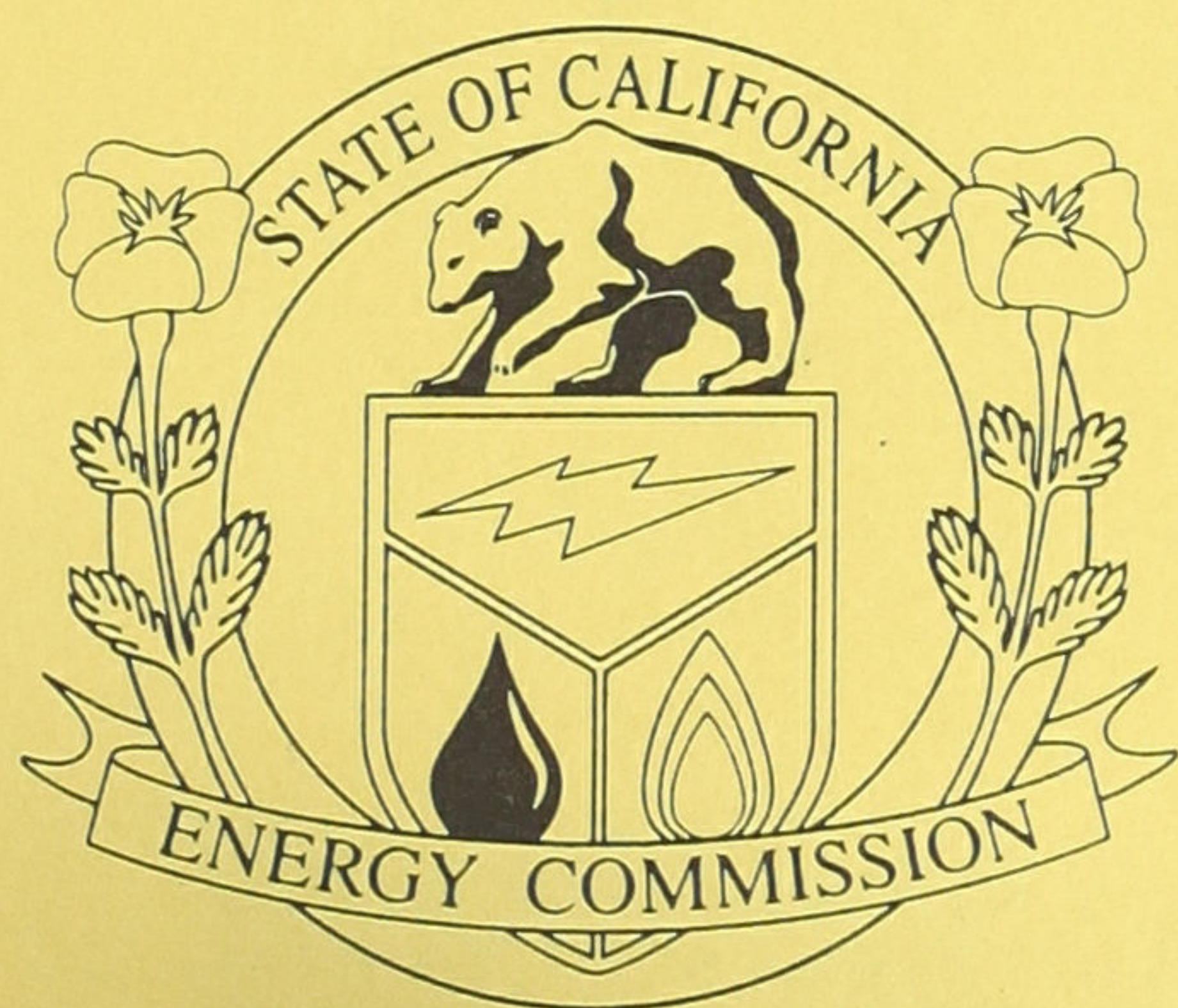


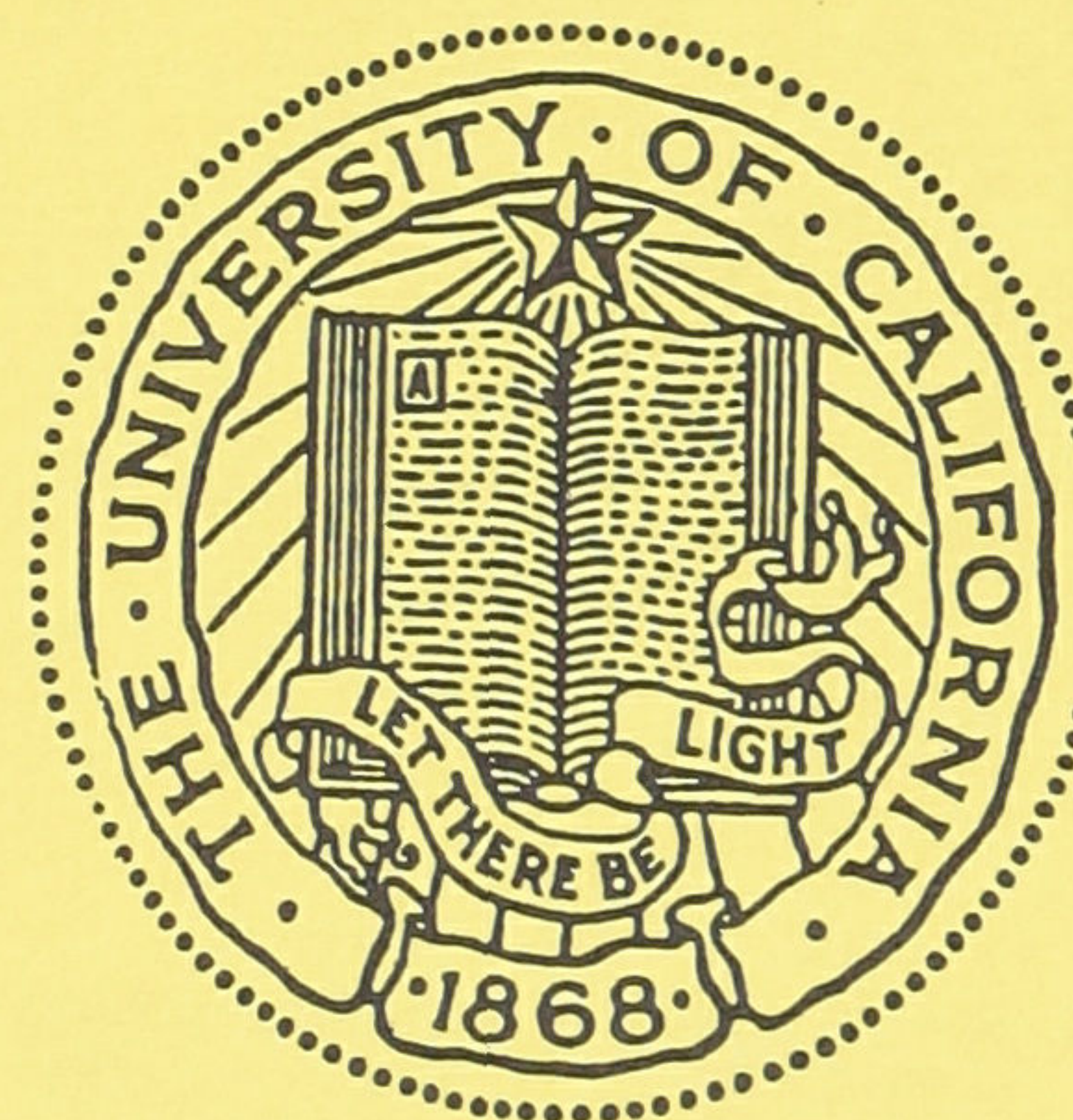
Using Solar Energy to Pump Water for Livestock in Remote Areas

Ralph L. Phillips

James L. Sullins



State of California
Energy Commission



Univeristy of California
Cooperative Extension

The solar project is a cooperative effort of the following:

*State of California Energy Commission
University of California Cooperative Extension
Snedden Ranch
Bar Mt. Ranch
Shield F. Ranch*

*San Bernardino County Range Improvement Committee
Kern County Section 15 Grazing Advisory Committee*

The Bar Mountain Solar System

County
r

of our rangelands. In most
ing rates by more uniform
the leading cause of poor

When watering sites are
ur (Holechek, et al. 1989).
sites with use dropping off
d Woolfolk 1953, Mueggler
s traveled to water can use
l for grazing and rest, as well
on potential (Holechek et al.
ording to the terrain, breed,
to 2.0 miles in flat country
distribution systems could
of our rangelands.

e or 300 sheep (Holechek, et
ization and increase livestock
d operating expenses often
cent technological advances

and generators to pump water
approached the University of
formation on the use of solar
had excellent cost records for
management was sure that
anted to design a project to

into a cooperative project
ngeland. The ranch supplied
alifornia Energy Commission
Cooperative Extension, Kern
and several solar equipment
d with the ranch in collecting

Errata Sheet 1

Using Solar Energy to Pump Water for Livestock in Remote Areas

Ralph L. Phillips
James L. Sullins

Literature Cited

BARNES, W.C. 1914. Stock-watering places on western grazing lands. U.S. Dept Agri Farmers Bull. 592.

BECK R.F. 1978. A grazing system for semiarid lands. Proc. Int. Rangel. Congr. 1:569-572.

HOLECHEK, J.L., R.D. PIEPER AND C.H. HERBEL. 1989. Range management principles and practices. SF85 H56 1989 ISBN 0-13-752791-8.

HOLSCHER, C.E., AND E.J. WOOLFOLK. 1953. Foraging utilization by cattle on northern Great Plains ranges. U.S. Dept Agri Cir. 918.

MUEGGLER, W.F. 1965. Cattle distribution on steep slopes. J. Range Manage 18:255-257.

VALENTINE, K.A. 1947. Distance from water as a factor in grazing capacity of rangeland. J. For. 10:749-754.

The ranch personnel participated in the project design. Shadow patterns around each well site were identified. This required considerable time; however, it is essential to find areas

The Bar Mountain Solar System

Ralph L. Phillips, Livestock Advisor-Kern County

Jim L. Sullins, Area Livestock Advisor

Uneven use of rangeland by livestock is a problem on much of our rangelands. In most cases, we can improve range condition without reducing stocking rates by more uniform range utilization. On most ranges poor water distribution is the leading cause of poor livestock distribution, resulting in uneven range utilization. When watering sites are infrequent, large sacrifice areas around water sites often occur (Holechek, et al. 1989). Studies have shown up to 100% use of forage around water sites with use dropping off rapidly as distance from the water site increases (Holscher and Woolfolk 1953, Mueggler 1965, Valentine 1947, Beck 1978). In addition, long distances traveled to water can use energy needed for weight gain and milk production, time needed for grazing and rest, as well as increasing the number of trails which may increase the erosion potential (Holechek et al. 1989). Recommended distances between water sites vary according to the terrain, breed, and type of animal; varying from 0.5 miles in rough country to 2.0 miles in flat country (Barnes 1914; Holechek, et al. 1989). Water pumping and distribution systems could improve range utilization and livestock performance on much of our rangelands.

Numerous small water sites planned for approximately 50 cattle or 300 sheep (Holechek, et al. 1989) properly spaced will improve range condition and utilization and increase livestock performance. Large expensive traditional systems and related operating expenses often make water development cost ineffective and impractical. Recent technological advances may make solar pumping systems cost effective alternatives.

Historically, the Bar Mountain Ranch used gasoline engines and generators to pump water where grid power was not available. Early in 1989, the ranch approached the University of California Cooperative Extension in Kern County requesting information on the use of solar energy (photovoltaic) for pumping livestock water. The ranch had excellent cost records for pumping water using gasoline engines and generators. Ranch management was sure that solar power could pay for itself in two to three years and wanted to design a project to compare traditional pumping with solar pumping.

Bar Mountain Ranch and Cooperative Extension entered into a cooperative project demonstrating the use of solar power for pumping water on rangeland. The ranch supplied all of the equipment capital and labor for the project. The California Energy Commission has provided used solar panels and some capital for supplies. Cooperative Extension, Kern County, has coordinated information between the ranch and several solar equipment manufacturers. The Kern County Farm Advisor has cooperated with the ranch in collecting data and extending the information to interested parties.

Pump Design

The ranch personnel participated in the project design. Shadow patterns around each well site were identified. This required considerable time; however, it is essential to find areas

free of shadows. Shadow patterns should be checked at different times of the year throughout the day because shadowed areas change with seasons of the year. A small shadow in the right location on a panel may reduce pumping by as much as 50%.

Water use data and well data needed to design the systems were collected by ranch personnel. Cattle water requirements was the first information needed. This information was developed using previous water use and cattle numbers.

Second, well data was needed. The most important information is the static water level in the well. Static water level is the distance down the well that the water level maintains while the well is being pumped. Next, water lift must be determined, this is the height (lift) from the static water level to where water will be discharged (total dynamic lift or head). Ranch management used this information to determine the types of pumps they needed. All of this information was given to a solar energy consultant and equipment distributor who consulted with several solar energy companies before designing the systems. All of the solar water systems were equipped with large capacity water storage tanks. Storage tanks were used because it is cheaper to store water than it is to use batteries to store energy to pump water when there is restricted or no sunlight. Also, a large storage capacity can provide water during equipment maintenance periods or periods of increased water use.

Pumping Systems

The Bar Mountain Ranch project consists of three types of water systems with four different types of pumps. The following will be a discussion of each of the systems.

Grundfos System

The well at this site is 100 ft. deep, and the static water level is 60 ft. The pump is set at 80 ft. with a total dynamic lift of 75 ft. The maximum flow was calculated to be six gallons/minute. Actual maximum yields is eight gallons/minute.

The pump is an 18 stage centrifugal, equipped with a three phase AC motor. The system requires AC current, therefore, an inverter is needed to convert the solar panel's DC current to AC current. In addition, the controller is designed to allow low power pumping (during periods of low light) by use of phases. The controller allows the pump to operate at less than full sunlight.

The pump is constructed of stainless steel. It is rated at 14 gallons/minute. Fourteen, 53 watt solar panels would be required to run the pump at full capacity; however, the ranch only needs six gallons a minute to meet its needs, and only seven solar panels were used. (The pumping system is designed to use seven or fourteen, 53 watts panels.)

The solar panels are mounted on an eight panel tracker. The tracker is designed to follow the sun from east to west during the day, thereby, increasing water yields through longer pumping periods. The use of a tracker allows the pump to start earlier and run later in the day.

This system is equipped with an electronic float switch in the storage tank. When the water storage tank is full, power to the pump is switched off and when the water level in the tank is low, the power to the pump is switched on. A float switch is a must to conserve water.

Since the system was installed, July 27, 1989, it has worked with only one minor problem. The problem was related to designing the system with seven panels, which is at its minimum capacity and solar panel efficiency. Solar panels (particularly the older models used in this demonstration) produce less power if they become hot. The panel power output was too low, and the pump could not come up to its full power if the pump was stopped during the heat of the day. The panel's angle was set to receive the maximum sunlight--they were almost horizontal. It was thought that the horizontal setting would give maximum power output; however, this setting increased panel heat and reduced power output.

The pump company was notified of the problem; however, local experts could not solve the problem and they had to inquire in Europe (where the pump was designed and built) for a solution, this took about three weeks.

In the meantime, an electrical engineer from southern California became aware of the problem and suggested that the angle of the panels be set at 30° plus latitude. This was done and the problem was resolved. The steeper angle of the panels creates a chimney effect, and the resulting increased air flow over the panels reduces the panel temperature into operating range.

Table 1 shows the cost of this system. Labor for installation was not included. It was decided that labor costs vary from ranch to ranch and would contribute little to the table.

The major cost of this system is the pump and the solar panels, accounting for 75% of the cost of the system. The pump for this system is very good, but very expensive, and the electronics are very complicated. A rancher planning to do his own installation and repairs might be wise to consider a simpler pump system.

Tests were conducted during the summer and late fall to evaluate the benefits of using a tracking system. Pump flow rates, in gallons per minute, were taken every 15 minutes from the time the pump started in the morning, until the pump stopped in the evening. Total gallons of water pumped in one day were calculated using the gallons per minute readings throughout the day.

Water yield data was collected on June 26, 1990 while the tracker was operating (See Figure 1). The same type of data was collected on July 2, 1990 while the panels were not allowed to track (non-tracking). During tracking the pump started working at 7:30 a.m. and continued until 7:30 p.m. When the system was not tracking, the pump started at 7:45 a.m. and stopped at 5:45 p.m. There was about a two-hour difference in pumping time. The most important difference between tracking and non-tracking is the gallons of water per day. Tracking produced 5,268 gallons as compared to 3,912 gallons for non-tracking. This is an increase of 1,356 gallons or 25.7%.

The same tests were conducted in November. Tracking produced 3,380 gallons while non-tracking produced 3,010 gallons. Tracking increased water yields by 370 gallons or 10.9%. This data would suggest that trackers have a greater advantage in the summer than in the fall.

There was a 35.8% drop in water yield between summer tracking and fall tracking. This drop is due to the decrease in hours of sunlight. These tests were conducted on cloudless days. Water yields would drop even more in December with shorter days and a potential of increase in cloud cover. Wells located in foggy areas will experience even a greater drop in water yields. When designing water systems for year round use, water yields should be calculated for both the high and low seasons for both pumping capability and water demand. This may be difficult, for example comparing winter yields with summer yields under the different weather conditions.

Solarjack - Econo Sub-pump

This well is 100 ft. deep and the static water level is 40 ft. The pump is set at 90 ft. and the total dynamic lift is 50 ft. The maximum water flow is 1.75 gallons/minute.

The pump is a DC submersible diaphragm type pump (positive displacement) rated at two gallons/minute at 50 ft. of lift or less. Two, 53 watt panels provide enough power for maximum flow. A 3/8 nylon cord is used to suspend the pump at the desired depth, and the pump discharge can be plumbed with iron, PVC or poly pipe. The discharge pipe for this system is poly pipe. The two solar panels are mounted on a two panel tracker.

The solar panels are the most expensive part of this system (See Table 2). The pump is relatively inexpensive. These two components of the system account for about 68% of the cost of the system.

This system was installed on July 27, 1989. During the next six months, there were some problems with the pump and the tracker unit. Shortly after the pump was installed, it was discovered that the well was dirty (sand was being pulled into the pump). This type of pump, as installed, could not tolerate "dirty" water. The manufacturer stood behind the pump and replaced it at no charge.

Next, a shroud made of PVC pipe was installed over the pump. This addition helped, but did not resolve the problem, and a second pump was damaged. Once again, the manufacturer stood behind the pump and replaced it at no charge. A third pump was installed with a pipe shroud, and this time the end of the pipe was covered with a fine mesh screen. This appears to have resolved the problem, and the pump has been working fine for over one year. The original controller for this system was poorly designed. Since that time, the manufacturer replaced the original controller with an improved design.

The tracker stopped tracking for no apparent reason. The factory representative could not find an apparent problem, but it was replaced at no additional charge.

TABLE 1
TABLE 1
TABLE 1

The system has been fully operational since these corrections were made. It appears that this system will pump about 1,000 gallons of water per day. This is enough water for a herd of about 50 cows. This system demonstrated that it is critical to ensure that the water coming into the pump is clean.

Solarjack Jack Pump and Piston Pump System

This water system uses two types of pumps--one is a jack pump and the other is a triplex piston pump. The jack pump pulls the water out of the well and pushes it up into a 10,000 gallon storage tank. The piston pump is plumbed into the storage tank outlet. The piston pump then pushes water one mile with 450 ft. of lift. The water pumped by the piston pump is stored in a second 10,000 gallon tank at the top of a hill 450 ft. above the first tank.

This system was designed to demonstrate that water can be pushed to a higher elevation and stored in a tank for future use. The water from the upper tank can then be moved and redistributed to the lower elevations by gravity. No additional energy will be needed for water distribution at the lower elevations. The water at the higher elevation has the potential to improve forage utilization by increasing cattle distribution.

Jack Pumps

This well is 60 ft. deep and the pump is set at 40 ft. with a static water level of 20 ft. The total dynamic lift is 100 ft. and the maximum flow rate is 6.5 gallon/minute.

The counterweight jack pump is equipped with a 2.5 inch diameter open top cylinder pump. Five, 53 watt solar panels are required to operate the DC motor that drives the jack pump. The water level in the lower tank is controlled by an electronic float switch that is connected to the jack pump controller.

The two major cost factors of this system are the jack pump and the solar panels. The cost break down for the jack pump are shown in **Table 3**.

The jack pump was installed in the summer of 1990 and has operated with very few problems. The pump had limited use because of time and cattle management due to the drought.

The open cylinder pumping system has several advantages when compared to a standard jack pump system. The greatest advantage is that the "down hole" pipe does not need to be pulled to replace pump leathers. The pump can be pulled with the sucker rod. The expense of bringing in someone to pull the pump is eliminated with this system. However, the initial cost of the down hole pipe is a little more expensive. There is 40 ft. of 3 in. galvanized pipe down the well. A one and one-quarter inch pipe would have been used with the old type pump.

Piston Pump

The cost of this system is significantly higher because of the plumbing (See Table 4). Schedule 80 PVC pipe was used because of the high pressure generated in this system. The line pressure is about 200 psi at the pump. Also, there was an added expense of air release valves. These valves had to be installed to allow air trapped in high places in the pipe line to escape. When laying out pipe line, it is very advantageous to minimize high or low spots in the line--the fewer high spots, the fewer air release valves needed.

The water level in the upper tank is controlled with a pressure "kill switch". A float valve in the upper water tank shuts the water off when the tank is full. The pressure builds up in the water line, and when the pressure reaches the set pressure the motor is stopped. So far, this system has worked very well.

Triplex piston pumps are quite expensive for the volume of water they will move. They are designed to move water long distances with great lifts. The pump can develop pressures up to 1,500 psi--permitting the high lifts.

The pump requires ten, 53 watt solar panels to run the DC motor. The system is designed to deliver about two gallons/minute with a one mile run and a 450 ft. lift.

A piston pump has highly machined pistons that will not tolerate any dirt. Small amounts of dirt will score the piston sleeve and greatly reduce pump efficiency. A filter is mandatory to ensure that only clean water enters the pump.

Controller management is a valuable lesson learned with this system. The controllers on other systems in this demonstration were placed in the shade (by luck--not planning). The controller in this system was placed in full sunlight. The piston pump was hooked up on a hot day. Shortly afterwards, the power was turned on and soon the system stopped. After checking the system out, it was discovered that the controller had overheated and burned up. The manufacturer replaced the controller at no charge. Upon further investigation, it was found that the controller must be protected from direct sunlight. The controller itself generated heat and the additional heat from the direct sun causes it to overheat. Based on our experience and advice from manufacturers, controllers must be put in a shaded location that can provide good air movement.

Very recently a new controller has been introduced that will shut down the system when temperatures get too high, preventing the controller from burning up. However, this new controller does not solve the problem of pumping water on hot days. Even the new controllers should be put in shade to permit them to run on hot days when water needs are high.

Conclusion:

Solar energy for pumping water on rangeland has great potential and solar equipment technology is improving rapidly. The information gained from this project and other will help solve some of the minor problems associated with solar systems today. Solar energy is a sound technology, but not all of the application problems have been solved.

TABLE 1

GRUNDFOS PUMPS AND SYSTEM COST

1 - Grundfus Pump 1 HP	\$ 2,398.00
1 - 8 Panel Tracker	720.00
7 - 53 Watt Solar Panels @ 350.00	2,450.00
1 - Electrical Cable and Controller	230.00
Float Switch	30.00
Solar Stand and Cement	30.00
PVC Pipe for Wire	34.00
Wire from Panels to Controller	15.00
Freight	64.00
Tax	199.00
TOTAL	\$ 6,170.00

*Cost of labor for installation not included

Well and System Data

Pump type	-	Centrifugal (18 stage) AC motor, (3 phase)
Well depth	-	100 ft
Pump set at	-	80 ft
Static water level	-	60 ft
Lift	-	75 ft
Maximum flow rate	-	8 gallons/min.

July

hrs. pumping tracking	-	12 hrs.
Gallons of water/day tracking	-	5268 gallons
hrs. pumping non-tracking	-	10 hrs.
Gallons of water/day non-tracking	-	3912 gallons

November

hrs. pumping tracking	-	7.75 hrs.
Gallons of water/day tracking	-	3380 gallons
hrs. pumping non-tracking	-	8 hrs.
Gallons of water/day non-tracking	-	3010 gallons

FIG. 1: GRUNDFOS PUMP TRACKING VS NON-TRACKING

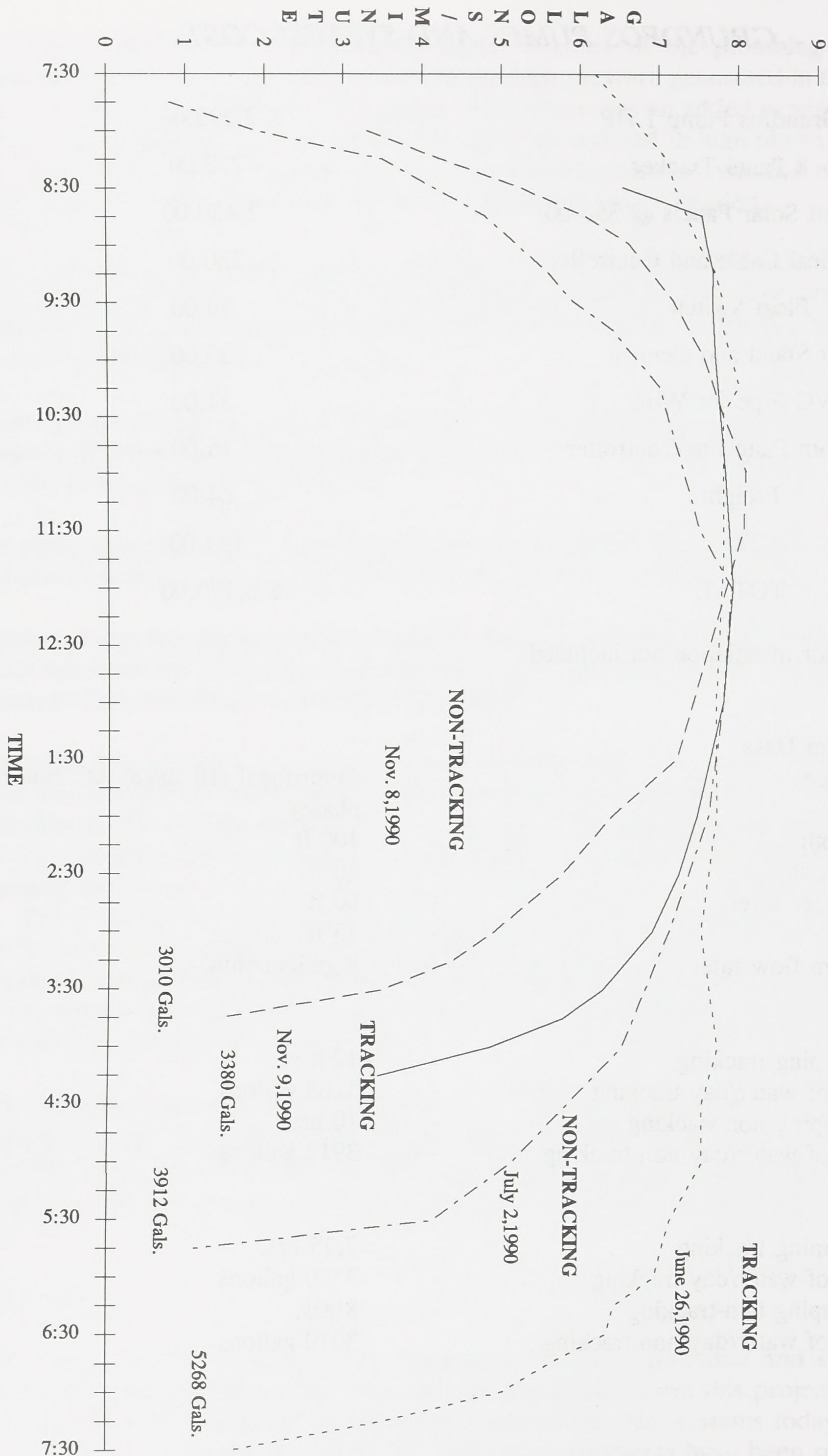


TABLE 2***SOLARJACK ECONO SUB-PUMP COSTS***

1 - Econo Sub-pump	\$ 560.00
1 - LCB 24 VDC (Controller)	66.00
1 - 2 Panel Tracker	260.00
1 - Strainer and Check Valve	21.00
2 - 53 Watt Solar Panels @ \$350.00 each	700.00
160 ft Discharge Hose, 250 psi	44.00
Electrical Wire	52.00
Solar Stand Pipe and Cement	30.00
Freight	56.00
<i>Tax</i>	<i>56.00</i>
<i>TOTAL</i>	<i>1,845.00</i>

* Cost of labor for installation is not included

Well and System Data

Pump Type	-	Diaphragm, DC Motor
Well Depth	-	100 ft.
Pump Set	-	90 ft.
Static Water Level	-	40 ft.
Lift	-	50 ft.
Maximum Flow	-	1.75 gallons/minute

TABLE 3

SOLARJACK PUMP SYSTEM COSTS

1	-	Jack Pump	1695.00
1	-	Polished Rod	68.00
1	-	Packing Gland	65.00
1	-	Rod Adaptor	20.00
2	-	Fiberglass Sucker Rods	101.00
1	-	Float Switch	30.00
1	-	Cylinder	320.00
1	-	Sucker Rod Splice Kit	39.00
1	-	Sand Filter	130.00
260 ft	-	2" Sch 40 PVC @ .48¢/ft	125.00
800 ft	-	Underground Wire @ .42¢/ft	336.00
40 ft	-	3" Galvanized Pipe	184.00
Miscellaneous plumbing and glue			96.00
5	-	53 Watt Solar Panels @ 350.00 each	1750.00
1	-	Storage Tank (10,000 gallons)	600.00
1	-	Solar Panel Rack and Posts	275.00
Concrete Pad and Fence			200.00
Trenching 200 @ .15¢/ft			30.00
Tax			150.00
TOTAL			6,214.00

*Cost of labor for installation not included

Well Data

Well depth	-	60 ft.
Pump set	-	40 ft.
Static water level	-	20 ft.
Lift	-	100 ft.
Maximum flow	-	6.5 gallons/minute

Table 4**TRIPLEX PISTON PUMP COSTS**

1	-	Triplex Piston Pump	\$1727.00
1	-	Check Valve	22.00
1	-	Oil Filled Pressure Gauge	22.00
1	-	Relief Valve	30.00
1	-	Pressure Tank	204.00
1	-	Pressure Switch	50.00
5600 ft	-	Sch 80 PVC Pipe with Couplers	2,245.00
200 ft	-	Underground Wire	84.00
1	-	1 ¼ Check Valve Brass	48.00
1	-	Filter	35.00
8	-	Air Relief Valves @ \$160.00	1280.00
1	-	Storage Tank, 10,000 gallons	600.00
1	-	10 Solar Panel Rack and Posts	545.00
10	-	53 Watt Solar Panels @350.00	3500.00
Miscellaneous fittings and glue			120.00
Trenching			780.00
Concrete Pad and Fence			200.00
Tax			273.00
TOTAL			11,765.00

*Cost of labor for installation is not included

System Data

Length of Pipe (run)	-	1 mile
Lift	-	450 ft.
Maximum flow	-	2.4 gallons/minute

ACTUAL RANCH CASH COST FOR PUMPING

Ralph L. Phillips, Livestock Advisor - Kern County
James L. Sullins, Area Livestock Advisor

The Bar Mt. Ranch is an excellent place to do field demonstrations. The management keeps very accurate records of costs and production. Their pumping expense records have been used to develop the following comparisons of cash cost for gasoline engines and solar power. A direct comparison of the use of gasoline engines and solar was not made at the same time, but a comparison was made under the same conditions at different times.

Some background information is needed in order to understand the comparison. The same pasture was used in the comparison. The water sources for the pasture are: two well sites, an old windmill and a live spring. One hundred and fifty cows grazed the pasture for the comparison.

Gasoline Engine Period

The gasoline engine records were collected from October 1, 1988 to July 27, 1989. The ranch started out with two jack pumps powered with gasoline engines at the two well sites. Records were kept on gasoline used and labor needed to start the pumps each day.

On November 11, 1988, one of the jack pumps broke down and was replaced with a submersible pump, powered with a gasoline generator. The second jack pump broke on February 20, 1989 and was not repaired or replaced. The windmill pumped water during this same time period.

Labor to repair or maintain the gasoline engines was not added into the cash costs of running the gasoline engine systems. Each round trip was seven miles from the ranch headquarters. The ranch management drove a jeep on each of the trips to the pumps. A value of \$10.00 was charged to each trip. Daily trips were made to start the engines.

Solar Power Period

Solar powered units were installed at the two well sites on July 27, 1989. The solar units replaced the two pumps powered by gasoline engines.

Ranch management has checked the solar units every other day since they were installed. Other ranchers who have used solar powered pumps feel that they can go three to four days without checking pumps and still not have water problems. However, the amount of water storage at the pump sites will be a big factor in determining how often a pump should be checked.

Cost Comparison

The major cash costs of either system was labor. Labor costs for the solar unit were about half those for the gasoline powered system (\$1,500.00 vs. \$2,990.00). The gasoline cost for the old system was only \$269.50. Total cash cost for the gasoline engine systems for 299 days was \$3,259.50 or \$10.90 per day (\$2,990.00 plus \$269.50), and \$1,500.00 or \$5.01 per day for the solar units. This amounts to a savings of \$1,759.50 or \$5.88 per day. These savings in cash costs could pay for both solar units in about 4.5 years.

Table 1 shows the cash cost of operating the gasoline engine powered systems vs. the cash cost for solar powered systems.

TABLE 1***Actual Cost of Pumping Water Using Old System Vs. Solar System******Gasoline Engine System (299 days)***

Gasoline 269.5 gallons at \$1.00/gallon	\$ 269.50
299 Trips to start pumps @ \$10.00/trip	\$2,990.00
TOTAL	\$3,259.50
Cost per Day	\$ 10.90

Solar Systems (299 days)

150 Trips (every other day) to check water system at \$10.00 per trip	
(Ranchers Choice)	\$1,500.00
TOTAL	\$1,500.00
Cost per Day	\$ 5.01

Cash savings over 299 days old system vs. solar	\$1,759.50
Savings per Day	\$ 5.88

In accordance with applicable State and Federal laws and University policy, the University of California does not discriminate in any of its policies, procedures, or practices on the basis of race, religion, color, national origin, sex, marital status, sexual orientation, age, veteran status, medical condition, or handicap. Inquiries regarding this policy may be addressed to the Affirmative Action Director, University of California, Agriculture and Natural Resources, 300 Lakeside Drive, 6th Floor, Oakland, CA 94612-3560. (415) 987-0097.

AN ECONOMIC COMPARISON OF FOUR DIFFERENT WATER PUMPING SYSTEMS

Ralph L. Phillips, Livestock Farm Advisor - Kern County

James L. Sullins, Area Livestock Advisor

A direct comparison of different types of water pumping systems is very difficult. It is hard to find two or three systems that are operating under similar conditions. The following is a discussion comparing a submersible pump powered with a gasoline generator, a submersed pump powered by solar energy, a jack pump powered by a gasoline engine and a jack pump powered with solar energy.

The comparisons should be made under a set of similar conditions. The conditions for this comparison were based on field data collected on the Bar Mountain Ranch and recommendations from equipment manufacturers. The following is a list of conditions used in this discussion:

1. Provide water for 150 cows for one year - 573,525 gallons or about 10.5 gallons per cow per day. The seasonal difference in water needs by the cattle were used in calculating the total water needed.
2. The lift for the water was 50 feet.
3. The gasoline engines consumed one-half gallon of gasoline per hour.
4. Oil was changed in the engines after 100 hours of operation.
5. Engines were overhauled after 1500 hours of operation.
6. Leathers on jack pumps were replaced every two years.
7. The necessary plumbing was already present at well site to accommodate the pump used.
8. The rancher did all the work and his labor was not charged against the operation.
9. The wells were within five miles of the home place, and labor and vehicle operating costs did not exceed \$10.00 per trip to well site.
10. Oil was valued at \$1.00 per quart and gasoline at \$1.25 per gallon.
11. Labor to clean solar panels was valued at \$10.00 per hour and panels were cleaned on routine trips to check the water systems.
12. Investment costs were calculated at 8% opportunity cost.

Cost comparisons:

Jack pumps: The initial equipment cost for the solar system was higher than the initial equipment cost of the gasoline system (\$3,720.00 vs. \$1,340.00). The major portion of the higher cost was solar panels (\$1,750.00). Also, a non-solar jack pump of equal quality to the solar jack pump could not be located for this comparison. This would account for some of the additional costs to the solar system.

The repair costs per year were lower for the solar system when compared to the gasoline engine system (\$30.00 vs. \$380.00). Over a ten year period they would add up to be \$3,800.00 for the engine system and \$300.00 for the solar - a difference of \$3,500.00 between the two systems.

The operating costs per year for the gasoline system were \$4,668.75 as compared to \$1,200.00 for the solar system, a difference of \$3,468.75.

The yearly cash cost savings for the solar system vs. gasoline engine system is \$3,738.75, which will more than offset the difference in initial equipment cost and it would pay for itself in one year.

Submersible pumps: Again, the initial cost of equipment is higher for solar equipment when compared to a gasoline generator (\$6,170.00 vs. \$1,200.00). The cost of the solar power pump is much higher than the generator powered pump (\$2,398.00 vs. \$750.00). The solar powered pump is rated as a better pump but many ranchers would question if it is that much better.

The repair costs would be much lower for the solar system. The more expensive pump should run longer without repairs than the less expensive pump. However, the repair costs for a gasoline generator would be about \$350.00 per year.

The yearly operating cost for the generator system would be \$4,210.00 as compared to \$1,280.00 for the solar system. The difference in yearly operating costs for the two systems is \$2,930.00.

Even with the greater equipment cost for the solar system, it would pay for itself in two years through reduced operating costs.

Generally speaking, the initial cost of solar pumping systems are more expensive than gasoline engine powered systems. However, the savings in operating costs will pay for a system in one to two years.

The following projected cost sheets will give a more detailed economical breakdown of the comparisons.

PROJECTED COSTS

Solar Jack Pump

Equipment Costs

1	Jack pump, motor and controller (life expectancy 15 years)	\$1,695.00
5	53 watt solar panels @ \$350 each (life expectancy 20 years)	1,750.00
1	Solar panel rack and posts	275.00
Total		\$3,720.00

Depreciation plus Interest

Jack pump	\$ 197.98
Solar panels	179.15
Solar panel rack and post	28.00
Total	\$ 405.13

Repair Costs

Pull pump and replace leather every two years using open top cylinders	\$ 30.00
Total	\$ 30.00

Operating Costs

122 Trips (every three days @ \$10/trip	\$1,220.00
Clean panels 12 times/year (1/2 hours @ \$10/hour)	60.00
Total	\$1,280.00

Cost per day	\$ 3.50
Cost per gallon of water	.002
Cost per cow per day	.023

150 cows for one year: an average of 10.5 gallons of water/cow/day

Rancher installed equipment using existing plumbing

PROJECTED COSTS **Jack Pump Powered with 3.5 HP Gasoline Engine**

Equipment Costs

1	Jack pump with 3.5 HP gasoline engine rated @ 6 gal/min (life expectancy 10 years)	\$1,340.00
	Total	\$1,340.00

Depreciation plus Interest

Jack pump engine	\$214.56
Total	\$214.56

Repair Costs

	<u>Open Top</u>	<u>Closed Top</u>
Engines overhauled after 1500 hrs	\$ 350.00	\$ 350.00
Pull pump and replace leather every two years (cost will depend on type of cylinder used)	30.00	500.00
Total	\$ 380.00	\$ 850.00

Operating Costs

Oil change every 100 hrs (15 changes, 1 qt. @ \$1/qt.)	\$ 15.00
Gasoline 2.2 gal/day @ \$1.25	1,003.75
365 trips @ \$10/trip	3,650.00
Total	\$4,668.75

Cost per day	\$ 12.79
Cost per gallon of water	.008
Cost per cow per day	.085

150 cows for one year: an average of 10.5 gallons of water/cow/day

Rancher installed equipment using existing plumbing

PROJECTED COSTS
2500 Watts of Gasoline Generator and
1/3 HP Submersible Pump

Equipment Costs

2500 Watt Generator (life expectancy 8 years)	\$ 750.00
1/3 HP Submersible Pump rated @ 11 gal/min. (life expectancy 10 years)	450.00
Total	\$1,200.00

Depreciation plus Interest

Generator	\$ 130.50
Pump	67.05
Total	\$ 197.55

Repair Costs

Engines overhauled after 1,500 hrs	\$ 350.00
Total	\$ 350.00

Operating Costs

Oil change every 100 hrs (15 changes, 1 qt. @ \$1/qt.)	\$ 15.00
Gasoline 1.2 gal/day @ \$1.25	548.00
365 trips @ \$10/trip	3,650.00
Total	\$4,210.00

Cost per day	\$ 11.53
Cost per gallon of water	.007
Cost per cow per day	.077

150 cows for one year: an average of 10.5 gallons of water/cow/day

Rancher installed equipment using existing plumbing

PROJECTED COSTS

Submersible Solar Unit

Equipment Costs

1	HP Submersible Pump rated @ 14 gal/min (life expectancy 8 years)	\$2,398.00
7	53 watt solar panels @ \$350 each (life expectancy 20 years)	2,450.00
1	8 Panel Tracker	720.00
	Wire, pipe & supplies	602.00
	Total	\$6,170.00

Depreciation plus Interest

Jack pump	\$ 417.25
Solar panels	249.41
8 Panel Tracker	73.30
Wire pipe & supplies	61.28
Total	\$ 801.24

Operating Costs

122 Trips (every three days @ \$10/trip)	\$1,220.00
Clean panels 12 times/year (1/2 hours @ \$10/hour)	60.00
Total	\$1,280.00

Cost per day	\$ 3.51
Cost per gallon of water	.002
Cost per cow per day	.023

150 cows for one year: an average of 10.5 gallons of water/cow/day

Rancher installed equipment using existing plumbing

In accordance with applicable State and Federal laws and University policy, the University of California does not discriminate in any of its policies, procedures, or practices on the basis of race, religion, color, national origin, sex, marital status, sexual orientation, age, veteran status, medical condition, or handicap. Inquiries regarding this policy may be addressed to the Affirmative Action Director, University of California, Agriculture and Natural Resources, 300 Lakeside Drive, 6th Floor, Oakland, CA 94612-3560. (415) 987-0097.