
DIESEL	-106	1283	1000	-610	1674	1469	-84.80
AUTOMATED GATED PIPE							
ELECTRIC	-1	1283	1000	-20	2263	1911	-16.64
NATURAL GAS	-7	1283	1000	-20	2263	1911	-16.64
DIESEL	-5	1283	1000	-30	2253	1904	-16.64
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-11	1283	813	-161	1935	1665	-56.50
NATURAL GAS	-52	1283	813	-159	1937	1667	-56.50
DIESEL	41	1283	813	-237	1859	1608	-56.50
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-31	1283	813	-448	1648	1450	-68.90
NATURAL GAS	-145	1283	813	-443	1653	1454	-68.90
DIESEL	-115	1283	813	-660	1435	1290	-68.90
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-13	1283	1000	-198	2085	1778	-69.54
NATURAL GAS	-64	1283	1000	-195	2088	1780	-69.54
DIESEL	-51	1283	1000	-292	1992	1708	-69.54
LATERAL MOVE							
ELECTRIC	-89	1283	1000	-1310	974	944	-84.80
NATURAL GAS	-423	1283	1000	-1294	990	956	-84.80
DIESEL	-335	1283	1000	-1930	353	479	-84.80

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-22. Change in Energy Use and Levelized Costs for Colorado

Systems: Surged and Jetted Wells

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
CONVENTIONAL WELL VS SURGED WELL						
ELECTRIC	-20	137	0	-276	-138	-79
NATURAL GAS	-95	137	0	-2521	-115	-61
DIESEL	-76	137	0	-441	-304	-203
CONVENTIONAL WELL VS JETTED WELL						
ELECTRIC	-25	278	0	-346	-68	-1
NATURAL GAS	-120	278	0	-316	-38	21
DIESEL	-95	278	0	-553	-275	-157

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-23. Change in Energy Use and Levelized Costs for Colorado

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, Reduced-Pressure Center Pivot, Redesigned Pump and Variable Speed Pump

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE VS AUTOMATED GATED PIPE						
ELECTRIC	-26	2812	888	-340	3360	2989
NATURAL GAS	-121	2812	888	-310	3389	3011
DIESEL	-96	2812	888	-544	3156	2836
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-148	975	228	-1969	-765	-412
NATURAL GAS	-700	975	228	-1798	-595	-284
DIESEL	-554	975	228	-3150	-1946	-1297
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-133	898	210	-1776	-668	-351
NATURAL GAS	-632	898	210	-1622	-514	-236
DIESEL	-500	898	210	-2842	-1733	-1150
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-86	0	0	-1148	-1148	-861
NATURAL GAS	-408	0	0	-1049	-1049	-787
DIESEL	-323	0	0	-1837	-1837	-1378
GATED PIPE VS GATED PIPE WITH REDESIGNED PUMP						
ELECTRIC	-9	26	0	-113	-88	-61
NATURAL GAS	-40	26	0	-103	-78	-54
DIESEL	-32	26	0	-181	-156	-112
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH REDESIGNED PUMP						
ELECTRIC	-14	26	0	-188	-163	-118
NATURAL GAS	-67	26	0	-172	-146	-106
DIESEL	-53	26	0	-301	-276	-203
GATED PIPE VS GATED PIPE WITH VARIABLE SPEED PUMP						
ELECTRIC	-7	1027	400	-96	1330	1169
NATURAL GAS	-34	1027	400	-88	1339	1175
DIESEL	-27	1027	400	-154	1273	1126
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH VARIABLE SPEED PUMP						
ELECTRIC	-12	1027	400	-160	1267	1121
NATURAL GAS	-57	1027	400	-146	1280	1131
DIESEL	-45	1027	400	-256	1171	1049

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-24. Change in Energy Use and Levelized Costs for Colorado

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, and Reduced-Pressure Center Pivot

Water Source: Surface Water

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
GATED PIPE VS AUTOMATED GATED PIPE						
ELECTRIC	-3	2812	888	-41	3659	3213
NATURAL GAS	-15	2812	888	-37	3662	3215
DIESEL	-11	2812	888	-65	3634	3194
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-132	975	228	-1754	-550	-250
NATURAL GAS	-624	975	228	-1602	-398	-136
DIESEL	-494	975	228	-2805	-1602	-1039
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-120	898	210	-1601	-493	-220
NATURAL GAS	-570	898	210	-1463	-354	-116
DIESEL	-451	898	210	-2562	-1454	-941
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-86	0	0	-1148	-1148	-861
NATURAL GAS	-400	0	0	-1049	-1049	-787
DIESEL	-323	0	0	-1837	-1837	-1378

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-25. Change in Energy Use and Levelized Costs for Colorado

Systems: Computerized Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE						
ELECTRIC	-7	0	800	-89	711	534
NATURAL GAS	-32	0	800	-81	719	539
DIESEL	-25	0	800	-142	658	494
CENTER PIVOT						
ELECTRIC	-51	0	650	-676	-26	-19
NATURAL GAS	-240	0	650	-617	33	24
DIESEL	-190	0	650	-1081	-431	-324
AUTOMATED GATED PIPE						
ELECTRIC	-5	0	800	-71	729	547
NATURAL GAS	-25	0	800	-65	735	551
DIESEL	-20	0	800	-113	687	515
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-19	0	650	-251	399	299
NATURAL GAS	-89	0	650	-229	421	315
DIESEL	-71	0	650	-402	248	186
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-30	0	650	-401	249	187
NATURAL GAS	-143	0	650	-367	283	213
DIESEL	-113	0	650	-642	8	6
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-23	0	800	-309	491	368
NATURAL GAS	-110	0	800	-282	518	388
DIESEL	-87	0	800	-495	305	229
LATERAL MOVE						
ELECTRIC	-59	0	800	-780	20	15
NATURAL GAS	-277	0	800	-712	88	66
DIESEL	-220	0	800	-1248	-448	-336

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-26. Change in Energy Use, Levelized Costs, and Water Use
for Colorado

Systems: Computerized Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE							
ELECTRIC	-1	0	800	-11	789	592	-9.60
NATURAL GAS	-4	0	800	-10	790	593	-9.60
DIESEL	-3	0	800	-17	783	587	-9.60
CENTER PIVOT							
ELECTRIC	-33	0	650	-444	206	155	-28.60
NATURAL GAS	-158	0	650	-405	245	184	-28.60
DIESEL	-125	0	650	-710	-60	-45	-28.60
AUTOMATED GATED PIPE							
ELECTRIC	-1	0	800	-9	791	594	-7.68
NATURAL GAS	-3	0	800	-8	792	594	-7.68
DIESEL	-2	0	800	-14	786	590	-7.68
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-5	0	650	-61	589	442	-23.45
NATURAL GAS	-22	0	650	-55	595	446	-23.45
DIESEL	-17	0	650	-97	553	415	-23.45
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-13	0	650	-169	481	361	-28.60
NATURAL GAS	-60	0	650	-154	496	372	-28.60
DIESEL	-48	0	650	-270	380	285	-28.60
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-6	0	800	-75	725	544	-28.86
NATURAL GAS	-27	0	800	-68	732	549	-28.86
DIESEL	-21	0	800	-119	681	510	-28.86
LATERAL MOVE							
ELECTRIC	-37	0	800	-494	306	230	-35.20
NATURAL GAS	-176	0	800	-451	349	262	-35.20
DIESEL	-139	0	800	-790	10	7	-35.20

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-27. Change in Energy Use and Levelized Costs for Colorado

Systems: Instrumented Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE						
ELECTRIC	-6	1283	1000	-74	2209	1871
NATURAL GAS	-26	1283	1000	-67	2216	1876
DIESEL	-21	1283	1000	-118	2165	1838
CENTER PIVOT						
ELECTRIC	-42	1283	813	-553	1543	1371
NATURAL GAS	-197	1283	813	-505	1591	1407
DIESEL	-156	1283	813	-885	1211	1122
AUTOMATED GATED PIPE						
ELECTRIC	-4	1283	1000	-59	2224	1882
NATURAL GAS	-21	1283	1000	-54	2229	1886
DIESEL	-17	1283	1000	-95	2189	1855
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-15	1283	813	-205	1890	1632
NATURAL GAS	-73	1283	813	-188	1908	1645
DIESEL	-58	1283	813	-329	1767	1539
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-25	1283	813	-328	1767	1539
NATURAL GAS	-117	1283	813	-300	1796	1561
DIESEL	-92	1283	813	-525	1570	1392
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-19	1283	1000	-253	2030	1737
NATURAL GAS	-90	1283	1000	-231	2052	1753
DIESEL	-71	1283	1000	-405	1879	1623
LATERAL MOVE						
ELECTRIC	-48	1283	1000	-638	1645	1448
NATURAL GAS	-227	1283	1000	-583	1700	1489
DIESEL	-180	1283	1000	-1021	1262	1161

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-28. Change in Energy Use, Levelized, Costs and Water Use for Colorado

Systems: Instrumented Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE							
ELECTRIC	-1	1283	1000	-9	2274	1920	-8.00
NATURAL GAS	-3	1283	1000	-8	2275	1920	-8.00
DIESEL	-2	1283	1000	-14	2269	1916	-8.00
CENTER PIVOT							
ELECTRIC	-27	1283	813	-363	1733	1514	-23.40
NATURAL GAS	-129	1283	813	-331	1764	1537	-23.40
DIESEL	-102	1283	813	-581	1515	1350	-23.40
AUTOMATED GATED PIPE							
ELECTRIC	-1	1283	1000	-7	2276	1921	-6.40
NATURAL GAS	-3	1283	1000	-6	2277	1921	-6.40
DIESEL	-2	1283	1000	-11	2272	1918	-6.40
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-4	1283	813	-50	2046	1749	-19.19
NATURAL GAS	-18	1283	813	-45	2050	1752	-19.19
DIESEL	-14	1283	813	-79	2016	1726	-19.19
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-10	1283	813	-138	1958	1682	-23.40
NATURAL GAS	-49	1283	813	-126	1969	1691	-23.40
DIESEL	-39	1283	813	-221	1875	1620	-23.40
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-5	1283	1000	-61	2222	1881	-23.62
NATURAL GAS	-22	1283	1000	-56	2228	1885	-23.62
DIESEL	-17	1283	1000	-98	2186	1853	-23.62
LATERAL MOVE							
ELECTRIC	-30	1283	1000	-404	1879	1623	-28.80
NATURAL GAS	-144	1283	1000	-369	1914	1649	-28.80
DIESEL	-114	1283	1000	-647	1637	1441	-28.80

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-29. Change in Energy Use and Levelized Costs for Florida

Systems: Surged and Jetted Wells

Water Source: Groundwater

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
CONVENTIONAL WELL VS SURGED WELL						
ELECTRIC	-6	103	0	-104	-2	17
DIESEL	-23	103	0	-161	-58	-25
CONVENTIONAL WELL VS JETTED WELL						
ELECTRIC	-8	244	0	-131	113	128
DIESEL	-29	244	0	-202	42	75

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-30. Change in Energy Use and Levelized Costs for Florida

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, Reduced-Pressure Center Pivot, Redesigned Pump and Variable Speed Pump

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE VS AUTOMATED GATED PIPE						
ELECTRIC	-19	2812	888	-319	3381	3004
DIESEL	-72	2812	888	-491	3209	2875
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-135	975	228	-2243	-1040	-617
DIESEL	-505	975	228	-3451	-2248	-1523
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-122	898	210	-2029	-921	-541
DIESEL	-457	898	210	-3122	-2013	-1360
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-81	0	0	-1342	-1342	-1006
DIESEL	-302	0	0	-2064	-2064	-1548
GATED PIPE VS GATED PIPE WITH REDESIGNED PUMP						
ELECTRIC	-6	26	0	-106	-81	-56
DIESEL	-24	26	0	-164	-138	-99
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH REDESIGNED PUMP						
ELECTRIC	-12	26	0	-203	-177	-129
DIESEL	-46	26	0	-312	-287	-211
GATED PIPE VS GATED PIPE WITH VARIABLE SPEED PUMP						
ELECTRIC	-5	1027	400	-90	1336	1173
DIESEL	-20	1027	400	-139	1288	1137
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH VARIABLE SPEED PUMP						
ELECTRIC	-10	1027	400	-172	1254	1112
DIESEL	-39	1027	400	-265	1161	1042

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A.31. Change in Energy Use and Levelized Costs for Florida

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, Reduced-Pressure Center Pivot, Redesign Pump and Variable Speed Pump

Water Source: Surface Water

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
GATED PIPE VS AUTOMATED GATED						
ELECTRIC	-2	2812	888	-35	3665	3217
DIESEL	-8	2812	888	-54	3646	3203
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-123	975	228	-2040	-837	-465
DIESEL	-460	975	228	-3138	-1935	-1289
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-112	898	210	-1864	-755	-417
DIESEL	-420	898	210	-2867	-1759	-1169
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-81	0	0	-1342	-1342	-1006
DIESEL	-302	0	0	-2064	-2064	-1548

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-32. Change in Energy Use and Levelized Costs for Florida

Systems: Computerized Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE						
ELECTRIC	-4	0	800	-74	726	545
DIESEL	-17	0	800	-114	686	515
CENTER PIVOT						
ELECTRIC	-45	0	650	-743	-93	-70
DIESEL	-167	0	650	-1144	-494	-370
SOLID SET						
ELECTRIC	-48	0	800	-791	9	7
DIESEL	-178	0	800	-1217	-417	-313
TRAVELING GUN						
ELECTRIC	-74	0	800	-1225	-425	-319
DIESEL	-276	0	800	-1885	-1085	-814
TRICKLE						
ELECTRIC	-27	0	800	-450	350	263
DIESEL	-101	0	800	-692	108	81
AUTOMATED GATED PIPE						
ELECTRIC	-4	0	800	-59	741	556
DIESEL	-13	0	800	-91	709	532
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-15	0	650	-248	402	302
DIESEL	-56	0	650	-382	268	201
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-25	0	650	-416	234	176
DIESEL	-94	0	650	-640	10	8
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-18	0	800	-305	495	371
DIESEL	-69	0	800	-470	330	248
LATERAL MOVE						
ELECTRIC	-51	0	800	-853	-53	-40
DIESEL	-192	0	800	-1312	-512	-384

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-33. Change in Energy Use and Levelized Costs for Florida

Systems: Computerized Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE							
ELECTRIC	-0	0	800	-8	792	594	-8.00
DIESEL	-2	0	800	-12	788	591	-8.00
CENTER PIVOT							
ELECTRIC	-31	0	650	-519	131	98	-27.30
DIESEL	-117	0	650	-799	-149	-112	-27.30
SOLID SET							
ELECTRIC	-31	0	800	-515	285	214	-33.60
DIESEL	-116	0	800	-792	8	6	-33.60
TRAVELING GUN							
ELECTRIC	-57	0	800	-949	-149	-112	-33.60
DIESEL	-214	0	800	-1460	-660	-495	-33.60
TRICKLE							
ELECTRIC	-10	0	800	-174	626	470	-33.60
DIESEL	-39	0	800	-267	533	400	-33.60
AUTOMATED GATED PIPE							
ELECTRIC	-0	0	800	-6	794	595	-6.40
DIESEL	-1	0	800	-10	790	593	-6.40
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-4	0	650	-64	586	439	-22.39
DIESEL	-14	0	650	-99	551	414	-22.39
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-12	0	650	-192	458	344	-27.30
DIESEL	-43	0	650	-295	355	267	-27.30
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-5	0	800	-79	721	541	-27.55
DIESEL	-18	0	800	-121	679	509	-27.55
LATERAL MOVE							
ELECTRIC	-35	0	800	-577	223	167	-33.60
DIESEL	-130	0	800	-888	-88	-66	-33.60

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-34. Change in Energy Use, Levelized Costs, and Water Use
for Florida

Systems: Instrumented Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE						
ELECTRIC	-4	1283	1000	-59	2224	1882
DIESEL	-13	1283	1000	-91	2192	1858
CENTER PIVOT						
ELECTRIC	-36	1283	813	-602	1494	1334
DIESEL	-136	1283	183	-926	1170	1091
SOLID SET						
ELECTRIC	-38	1283	1000	-640	1643	1446
DIESEL	-144	1283	1000	-985	1298	1188
TRAVELING GUN						
ELECTRIC	-60	1283	1000	-992	1291	1182
DIESEL	-223	1283	1000	-1526	757	782
TRICKLE						
ELECTRIC	-22	1283	1000	-364	1919	1653
DIESEL	-82	1283	1000	-560	1723	1506
AUTOMATED GATED PIPE						
ELECTRIC	-3	1283	1000	-47	2236	1891
DIESEL	-11	1283	1000	-73	2211	1872
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-12	1283	813	-201	1895	1635
DIESEL	-45	1283	813	-309	1787	1554
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-20	1283	813	-337	1759	1533
DIESEL	-76	1283	813	-518	1578	1397
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-15	1283	1000	-247	2036	1741
DIESEL	-56	1283	1000	-380	1903	1641
LATERAL MOVE						
ELECTRIC	-41	1283	1000	-691	1593	1408
DIESEL	-156	1283	1000	-1062	1221	1130

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-35. Change in Energy Use and Levelized Costs for Florida

Systems: Instrumented Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE							
ELECTRIC	-0	1283	1000	-6	2277	1921	-6.40
DIESEL	-1	1283	1000	-10	2273	1919	-6.40
CENTER PIVOT							
ELECTRIC	-25	1283	813	-420	1675	1470	-22.10
DIESEL	-95	1283	813	-647	1449	1301	-22.10
SOLID SET							
ELECTRIC	-25	1283	1000	-417	1866	1614	-27.20
DIESEL	-94	1283	1000	-641	1642	1445	-27.20
TRAVELING GUN							
ELECTRIC	-46	1283	1000	-768	1515	1350	-27.20
DIESEL	-173	1283	1000	-1182	1101	1040	-27.20
TRICKLE							
ELECTRIC	-8	1283	1000	-141	2143	1821	-27.20
DIESEL	-32	1283	1000	-216	2067	1764	-27.20
AUTOMATED GATED PIPE							
ELECTRIC	-0	1283	1000	-5	2278	1922	-5.12
DIESEL	-1	1283	1000	-8	2275	1920	-5.12
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-3	1283	813	-52	2044	1747	-18.12
DIESEL	-12	1283	813	-80	2016	1726	-18.12
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-9	1283	813	-155	1941	1669	-22.10
DIESEL	-35	1283	813	-239	1857	1607	-22.10
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-4	1283	1000	-64	2219	1878	-22.30
DIESEL	-14	1283	1000	-98	2185	1853	-22.30
LATERAL MOVE							
ELECTRIC	-28	1283	1000	-467	1816	1576	-27.20
DIESEL	-105	1283	1000	-719	1565	1387	-27.20

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-36. Change in Energy Use and Levelized Costs for Idaho

Systems: Surged and Jetted Wells

Water Source: Groundwater

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
CONVENTIONAL WELL VS SURGED WELL						
ELECTRIC	-20	183	0	174	9	40
NATURAL GAS	-93	183	0	-374	-191	-110
DIESEL	-73	183	0	-428	-244	-151
CONVENTIONAL WELL VS JETTED WELL						
ELECTRIC	-25	324	0	-218	106	137
NATURAL GAS	-116	324	0	-469	-145	-51
DIESEL	-92	324	0	-537	-212	-102

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-37. Change in Energy Use and Levelized Costs for Idaho

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, Reduced-Pressure Center Pivot, Redesigned Pump and Variable Speed Pump

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE VS AUTOMATED GATED PIPE						
ELECTRIC	-169	2812	888	-1462	2238	2147
NATURAL GAS	-800	2812	888	-3144	556	886
DIESEL	-633	2812	888	-3596	103	546
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-517	975	228	-4477	-3274	-2293
NATURAL GAS	-2449	975	228	-9629	-8426	-6157
DIESEL	-1939	975	228	-11016	-9813	-7197
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-461	898	210	-3988	-2880	-2010
NATURAL GAS	-2182	898	210	-8578	-7470	-5453
DIESEL	-1728	898	210	-9814	-8706	-6380
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-263	0	0	-2280	-2280	-1710
NATURAL GAS	-1248	0	0	-4905	-4905	-3678
DIESEL	-988	0	0	-5611	-5611	-4208
GATED PIPE VS GATED PIPE WITH REDESIGNED PUMP						
ELECTRIC	-56	26	0	-487	-462	-342
NATURAL GAS	-267	26	0	-1048	-1022	-762
DIESEL	-211	26	0	-1199	-1173	-876
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH REDESIGNED PUMP						
ELECTRIC	-63	26	0	-545	-519	-385
NATURAL GAS	-298	26	0	-1172	-1146	-856
DIESEL	-236	26	0	-1341	-1315	-982
GATED PIPE VS GATED PIPE WITH VARIABLE SPEED PUMP						
ELECTRIC	-48	1027	400	-414	1013	931
NATURAL GAS	-226	1027	400	-890	537	574
DIESEL	-179	1027	400	-1018	409	478
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH VARIABLE SPEED PUMP						
ELECTRIC	-53	1027	400	-463	964	894
NATURAL GAS	-253	1027	400	-995	431	495
DIESEL	-200	1027	400	-1138	288	387

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-38. Change in Energy Use and Levelized Costs for Idaho

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, and Reduced-Pressure Center Pivot

Water Source: Surface Water

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
GATED PIPE VS AUTOMATED GATED PIPE						
ELECTRIC	-10	2812	888	-86	3613	3179
NATURAL GAS	-47	2812	888	-186	3514	3104
DIESEL	-37	2812	888	-212	3487	3084
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-403	975	228	-3486	-2283	-1550
NATURAL GAS	-1907	975	228	-7498	-6295	-4559
DIESEL	-1510	975	228	-8578	-7375	-5369
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-368	898	210	-3183	-2075	-1407
NATURAL GAS	-1742	898	210	-6847	-5738	-4154
DIESEL	-1379	898	210	-7833	-6725	-4894
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-263	0	0	-2280	-2280	-1710
NATURAL GAS	-1248	0	0	-4905	-4905	-3678
DIESEL	-988	0	0	-5611	-5611	-4208

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-39. Change in Energy Use and Levelized Costs for Idaho

Systems: Computerized Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE						
ELECTRIC	-43	0	800	-375	425	319
NATURAL GAS	-205	0	800	-806	-6	-5
DIESEL	-162	0	800	-922	-122	-92
CENTER PIVOT						
ELECTRIC	-225	0	650	-1949	-1299	-974
NATURAL GAS	-1066	0	650	-4192	-3542	-2656
DIESEL	-844	0	650	-4796	-4146	-3109
TOWLINE, SIDE ROLL						
ELECTRIC	-253	0	800	-2193	-1393	-1045
NATURAL GAS	-1200	0	800	-4716	-3916	-2937
DIESEL	-950	0	800	-5396	-4596	-3447
HAND MOVED						
ELECTRIC	-250	0	800	-2167	-1367	-1025
NATURAL GAS	-1186	0	800	-4661	-3861	-2896
DIESEL	-939	0	800	-5332	-4532	-3399
SOLID SET						
ELECTRIC	-253	0	800	-2193	-1393	-1045
NATURAL GAS	-1200	0	800	-4716	-3916	-2937
DIESEL	-950	0	800	-5396	-4596	-3447
AUTOMATED GATED PIPE						
ELECTRIC	-35	0	800	-300	500	375
NATURAL GAS	-164	0	800	-645	155	116
DIESEL	-130	0	800	-738	62	47
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-115	0	650	-998	-348	-261
NATURAL GAS	-546	0	650	-2147	-1497	-1122
DIESEL	-432	0	650	-2456	-1806	-1354
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-162	0	650	-1405	-755	-566
NATURAL GAS	-769	0	650	-3022	-2372	-1779
DIESEL	-609	0	650	-3458	-2808	-2106
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-142	0	800	-1228	-428	-321
NATURAL GAS	-672	0	800	-2642	-1842	-1381
DIESEL	-532	0	800	-3022	-2222	-1667
LATERAL MOVE						
ELECTRIC	-265	0	800	-2296	-1496	-1122
NATURAL GAS	-1256	0	800	-4938	-4138	-3103
DIESEL	-994	0	800	-5649	-4849	-3637

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-40. Change in Energy Use, Levelized Costs, and Water Use
for Idaho

Systems: Computerized Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE							
ELECTRIC	-3	0	800	-22	778	583	-28.80
NATURAL GAS	-12	0	800	-48	752	564	-28.80
DIESEL	-10	0	800	-54	746	559	-28.80
CENTER PIVOT							
ELECTRIC	-102	0	650	-882	-232	-174	-87.10
NATURAL GAS	-483	0	650	-1898	-1248	-936	-87.10
DIESEL	-382	0	650	-2171	-1521	-1141	-87.10
TOWLINE, SIDE ROLL							
ELECTRIC	-102	0	800	-880	-80	-60	-107.20
NATURAL GAS	-482	0	800	-1893	-1093	-820	-107.20
DIESEL	-381	0	800	-2166	-1366	-1024	-107.20
HAND MOVED							
ELECTRIC	-99	0	800	-854	-54	-41	-107.20
NATURAL GAS	-467	0	800	-1838	-1038	-778	-107.20
DIESEL	-370	0	800	-2103	-1303	-977	-107.20
SOLID SET							
ELECTRIC	-102	0	800	-880	-80	-60	-107.20
NATURAL GAS	-482	0	800	-1893	-1093	-820	-107.20
DIESEL	-381	0	800	-2166	-1366	-1024	-107.20
AUTOMATED GATED PIPE							
ELECTRIC	-2	0	800	-18	782	587	-23.04
NATURAL GAS	-10	0	800	-38	762	571	-23.04
DIESEL	-8	0	800	-44	756	567	-23.04
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-14	0	650	-123	527	395	-71.42
NATURAL GAS	-68	0	650	-266	384	288	-71.42
DIESEL	53	0	650	-304	346	260	-71.42
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-39	0	650	-339	311	233	-87.10
NATURAL GAS	-185	0	650	-729	-79	-59	-87.10
DIESEL	-147	0	650	-834	-184	-138	-87.10
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-18	0	800	-152	648	486	-87.90
NATURAL GAS	-83	0	800	-327	473	355	-87.90
DIESEL	-66	0	800	-374	426	320	-87.90
LATERAL MOVE							
ELECTRIC	-114	0	800	-983	-183	-137	-107.20
NATURAL GAS	-538	0	800	-2115	-1315	-986	-107.20
DIESEL	-426	0	800	-2419	-1619	-1214	-107.20

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-41. Change in Energy Use and Levelized Costs for Idaho

Systems: Instrumented Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE						
ELECTRIC	-34	1283	1000	-291	1992	1708
NATURAL GAS	-159	1283	1000	-627	1656	1456
DIESEL	-126	1283	1000	-717	1566	1388
CENTER PIVOT						
ELECTRIC	-188	1283	813	-1629	467	564
NATURAL GAS	-891	1283	813	-3504	-1408	-842
DIESEL	-706	1283	813	-4008	-1913	-1221
TOWLINE, SIDE ROLL						
ELECTRIC	-212	1283	1000	-1833	450	552
NATURAL GAS	-1003	1283	1000	-3942	-1659	-1030
DIESEL	-794	1283	1000	-4510	-2227	-1456
HAND MOVED						
ELECTRIC	-209	1283	1000	-1811	472	568
NATURAL GAS	-991	1283	1000	-3896	-1613	-996
DIESEL	-785	1283	1000	-4457	-2174	-1416
SOLID SET						
ELECTRIC	-212	1283	1000	-1833	450	552
NATURAL GAS	-1003	1283	1000	-3942	-1659	-1030
DIESEL	-794	1283	1000	-4510	-2227	-1456
AUTOMATED GATED PIPE						
ELECTRIC	-27	1283	1000	-233	2050	1751
NATURAL GAS	-128	1283	1000	-502	1782	1550
DIESEL	-101	1283	1000	-574	1709	1496
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-96	1283	813	-834	1262	1160
NATURAL GAS	-456	1283	813	-1794	302	440
DIESEL	-361	1283	813	-2052	43	246
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-136	1283	813	-1175	921	905
NATURAL GAS	-643	1283	813	-2526	-430	-109
DIESEL	-509	1283	813	-2890	-794	-382
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-119	1283	1000	-1027	1257	1156
NATURAL GAS	-562	1283	1000	-2208	75	270
DIESEL	-445	1283	1000	-2526	-243	32
LATERAL MOVE						
ELECTRIC	-222	1283	1000	-1919	364	487
NATURAL GAS	-1050	1283	1000	-4127	-1844	-1169
DIESEL	-831	1283	1000	-4722	-2438	-1615

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-42. Change in Energy Use, Levelized, Costs and Water Use
for Idaho

Systems: Instrumented Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE							
ELECTRIC	-2	1283	1000	-17	2266	1913	-22.40
NATURAL GAS	-9	1283	1000	-37	2246	1899	-22.40
DIESEL	-7	1283	1000	-42	2241	1895	-22.40
CENTER PIVOT							
ELECTRIC	-85	1283	813	-738	1358	1233	-72.80
NATURAL GAS	-404	1283	813	-1586	509	596	-72.80
DIESEL	-319	1283	813	-1815	281	425	-72.80
TOWLINE, SIDE ROLL							
ELECTRIC	-85	1283	813	-738	1358	1233	-72.80
NATURAL GAS	-403	1283	1000	-1582	701	740	-89.60
DIESEL	-319	1283	1000	-1810	473	569	-89.60
HAND MOVED							
ELECTRIC	-82	1283	1000	-714	1569	1391	-89.60
NATURAL GAS	-391	1283	1000	-1536	747	774	-89.60
DIESEL	-309	1283	1000	-1757	526	608	-89.60
SOLID SET							
ELECTRIC	-85	1283	1000	-736	1548	1375	89.60
NATURAL GAS	-403	1283	1000	-1582	701	740	-89.60
DIESEL	-319	1283	1000	-1810	473	569	-89.60
AUTOMATED GATED PIPE							
ELECTRIC	-2	1283	1000	-14	2269	1916	-17.92
NATURAL GAS	-8	1283	1000	-30	2254	1904	-17.92
DIESEL	-6	1283	1000	-34	2249	1901	-17.92
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-12	1283	813	-103	1993	1708	-59.70
NATURAL GAS	-56	1283	813	-222	1874	1619	-59.70
DIESEL	-45	1283	813	-254	1842	1595	-59.70
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-33	1283	813	-283	1813	1573	-72.80
NATURAL GAS	-155	1283	813	-609	1487	1329	-72.80
DIESEL	-123	1283	813	-697	1399	1263	-72.80
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-15	1283	1000	-127	2156	1831	-73.47
NATURAL GAS	-69	1283	1000	-273	2010	1721	-73.47
DIESEL	-55	1283	1000	-313	1971	1692	-73.47
LATERAL MOVE							
ELECTRIC	-95	1283	1000	-822	1462	1310	-89.60
NATURAL GAS	-450	1283	1000	-1767	516	601	-89.60
DIESEL	-356	1283	1000	-2022	261	410	-89.60

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-43. Change in Energy Use and Levelized Costs for Kansas

Systems: Surged and Jetted Wells

Water Source: Groundwater

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
CONVENTIONAL WELL VS SURGED WELL						
ELECTRIC	-26	160	0	-426	-266	-171
NATURAL GAS	-123	160	0	-237	-77	-29
DIESEL	-97	160	0	-592	-432	-296
CONVENTIONAL WELL VS JETTED WELL						
ELECTRIC	-33	301	0	-535	-234	-122
NATURAL GAS	-154	301	0	-297	4	56
DIESEL	-122	301	0	-743	-442	-278

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-44. Change in Energy Use and Levelized Costs for Kansas

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, Reduced-Pressure Center Pivot, Redesigned Pump and Variable Speed Pump

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE VS AUTOMATED GATED PIPE						
ELECTRIC	-60	2812	888	-955	2744	2527
NATURAL GAS	-283	2812	888	-531	3169	2845
DIESEL	-224	2812	888	-1326	2373	2248
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-249	975	228	-3975	-2771	-1916
NATURAL GAS	-1178	975	228	-2208	-1005	-591
DIESEL	-932	975	228	-5519	-4316	-3074
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-223	898	210	-3566	-2458	-1693
NATURAL GAS	-1057	898	210	-1981	-873	-505
DIESEL	-836	898	210	-4952	-3843	-2733
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-137	0	0	-2188	-2188	-1641
NATURAL GAS	-648	0	0	-1215	-1215	-911
DIESEL	-513	0	0	-3038	-3038	-2278
GATED PIPE VS GATED PIPE WITH REDESIGNED PUMP						
ELECTRIC	-20	26	0	-318	-293	-215
NATURAL GAS	-94	26	0	-177	-151	-109
DIESEL	-75	26	0	-442	-416	-308
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH REDESIGNED PUMP						
ELECTRIC	-27	26	0	-426	-401	-296
NATURAL GAS	-126	26	0	-237	-211	-154
DIESEL	-100	26	0	-592	-566	-420
GATED PIPE VS GATED PIPE WITH VARIABLE SPEED PUMP						
ELECTRIC	-17	1027	400	-270	1156	1038
NATURAL GAS	-90	1027	400	-150	1276	1128
DIESEL	-63	1027	400	-375	1051	959
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH VARIABLE SPEED PUMP						
ELECTRIC	-23	1027	400	-362	1065	970
NATURAL GAS	-107	1027	400	-201	1226	1090
DIESEL	-85	1027	400	-503	924	864

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-45. Change in Energy Use and Levelized Costs for Kansas

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, and Reduced-Pressure Center Pivot

Water Source: Surface Water

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
GATED PIPE VS AUTOMATED GATED PIPE						
ELECTRIC	-6	2812	888	-103	3596	3166
NATURAL GAS	-31	2812	888	-57	3642	3200
DIESEL	-24	2812	888	-143	3556	3136
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-210	975	228	-3359	-2156	-1455
NATURAL GAS	-995	975	228	-1866	-663	-335
DIESEL	-788	975	228	-4665	-3462	-2434
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-192	898	210	-3066	-1958	-1319
NATURAL GAS	-908	898	210	-1703	-595	-296
DIESEL	-719	898	210	-4258	-3149	-2212
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-137	0	0	-2188	-2188	-1641
NATURAL GAS	-658	0	0	-1215	-1215	-911
DIESEL	-513	0	0	-3038	-3038	-2278

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-46. Change in Energy Use and Levelized Costs for Kansas

Systems: Computerized Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE						
ELECTRIC	-15	0	800	-236	564	423
NATURAL GAS	-70	0	800	-131	669	502
DIESEL	-55	0	800	-328	472	354
CENTER PIVOT						
ELECTRIC	-96	0	650	-1533	-883	-662
NATURAL GAS	-454	0	650	-852	-202	-151
DIESEL	-360	0	650	-2129	-1479	-1109
AUTOMATED GATED PIPE						
ELECTRIC	-12	0	800	-189	611	458
NATURAL GAS	-56	0	800	-105	695	521
DIESEL	-44	0	800	-262	538	403
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-42	0	650	-678	-28	-21
NATURAL GAS	-201	0	650	-377	273	205
DIESEL	-159	0	650	-942	-292	-219
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-63	0	650	-1009	-359	-269
NATURAL GAS	-299	0	650	-560	90	67
DIESEL	-237	0	650	-1400	-750	-563
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-52	0	800	-835	-35	-26
NATURAL GAS	-247	0	800	-464	336	252
DIESEL	-196	0	800	-1159	-359	-269
LATERAL MOVE						
ELECTRIC	-112	0	800	-1787	-987	-741
NATURAL GAS	-530	0	800	-992	-193	-145
DIESEL	-419	0	800	-2482	-1682	-1262

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-47. Change in Energy Use, Levelized Costs, and Water Use
for Kansas

Systems: Computerized Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE							
ELECTRIC	-2	0	800	-26	774	581	-14.40
NATURAL GAS	-8	0	800	-14	786	589	-14.40
DIESEL	-6	0	800	-35	765	573	-14.40
CENTER PIVOT							
ELECTRIC	-54	0	650	-867	-217	-163	-45.50
NATURAL GAS	-257	0	650	-482	168	126	-45.50
DIESEL	-203	0	650	-1204	-554	-416	-45.50
AUTOMATED GATED PIPE							
ELECTRIC	-1	0	800	-20	780	585	-11.52
NATURAL GAS	-6	0	800	-11	789	591	-11.52
DIESEL	-5	0	800	-28	772	579	-11.52
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-8	0	650	-132	518	388	-37.31
NATURAL GAS	-39	0	650	-74	576	432	-37.31
DIESEL	-31	0	650	-184	466	350	-37.31
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-21	0	650	-343	307	230	-45.50
NATURAL GAS	-102	0	650	-190	460	345	-45.50
DIESEL	-80	0	650	-476	174	130	-45.50
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-10	0	800	-163	637	478	-45.92
NATURAL GAS	-48	0	800	-90	710	532	-45.92
DIESEL	-38	0	800	-226	574	430	-45.92
LATERAL MOVE							
ELECTRIC	-61	0	800	-968	-168	-126	-56.00
NATURAL GAS	-287	0	800	-538	262	197	-56.00
DIESEL	-227	0	800	-1344	-544	-408	-56.00

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-48. Change in Energy Use and Levelized Costs for Kansas

Systems: Instrumented Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE						
ELECTRIC	-11	1283	1000	-184	2100	1789
NATURAL GAS	-54	1283	1000	-102	2181	1850
DIESEL	-43	1283	1000	-255	2028	1735
CENTER PIVOT						
ELECTRIC	-79	1283	813	-1270	826	833
NATURAL GAS	-376	1283	813	-706	1390	1257
DIESEL	-298	1283	813	-1764	332	463
AUTOMATED GATED PIPE						
ELECTRIC	-9	1283	1000	-147	2136	1816
NATURAL GAS	-44	1283	1000	-82	2202	1865
DIESEL	-34	1283	1000	-204	2079	1773
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-35	1283	813	-562	1534	1364
NATURAL GAS	-166	1283	813	-312	1784	1552
DIESEL	-132	1283	813	-780	1316	1201
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-52	1283	813	-836	1260	1159
NATURAL GAS	-248	1283	813	-464	1632	1438
DIESEL	-196	1283	813	-1160	935	915
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-43	1283	1000	-692	1592	1408
NATURAL GAS	-205	1283	1000	-384	1899	1638
DIESEL	-162	1283	1000	-960	1323	1206
LATERAL MOVE						
ELECTRIC	-93	1283	1000	-1481	801	816
NATURAL GAS	-439	1283	1000	-823	1461	1309
DIESEL	-347	1283	1000	-2057	227	384

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-49. Change in Energy Use, Levelized Costs and Water Use
for Kansas

Systems: Instrumented Scheduling

Water Source: Surface Water

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>	<u>Water Use^(c)</u>
GATED PIPE							
ELECTRIC	-1	1283	1000	-20	2263	1911	-11.20
NATURAL GAS	-6	1283	1000	-11	2272	1918	-11.20
DIESEL	-5	1283	1000	-28	2256	1906	-11.20
CENTER PIVOT							
ELECTRIC	-45	1283	813	-719	1377	1247	-37.70
NATURAL GAS	-213	1283	813	-399	1697	1486	-37.70
DIESEL	-169	1283	813	-998	1098	1037	-37.70
AUTOMATED GATED PIPE							
ELECTRIC	-1	1283	1000	-16	2267	1914	-8.96
NATURAL GAS	-5	1283	1000	-9	2274	1920	-8.96
DIESEL	-4	1283	1000	-22	2261	1910	-8.96
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-7	1283	813	-110	1986	1703	-30.91
NATURAL GAS	-32	1283	813	-61	2035	1740	-30.91
DIESEL	26	1283	813	-152	1944	1672	-30.91
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-18	1283	813	-284	1812	1573	-37.70
NATURAL GAS	-84	1283	813	-158	1938	1667	-37.70
DIESEL	-67	1283	813	-395	1701	1490	-37.70
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-8	1283	1000	-135	2148	1825	-38.05
NATURAL GAS	-40	1283	1000	-75	2208	1870	-38.05
DIESEL	-32	1283	1000	-187	2096	1786	-38.05
LATERAL MOVE							
ELECTRIC	-50	1283	1000	-802	1481	1325	-46.40
NATURAL GAS	-238	1283	1000	-446	1838	1592	-46.40
DIESEL	-188	1283	1000	-1114	1169	1091	-46.40

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-50. Change in Energy Use and Levelized Costs for Montana

Systems: Surged and Jetted Wells

Water Source: Groundwater

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
CONVENTIONAL WELL VS SURGED WELL						
ELECTRIC	-29	114	0	-296	-182	-116
DIESEL	-108	114	0	-640	-527	-375
CONVENTIONAL WELL VS JETTED WELL						
ELECTRIC	-36	255	0	-371	-117	-42
DIESEL	-136	255	0	-804	-549	-366

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-51. Change in Energy Use and Levelized Costs for Montana

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, Reduced-Pressure Center Pivot, Redesigned Pump and Variable Speed Pump

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE VS AUTOMATED GATED PIPE						
ELECTRIC	-51	2812	888	-510	3190	2861
DIESEL	-191	2812	888	-1103	2597	2416
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-345	975	228	-3445	-2242	-1519
DIESEL	-1294	975	228	-7452	-6248	-4524
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-312	898	210	-3114	-2006	-1355
DIESEL	-1169	898	210	-6737	-5628	-4071
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-205	0	0	-2050	-2050	-1538
DIESEL	-770	0	0	-4434	-4434	-3326
GATED PIPE VS GATED PIPE WITH REDESIGNED PUMP						
ELECTRIC	-17	26	0	-170	-144	-104
DIESEL	-64	26	0	-368	-342	-252
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH REDESIGNED PUMP						
ELECTRIC	-32	26	0	-315	-290	-213
DIESEL	-118	26	0	-682	-657	-488
GATED PIPE VS GATED PIPE WITH VARIABLE SPEED PUMP						
ELECTRIC	-14	1027	400	-144	1282	1133
DIESEL	-54	1027	400	-312	1114	1007
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH VARIABLE SPEED PUMP						
ELECTRIC	-27	1027	400	-268	1159	1040
DIESEL	-101	1027	400	-579	847	807

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-52. Change in Energy Use and Levelized Costs for Montana

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, and Reduced-Pressure Center Pivot

Water Source: Surface Water

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
GATED PIPE VS AUTOMATED GATED PIPE						
ELECTRIC	-32	2812	888	-316	3384	3007
DIESEL	-119	2812	888	-683	3017	2731
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-331	975	228	-3305	-2102	-1414
DIESEL	-1241	975	228	-7149	-5946	-4297
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-300	898	210	-3001	-1893	-1270
DIESEL	-1127	898	210	-6491	-5383	-3887
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-205	0	0	-2050	-2050	-1538
DIESEL	-770	0	0	-4434	-4434	-3326

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-53. Change in Energy Use and Levelized Costs for Montana

Systems: Computerized Scheduling

Water Source: Groundwater

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
GATED PIPE						
ELECTRIC	-13	0	800	-130	670	502
DIESEL	-49	0	800	-282	518	389
CENTER PIVOT						
ELECTRIC	-115	0	650	-1145	-495	-371
DIESEL	-430	0	650	-2476	-1826	-1370
AUTOMATED GATED PIPE						
ELECTRIC	-10	0	800	-104	696	522
DIESEL	-39	0	800	-225	575	431
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-39	0	650	-391	259	194
DIESEL	-147	0	650	-846	-196	-147
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-65	0	650	-649	1	1
DIESEL	-244	0	650	-1403	-753	-565
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-48	0	800	-481	319	239
DIESEL	-181	0	800	-1041	-241	-181
LATERAL MOVE						
ELECTRIC	-132	0	800	-1315	-515	-386
DIESEL	-494	0	800	-2845	-2045	-1534

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-54. Change in Energy Use, Levelized Costs, and Water Use for Montana

Systems: Computerized Scheduling

Water Source: Surface Water

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>	<u>Water Use^(c)</u>
GATED PIPE							
ELECTRIC	-8	0	800	-81	719	540	-22.40
DIESEL	-30	0	800	-174	626	469	-22.40
CENTER PIVOT							
ELECTRIC	-99	0	650	-992	-342	-257	-68.90
DIESEL	-373	0	650	-2146	-1496	-1122	-68.90
AUTOMATED GATED PIPE							
ELECTRIC	-6	0	800	-65	735	552	-17.92
DIESEL	-24	0	800	-140	660	495	-17.92
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-27	0	650	-266	384	288	-56.50
DIESEL	-100	0	650	-575	75	56	-56.50
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-50	0	650	-496	154	115	-68.90
DIESEL	-186	0	650	-1073	-423	-317	-68.90
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-33	0	800	-327	473	354	-69.54
DIESEL	-123	0	800	-708	92	69	-69.54
LATERAL MOVE							
ELECTRIC	-113	0	800	-1127	-327	-245	-84.80
DIESEL	-423	0	800	-2438	-1638	-1229	-84.80

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-55. Change in Energy Use and Levelized Costs for Montana

Systems: Instrumented Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE						
ELECTRIC	-10	1283	1000	-102	2181	1850
DIESEL	-38	1283	1000	-221	2062	1760
CENTER PIVOT						
ELECTRIC	-95	1283	813	-950	1145	1073
DIESEL	-357	1283	813	-2056	40	244
AUTOMATED GATED PIPE						
ELECTRIC	-8	1283	1000	-82	2201	1865
DIESEL	-31	1283	1000	-177	2106	1793
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-33	1283	813	-325	1771	1542
DIESEL	-122	1283	813	-702	1393	1259
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-54	1283	813	-539	1557	1382
DIESEL	-202	1283	813	-1165	931	912
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-40	1283	1000	-400	1884	1627
DIESEL	-150	1283	1000	-865	1419	1278
LATERAL MOVE						
ELECTRIC	-109	1283	1000	-1092	1191	1107
DIESEL	-410	1283	1000	-2362	-78	155

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-56. Change in Energy Use, Levelized Costs and Water Use for Montana

Systems: Instrumented Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE							
ELECTRIC	-6	1283	1000	-63	2220	1879	-17.60
DIESEL	-24	1283	1000	-137	2146	1824	-17.60
CENTER PIVOT							
ELECTRIC	-82	1283	813	-824	1272	1168	-57.20
DIESEL	-309	1283	813	-1782	314	449	-57.20
AUTOMATED GATED PIPE							
ELECTRIC	-5	1283	1000	-51	2233	1888	-14.08
DIESEL	-19	1283	1000	-110	2174	1844	-14.08
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-22	1283	813	-221	1875	1620	-46.90
DIESEL	-83	1283	813	-478	1618	1427	-46.90
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-41	1283	813	-412	1684	1477	-57.20
DIESEL	-155	1283	813	-891	1205	1118	-57.20
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-27	1283	1000	-272	2011	1722	-57.73
DIESEL	-102	1283	1000	-588	1695	1485	-57.73
LATERAL MOVE							
ELECTRIC	-94	1283	1000	-936	1347	1224	-70.40
DIESEL	-351	1283	1000	-2024	259	408	-70.40

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-57. Change in Energy Use and Levelized Costs for Nebraska

Systems: Surged and Jetted Wells

Water Source: Groundwater

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
CONVENTIONAL WELL VS SURGED WELL						
ELECTRIC	-16	111	0	-219	-108	-62
NATURAL GAS	-76	111	0	-179	-68	-31
DIESEL	-60	111	0	-366	-255	-171
CONVENTIONAL WELL VS JETTED WELL						
ELECTRIC	-20	252	0	-275	-23	27
NATURAL GAS	-95	252	0	-225	27	65
DIESEL	-75	252	0	-459	-207	-110

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-58. Change in Energy Use and Levelized Costs for Nebraska

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, Reduced-Pressure Center Pivot, Redesigned Pump and Variable Speed Pump

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE VS AUTOMATED GATED PIPE						
ELECTRIC	-35	2812	888	-471	3228	2890
NATURAL GAS	-168	2812	888	-385	3315	2955
DIESEL	-133	2812	888	-786	2914	2654
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-239	975	228	-3188	-1985	-1326
NATURAL GAS	-1134	975	228	-2603	-1400	-887
DIESEL	-898	975	228	-5315	-4111	-2921
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-216	898	210	-2882	-1774	-1181
NATURAL GAS	-1025	898	210	-2353	-1245	-784
DIESEL	-812	898	210	-4805	-3696	-2623
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-142	0	0	-1897	-1897	-1423
NATURAL GAS	-675	0	0	-1549	-1549	-1162
DIESEL	-534	0	0	-3163	-3163	-2372
GATED PIPE VS GATED PIPE WITH REDESIGNED PUMP						
ELECTRIC	-12	26	0	-157	-131	-94
NATURAL GAS	-56	26	0	-128	-103	-73
DIESEL	-44	26	0	-262	-236	-173
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH REDESIGNED PUMP						
ELECTRIC	-22	26	0	-292	-266	-195
NATURAL GAS	-104	26	0	-238	-213	-155
DIESEL	-82	26	0	-487	-461	-341
GATED PIPE VS GATED PIPE WITH VARIABLE SPEED PUMP						
ELECTRIC	-10	1027	400	-133	1293	1141
NATURAL GAS	-47	1027	400	-109	1318	1159
DIESEL	-38	1027	400	-222	1204	1074
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH VARIABLE SPEED PUMP						
ELECTRIC	-19	1027	400	-248	1179	1055
NATURAL GAS	-88	1027	400	-202	1224	1089
DIESEL	-70	1027	400	-413	1014	931

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-59. Change in Energy Use and Levelized Costs for Nebraska

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, and Reduced-Pressure Center Pivot

Water Source: Surface Water

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
GATED PIPE VS AUTOMATED GATED PIPE						
ELECTRIC	-8	2812	888	-112	3587	3159
NATURAL GAS	-40	2812	888	-92	3608	3175
DIESEL	-32	2812	888	-187	3512	3103
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-220	975	228	-2929	-1726	-1132
NATURAL GAS	-1042	975	228	-2392	-1188	-729
DIESEL	-825	975	228	-4883	-3680	-2598
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-201	898	210	-2672	-1564	-1023
NATURAL GAS	-950	898	210	-2182	-1073	-655
DIESEL	-752	898	210	-4454	-3346	-2360
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-142	0	0	-1897	-1897	-1423
NATURAL GAS	-675	0	0	-1549	-1549	-1162
DIESEL	-534	0	0	-3163	-3163	-2372

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-60. Change in Energy Use and Levelized Costs for Nebraska

Systems: Computerized Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE						
ELECTRIC	-9	0	800	-124	676	507
NATURAL GAS	-44	0	800	-101	699	524
DIESEL	-35	0	800	-207	593	445
CENTER PIVOT						
ELECTRIC	-78	0	650	-1037	-387	-290
NATURAL GAS	-369	0	650	-847	-197	-147
DIESEL	-292	0	650	-1729	-1079	-809
TOWLINE, SIDE ROLL						
ELECTRIC	-83	0	800	-1106	-306	-230
NATURAL GAS	-393	0	800	-903	-103	-77
DIESEL	-311	0	800	-1844	-1044	-783
HAND MOVED						
ELECTRIC	-81	0	800	-1085	-285	-214
NATURAL GAS	-386	0	800	-886	-86	-64
DIESEL	-305	0	800	-1808	-1008	-756
TRAVELING GUN						
ELECTRIC	-128	0	800	-1702	-902	-676
NATURAL GAS	-605	0	800	-1389	-589	-442
DIESEL	-479	0	800	-2837	-2037	-1527
AUTOMATED GATED PIPE						
ELECTRIC	-7	0	800	-99	701	526
NATURAL GAS	-35	0	800	-81	719	539
DIESEL	-28	0	800	-165	635	476
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC-27	27	0	650	-354	296	222
NATURAL GAS	-126	0	650	-289	361	271
DIESEL	-100	0	650	-591	59	45
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-44	0	650	-588	62	47
NATURAL GAS	-209	0	650	-480	170	128
DIESEL	-165	0	650	-980	-330	-247
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-33	0	800	-436	364	273
NATURAL GAS	-155	0	800	-356	444	333
DIESEL	-123	0	800	-727	73	55
LATERAL MOVE						
ELECTRIC	-89	0	800	-1191	-391	-293
NATURAL GAS	-424	0	800	-972	-172	-129
DIESEL	-335	0	800	-1986	-1186	-889

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-61. Change in Energy Use, Levelized Costs and Water Use for Nebraska

Systems: Computerized Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE							
ELECTRIC	-2	0	800	-30	770	578	-16.00
NATURAL GAS	-11	0	800	-24	776	582	-16.00
DIESEL	-8	0	800	-49	751	563	-16.00
CENTER PIVOT							
ELECTRIC	-57	0	650	-760	-110	-83	46.80
NATURAL GAS	-270	0	650	-621	29	22	-46.80
DIESEL	-214	0	650	-1268	-618	-463	-46.80
TOWLINE, SIDE ROLL							
ELECTRIC	-58	0	800	-766	34	26	-57.60
NATURAL GAS	-272	0	800	-625	175	131	-57.60
DIESEL	-216	0	800	-1276	-476	-357	-57.60
HAND MOVED							
ELECTRIC	-56	0	800	-744	56	42	-57.60
NATURAL GAS	-265	0	800	-608	192	144	-57.60
DIESEL	-210	0	800	-1241	-441	-331	-57.60
TRAVELING GUN							
ELECTRIC	-102	0	800	-1361	-561	-421	-57.60
NATURAL GAS	-484	0	800	-1111	-311	-234	-57.60
DIESEL	-383	0	800	-2269	-1469	-1102	-57.60
AUTOMATED GATED PIPE							
ELECTRIC	-2	0	800	-24	776	582	-12.80
NATURAL GAS	-8	0	800	-19	781	586	-12.80
DIESEL	-7	0	800	-39	761	570	-12.80
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-10	0	650	-128	522	392	-38.38
NATURAL GAS	-45	0	650	-104	546	409	-38.38
DIESEL	-36	0	650	-213	437	328	-38.38
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-23	0	650	-311	339	254	-46.80
NATURAL GAS	-111	0	650	-254	396	297	-46.80
DIESEL	-88	0	650	-519	131	99	-46.80
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-12	0	800	-157	643	482	-47.23
NATURAL GAS	-56	0	800	-128	672	504	-47.23
DIESEL	-44	0	800	-262	538	404	-47.23
LATERAL MOVE							
ELECTRIC	-64	0	800	-851	-51	-38	-57.60
NATURAL GAS	-303	0	800	-695	105	79	-57.60
DIESEL	-240	0	800	-1418	-618	-464	-57.60

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-62. Change in Energy Use and Levelized Costs for Nebraska

Systems: Instrumented Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE						
ELECTRIC	-7	1283	1000	-99	2184	1852
NATURAL GAS	-35	1283	1000	-81	2202	1866
DIESEL	-28	1283	1000	-165	2118	1802
CENTER PIVOT						
ELECTRIC	-65	1283	813	-864	1232	1138
NATURAL GAS	-307	1283	813	-705	1390	1257
DIESEL	-243	1283	813	-1440	655	705
TOWLINE, SIDE ROLL						
ELECTRIC	-69	1283	1000	-922	1362	1235
NATURAL GAS	-328	1283	1000	-752	1531	1362
DIESEL	-260	1283	1000	-1536	747	774
HAND MOVED						
ELECTRIC	-68	1283	1000	-904	1379	1248
NATURAL GAS	-322	1283	1000	-738	1545	1373
DIESEL	-255	1283	1000	-1507	776	796
TRAVELING GUN						
ELECTRIC	-106	1283	1000	-1418	865	863
NATURAL GAS	-504	1283	1000	-1158	1126	1058
DIESEL	-399	1283	1000	-2364	-81	153
AUTOMATED GATED PIPE						
ELECTRIC	-6	1283	1000	-79	2204	1867
NATURAL GAS	-28	1283	1000	-65	2218	1878
DIESEL	-22	1283	1000	-132	2151	1827
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-22	1283	813	-295	1801	1564
NATURAL GAS	-105	1283	813	-241	1855	1605
DIESEL	-83	1283	813	-492	1604	1417
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-37	1283	813	-490	1606	1418
NATURAL GAS	-174	1283	813	-400	1696	1486
DIESEL	-138	1283	813	-816	1280	1174
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-27	1283	1000	-363	1920	1654
NATURAL GAS	-129	1283	1000	-297	1987	1704
DIESEL	-102	1283	1000	-606	1678	1472
LATERAL MOVE						
ELECTRIC	-75	1283	1000	-993	1291	1182
NATURAL GAS	-353	1283	1000	-810	1473	1319
DIESEL	-280	1283	1000	-1655	629	685

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-63. Change in Energy Use, Levelized Costs and Water Use for Nebraska

Systems: Instrumented Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE							
ELECTRIC	-2	1283	1000	-24	2260	1909	-12.80
NATURAL GAS	-8	1283	1000	-19	2264	1912	-12.80
DIESEL	-7	1283	1000	-39	2244	1897	-12.80
CENTER PIVOT							
ELECTRIC	-48	1283	813	-634	1462	1310	-39.00
NATURAL GAS	-225	1283	813	-517	1578	1398	-39.00
DIESEL	-178	1283	813	-1056	1039	993	-39.00
TOWLINE, SIDE ROLL							
ELECTRIC	-48	1283	1000	-638	1645	1448	-48.00
NATURAL GAS	-227	1283	1000	-521	1762	1536	-48.00
DIESEL	-180	1283	1000	-1064	1220	1129	-48.00
HAND MOVED							
ELECTRIC	-47	1283	1000	-620	1663	1461	-48.00
NATURAL GAS	-221	1283	1000	-506	1777	1546	-48.00
DIESEL	-175	1283	1000	-1034	1249	1151	-48.00
TRAVELING GUN							
ELECTRIC	-35	1283	1000	-1134	1149	1076	-48.00
NATURAL GAS	-404	1283	1000	-926	1357	1232	-48.00
DIESEL	-319	1283	1000	-1891	392	508	-48.00
AUTOMATED GATED PIPE							
ELECTRIC	-1	1283	1000	-19	2264	1912	-10.24
NATURAL GAS	-7	1283	1000	-15	2268	1915	-10.24
DIESEL	-5	1283	1000	-32	2252	1903	-10.24
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-8	1283	813	-106	1989	1706	-31.98
NATURAL GAS	-38	1283	813	-87	2009	1721	-31.98
DIESEL	-30	1283	813	-177	1919	1653	-31.98
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-19	1283	813	-259	1837	1591	-39.00
NATURAL GAS	-92	1283	813	-212	1884	1627	-39.00
DIESEL	-73	1283	813	-432	1664	1462	-39.00
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-10	1283	1000	-131	2152	1828	-39.36
NATURAL GAS	-47	1283	1000	-107	2176	1846	-39.36
DIESEL	-37	1283	1000	-218	2065	1763	-39.36
LATERAL MOVE							
ELECTRIC	-53	1283	1000	-709	1574	1395	-48.00
NATURAL GAS	-252	1283	1000	-579	1704	1492	-48.00
DIESEL	-200	1283	1000	-1182	1101	1040	-48.00

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-64. Change in Energy Use and Levelized Costs for Nebraska

Systems: Surged and Jetted Wells

Water Source: Groundwater

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
CONVENTIONAL WELL VS SURGED WELL						
ELECTRIC	-76	122	0	-1044	-922	-670
DIESEL	-286	122	0	-1717	-1595	-1175
CONVENTIONAL WELL VS JETTED WELL						
ELECTRIC	-96	263	0	-1310	-1047	-739
DIESEL	-359	263	0	-2155	-1892	-1372

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-65. Change in Energy Use and Levelized Costs for Nevada

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, Reduced-Pressure Center Pivot, Redesigned Pump and Variable Speed Pump

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE VS AUTOMATED GATED PIPE						
ELECTRIC	-94	2812	888	-1253	2446	2303
DIESEL	-353	2812	888	-2061	1639	1698
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-636	975	228	-8474	-7270	-5290
DIESEL	-2386	975	228	-13936	-12733	-9387
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-575	898	210	-7661	-6552	-4765
DIESEL	-2157	898	210	-12599	-11490	-8468
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-379	0	0	-5042	-5042	-3782
DIESEL	-1420	0	0	-8293	-8293	-6220
GATED PIPE VS GATED PIPE WITH REDESIGNED PUMP						
ELECTRIC	-31	26	0	-418	-392	-290
DIESEL	-118	26	0	-687	-661	-492
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH REDESIGNED PUMP						
ELECTRIC	-58	26	0	-776	-750	-558
DIESEL	-218	26	0	-1276	-1250	-933
GATED PIPE VS GATED PIPE WITH VARIABLE SPEED PUMP						
ELECTRIC	-27	1027	400	-355	1072	975
DIESEL	-100	1027	400	-583	843	804
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH VARIABLE SPEED PUMP						
ELECTRIC	-49	1027	400	-659	768	747
DIESEL	-185	1027	400	-1083	343	429

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-66. Change in Energy Use and Levelized Costs for Nevada

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, and Reduced-Pressure Center Pivot

Water Source: Surface Water

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
GATED PIPE VS AUTOMATED GATED PIPE						
ELECTRIC	-22	2812	888	-298	3401	3020
DIESEL	-84	2812	888	-491	3209	2875
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-585	975	228	-7786	-6583	-4775
DIESEL	-2193	975	228	-12805	-11602	-8539
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-533	898	210	-7102	-5994	-4346
DIESEL	-2000	898	210	-11680	-10572	-7779
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-379	0	0	-5042	-5042	-3782
DIESEL	-1420	0	0	-8293	-8293	-6220

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-67. Change in Energy Use and Levelized Costs for Nevada

Systems: Computerized Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE						
ELECTRIC	-23	0	800	-310	490	367
DIESEL	-87	0	800	-510	290	217
CENTER PIVOT						
ELECTRIC	-210	0	650	-2794	-2144	-1608
DIESEL	-787	0	650	-4595	-3945	-2959
AUTOMATED GATED PIPE						
ELECTRIC	-19	0	800	-248	552	414
DIESEL	-70	0	800	-408	392	294
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-72	0	650	-955	-305	-228
DIESEL	-269	0	650	-1570	-920	-690
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-119	0	650	-1583	-933	-700
DIESEL	-446	0	650	-2604	-1954	-1465
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-88	0	800	-1175	-375	-281
DIESEL	-331	0	800	-1932	-1132	-849
LATERAL MOVE						
ELECTRIC	-241	0	800	-3209	-2409	-1807
DIESEL	-904	0	800	-5278	-4478	-3359

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-68. Change in Energy Use, Levelized Costs and Water Use for Nevada

Systems: Computerized Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE							
ELECTRIC	-6	0	800	-74	726	545	-40.00
DIESEL	-21	0	800	-121	679	509	-40.00
CENTER PIVOT							
ELECTRIC	-154	0	650	-2049	-1399	-1049	-126.10
DIESEL	-577	0	650	-3370	-2720	-2040	-126.10
AUTOMATED GATED PIPE							
ELECTRIC	-4	0	800	-59	741	556	-32.00
DIESEL	-17	0	800	-97	703	527	-32.00
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-26	0	650	-344	306	230	-103.40
DIESEL	-97	0	650	-565	85	64	-103.40
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-63	0	650	-838	-188	-141	-126.10
DIESEL	-236	0	650	-1378	-728	-546	-126.10
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-32	0	800	-423	377	283	-127.26
DIESEL	-119	0	800	-696	104	78	-127.26
LATERAL MOVE							
ELECTRIC	-172	0	800	-2292	-1492	-1119	-155.20
DIESEL	-646	0	800	-3770	-2970	-2228	-155.20

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-69. Change in Energy Use and Levelized Costs for Nevada

Systems: Instrumented Scheduling

Water Source: Groundwater

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
GATED PIPE						
ELECTRIC	-19	1283	1000	-248	2035	1740
DIESEL	-70	1283	1000	-408	1875	1620
CENTER PIVOT						
ELECTRIC	-175	1283	813	-2333	-237	36
DIESEL	-657	1283	813	-3837	-1741	-1092
AUTOMATED GATED PIPE						
ELECTRIC	-15	1283	1000	-199	2085	1777
DIESEL	-56	1283	1000	-326	1957	1681
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-60	1283	813	-797	1299	1188
DIESEL	-224	1283	813	-1311	785	802
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-99	1283	813	-1322	774	794
DIESEL	-372	1283	813	-2174	-79	155
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-74	1283	1000	-981	1302	1191
DIESEL	-276	1283	1000	-1613	670	716
LATERAL MOVE						
ELECTRIC	-201	1283	1000	-2680	-397	-84
DIESEL	-755	1283	1000	-4408	-2124	-1379

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-70. Change in Energy Use, Levelized Costs, and Water Use for Nevada

Systems: Instrumented Scheduling

Water Source: Surface Water

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>	<u>Water Use^(c)</u>
GATED PIPE							
ELECTRIC	-4	1283	1000	-59	2224	1882	-32.00
DIESEL	-17	1283	1000	-97	2186	1853	-32.00
CENTER PIVOT							
ELECTRIC	-128	1283	813	-1711	385	503	-105.30
DIESEL	-482	1283	813	-2814	-718	-325	-105.30
AUTOMATED GATED PIPE							
ELECTRIC	-4	1283	1000	-47	2236	1891	-25.60
DIESEL	-13	1283	1000	-78	2206	1868	-25.60
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-22	1283	813	-287	1809	1570	-86.35
DIESEL	-81	1283	813	-472	1624	1432	-86.35
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-53	1283	813	-700	1396	1261	-105.30
DIESEL	-197	1283	813	-1151	945	922	-105.30
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-27	1283	1000	-353	1930	1661	-106.27
DIESEL	-99	1283	1000	-581	1702	1491	-106.27
LATERAL MOVE							
ELECTRIC	-144	1283	1000	-1914	369	491	-129.60
DIESEL	-539	1283	1000	-3148	-865	-435	-129.60

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-71. Change in Energy Use and Levelized Costs for New Mexico

Systems: Surged and Jetted Wells

Water Source: Groundwater

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
CONVENTIONAL WELL VS SURGED WELL						
ELECTRIC	-59	204	0	-1005	-801	-584
NATURAL GAS	-278	204	0	-764	-560	-383
DIESEL	-220	204	0	-1304	-1100	-789
CONVENTIONAL WELL VS JETTED WELL						
ELECTRIC	-74	345	0	-1261	-916	-626
NATURAL GAS	-349	345	0	-958	-613	-399
DIESEL	-277	345	0	-1637	-1292	-907

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-72. Change in Energy Use and Levelized Costs for New Mexico

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, Reduced-Pressure Center Pivot, Redesigned Pump and Variable Speed Pump

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE VS AUTOMATED GATED PIPE						
ELECTRIC	-128	2812	888	-2132	1568	1644
NATURAL GAS	-607	2812	888	-1620	2080	2028
DIESEL	-480	2812	888	-2767	933	1168
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-410	975	228	-6827	-5623	-4055
NATURAL GAS	-1943	975	228	-5187	-3984	-2825
DIESEL	-1538	975	228	-8859	-7656	-5580
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-366	898	210	-6089	-4981	-3586
NATURAL GAS	-1733	898	210	4627	-3518	-2489
DIESEL	-1372	898	210	-7902	-6794	-4946
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-212	0	0	-3526	-3526	-2644
NATURAL GAS	-1003	0	0	-2679	-2679	-2009
DIESEL	-794	0	0	-4576	-4576	-3432
GATED PIPE VS GATED PIPE WITH REDESIGNED PUMP						
ELECTRIC	-43	26	0	-711	-685	-509
NATURAL GAS	-202	26	0	-540	-514	-381
DIESEL	-160	26	0	-922	-897	-668
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH REDESIGNED PUMP						
ELECTRIC	-49	26	0	-814	-788	-587
NATURAL GAS	-232	26	0	-618	-593	-440
DIESEL	-183	26	0	-1056	-1030	-768
GATED PIPE VS GATED PIPE WITH VARIABLE SPEED PUMP						
ELECTRIC	-36	1027	400	-603	823	789
NATURAL GAS	-172	1027	400	-458	968	897
DIESEL	-136	1027	400	-783	644	654
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH VARIABLE SPEED PUMP						
ELECTRIC	-42	1027	400	-691	736	723
NATURAL GAS	-197	1027	400	-525	902	847
DIESEL	-156	1027	400	-897	530	569

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-73. Change in Energy Use and Levelized Costs for New Mexico

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, and Reduced-Pressure Center Pivot

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE VS AUTOMATED GATED PIPE						
ELECTRIC	-5	2812	888	-84	3616	3181
NATURAL GAS	-24	2812	888	-64	3636	3196
DIESEL	-19	2812	888	-108	3591	3162
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-322	975	228	-5354	-4151	-2951
NATURAL GAS	-1524	975	228	-4068	-2865	-1986
DIESEL	-1206	975	228	-6949	-5746	-4147
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-294	898	210	-4893	-3785	-2689
NATURAL GAS	-1392	898	210	-3718	-2610	-1807
DIESEL	-1102	898	210	-6350	-5242	-3782
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-212	0	0	-3526	-3526	-2644
NATURAL GAS	-1003	0	0	-2679	-2679	-2009
DIESEL	-794	0	0	-4576	-4576	-3432

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-74. Change in Energy Use and Levelized Costs for New Mexico

Systems: Computerized Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE						
ELECTRIC	-32	0	800	-527	273	205
NATURAL GAS	-150	0	800	-401	399	299
DIESEL	-119	0	800	-684	116	87
CENTER PIVOT						
ELECTRIC	-175	0	650	-2916	-2266	-1700
NATURAL GAS	-830	0	650	-2216	-1566	-1174
DIESEL	-657	0	650	-3785	-3135	-2351
AUTOMATED GATED PIPE						
ELECTRIC	-25	0	800	-422	378	284
NATURAL GAS	-120	0	800	-321	479	360
DIESEL	-95	0	800	-547	253	189
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-88	0	650	-1461	-811	-609
NATURAL GAS	-416	0	650	-1110	-460	-345
DIESEL	-329	0	650	-1897	-1247	-935
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-125	0	650	-2074	-1424	-1068
NATURAL GAS	-590	0	650	-1576	-926	-694
DIESEL	-467	0	650	-2691	-2041	-1531
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-108	0	800	-1799	-999	-749
NATURAL GAS	-512	0	800	-1367	-567	-425
DIESEL	-405	0	800	-2334	-1534	-1151
LATERAL MOVE						
ELECTRIC	-206	0	800	-3430	-2630	-1972
NATURAL GAS	-976	0	800	-2606	-1806	-1355
DIESEL	-773	0	800	-4451	-3651	-2738

(a) Million Btu/year.

(b) 1980 dollars/year.

**TABLE A-75. Change in Energy Use, Levelized Costs, and Water Use
for New Mexico**

Systems: Computerized Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE							
ELECTRIC	-1	0	800	-21	779	584	-22.40
NATURAL GAS	-6	0	800	-16	784	588	-22.40
DIESEL	-5	0	800	-27	773	580	-22.40
CENTER PIVOT							
ELECTRIC	-80	0	650	-1329	-679	-509	-70.20
NATURAL GAS	-378	0	650	-1009	-359	-270	-70.20
DIESEL	-299	0	650	-1724	-1074	-806	-70.20
AUTOMATED GATED PIPE							
ELECTRIC	-1	0	800	-17	783	588	-17.92
NATURAL GAS	-5	0	800	-13	787	591	-17.92
DIESEL	-4	0	800	-21	779	584	-17.92
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-10	0	650	-159	491	368	-57.56
NATURAL GAS	-45	0	650	-121	529	397	-57.56
DIESEL	-36	0	650	-207	443	332	-57.56
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-29	0	650	-486	164	123	-70.20
NATURAL GAS	-138	0	650	-369	281	211	-70.20
DIESEL	-110	0	650	-631	19	14	-70.20
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-12	0	800	-196	604	453	-70.85
NATURAL GAS	-56	0	800	-149	651	488	-70.85
DIESEL	-44	0	800	-255	545	409	-70.85
LATERAL MOVE							
ELECTRIC	-89	0	800	-1476	-676	-507	-86.40
NATURAL GAS	-420	0	800	-1121	-321	-241	-86.40
DIESEL	-332	0	800	-1915	-1115	-836	-86.40

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-76. Change in Energy Use and Levelized Costs for New Mexico

Systems: Instrumented Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE						
ELECTRIC	-25	1283	1000	-414	1869	1616
NATURAL GAS	-118	1283	1000	-315	1968	1690
DIESEL	-93	1283	1000	-538	1746	1523
CENTER PIVOT						
ELECTRIC	-146	1283	813	-2430	-334	-37
NATURAL GAS	-692	1283	813	-1847	249	401
DIESEL	-548	1283	813	-3154	-1058	-580
AUTOMATED GATED PIPE						
ELECTRIC	-20	1283	1000	-331	1952	1678
NATURAL GAS	-94	1283	1000	-252	2031	1737
DIESEL	-75	1283	1000	-430	1853	1604
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-73	1283	813	-1218	878	872
NATURAL GAS	-347	1283	813	-925	1170	1092
DIESEL	-274	1283	813	-1580	515	600
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-104	1283	813	-1728	368	490
NATURAL GAS	-492	1283	813	-1313	783	801
DIESEL	-389	1283	813	-2243	-147	104
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-90	1283	1000	-1499	784	802
NATURAL GAS	-427	1283	1000	-1139	1144	1072
DIESEL	-338	1283	1000	-1945	338	467
LATERAL MOVE						
ELECTRIC	-172	1283	1000	-2858	-575	-217
NATURAL GAS	-813	1283	1000	-2172	112	298
DIESEL	-644	1283	1000	-3709	-1426	-856

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-77. Change in Energy Use, Levelized Costs and Water Use for New Mexico

Systems: Instrumented Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE							
ELECTRIC	-1	1283	1000	-16	2267	1914	-17.60
NATURAL GAS	-5	1283	1000	-12	2271	1917	-17.60
DIESEL	-4	1283	1000	-21	2262	1911	-17.60
CENTER PIVOT							
ELECTRIC	-67	1283	813	-1107	989	955	-58.50
NATURAL GAS	-315	1283	813	-841	1255	1155	-58.50
DIESEL	-249	1283	813	-1437	659	708	-58.50
AUTOMATED GATED PIPE							
ELECTRIC	-1	1283	1000	-13	2270	1917	-14.08
NATURAL GAS	-4	1283	1000	-10	2273	1919	-14.08
DIESEL	-3	1283	1000	-17	2266	1914	-14.08
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-8	1283	813	-133	1963	1686	-47.97
NATURAL GAS	-38	1283	813	-101	1995	1710	-47.97
DIESEL	-30	1283	813	-172	1923	1656	-47.97
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-24	2383	813	-405	1691	1482	-58.50
NATURAL GAS	-115	1283	813	-308	1788	1555	-58.50
DIESEL	-91	1283	813	-526	1570	1391	-58.50
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-10	1283	1000	-164	2120	1804	-59.04
NATURAL GAS	-47	1283	1000	-124	2159	1833	-59.04
DIESEL	-37	1283	1000	-212	2071	1767	-59.04
LATERAL MOVE							
ELECTRIC	-74	1283	1000	-1230	1054	1004	-72.00
NATURAL GAS	-350	1283	1000	-934	1349	1226	-72.00
DIESEL	-277	1283	1000	-1596	687	729	-72.00

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-78. Change in Energy Use and Levelized Costs for Oklahoma

Systems: Surged and Jetted Wells

Water Source: Groundwater

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>AfterTax^(b) Costs</u>
CONVENTIONAL WELL VS SURGED WELL						
ELECTRIC	-51	192	0	-743	-551	-379
NATURAL GAS	-239	192	0	-960	-769	-542
DIESEL	-189	192	0	-1233	-1042	-747
CONVENTIONAL WELL VS JETTED WELL						
ELECTRIC	-63	333	0	-932	-599	-390
NATURAL GAS	-300	333	0	-1205	-873	-595
DIESEL	-238	333	0	-1548	1215	-852

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-79. Change in Energy Use and Levelized Costs for Oklahoma

Systems: Automatic Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, Reduced-Pressure Center Pivot, Redesigned Pump and Variable Speed Pump

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	AfterTax ^(b) Costs
GATED PIPE VS AUTOMATED GATED PIPE						
ELECTRIC	-75	2812	888	-1068	2632	2443
NATURAL GAS	-353	2812	888	-1381	2319	2208
DIESEL	-280	2812	888	-1773	1926	1913
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-285	975	228	-4073	-2870	-1990
NATURAL GAS	-1348	975	228	-5267	-4064	-2886
DIESEL	-1067	975	228	-6764	-5561	-4008
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-255	898	210	-3648	-2540	-1755
NATURAL GAS	-1207	898	210	-4718	-3609	-2557
DIESEL	-956	898	210	-6058	-4950	-3563
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-154	0	0	-2201	2201	-1650
NATURAL GAS	-728	0	0	-2846	-2846	-2134
DIESEL	-576	0	0	-3655	-3655	-2741
GATED PIPE VS GATED PIPE WITH REDESIGNED PUMP						
ELECTRIC	-25	26	0	-356	-330	-243
NATURAL GAS	-118	26	0	-460	-435	-322
DIESEL	-93	26	0	-591	-565	-420
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH REDESIGNED PUMP						
ELECTRIC	-32	26	0	-451	-426	-315
NATURAL GAS	149	26	0	-584	-558	-414
DIESEL	-118	26	0	-750	-724	-539
GATED PIPE VS GATED PIPE WITH VARIABLE SPEED PUMP						
ELECTRIC	-21	1027	400	-302	1124	1014
NATURAL GAS	-100	1027	400	-391	1036	948
DIESEL	-79	1027	400	-502	925	865
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH VARIABLE SPEED PUMP						
ELECTRIC	-27	1027	400	-383	1043	954
NATURAL GAS	-127	1027	400	-496	931	869
DIESEL	-100	1027	400	-637	790	764

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-80. Change in Energy Use and Levelized Costs for Oklahoma

Systems: Automatic Gated Pipe, Low-Energy Precision Application Lateral Move,
Low-Energy Precision Application Center Pivot, and Low Pressure Center
Pivot

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	AfterTax ^(b) Costs
GATED PIPE VS AUTOMATED GATED PIPE						
ELECTRIC	-8	2812	888	-109	3590	3161
NATURAL GAS	-36	2812	888	-141	3558	3137
DIESEL	-29	2812	888	-182	3518	3107
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-236	975	228	-3383	-2180	-1472
NATURAL GAS	-1119	975	228	-4375	-3172	-2216
DIESEL	-886	975	228	-5618	-4415	-3149
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-216	898	210	-3087	-1979	-1335
NATURAL GAS	-1022	898	210	-3993	-2884	-2014
DIESEL	-809	898	210	-5127	-4019	-2864
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-154	0	0	-2201	-2201	-1650
NATURAL GAS	-728	0	0	-2846	-2846	-2134
DIESEL	-576	0	0	-3655	-3655	-2741

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-81. Change in Energy Use and Levelized Costs for Oklahoma

Systems: Computerized Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	AfterTax ^(b) Costs
GATED PIPE						
ELECTRIC	-18	0	800	-260	540	405
NATURAL GAS	-86	0	800	-337	463	347
DIESEL	-68	0	800	-432	368	276
CENTER PIVOT						
ELECTRIC	-112	0	650	-1610	-960	-720
NATURAL GAS	-533	0	650	-2082	-1432	-1074
DIESEL	-422	0	650	-2674	-2024	-1518
TOWLINE, SIDE ROLL						
ELECTRIC	-125	0	800	-1784	-984	-738
NATURAL GAS	-590	0	800	-2307	-1507	-1130
DIESEL	-467	0	800	-2962	-2162	-1622
AUTOMATED GATED PIPE						
ELECTRIC	-15	0	800	-208	592	444
NATURAL GAS	-69	0	800	-269	531	398
DIESEL	-55	0	800	-346	454	341
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-52	0	650	-743	-93	-70
NATURAL GAS	-246	0	650	-960	-310	-233
DIESEL	-195	0	650	-1233	-583	-438
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-76	0	650	-1087	-437	-328
NATURAL GAS	-360	0	650	-1406	-756	-567
DIESEL	-285	0	650	-1805	1155	-866
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-64	0	800	-914	-114	-86
NATURAL GAS	-302	0	800	-1182	-382	-287
DIESEL	-239	0	800	-1518	-718	-539
LATERAL MOVE						
ELECTRIC	-312	0	800	-1883	-1083	-812
NATURAL GAS	-623	0	800	-2435	-1635	-1226
DIESEL	-493	0	800	-3127	-2327	-1745

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-82. Change in Energy Use, Levelized Costs, and Water Use for Oklahoma

Systems: Computerized Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE							
ELECTRIC	-2	0	800	-27	773	580	-16.00
NATURAL GAS	-9	0	800	-35	765	574	-16.00
DIESEL	-7	0	800	-44	756	567	-16.00
CENTER PIVOT							
ELECTRIC	-61	0	650	-870	-220	-165	-50.70
NATURAL GAS	-288	0	650	-1124	-474	-356	-50.70
DIESEL	-228	0	650	-1444	-794	-596	-50.70
TOWLINE, SIDE ROLL							
ELECTRIC	-61	0	800	-872	-72	-54	-62.40
NATURAL GAS	-289	0	800	-1128	-328	-246	-62.40
DIESEL	-228	0	800	-1448	-648	-486	-62.40
AUTOMATED GATED PIPE							
ELECTRIC	-1	0	800	-21	779	584	-12.80
NATURAL GAS	-7	0	800	-28	772	579	-12.80
DIESEL	-6	0	800	-35	765	573	-12.80
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-9	0	650	-135	515	386	-41.57
NATURAL GAS	-45	0	650	-175	475	356	-41.57
DIESEL	-35	0	650	-225	425	319	-41.57
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-24	0	650	-346	304	228	-50.70
NATURAL GAS	-115	0	650	-448	202	152	-50.70
DIESEL	-91	0	650	-575	75	56	-50.70
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-12	0	800	-167	633	475	-51.17
NATURAL GAS	-55	0	800	-215	585	438	-51.17
DIESEL	-44	0	800	-277	523	393	-51.17
LATERAL MOVE							
ELECTRIC	-68	0	800	-971	-171	-128	-62.40
NATURAL GAS	-321	0	800	-1256	-456	-342	-62.40
DIESEL	-254	0	800	-1613	-813	-610	-62.40

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-83. Change in Energy Use and Levelized Costs for Oklahoma

Systems: Instrumented Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	After-Tax ^(b) Costs
GATED PIPE						
ELECTRIC	-15	1283	1000	-208	2075	1770
NATURAL GAS	-69	1283	1000	-269	2014	1724
DIESEL	-55	1283	1000	-346	1937	1667
CENTER PIVOT						
ELECTRIC	-95	1283	813	-1362	733	764
NATURAL GAS	-451	1283	813	-1762	334	464
DIESEL	-357	1283	813	-2263	-167	89
TOWLINE, SIDE ROLL						
ELECTRIC	-105	1283	1000	-1509	774	794
NATURAL GAS	-499	1283	1000	-1952	322	463
DIESEL	-395	1283	1000	-2506	-223	47
AUTOMATED GATED PIPE						
ELECTRIC	-12	1283	1000	-167	2117	1801
NATURAL GAS	-55	1283	1000	-216	2068	1765
DIESEL	-44	1283	1000	-277	2006	1719
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-44	1283	813	-628	1467	1314
NATURAL GAS	-208	1283	813	813	1283	1176
DIESEL	-165	1283	813	-1044	1052	1003
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-64	1283	813	-920	1176	1096
NATURAL GAS	-304	1283	813	-1189	906	894
DIESEL	-241	1283	813	-1527	568	640
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-54	1283	1000	-773	1510	1346
NATURAL GAS	-256	1283	1000	-1000	1283	1176
DIESEL	-203	1283	1000	-1285	999	963
LATERAL MOVE						
ELECTRIC	-111	1283	1000	-1593	690	732
NATURAL GAS	-527	1283	1000	-2060	223	381
DIESEL	-417	1283	1000	-2646	-362	-58

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-84. Change in Energy Use, Levelized Costs, and Water Use for Oklahoma

Systems: Instrumented Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE							
ELECTRIC	-1	1283	1000	-21	2262	1910	-12.80
NATURAL GAS	-7	1283	1000	-28	2256	1906	-12.80
DIESEL	-6	1283	1000	-35	2248	1900	-12.80
CENTER PIVOT							
ELECTRIC	-51	1283	813	-736	1360	1234	-42.90
NATURAL GAS	-243	1283	813	-951	1144	1072	-42.90
DIESEL	-193	1283	813	-1222	874	869	-42.90
TOWLINE, SIDE ROLL							
ELECTRIC	-52	1283	1000	-738	1545	1373	-52.80
NATURAL GAS	-244	1283	1000	-954	1329	1211	-52.80
DIESEL	-193	1283	1000	-1225	1058	1007	-52.80
AUTOMATED GATED PIPE							
ELECTRIC	-1	1283	1000	-17	2266	1914	-10.24
NATURAL GAS	-6	1283	1000	-22	2261	1910	-10.24
DIESEL	-4	1283	1000	-28	2255	1905	-10.24
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-8	1283	813	-115	1981	1700	-35.18
NATURAL GAS	-38	1283	813	-148	1948	1675	-35.18
DIESEL	-30	1283	813	-190	1906	1643	-35.18
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-20	1283	813	-293	1803	1566	-42.90
NATURAL GAS	-97	1283	813	-379	1717	1502	-42.90
DIESEL	-77	1283	813	-486	1609	1421	-42.90
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-10	1283	1000	-141	2142	1821	-43.30
NATURAL GAS	-47	1283	1000	-182	2101	1790	-43.30
DIESEL	-37	1283	1000	-234	2049	1751	-43.30
LATERAL MOVE							
ELECTRIC	-57	1283	1000	-822	1462	1310	-52.80
NATURAL GAS	-272	1283	1000	-1063	1221	1129	-52.80
DIESEL	-215	1283	1000	-1365	919	903	-52.80

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-85. Change in Energy Use and Levelized Costs for Oregon

Systems: Surged and Jetted Wells

Water Source: Groundwater

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
CONVENTIONAL WELL VS SURGED WELL						
ELECTRIC	-73	217	0	-601	-384	-249
DIESEL	-275	217	0	-1556	-1338	-965
CONVENTIONAL WELL VS JETTED WELL						
ELECTRIC	-92	358	0	-755	-397	-234
DIESEL	-345	358	0	-1952	-1594	-1132

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-86. Change in Energy Use and Levelized Costs for Oregon

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, Reduced-Pressure Center Pivot, Redesign Pump and Variable Speed Pump

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE VS AUTOMATED GATED PIPE						
ELECTRIC	-161	2812	888	-1287	2413	2278
DIESEL	-604	2812	888	-3330	370	746
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-493	975	228	-3939	-2736	-1889
DIESEL	-1849	975	228	-10191	-8988	-6579
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-439	898	210	-3509	-2401	-1651
DIESEL	-1648	898	210	-9079	-7971	-5828
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-251	0	0	-2006	-2006	-1505
DIESEL	-942	0	0	-5191	-5191	-3893
GATED PIPE VS GATED PIPE WITH REDESIGNED PUMP						
ELECTRIC	-54	26	0	-429	-403	-298
DIESEL	-201	26	0	-1110	-1084	-809
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH REDESIGNED PUMP						
ELECTRIC	-60	26	0	-479	-454	-336
DIESEL	-225	26	0	-1240	-1215	-907
GATED PIPE VS GATED PIPE WITH VARIABLE SPEED PUMP						
ELECTRIC	-46	1027	400	-364	1062	968
DIESEL	-171	1027	400	-942	484	534
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH VARIABLE SPEED PUMP						
ELECTRIC	-51	1027	400	-407	1020	936
DIESEL	-191	1027	400	-1053	373	451

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-87. Change in Energy Use and Levelized Costs for Oregon

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, and Reduced-Pressure Center Pivot

Water Source: Surface Water

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
GATED PIPE VS AUTOMATED GATED PIPE						
ELECTRIC	-10	2812	888	-76	3624	3186
DIESEL	-36	2812	888	-197	3503	3096
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-384	975	228	-3067	-1864	-1236
DIESEL	-1440	975	228	-7936	-6732	-4887
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-351	898	210	-2801	-1693	-1120
DIESEL	-1315	898	210	-7246	-6138	-4454
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-251	0	0	-2006	-2006	-1505
DIESEL	-942	0	0	-5191	-5191	-3893

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-88. Change in Energy Use and Levelized Costs for Oregon

Systems: Computerized Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE						
ELECTRIC	-41	0	800	-327	473	355
DIESEL	-153	0	800	-845	-45	-34
CENTER PIVOT						
ELECTRIC	-215	0	650	-1718	-1068	-801
DIESEL	-806	0	650	-4443	-3793	-2845
TOWLINE, SIDE ROLL						
ELECTRIC	-242	0	800	-1932	-1132	-849
DIESEL	-907	0	800	-4999	-4199	-3150
HAND MOVED						
ELECTRIC	-239	0	800	-1910	-1110	-832
DIESEL	-897	0	800	-4941	-4141	-3106
AUTOMATED GATED PIPE						
ELECTRIC	-33	0	800	-261	539	404
DIESEL	-123	0	800	-676	124	93
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-110	0	650	-879	-229	-172
DIESEL	-413	0	650	-2275	-1625	-1219
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-155	0	650	-1238	-588	-441
DIESEL	-581	0	650	-3204	-2554	-1915
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-136	0	800	-1082	-282	-212
DIESEL	-508	0	800	-2800	-2000	-1500
LATERAL MOVE						
ELECTRIC	-253	0	800	-2023	-1223	-917
DIESEL	-950	0	800	-5234	-4434	-3326

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-89. Change in Energy Use, Levelized Costs, and Water Use for Oregon

Systems: Computerized Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE							
ELECTRIC	-2	0	800	-19	781	586	-27.20
DIESEL	-9	0	800	-50	750	563	-27.20
CENTER PIVOT							
ELECTRIC	-97	0	650	-778	-128	-96	-83.20
DIESEL	-365	0	650	-2012	-1362	-1021	-83.20
TOWLINE, SIDE ROLL							
ELECTRIC	-97	0	800	-776	24	18	-102.40
DIESEL	-364	0	800	-2007	-1207	-905	-102.40
HAND MOVED							
ELECTRIC	-94	0	800	-753	47	35	-102.40
DIESEL	-354	0	800	-1948	-1148	-861	-102.40
AUTOMATED GATED PIPE							
ELECTRIC	-2	0	800	-15	785	588	-21.76
DIESEL	-7	0	800	-40	760	570	-21.76
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-14	0	650	-109	541	406	-68.22
DIESEL	-51	0	650	-281	369	276	-68.22
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-37	0	650	-299	351	264	-83.20
DIESEL	-140	0	650	-772	-122	-92	-83.20
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-17	0	800	-134	666	500	-83.97
DIESEL	-63	0	800	-346	454	340	-83.97
LATERAL MOVE							
ELECTRIC	-108	0	800	-866	-66	-50	-102.40
DIESEL	-407	0	800	-2242	-1442	-1081	-102.40

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-90. Change in Energy Use and Levelized Costs for Oregon

Systems: Instrumented Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE						
ELECTRIC	-31	1283	1000	-250	2034	1739
DIESEL	-117	1283	1000	-646	1637	1442
CENTER PIVOT						
ELECTRIC	-181	1283	813	-1449	647	699
DIESEL	-680	1283	813	-3749	-1653	-1026
TOWLINE, SIDE ROLL						
ELECTRIC	-204	1283	1000	-1631	653	703
DIESEL	-765	1283	1000	-4218	-1935	-1237
HAND-MOVED						
ELECTRIC	-202	1283	1000	-1611	672	718
DIESEL	-757	1283	1000	-4169	-1886	-1200
AUTOMATED GATED PIPE						
ELECTRIC	-25	1283	1000	-200	2083	1777
DIESEL	-94	1283	1000	-517	1766	1539
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-93	1283	813	-742	1354	1229
DIESEL	-348	1283	813	-1920	176	346
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-131	1283	813	-1045	1051	1002
DIESEL	-491	1283	813	-2703	-608	-242
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-114	1283	1000	-913	1370	1241
DIESEL	-429	1283	1000	-2363	-80	154
LATERAL MOVE						
ELECTRIC	-214	1283	1000	-1707	576	646
DIESEL	-801	1283	1000	-4416	-2133	-1386

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-91. Change in Energy Use, Levelized Costs, and Water Use for Oregon

Systems: Instrumented Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE							
ELECTRIC	-2	1283	1000	-15	2269	1915	-20.80
DIESEL	-7	1283	1000	-38	2245	1898	-20.80
CENTER PIVOT							
ELECTRIC	-82	1283	813	-656	1440	1294	-70.20
DIESEL	-308	1283	813	-1698	398	513	-70.20
TOWLINE, SIDE ROLL							
ELECTRIC	-82	1283	1000	-654	1629	1435	-86.40
DIESEL	-307	1283	1000	-1693	590	656	-86.40
HAND MOVED							
ELECTRIC	-80	1283	1000	-635	1648	1450	-86.40
DIESEL	-298	1283	1000	-1644	640	694	-86.40
AUTOMATED GATED PIPE							
ELECTRIC	-1	1283	1000	-12	2271	1917	-16.64
DIESEL	-6	1283	1000	-31	2253	1903	-16.64
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-11	1283	813	-92	2004	1717	-57.56
DIESEL	-43	1283	813	-238	1858	1608	-57.56
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-32	1283	813	-252	1844	1597	-70.20
DIESEL	-118	1283	813	-652	1444	1297	-70.20
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-14	1283	1000	-113	2170	1842	-70.85
DIESEL	-53	1283	1000	-292	1991	1707	-70.85
LATERAL MOVE							
ELECTRIC	-92	1283	1000	-731	1552	1378	-86.40
DIESEL	-343	1283	1000	-1891	392	508	-86.40

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-92. Change in Energy Use and Levelized Costs for Texas

Systems: Surged and Jetted Wells

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
CONVENTIONAL WELL VS SURGED WELL						
ELECTRIC	-37	186	0	-576	-390	-260
NATURAL GAS	-74	186	0	-579	-393	-262
DIESEL	-137	186	0	-813	-627	-437
CONVENTIONAL WELL VS JETTED WELL						
ELECTRIC	-46	327	0	-723	-396	-239
NATURAL GAS	-218	327	0	-727	-400	-242
DIESEL	-172	327	0	-1020	-693	-462

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-93. Change in Energy Use and Levelized Costs for Texas

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, Reduced-Pressure Center Pivot, Redesigned Pump and Variable Speed Pump

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE VS AUTOMATED GATED PIPE						
ELECTRIC	-57	2812	888	-880	2819	2583
NATURAL GAS	-272	2812	888	-885	2815	2580
DIESEL	-216	2812	888	-1242	2458	2312
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-219	975	228	-3348	-2145	-1446
NATURAL GAS	-1035	975	228	-3365	-2161	-1458
DIESEL	-820	975	228	-4722	-3519	-2476
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-196	898	210	-2998	-1890	-1268
NATURAL GAS	-927	898	210	-3013	-1905	-1279
DIESEL	-734	898	210	-4229	-3121	-2191
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-118	0	0	-1809	-1809	-1357
NATURAL GAS	-559	0	0	-1818	-1818	-1363
DIESEL	-443	0	0	-2551	-2551	-1913
GATED PIPE VS GATED PIPE WITH REDESIGNED PUMP						
ELECTRIC	-19	26	0	-293	-268	-197
NATURAL GAS	-91	26	0	-295	-269	-198
DIESEL	-72	26	0	-414	-388	-287
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH REDESIGNED PUMP						
ELECTRIC	-24	26	0	-371	-345	-255
NATURAL GAS	-115	26	0	-373	-347	-256
DIESEL	-91	26	0	-523	-498	-369
GATED PIPE VS GATED PIPE WITH VARIABLE SPEED PUMP						
ELECTRIC	-16	1027	400	-249	1177	1054
NATURAL GAS	-77	1027	400	-250	1176	1053
DIESEL	-61	1027	400	-351	1075	977
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH VARIABLE SPEED PUMP						
ELECTRIC	-21	1027	400	-315	1112	1005
NATURAL GAS	-97	1027	400	-317	1110	1004
DIESEL	-77	1027	400	-444	982	908

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-94. Change in Energy Use and Levelized Costs for Texas

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot and Reduced-Pressure Center Pivot

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE VS AUTOMATED GATED PIPE						
ELECTRIC	-13	2812	888	-193	3506	3098
NATURAL GAS	-60	2812	888	-194	3505	3098
DIESEL	-47	2812	888	-273	3427	3039
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-186	975	228	-2855	-1651	-1076
NATURAL GAS	-883	975	228	-2869	-1666	-1087
DIESEL	-699	975	228	-4026	-2823	-1955
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-170	898	210	-2598	-1489	-967
NATURAL GAS	-803	898	210	-2611	-1502	-977
DIESEL	-636	898	210	-3664	-2556	-1767
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-118	0	0	-1809	-1809	-1357
NATURAL GAS	-559	0	0	-1818	-1818	-1363
DIESEL	-443	0	0	-2551	-2551	-1913

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-95. Change in Energy Use and Levelized Costs for Texas

Systems: Computerized Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE						
ELECTRIC	-15	0	800	-223	577	433
NATURAL GAS	-69	0	800	-224	576	432
DIESEL	-55	0	800	-314	486	364
CENTER PIVOT						
ELECTRIC	-87	0	650	-1325	-675	-506
NATURAL GAS	-410	0	650	-1332	-682	-511
DIESEL	-324	0	650	-1869	-1219	-914
TOWLINE, SIDE ROLL						
ELECTRIC	-96	0	800	-1468	-668	-501
NATURAL GAS	-454	0	800	-1475	-675	-506
DIESEL	-359	0	800	-2070	-1270	-953
HAND MOVED						
ELECTRIC	-95	0	800	-1447	-647	-486
NATURAL GAS	-448	0	800	-1455	-655	-491
DIESEL	-354	0	800	-2042	-1242	-931
TRAVELING GUN						
ELECTRIC	-133	0	800	-2039	-1239	-929
NATURAL GAS	-631	0	800	-2049	-1249	-937
DIESEL	-499	0	800	-2875	-2075	-1557
AUTOMATED GATED PIPE						
ELECTRIC	-12	0	800	-178	622	466
NATURAL GAS	-55	0	800	-179	621	466
DIESEL	-44	0	800	-251	549	411
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-40	0	650	-611	39	29
NATURAL GAS	-189	0	650	-614	36	27
DIESEL	-150	0	650	-862	-212	-159
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-58	0	650	-894	-244	-183
NATURAL GAS	-277	0	650	-899	-249	-187
DIESEL	-219	0	650	-1262	-612	-459
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-49	0	800	-752	48	36
NATURAL GAS	-233	0	800	-756	44	33
DIESEL	-184	0	800	-1061	-261	-196
LATERAL MOVE						
ELECTRIC	-101	0	800	-1549	-749	-562
NATURAL GAS	-479	0	800	-1557	-757	-568
DIESEL	-379	0	800	-2185	-1385	-1039

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-96. Change in Energy Use, Levelized Costs, and Water Use for Texas

Systems: Computerized Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE							
ELECTRIC	-3	0	800	-49	751	563	-12.80
NATURAL GAS	-15	0	800	-49	751	563	-12.80
DIESEL	-12	0	800	-69	731	548	-12.80
CENTER PIVOT							
ELECTRIC	-52	0	650	-795	-145	-109	-39.00
NATURAL GAS	-246	0	650	-799	-149	-112	-39.00
DIESEL	-195	0	650	-1121	-471	-354	-39.00
TOWLINE, SIDE ROLL							
ELECTRIC	-53	0	800	-815	-15	-12	-48.00
NATURAL GAS	-252	0	800	-820	-20	-15	-48.00
DIESEL	-200	0	800	-1150	-350	-263	-48.00
HAND MOVED							
ELECTRIC	-52	0	800	-795	5	4	-48.00
NATURAL GAS	-246	0	800	-799	1	1	-48.00
DIESEL	-195	0	800	-1121	-321	-241	-48.00
TRAVELING GUN							
ELECTRIC	-91	0	800	-1386	-586	-440	-48.00
NATURAL GAS	-429	0	800	-1393	-593	-445	-48.00
DIESEL	-339	0	800	-1955	-1155	-866	-48.00
AUTOMATED GATED PIPE							
ELECTRIC	-3	0	800	-39	761	571	-10.24
NATURAL GAS	-12	0	800	-39	761	570	-10.24
DIESEL	-10	0	800	-55	745	559	-10.24
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-12	0	650	-177	473	355	-31.98
NATURAL GAS	-55	0	650	-177	473	354	-31.98
DIESEL	-43	0	650	-249	401	301	-31.98
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-24	0	650	-364	286	214	-39.00
NATURAL GAS	-113	0	650	-366	284	213	-39.00
DIESEL	-89	0	650	-514	136	102	-39.00
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-14	0	800	-217	583	437	-39.36
NATURAL GAS	-67	0	800	-218	582	436	-39.36
DIESEL	-53	0	800	-307	493	370	-39.36
LATERAL MOVE							
ELECTRIC	-59	0	800	-897	-97	-73	-48.00
NATURAL GAS	-277	0	800	-901	-101	-76	-48.00
DIESEL	-220	0	800	-1265	-465	-349	-48.00

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-97. Change in Energy Use and Levelized Costs for Texas

Systems: Instrumented Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE						
ELECTRIC	-11	1283	1000	-167	2116	1801
NATURAL GAS	-52	1283	1000	-168	2115	1800
DIESEL	-41	1283	1000	-236	2047	1749
CENTER PIVOT						
ELECTRIC	-72	1283	813	-1104	991	958
NATURAL GAS	-342	1283	813	-1110	986	953
DIESEL	-270	1283	813	-1557	538	618
TOWLINE, SIDE ROLL						
ELECTRIC	-80	1283	1000	-1223	1060	1009
NATURAL GAS	-378	1283	1000	-1229	1054	1004
DIESEL	-299	1283	1000	-1725	558	632
HAND MOVED						
ELECTRIC	-79	1283	1000	-1206	1077	1022
NATURAL GAS	-373	1283	1000	-1212	1071	1017
DIESEL	-295	1283	1000	-1701	582	650
TRAVELING GUN						
ELECTRIC	-111	1283	1000	-1699	584	652
NATURAL GAS	-525	1283	1000	-1707	576	646
DIESEL	-416	1283	1000	-2396	-113	129
AUTOMATED GATED PIPE						
ELECTRIC	-9	1283	1000	-134	2150	1826
NATURAL GAS	-41	1283	1000	-134	2149	1826
DIESEL	-33	1283	1000	-189	2095	1785
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-33	1283	813	-509	1586	1404
NATURAL GAS	-158	1283	813	-512	1584	1402
DIESEL	-125	1283	813	-718	1377	1247
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-49	1283	813	-745	1350	1227
NATURAL GAS	-231	1283	813	-749	1347	1224
DIESEL	-183	1283	813	-1051	1044	997
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-41	1283	1000	-627	1656	1456
NATURAL GAS	-194	1283	1000	-630	1653	1454
DIESEL	-153	1283	1000	-884	1399	1263
LATERAL MOVE						
ELECTRIC	-84	1283	1000	-1291	992	958
NATURAL GAS	-399	1283	1000	-1298	986	953
DIESEL	-316	1283	1000	-1821	462	561

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-98. Change in Energy Use, Levelized Costs, and Water Use for Texas

Systems: Instrumented Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE							
ELECTRIC	-2	1283	1000	-37	2247	1899	-9.60
NATURAL GAS	-11	1283	1000	-37	2246	1899	-9.60
DIESEL	-9	1283	1000	-52	2232	1888	-9.60
CENTER PIVOT							
ELECTRIC	-43	1283	813	-663	1433	1289	-32.50
NATURAL GAS	-205	1283	813	-666	1430	1286	-32.50
DIESEL	-162	1283	813	-934	1161	1085	-32.50
TOWLINE, SIDE ROLL							
ELECTRIC	-44	1283	1000	-680	1604	1417	-40.00
NATURAL GAS	-210	1283	1000	-683	1600	1414	-40.00
DIESEL	-166	1283	1000	-958	1325	1207	-40.00
HAND MOVED							
ELECTRIC	-43	1283	1000	-663	1621	1429	-40.00
NATURAL GAS	-205	1283	1000	-666	1617	1427	-40.00
DIESEL	-162	1283	1000	-934	1349	1225	-40.00
TRAVELING GUN							
ELECTRIC	-75	1283	1000	-1155	1128	1060	-40.00
NATURAL GAS	-357	1283	1000	-1161	1122	1056	-40.00
DIESEL	-283	1283	1000	-1629	654	704	-40.00
AUTOMATED GATED PIPE							
ELECTRIC	-2	1283	1000	-29	2254	1904	-7.68
NATURAL GAS	-9	1283	1000	-30	2254	1904	-7.68
DIESEL	-7	1283	1000	-41	2242	1895	-7.68
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-10	1283	813	-147	1949	1675	-26.65
NATURAL GAS	-46	1283	813	-148	1948	1675	-26.65
DIESEL	-36	1283	813	-208	1888	1630	-26.65
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-20	1283	813	-304	1792	1558	-32.50
NATURAL GAS	-94	1283	813	-305	1791	1557	-32.50
DIESEL	-74	1283	813	-428	1667	1464	-32.50
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-12	1283	1000	-181	2102	1791	-32.80
NATURAL GAS	-56	1283	1000	-182	2101	1790	-32.80
DIESEL	-44	1283	1000	-255	2028	1735	-32.80
LATERAL MOVE							
ELECTRIC	-49	1283	1000	-748	1536	1366	-40.00
NATURAL GAS	-231	1283	1000	-751	1532	1363	-40.00
DIESEL	-183	1283	1000	-1054	1229	1136	-40.00

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-99. Change in Energy Use and Levelized Costs for Utah

Systems: Surged and Jetted Wells

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
CONVENTIONAL WELL VS SURGED WELL						
ELECTRIC	-73	198	0	-1053	-855	-606
NATURAL GAS	-347	198	0	-928	-730	-512
DIESEL	-275	198	0	-1649	-1451	-1053
CONVENTIONAL WELL VS JETTED WELL						
ELECTRIC	-92	339	0	-1321	-983	-677
NATURAL GAS	-436	339	0	-1164	-826	-559
DIESEL	-345	339	0	-2069	-1730	-1237

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-100. Change in Energy Use and Levelized Costs for Utah

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, Reduced-Pressure Center Pivot, Redesign Pump and Variable Speed Pump

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE VS AUTOMATED GATED PIPE						
ELECTRIC	-128	2812	888	-1787	1913	1903
NATURAL GAS	-605	2812	888	-1575	2125	2062
DIESEL	-479	2812	888	-2798	902	1145
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-444	975	228	-6206	-5002	-3589
NATURAL GAS	-2102	975	228	-5468	-4265	-3036
DIESEL	-1664	975	228	-9717	-8514	-6223
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-397	898	210	-5546	-4438	-3179
NATURAL GAS	-1878	898	210	-4887	-3779	-2685
DIESEL	-1487	898	210	-8684	-7576	-5532
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-234	0	0	-3277	-3277	-2458
NATURAL GAS	-1110	0	0	-2888	-2888	-2166
DIESEL	-879	0	0	-5132	-5132	-3849
GATED PIPE VS GATED PIPE WITH REDISIGNED PUMP						
ELECTRIC	-43	26	0	-596	-570	-423
NATURAL GAS	-202	26	0	-525	-499	-370
DIESEL	-160	26	0	-933	-907	-676
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH REDESIGNED PUMP						
ELECTRIC	-51	26	0	-714	-689	-512
NATURAL GAS	-242	26	0	-629	-604	-449
DIESEL	-192	26	0	-1118	-1093	-815
GATED PIPE VS GATED PIPE WITH VARIABLE SPEED PUMP						
ELECTRIC	-36	1027	400	-506	921	862
NATURAL GAS	-171	1027	400	-446	981	907
DIESEL	-136	1027	400	-792	635	647
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH VARIABLE SPEED PUMP						
ELECTRIC	-43	1027	400	-606	820	786
NATURAL GAS	-205	1027	400	-534	892	840
DIESEL	-163	1027	400	-950	477	529

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-101. Change in Energy Use and Levelized Costs for Utah

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, and Reduced-Pressure Center Pivot

Water Source: Surface water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE VS AUTOMATED GATED PIPE						
ELECTRIC	-11	2812	888	-155	3544	3127
NATURAL GAS	-53	2812	888	-137	3563	3141
DIESEL	-42	2812	888	-243	3456	3061
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-360	975	228	-5033	-3830	-2710
NATURAL GAS	-1704	975	228	-4435	-3232	-2261
DIESEL	-1349	975	228	-7880	-6677	-4845
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-328	898	210	-4593	-3485	-2464
NATURAL GAS	-1556	898	210	-4048	-2939	-2055
DIESEL	-1232	898	210	-7192	-6084	-4413
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-234	0	0	-3277	-3277	-2458
NATURAL GAS	-1110	0	0	-2888	-2888	-2166
DIESEL	-879	0	0	-5132	-5132	-3849

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-102. Change in Energy Use and Levelized Costs for Utah

System: Computerized Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE						
ELECTRIC	-33	0	800	-457	343	257
NATURAL GAS	-155	0	800	-402	398	298
DIESEL	-122	0	800	-715	85	64
CENTER PIVOT						
ELECTRIC	-184	0	650	-2571	-1921	-1441
NATURAL GAS	-871	0	650	-2266	-1616	-1212
DIESEL	-689	0	650	4026	-3376	-2532
TOWLINE, SIDE ROLL						
ELECTRIC	-205	0	800	-2867	-2067	-1550
NATURAL GAS	-971	0	800	-2526	-1726	-1295
DIESEL	-769	0	800	-4489	-3689	-2767
HAND MOVED						
ELECTRIC	-202	0	800	-2830	-2030	-1522
NATURAL GAS	-958	0	800	-2494	-1694	-1270
DIESEL	-759	0	800	-4431	-3631	-2723
AUTOMATED GATED PIPE						
ELECTRIC	-26	0	800	-365	435	326
NATURAL GAS	-124	0	800	-322	478	359
DIESEL	-98	0	800	-572	228	171
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-89	0	650	-1240	-590	-443
NATURAL GAS	-420	0	650	-1093	-443	-332
DIESEL	-333	0	650	-1942	-1292	-969
LOW-PRESSURE CENTER PIVOT						
ELECTRIC	-128	0	650	-1785	-1135	-851
NATURAL GAS	-604	0	650	-1573	-923	-692
DIESEL	-479	0	650	-2795	-2145	-1609
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-109	0	800	-1527	-727	-545
NATURAL GAS	-517	0	800	-1345	-545	-409
DIESEL	-409	0	800	-2390	-1590	-1193
LATERAL MOVE						
ELECTRIC	-216	0	800	-3016	-2216	-1662
NATURAL GAS	-1021	0	800	-2658	-1858	-1393
DIESEL	-809	0	800	-4722	-3922	-2942

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-103. Change in Energy Use, Levelized Costs, and Water Use for Utah

System: Computerized Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE							
ELECTRIC	-3	0	800	-40	760	570	-25.00
NATURAL GAS	-13	0	800	-35	765	574	-25.60
DIESEL	-11	0	800	-62	738	553	-25.60
CENTER PIVOT							
ELECTRIC	-93	0	650	-1301	-651	-488	-78.00
NATURAL GAS	-441	0	650	-1146	-496	-372	-78.00
DIESEL	-349	0	650	-2037	-1387	-1040	-78.00
TOWLINE, SIDE ROLL							
ELECTRIC	-93	0	800	-1303	-503	-377	-96.00
NATURAL GAS	-441	0	800	-1148	-348	-261	-96.00
DIESEL	-349	0	800	-2041	-1241	-930	-96.00
HAND MOVED							
ELECTRIC	-91	0	800	-1266	-466	-349	-96.00
NATURAL GAS	-429	0	800	-1116	-316	-237	-96.00
DIESEL	-339	0	800	-1982	-1182	-887	-96.00
AUTOMATED GATED PIPE							
ELECTRIC	-2	0	800	-32	768	576	-20.48
NATURAL GAS	-11	0	800	-28	772	579	-20.48
DIESEL	-9	0	800	-50	750	563	-20.48
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-14	0	650	-198	452	339	-63.96
NATURAL GAS	-67	0	650	-175	475	356	-63.96
DIESEL	-53	0	650	-311	339	254	-63.96
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-37	0	650	-514	136	102	-78.00
NATURAL GAS	-174	0	650	-453	197	148	-78.00
DIESEL	-138	0	650	-805	-155	-116	-78.00
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-17	0	800	-244	556	417	-78.72
NATURAL GAS	-83	0	800	-215	585	439	-78.72
DIESEL	-65	0	800	-382	418	313	-78.72
LATERAL MOVE							
ELECTRIC	-104	0	800	-1452	-652	-489	-96.00
NATURAL GAS	-492	0	800	-1280	-480	-360	-96.00
DIESEL	-389	0	800	-2274	-1474	-1105	-96.00

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-104. Change in Energy Use and Levelized Costs for Utah

System: Instrumented Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE						
ELECTRIC	-27	1283	1000	-371	1912	1648
NATURAL GAS	-126	1283	1000	-327	1956	1681
DIESEL	-99	1283	1000	-581	1702	1491
CENTER PIVOT						
ELECTRIC	-153	1283	813	-2143	-47	179
NATURAL GAS	-726	1283	813	-1888	207	369
DIESEL	-575	1283	813	-3355	-1260	-731
TOWLINE, SIDE ROLL						
ELECTRIC	-171	1283	1000	-2389	-106	134
NATURAL GAS	-809	1283	1000	-2105	178	347
DIESEL	-641	1283	1000	-3741	-1458	-879
HAND MOVED						
ELECTRIC	-169	1283	1000	-2358	-75	158
NATURAL GAS	-799	1283	1000	-2078	205	368
DIESEL	-632	1283	1000	-3692	-1409	-843
AUTOMATED GATED PIPE						
ELECTRIC	-21	1283	1000	-297	1986	1704
NATURAL GAS	-101	1283	1000	-262	2022	1730
DIESEL	-80	1283	1000	-465	1818	1578
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-74	1283	813	-1034	1062	1010
NATURAL GAS	-350	1283	813	-911	1185	1103
DIESEL	-277	1283	813	-1618	477	572
LOW-PRESSURE CENTER PIVOT						
ELECTRIC	-106	1283	813	-1487	608	670
NATURAL GAS	-504	1283	813	-1311	785	803
DIESEL	-399	1283	813	-2329	-233	39
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-91	1283	1000	-1272	1011	972
NATURAL GAS	-431	1283	1000	-1121	1162	1086
DIESEL	-341	1283	1000	-1992	291	432
LATERAL MOVE						
ELECTRIC	-180	1283	1000	-2513	-230	41
NATURAL GAS	-851	1283	1000	-2215	69	265
DIESEL	-674	1283	1000	-3935	-1652	-1025

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-105. Change in Energy Use, Levelized Costs, and Water Use for Utah

System: Instrumented Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE							
ELECTRIC	-2	1283	1000	-32	2251	1902	-20.80
NATURAL GAS	-11	1283	1000	-28	2255	1905	-20.80
DIESEL	-9	1283	1000	-51	2233	1888	-20.80
CENTER PIVOT							
ELECTRIC	-78	1283	813	-1084	1012	973	-65.00
NATURAL GAS	-367	1283	813	-955	1141	1069	-65.00
DIESEL	-291	1283	813	-1697	398	513	-65.00
TOWLINE, SIDE ROLL							
ELECTRIC	-78	1283	1000	-1086	1197	1112	-80.00
NATURAL GAS	-368	1283	1000	-957	1326	1209	-80.00
DIESEL	-291	1283	1000	-1700	583	651	-80.00
HAND MOVED							
ELECTRIC	-75	1283	1000	-1055	1228	1135	-80.00
NATURAL GAS	-357	1283	1000	-930	1354	1229	-80.00
DIESEL	-283	1283	1000	-1652	631	687	-80.00
AUTOMATED GATED PIPE							
ELECTRIC	-2	1283	1000	-26	2257	1907	-16.64
NATURAL GAS	-9	1283	1000	-23	2261	1909	-16.64
DIESEL	-7	1283	1000	-40	2243	1896	-16.64
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-12	1283	813	-165	1930	1662	-53.30
NATURAL GAS	-56	1283	813	-146	1950	1676	-53.30
DIESEL	-44	1283	813	-259	1837	1591	-53.30
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-31	1283	813	-429	1667	1464	-65.00
NATURAL GAS	-145	1283	813	-378	1718	1502	-65.00
DIESEL	-115	1283	813	-671	1425	1282	-65.00
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-15	1283	1000	-204	2080	1774	-65.60
NATURAL GAS	-69	1283	1000	-179	2104	1792	-65.60
DIESEL	-55	1283	1000	-319	1965	1687	-65.60
LATERAL MOVE							
ELECTRIC	-87	1283	1000	-1210	1073	1019	-80.00
NATURAL GAS	-410	1283	1000	-1066	1217	1127	-80.00
DIESEL	-324	1283	1000	-1895	388	505	-80.00

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-106. Change in Energy Use and Levelized Costs for Washington

Systems: Surged and Jetted Wells

Water Source: Groundwater

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
CONVENTIONAL WELL VS SURGED WELL ELECTRIC	-103	227	0	-5621	-335	-211
CONVENTIONAL WELL VS JETTED WELL ELECTRIC	-129	368	0	-705	-337	-187

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-107. Change in Energy Use and Levelized Costs for Washington

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, Reduced-Pressure Center Pivot, Redesign Pump and Variable Speed Pump

Water Source: Groundwater

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
GATED PIPE VS AUTOMATED GATED PIPE ELECTRIC	-253	2812	888	-1350	2349	2231
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE ELECTRIC	-733	975	228	-3904	-2701	-1863
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT ELECTRIC	-652	898	210	-3473	-2364	-1623
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT ELECTRIC	-366	0	0	-1953	-1953	-1465
GATED PIPE VS GATED PIPE WITH REDESIGNED PUMP ELECTRIC	-84	26	0	-450	-424	-314
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH REDESIGNED PUMP ELECTRIC	-92	26	0	-488	-462	-342
GATED PIPE VS GATED PIPE WITH VARIABLE SPEED PUMP ELECTRIC	-72	1027	400	-382	1044	954
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH VARIABLE SPEED PUMP ELECTRIC	-78	1027	400	-414	1013	930

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-108. Change in Energy Use and Levelized Costs for Washington

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, and Reduced-Low Pressure Center Pivot

Water Source: Surface Water

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
GATED PIPE VS AUTOMATED GATED PIPE ELECTRIC	-27	2812	886	-143	3556	3136
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE ELECTRIC	-570	975	228	-3036	-1832	-1212
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT ELECTRIC	-519	898	210	-2767	-1659	-1094
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT ELECTRIC	-366	0	0	-1953	-1953	-1465

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-109. Change in Energy Use and Levelized Costs for Washington

System: Computerized Scheduling

Water Source: Groundwater

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
GATED PIPE ELECTRIC	-62	0	800	-331	469	351
CENTER PIVOT ELECTRIC	-330	0	650	-1759	-1109	-832
TOWLINE, SIDE ROLL ELECTRIC	-373	0	800	-1987	-1187	-890
HAND MOVED ELECTRIC	-369	0	800	-1965	-1165	-873
SOLID SET ELECTRIC	-373	0	800	-1987	-1187	-890
AUTOMATED GATED PIPE ELECTRIC	-50	0	800	-265	535	401
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT ELECTRIC	-173	0	650	-924	-274	-205
REDUCED-PRESSURE CENTER PIVOT ELECTRIC	-242	0	650	-1289	-639	-479
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE ELECTRIC	-213	0	800	-1137	-337	-253
LATERAL MOVE ELECTRIC	-390	0	800	-2076	-1276	-957

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-110. Change in Energy Use, Levelized Costs, and Water Use for Washington

Systems: Computerized Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE ELECTRIC	-7	0	800	-35	765	574	-38.40
CENTER PIVOT ELECTRIC	-153	0	650	-816	-166	-125	-122.20
TOWLINE, SIDE ROLL ELECTRIC	-155	0	800	-827	-27	-20	-150.40
HAND MOVED ELECTRIC	-151	0	800	-805	-5	-3	-150.40
SOLID SET ELECTRIC	-155	0	800	-827	-27	-20	-150.40
AUTOMATED GATED PIPE ELECTRIC	-5	0	800	-28	772	579	-30.72
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT ELECTRIC	-28	0	650	-151	499	374	-100.20
REDUCED-PRESSURE CENTER PIVOT ELECTRIC	-65	0	650	-347	303	227	-122.20
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE ELECTRIC	-35	0	800	-186	614	461	-123.33
LATERAL MOVE ELECTRIC	-172	0	800	-916	-116	-87	-150.40

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-111. Change in Energy Use and Levelized Costs for Washington

System: Instrumented Scheduling

Water Source: Groundwater

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
GATED PIPE ELECTRIC	-52	1283	1000	-276	2007	1719
CENTER PIVOT ELECTRIC	-274	1283	813	-1459	636	691
TOWLINE, SIDE ROLL ELECTRIC	-309	1283	1000	-1649	635	690
HAND MOVED ELECTRIC	-306	1283	1000	-1630	653	704
SOLID SET ELECTRIC	-309	1283	1000	-1649	635	690
AUTOMATED GATED PIPE ELECTRIC	-41	1283	1000	-221	2062	1761
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT ELECTRIC	-144	1283	813	-767	1329	1211
REDUCED-PRESSURE CENTER PIVOT ELECTRIC	-201	1283	813	-1070	1026	983
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE ELECTRIC	-177	1283	1000	-944	1340	1219
LATERAL MOVE ELECTRIC	-323	1283	1000	-1722	561	634

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-112. Change in Energy Use, Levelized Costs, and Water Use for Washington

Systems: Instrumented Scheduling

Water Source: Surface Water

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>	<u>Water Use^(c)</u>
GATED PIPE ELECTRIC	-6	1283	1000	-29	2254	1904	-32.00
CENTER PIVOT ELECTRIC	-127	1283	813	-677	1418	1278	-101.40
TOWLINE, SIDE ROLL ELECTRIC	-129	1283	1000	-686	1597	1412	-124.80
HAND MOVED ELECTRIC	-125	1283	1000	-668	1616	1426	-124.80
SOLID SET ELECTRIC	-129	1283	1000	-686	1597	1412	-124.80
AUTOMATED GATED PIPE ELECTRIC	-4	1283	1000	-23	2260	1909	-25.60
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT ELECTRIC	-24	1283	813	-125	1970	1692	-83.15
REDUCED-PRESSURE CENTER PIVOT ELECTRIC	-54	1283	813	-288	1808	1570	-101.40
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE ELECTRIC	-29	1283	1000	-154	2129	1811	-102.34
LATERAL MOVE ELECTRIC	-143	1283	1000	-760	1523	1356	-124.80

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-113. Change in Energy Use and Levelized Costs for Wyoming

Systems: Surged and Jetted Wells

Water Source: Groundwater

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
CONVENTIONAL WELL VS SURGED WELL						
ELECTRIC	-28	146	0	-325	-179	-108
NATURAL GAS	-132	146	0	-355	-210	-131
DIESEL	-105	146	0	-637	-491	-343
CONVENTIONAL WELL VS JETTED WELL						
ELECTRIC	-35	287	0	-408	-121	-40
NATURAL GAS	-166	287	0	-446	-159	-68
DIESEL	-132	287	0	-799	-513	-334

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-114. Change in Energy Use and Levelized Costs for Wyoming

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, Reduced-Pressure Center Pivot, Redesigned Pump and Variable Speed Pump

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE VS AUTOMATED GATED PIPE						
ELECTRIC	-51	2812	888	-579	3121	2809
NATURAL GAS	-242	2812	888	-633	3066	2768
DIESEL	-192	2812	888	-1136	2564	2391
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-247	975	228	-2791	-1587	-1028
NATURAL GAS	-1168	975	228	-3052	-1849	-1224
DIESEL	-925	975	228	-5474	-4271	-3040
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-222	898	210	-2510	-1402	-902
NATURAL GAS	-1051	898	210	-2746	-1638	-1079
DIESEL	-832	898	210	-4924	-3816	-2712
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-140	0	-0	-1580	-1580	-1185
NATURAL GAS	-662	0	0	-1729	-1729	-1297
DIESEL	-524	0	0	-3100	-3100	-2325
GATED PIPE VS GATED PIPE WITH REDESIGNED PUMP						
ELECTRIC	-17	26	0	-193	-167	-121
NATURAL GAS	-81	26	0	-211	-185	-135
DIESEL	-64	26	0	-379	-353	-260
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH REDESIGNED PUMP						
ELECTRIC	-25	26	0	-284	-258	-189
NATURAL GAS	-119	26	0	-310	-285	-209
DIESEL	-94	26	0	-556	-531	-394
GATED PIPE VS GATED PIPE WITH VARIABLE SPEED PUMP						
ELECTRIC	-14	1027	400	-164	1263	1118
NATURAL GAS	-69	1027	400	-179	1247	1107
DIESEL	-54	1027	400	-321	1105	1000
CONVENTIONAL CENTER PIVOT VS CENTER PIVOT WITH VARIABLE SPEED PUMP						
ELECTRIC	-21	1027	400	-241	1186	1060
NATURAL GAS	-101	1027	400	-263	1163	1043
DIESEL	-80	1027	400	-472	954	887

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-115. Change in Energy Use and Levelized Costs for Wyoming

Systems: Automated Gated Pipe, Low-Energy Precision Application Lateral Move, Low-Energy Precision Application Center Pivot, and Reduced-Pressure Center Pivot

Water Source: Surface water

<u>System</u>	<u>Energy^(a) Use</u>	<u>Capital^(b) Cost</u>	<u>O&M^(b) Cost</u>	<u>Energy^(b) Cost</u>	<u>Total^(b) Cost</u>	<u>Aftertax^(b) Costs</u>
GATED PIPE VS AUTOMATED GATED PIPE						
ELECTRIC	-10	2812	888	-112	3588	3159
NATURAL GAS	-47	2812	888	-123	3577	3151
DIESEL	-37	2812	888	-220	3480	3078
CONVENTIONAL LATERAL MOVE VS LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-217	975	228	-2454	-1251	-775
NATURAL GAS	-1027	975	228	-2684	-1481	-948
DIESEL	-813	975	228	-4814	-3610	-2545
CONVENTIONAL CENTER PIVOT VS LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-198	898	210	-2237	-1129	-697
NATURAL GAS	-936	898	210	-2447	-1339	-854
DIESEL	-741	898	210	-4388	-3280	-2310
CONVENTIONAL CENTER PIVOT VS REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-140	0	0	-1580	-1580	-1185
NATURAL GAS	-662	0	0	-1729	-1729	-1297
DIESEL	-524	0	0	-3100	-3100	-2325

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-116. Change in Energy Use and Levelized Costs for Wyoming

System: Computerized Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE						
ELECTRIC	-12	0	800	-140	660	495
NATURAL GAS	-59	0	800	-153	647	485
DIESEL	-46	0	800	-275	525	394
CENTER PIVOT						
ELECTRIC	-91	0	650	-1028	-378	-284
NATURAL GAS	-430	0	650	-1125	-475	-356
DIESEL	-341	0	650	-2017	-1367	-1025
TOWLINE, SIDE ROLL						
ELECTRIC	-99	0	800	-1121	-321	-241
NATURAL GAS	-469	0	800	-1226	-426	-319
DIESEL	-371	0	800	-2198	-1398	-1049
HAND MOVED						
ELECTRIC	-97	0	800	-1103	-303	-227
NATURAL GAS	-462	0	800	-1206	-406	-305
DIESEL	-365	0	800	-2163	-1363	-1022
AUTOMATED GATED PIPE						
ELECTRIC	-10	0	800	-112	688	516
NATURAL GAS	-47	0	800	-123	677	508
DIESEL	-37	0	800	-220	580	435
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-37	0	650	-422	228	171
NATURAL GAS	-176	0	650	-461	189	142
DIESEL	-140	0	650	-827	-177	-133
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-57	0	650	-646	4	3
NATURAL GAS	-270	0	650	-707	-57	-43
DIESEL	-214	0	650	-1268	-618	-463
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-46	0	800	-519	281	211
NATURAL GAS	-217	0	800	-567	233	174
DIESEL	-172	0	800	-1018	-218	-163
LATERAL MOVE						
ELECTRIC	-105	0	800	-1193	-393	-295
NATURAL GAS	-499	0	800	-1305	-505	-379
DIESEL	-395	0	800	-2340	-1540	-1155

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-117. Change in Energy Use, Levelized Costs, and Water Use for Wyoming

System: Computerized Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE							
ELECTRIC	-2	0	800	-27	773	580	-14.40
NATURAL GAS	-11	0	800	-30	770	578	-14.40
DIESEL	-9	0	800	-53	747	560	-14.40
CENTER PIVOT							
ELECTRIC	-58	0	650	-661	-11	-8	-46.80
NATURAL GAS	-277	0	650	-723	-73	-55	-46.80
DIESEL	-219	0	650	-1296	-646	-485	-46.80
TOWLINE, SIDE ROLL							
ELECTRIC	-59	0	800	-669	131	98	-57.60
NATURAL GAS	-280	0	800	-732	68	51	-57.60
DIESEL	-222	0	800	-1312	-512	-384	-57.60
HAND MOVED							
ELECTRIC	-58	0	800	-651	149	112	-57.60
NATURAL GAS	-272	0	800	-712	88	66	-57.60
DIESEL	-216	0	800	-1276	-476	-357	-57.60
AUTOMATED GATED PIPE							
ELECTRIC	-2	0	800	-22	778	584	-11.52
NATURAL GAS	-9	0	800	-24	776	582	-11.52
DIESEL	-7	0	800	-43	757	568	-11.52
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-11	0	650	-120	530	397	-38.38
NATURAL GAS	-50	0	650	-132	518	389	-38.38
DIESEL	-40	0	650	-236	414	310	-38.38
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-25	0	650	-279	371	278	-46.80
NATURAL GAS	-117	0	650	-305	345	259	-46.80
DIESEL	-92	0	650	-547	103	77	-46.80
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-13	0	800	-148	652	489	-47.23
NATURAL GAS	-62	0	800	-162	638	478	-47.23
DIESEL	-92	0	800	-291	509	382	-47.23
LATERAL MOVE							
ELECTRIC	-65	0	800	-741	59	44	-57.60
NATURAL GAS	-310	0	800	-811	-11	-8	-57.60
DIESEL	-246	0	800	-1454	-654	-490	-57.60

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

TABLE A-118. Change in Energy Use and Levelized Costs for Wyoming

System: Instrumented Scheduling

Water Source: Groundwater

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs
GATED PIPE						
ELECTRIC	-10	1283	1000	-109	2174	1845
NATURAL GAS	-46	1283	1000	-119	2164	1837
DIESEL	-36	1283	1000	-214	2070	1766
CENTER PIVOT						
ELECTRIC	-76	1283	813	-857	1239	1143
NATURAL GAS	-359	1283	813	-937	1159	1083
DIESEL	-284	1283	813	-1681	415	525
TOWLINE, SIDE ROLL						
ELECTRIC	-83	1283	1000	-934	1349	1226
NATURAL GAS	-391	1283	1000	-1022	1262	1160
DIESEL	-309	1283	1000	-1832	451	552
HAND MOVED						
ELECTRIC	-81	1283	1000	-919	1364	1237
NATURAL GAS	-385	1283	1000	-1005	1278	1173
DIESEL	-304	1283	1000	-1802	481	575
AUTOMATED GATED PIPE						
ELECTRIC	-8	1283	1000	-87	2196	1861
NATURAL GAS	-36	1283	1000	-95	2188	1855
DIESEL	-29	1283	1000	-171	2112	1798
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT						
ELECTRIC	-31	1283	813	-351	1745	1522
NATURAL GAS	-147	1283	813	-384	1712	1498
DIESEL	-116	1283	813	-689	1407	1269
REDUCED-PRESSURE CENTER PIVOT						
ELECTRIC	-48	1283	813	-539	1557	1382
NATURAL GAS	-225	1283	813	-589	1507	1344
DIESEL	-178	1283	813	-1056	1039	993
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE						
ELECTRIC	-38	1283	1000	-432	1851	1602
NATURAL GAS	-181	1283	1000	-473	1810	1572
DIESEL	-143	1283	1000	-848	1435	1290
LATERAL MOVE						
ELECTRIC	-88	1283	1000	-994	1289	1181
NATURAL GAS	-416	1283	1000	-1087	1196	1111
DIESEL	-329	1283	1000	-1950	333	464

(a) Million Btu/year.

(b) 1980 dollars/year.

TABLE A-119. Change in Energy Use, Levelized Costs and Water Use for Wyoming

System: Instrumented Scheduling

Water Source: Surface Water

System	Energy ^(a) Use	Capital ^(b) Cost	O&M ^(b) Cost	Energy ^(b) Cost	Total ^(b) Cost	Aftertax ^(b) Costs	Water Use ^(c)
GATED PIPE							
ELECTRIC	-2	1283	1000	-21	2262	1911	-11.20
NATURAL GAS	-9	1283	1000	-23	2260	1909	-11.20
DIESEL	-7	1283	1000	-41	2242	1895	-11.20
CENTER PIVOT							
ELECTRIC	-49	1283	813	-551	1545	1373	-39.00
NATURAL GAS	-231	1283	813	-602	1493	1334	-39.00
DIESEL	-133	1283	813	-1080	1015	975	-39.00
TOWLINE, SIDE ROLL							
ELECTRIC	-49	1283	1000	-557	1726	1508	-48.00
NATURAL GAS	-233	1283	1000	-610	1674	1469	-48.00
DIESEL	-185	1283	1000	-1093	1190	1106	-48.00
HAND MOVED							
ELECTRIC	-48	1283	1000	-542	1741	1520	-48.00
NATURAL GAS	-227	1283	1000	-593	1690	1481	-48.00
DIESEL	-180	1283	1000	-1064	1220	1129	-48.00
AUTOMATED GATED PIPE							
ELECTRIC	-1	1283	1000	-17	2266	1914	-8.96
NATURAL GAS	-7	1283	1000	-18	2265	1912	-8.96
DIESEL	-6	1283	1000	-33	2250	1902	-8.96
LOW-ENERGY PRECISION APPLICATION, CENTER PIVOT							
ELECTRIC	-9	1283	813	-100	1995	1710	-31.98
NATURAL GAS	-42	1283	813	-110	1986	1703	-31.98
DIESEL	-33	1283	813	-197	1899	1638	-31.98
REDUCED-PRESSURE CENTER PIVOT							
ELECTRIC	-21	1283	813	-233	1863	1611	-39.00
NATURAL GAS	-97	1283	813	-254	1841	1595	-39.00
DIESEL	-77	1283	813	-456	1640	1444	-39.00
LOW-ENERGY PRECISION APPLICATION, LATERAL MOVE							
ELECTRIC	-11	1283	1000	-124	2160	1834	-39.36
NATURAL GAS	-52	1283	1000	-135	2143	1825	-39.36
DIESEL	-41	1283	1000	-242	2041	1745	-39.36
LATERAL MOVE							
ELECTRIC	-55	1283	1000	-618	1666	1463	-48.00
NATURAL GAS	-259	1283	1000	-676	1608	1420	-48.00
DIESEL	-205	1283	1000	-1211	1072	1018	-48.00

(a) Million Btu/year.

(b) 1980 dollars/year.

(c) Acre-inches/year.

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