THE MONTANA AGSOLAR PROJECT

Expanding the Agricultural Uses of Solar Energy in Montana

Funded by
The Montana Power Company
Universal System Benefits Charge Program

The National Center for Appropriate Technology

December 2000

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Foreword

This project was funded by Montana Power Company through the Universal System Benefits Charge program, which uses a small percentage of revenue from Montana Power customers to fund renewable energy projects and conservation measures. NCAT would like to thank David Ryan of Montana Power Company for his support of this project and his leadership in promoting renewable energy.

NCAT would also like to thank the landowners who agreed to work with us on solar pumping projects during the summer and fall of 2000:

Jim and Adele Ballard
Dan Doornbos
Rick and Pam Hirsch
Leo Schraudner
Jim and Carol Tomlinson
Don and Dan Ueland

All of these people generously contributed their own labor, time, money, and the use of heavy machinery and tools. We are grateful for their open-mindedness, willingness to try new technologies, ingenuity in solving problems, and patience and good humor when things didn't go exactly as planned.

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EXECUTIVE SUMMARY

Introduction

Intuitively, Montana – with its strong agricultural sector set in one of the least-populated areas in the country – represents an ideal candidate to embrace solar-electric technology. Indeed, more and more farm and ranch producers are turning to solar electric for a variety of uses, including water pumping, fencing, and powering remote outbuildings, among others. Current users recognize that today's solar-electric technology has advanced significantly over the last 10 to 15 years and is now cost-effective in many more applications, especially as an alternative to power-line extensions. Solar users also value the technology's improved performance and reliability, as well as its portability.

These results are encouraging, but in fact only a small proportion of the agricultural producers operating in Montana today have experienced the benefits of solar-electric technology. Believing in the technology's potential, Montana Power Company agreed to use a portion of its Universal System Benefits Charge monies to support the National Center for Appropriate Technology's Montana AgSolar Project. Employing two different approaches, the Montana AgSolar Project was designed to
(1) demonstrate solar-electric systems, while also (2) using market research to explore the feasibility of expanding the number of solar-electric systems throughout Montana Power Company's service region.

These activities brought the National Center for Appropriate Technology (NCAT) team of researchers into frequent contact with representatives of the key stakeholder groups, including utilities, County Extension and Natural Resource Conservation Service agents, solar-electric dealers and installers, and most importantly, farmers and ranchers. Through telephone and personal interviews and the interaction with producers as their demonstration systems were being installed, NCAT was able to learn much about the agricultural sector's perceptions of solar-electricity and the barriers that prohibit more widespread use. These perceptions and barriers, in turn, served as the basis for NCAT's proposed strategic plan for increasing the number of solar-electric systems in use throughout MPC's service region and the state as a whole.

Summary Of Findings

Overall, the research and demonstration results support an optimistic picture of the potential for solar-electric technologies in the agricultural community. Despite the promising results, the study found that solar electric will still have to overcome a number of barriers in order to be accepted more broadly. These barriers include:

- *A shortage of objective, up-to-date, and easily accessed information regarding solar-electric technology, applications, and dealers/installers*
- *The reality that solar-electric costs are higher than some producers can afford*
- *The perception that solar-electric costs are higher than most other alternatives*
- *The crucial importance of reliability*
- *Underestimation of solar's reliability in today's systems*
- *Uncertainty regarding the availability of solar-electric technologies*
- *Uncertainty about access to technical support for solar-electric systems*
- *Concerns regarding the susceptibility of solar-electric system to damage from vandalism*

- *General perception that the issue of energy savings ranks very low on a producer's list of priorities*
- *Inconsistent quality of instructions, hardware, and packaging*
- *A traditional reliance on surface water for agricultural purposes*
- *The generally conservative nature of the agricultural community*

NCAT also identified a number of significant opportunities for the expanded use of solar-electric technology in agriculture:

- *Opportunities to provide better information about costs*
- *Opportunities to create alternative funding mechanisms*
- *Opportunities to provide better information about ranching benefits*
- *Opportunities to provide better information about reliability and dependability*
- *Opportunities to provide better information about availability*
- *Opportunities for new dealers and installers*
- *Opportunities for utilities to save money*
- *Opportunities to develop marketing strategies appropriate to the way farmers and ranchers learn*
- *Opportunities for realizing environmental benefits*
- *Opportunities for dealers and manufacturers to improve instructions, hardware, and packaging*
- *Opportunities to replace failed windmills*
- *Opportunities for alternatives to line extensions*

Conclusion And Recommendations

Based on its research, NCAT believes that Montana's agricultural community is beyond the introductory stage of solar-electric technology, during which systems are often heavily subsidized to move them into the marketplace. Cost continues to be an issue, but there are many agricultural situations today where solar technology is or could be applied cost effectively if only the producer had the information and support needed to install the system. These findings lead to three significant conclusions:

1. *What farmers and ranchers want even more than lower costs is information – about appropriate applications, about reliability and dependability, about availability, and about current costs.*

2. *Solar water pumping makes possible a unique and valuable convergence of interests in an effort to address some of Montana's most intractable land-use problems.*

3. *Information dissemination efforts should not be aimed solely at individual farmers and ranchers. A much broader approach is needed to motivate other stakeholder groups as well.*

Toward this end, NCAT is proposing an ambitious strategic plan calling for the involvement and participation of numerous stakeholder groups. The goal of this plan and its specific objectives are presented below:

Goal of Strategic Plan: To increase the number of solar-electric installations in the agricultural sector throughout Montana

Objective 1: To publicize completion of the Montana AgSolar Project.

Objective 2: To identify and explore partnerships with stakeholders who stand to benefit from agricultural uses of solar-energy technology.

Objective 3: To strengthen the new Montana Renewable Energy Association (MREA) and build support within the organization for agricultural uses of solar-energy technology.

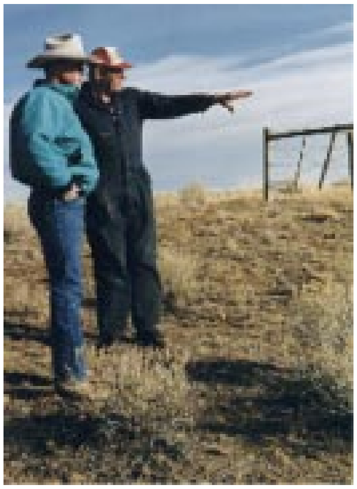
Objective 4: To identify and explore financing and incentive mechanisms.

Objective 5: To develop and implement a fresh marketing effort to disseminate current, factual, and objective information about solar-electric's applications in the agricultural sector.

Objective 6: To design and build a demonstration, track-mounted solar-pumping system that is significantly more portable and modular than the systems currently available.

Objective 7: To seek two- to three-year funding from appropriate industry players, foundations, and government agencies to support at least one well-qualified, full-time employee to help implement this strategic plan.

INTRODUCTION



Throughout the 1990s and continuing today, there have been signs of increasing interest in solar technologies, particularly for certain applications in agriculture. Farmers and ranchers are more frequently turning to solar-electric for stock watering and fencing, recognizing that solar is:

- cost-effective in many applications, especially where power line extensions are prohibitively expensive;
- easily made portable to allow the system to be moved from pasture to pasture;
- quiet; and
- long-lasting with little maintenance.

Utilities, too, are looking more favorably on solar electric as a legitimate alternative to expensive power-line extensions, where the utility is often unable to cover its line-maintenance costs. Utilities in a growing number of states (Nebraska, Colorado, Idaho, Arizona, North Dakota) have learned that they can increase their customer base by offering solar alternatives to their rural customers.

A third, critical source of interest is the increasing infrastructure of solar-equipment dealers and installers. Montana is now home to at least sixteen companies engaged in the sale, installation, and maintenance of solar-electric systems. These companies mean agricultural producers have more resources to turn to for help with this promising technology.

By themselves, neither the farmers and ranchers nor the utilities nor the dealers and installers would be able to move solar technologies forward in the marketplace at a meaningful rate. With signs of renewed interest from all of these sources, however, solar-electric technologies have a very real chance to make substantial inroads in the agricultural sector.

Intuitively, Montana – with its strong agricultural sector set in one of the least-populated areas in the country – represents an ideal candidate to embrace solar-electric technologies. The National Center for Appropriate Technology (NCAT), based in Butte, Montana has long been a champion of renewable energy. Knowing this, and recognizing that its customers face an uncertain future in light of deregulation, the Montana Power Company provided strong financial support for NCAT's Montana AgSolar Project. The project is funded by the Universal Systems Benefit Charge (USBC) program, which uses a small percentage of revenue from Montana Power customers to support renewable energy projects and conservation measures.

The Montana AgSolar Project was created and funded with two key objectives in mind. In the short term, the project aims to gain a clearer understanding of the barriers currently inhibiting solar-electric growth in Montana Power Company's service region. In the long term, the project aims to bring about an expansion in the number of agricultural uses of solar-electric power in Montana Power Company's service region and throughout Montana.

In pursuit of these objectives, NCAT and the Montana Power Company agreed to employ two different strategies concurrently: demonstration and market research. Both of these targeted the agricultural sector. In particular, NCAT installed solar-electric water-pumping systems at six demonstration sites within Montana Power Company's service region and actively publicized these projects. NCAT also undertook a research effort designed to explore the market potential of solar-electric technologies throughout the agricultural sector of Montana Power Company's service region.

In the course of this work, NCAT spoke to scores of individuals representing various stakeholder groups. These included farmers, ranchers, dealers, installers, utility representatives, and staff from local, state, and federal agencies. NCAT believes that this study reflects the best thinking currently available on the subject, by the people who are in the best position to assess the potential for agricultural uses of solar energy in Montana.

PART 1: DEMONSTRATION

A. Methodology

Purpose

In the demonstration portion of the project, the main goal was to draw wide attention and favorable publicity to agricultural uses of solar power within the Montana Power Company service territory. Solar energy is still uncommon in most parts of Montana, and people need to see functioning systems with their own eyes. There is a special need for demonstration projects in the agricultural community, where information often travels by word of mouth and where people often learn best from their neighbors.

NCAT decided that its staff members should participate directly in all of the installations. One reason for doing this was simply to learn as much as possible about solar-powered pumping by participating in all stages and aspects of the design and installation process. Through this hands-on experience NCAT hoped to learn more about practical and technical aspects of solar technology while also developing in-house expertise in designing and installing these systems. Another goal was to work closely with ranchers and farmers, in order to understand their needs and concerns better. These demonstration projects were intended to benefit Montana Power customers while also increasing NCAT's capacity to be a state and regional leader in the promotion of renewable energy.

Basic approach to demonstration projects

Initially, NCAT coordinated closely with Montana Fish, Wildlife, and Parks [MFWP], with the intention of incorporating solar components into projects that were already planned or under construction. NCAT took this approach in order to speed the process of identifying receptive landowners and also to simplify the search for good projects, ones with real ranching or environmental benefits. Another goal was to draw favorable attention to solar energy by participating in projects that would provide direct and measurable environmental benefits.

Conversations with MFWP began in June 1999. While these conversations generated excellent leads, not all of these leads panned out. So in the fall of 1999 NCAT broadened its search, asking staff members from several local, state, and federal agencies and conservation organizations for their project suggestions. Over twenty people provided suggestions, including representatives from the Natural Resources and Conservation Service; county extension agents; Conservation Districts; the Montana Department of Environmental Quality; and the Alternative Energy Resources Organization. A list of contacts is provided at the end of this report.

These conversations proved valuable in their own right, providing opportunities to talk to many of the conservation organizations and agencies that will play a critical role in promoting solar energy in Montana. Many of these people had never seriously considered the potential of solar energy. Others were extremely knowledgeable, had already given the subject considerable thought, knew of promising sites, or had experience installing and operating PV systems.

Choosing and arranging demonstration projects

Based on these interviews, as well as conversations with many other people, NCAT received numerous project suggestions. Site visits began in September 1999 and eventually included twelve sites altogether. Most of these visits took place between September and December 1999, although suggestions and site visits continued through the spring and summer of 2000.

After an initial screening to confirm that the potential projects were located in Montana Power Company service territory, NCAT evaluated these sites based on the following six criteria:

1. suitability of the site for demonstrating ranching and environmental benefits of solar energy;
2. cost-effectiveness;
3. likelihood of completing the project by the end of the year 2000;
4. likelihood of positive publicity;
5. motivation and interest on the part of the landowner; and
6. diversity of projects.

NCAT originally intended to demonstrate a variety of agricultural uses of solar energy. Almost all of the project suggestions received, however, were either for solar-powered pumping or electric fencing. A promising electric fencing demonstration project fell by the wayside when it experienced lengthy delays. NCAT made numerous inquiries but failed to identify another suitable electric fencing demonstration project. In the end, all six projects demonstrated solar-powered pumping for stock-watering.

In choosing and planning projects, NCAT could not assume the uncertainty and financial risk of well-drilling. (Well-drilling in Montana averages $20 to $25 per foot of depth, and wells may be up to several hundred feet deep.) So at the outset, and before any agreements were signed, landowners agreed to bear the responsibility and risk of establishing an adequate water source. Two promising projects failed because the landowners could not find adequate water.

Some candidate sites ranked low because they were near existing power lines, had low landowner interest, or because delays caused by other participating agencies made it unlikely that NCAT could meet construction deadlines. One landowner was interested in providing water to a feedlot that is used primarily during the winter months. Because of the limited available sunlight in the winter, however, the project would have required a large and prohibitively expensive solar array. Coping with bitterly cold winter temperatures and freezing water would also have posed major design challenges.

Once projects were selected, each participant was asked to sign an agreement spelling out obligations and describing the hardware and services NCAT was offering to provide.

Among other things, each participant agreed:

- to provide NCAT with information necessary to analyze the economic, ranching, and environmental aspects of the project;
- to arrange at least one organized tour of the project for interested members of the public; and
- to allow NCAT to describe and publicize the project in brochures, news stories, press releases, websites, and other ways.

Building projects

With signed agreements in hand, NCAT ordered solar equipment. Hardware for four of the projects came from Sunelco of Hamilton, Montana. Hardware for the Ballard project came from Midland Implement of Billings. The trailer-mounted system installed on the Schraudner Ranch came from Applied Power of Washington state.

Installations were completed in May (Ballard), June (Tomlinson), August (Schraudner), September (Ueland), and October (Hirsch). The remaining installation, on the Sauerbier Ranch, was delayed because of fire danger and travel restrictions in Montana during the severe drought of 2000. This project is still in progress.

The projects varied widely in cost. The total cost of solar components ranged from $2400 on the low end to $24,500 on the high end. In five of the six projects, USBC funds administered by NCAT paid the majority of solar hardware costs, and in the case of four projects USBC funds paid nearly the entire cost of solar components. In every case landowners provided the use of heavy machinery as well as in-kind services including at least 30-40 hours of labor by the landowners themselves or their employees. One landowner did nearly all of the installation work by himself. All participants provided at least some hardware, and one landowner spent over $4000 on hardware. All participants installed their own mounting posts. Most participants paid the entire cost of water pipes, well-drilling, and tanks, although USBC funds paid part of these costs in a few cases. The trailer-mounted system that NCAT helped install at the Schraudner Ranch belongs to Montana Department of Environmental Quality, and is on loan to the local conservation district for demonstration purposes.

Project Economics: Assumptions and Methods

There are any number of ways to compare project alternatives and estimate the benefits of using solar energy to pump water for livestock. The approach to each project described here was somewhat different. In most cases, a life cycle cost was calculated using *BLCC 4.1*, an economics program developed by the National Institute for Standards and Technology. Since this program was developed for comparing energy conservation alternatives in buildings, the life cycle costs generated here for these projects are estimates. For each project, line extension costs are also included. These are gross

estimates since a line extension cost is based on terrain, among other things. For most of the projects, the solar pumping system was compared to the next most likely alternative, which varied from project to project. Also for each project, an estimated cost of solar-pumped water per cow per day was calculated.

Publicizing Projects

NCAT has already profiled each of the demonstration projects on its Montana Green Power website (www. montanagreenpower.com). Press releases will go out from fall 2000 to spring 2001. Organized and well-publicized tours will take place for all projects in the spring of 2001. NCAT will prepare and distribute a brochure that will feature the demonstration projects and help consumers estimate cost-effectiveness, design their own systems, find qualified contractors and repair people, and choose and purchase hardware.

B. Detailed Project Descriptions

Tomlinson Ranch, Gold Creek Montana

- *Location:* Gold Creek, Montana
- *Season of Use:* June to September
- *Solar Modules:* Two 120-Watt panels
- *Pump:* Submersible diaphragm (DC)
- *Cost of Solar Components:* $3200
- *Primary Benefits:* Improved reliability and convenience, compared to gas-powered generator

Background

From June to September every summer, Jim Tomlinson pastures 20-25 cow/calf pairs or replacement heifers in timber and grassland several miles from the town of Gold Creek, Montana. The area is steep, rugged, and remote. A creek flows along one side of the property but sinks beneath the surface and goes dry along the way. To give his cattle a reliable water supply and to provide access to forage far from the creek, Tomlinson installed a stock-watering system about ten years ago. Prior to this development the cattle sometimes needed to go far up the creek to find water.

Some years ago Tomlinson drilled a 160 foot deep well on a bench on the property. Since the nearest power line was about two miles away, he decided to use an eight horesepower gasoline-powered generator to pump water. The well produces up to 12 gallons per minute, and water flows into a 1350-gallon underground cistern. Water flows from the cistern by gravity into a 700-gallon stock tank, with a float valve ensuring that the flow stops once the stock tank is full.

The well has a static level of 120 feet below the ground surface in a good water year, although during the current drought year (2000) the water level has been at 145-150 feet. Tomlinson originally installed a one-half horsepower submersible alternating current pump. This system worked but also created some headaches. About every five days, he has needed to travel 45 minutes (28 miles) each way from his home just to run the generator and fill the stock tank. While Tomlinson would normally come up to check on the cows at least once a week anyway, he's been forced to stick to a rigid schedule for watering. This has presented problems, especially during haying and irrigating seasons. A few years ago he also needed to replace a generator that was stolen.

Project

Tomlinson considered solar power at the time the well was drilled ten years ago. Although he was put off by an estimated cost of $4,000, he has continued to be interested in finding an alternative to the gas-powered generator. Tomlinson's generator — replacing the earlier one that was stolen — was an old World War II surplus model that had originally belonged to his father. Fuel costs are modest. The system runs for about two hours on a gallon of gas, and this is usually enough to re-fill the tank.

Working with NCAT, Tomlinson installed a solar-powered pumping system this June. The system uses two 120-Watt PV modules, a passive tracking rack, and a submersible diaphragm pump with a maximum flow rate of just under one gallon per minute. The panels were located about 90 feet from the well to avoid shading from trees. Solar exposure at this location is adequate, although Tomlinson will probably cut one or two trees that partially shade the panels during late August and September. After the cows are moved off the pasture each fall, he plans to remove the tracker and panels and store them at the ranch to avoid vandalism during hunting season.

Tomlinson increased his storage capacity by installing a second 700 gallon watering tank next to the first one. This will ensure adequate water during cloudy weather, when solar pumping will be reduced. A float switch in the cistern is connected to the pump controller. When both watering tanks and the cistern are full, the pump shuts off.

The environmental benefits from this project will be minor. Riparian areas are not directly affected, and Tomlinson will not change his grazing practices in any significant way. The ranching benefits of the project, however, are considerable. Solar pumping should be reliable and nearly maintenance-free, keeping Tomlinson's tanks full all summer long and freeing up his schedule during the busy times of irrigating and haying. An unexpected benefit is that he was able to continue pumping and watering his cattle as usual this summer, despite the drought in Montana. Because of the severely dry conditions and extreme fire danger, he would not have been allowed to run a gasoline-powered generator in the forest this summer.

Equipment Description

(equipment ordered from Sunelco, Hamilton, MT)
Solar panels: Two Kyocera KC-120 120-Watt multi-crystal photovoltaic modules, wired in series to produce 30 nominal volts direct current.
Pump: Solarjack SDS-D-228 duplex submersible diaphragm pump, designed for a maximum flow rate of 1 to 1.2 gallons per minute during the summer months. The pump is set at about 155 feet below ground level.

Even though I come up regularly to check on the cows, if I can't get there, I know the cows have water.

Controller: Solarjack PCA10-30 pump controller includes linear current booster, adjustable voltage output, and controls for the float switch installed in the cistern.

Mounting structure: Zomeworks UTR020 universal passive tracking rack, mounted on an eight foot, 2½ inch diameter black steel pipe, set in concrete.

Expected Output: The system is expected to produce average flows of 927 gallons per day (GPD) in June, 954 GPD in July, 895 GPD in August, and 759 GPD in September.

Problems encountered

- The tracking rack had a piece of steel welded in a position that prevented the panels from being installed as close together as recommended. Consequently, one of the modules' connecting wires was too short and had to be replaced.
- It was necessary to drill new holes in the panel frames since the predrilled mounting holes on the tracking rack were not close enough together.
- The installation kit had missing washers, grounding clips, and screws.
- After a couple weeks, Tomlinson found that he was only getting about one-half gallon per minute and 180-250 gallons per day far less than he had expected. One problem was that the pump controller required adjustments to maximize voltage output. (Tomlinson received the wrong instructions for the pump controller that he had ordered.) After these adjustments were made, flows increased to .75 to .8 gallons per minute, still below the expected rate of 1 to 1.2 gallons per minute. The remaining problem is that during installation a one-eighth inch weep hole was drilled in the delivery pipe to prevent freezing up. This hole was allowing too much water out, approximately one-fourth gallon per minute. Tomlinson plans to plug the hole during the summer and open it in the fall. This should substantially increase summertime flows while avoiding freeze-up problems.

Economics

Since the site is about two miles from the nearest power line, a line extension would have cost around $40,000.

The solar pumping system replaced an old 2500 Watt generator that operated an AC submersible pump. Every five days Tomlinson made a 56 mile round trip and filled the generator tank with one gallon of gasoline, started it up, and let it pump water until it ran out of gas. While the generator was still functional at the time of the solar installation, replacement was inevitable due to its age.

An equivalent generator would cost about $600 and require one gallon of gasoline every five days for three months at an estimated cost of $32. Maintenance costs over a three month period are estimated at $25. Tomlinson estimated that using a generator would result in one extra trip per week compared to the solar system. Over a three-month period, these extra trips would cost $84 for vehicle fuel and $234 for wages, assuming that an employee would be paid to make the extra trips.

The cost of the solar components was $3200. The maintenance cost of replacing the diaphragms in the pump is $80 to $100 but only needs to be done about every 3 years.

Using these assumptions, the present value of the life cycle cost over a ten year period for the generator would be $3801. Over the same period, the life cycle cost for the solar pumping system would be $3279, showing a savings of $521 for the solar alternative.

The average cost of solar-pumped water per cow per day is $0.15, assuming 25 cows and a three-month period of use over a ten-year period. Over the same ten-year period, the cost per gallon of water pumped would be $0.007.

Ballard Ranch, Lavina, Montana

- *Location:* Lavina, Montana
- *Season of Use:* June to September
- *Solar Modules:* Four 80-Watt panels
- *Pump:* Submersible piston (DC)
- *Cost of Solar Components:* $5500
- *Primary Benefits:* Improved reliability and convenience, compared to windmill

Background

Jim and Adele Ballard graze 250 cattle on their ranch in the Musselshell River valley near Lavina, Montana. For many decades, the Ballard Ranch has used a windmill to pump water from a 65 foot deep well to a pair of stock tanks holding about 4000 gallons. These tanks serve two summer pastures, and in most summers 100 cow/calf pairs rely on these tanks for their drinking water. At its peak, the windmill pumped over 2000 gallons per day. Windmill maintenance became a headache, though, and in 1999 Jim spent ten days fixing the windmill. (At one time, the ranch made use of three windmills to pump water in widespread pastures; only one is still in operation.) This windmill was built in 1949, and by 1999 everything above ground was in poor condition. Hauling water to this pasture had been common in the last couple of years. In 1999, the Ballards hauled water 45 days.

Since the well is one and one-half miles from the nearest power line, a grid-powered electric pumping system was out of the question, requiring a prohibitively expensive line extension. Replacing the defunct windmill would have cost over $5000 for new equipment, or somewhat less for salvaged equipment. The Ballards happened to see a photovoltaic pumping system at a neighbor's ranch, one of two solar stock-watering wells sponsored by the Painted Robe Watershed Group. The Ballards' research indicated that a PV system would cost about the same as a replacement windmill but would require less maintenance. Their third option, a gasoline or propane-powered generator with an automatic start capability, looked considerably more expensive. Also, the site is five miles from the Ballards' home over dirt roads. The Ballards were eager to avoid the frequent trips that might have been required to operate a generator.

Project

Working with NCAT, Midland Implement Company of Billings, and Farm Tuff of Broadview, the Ballards removed the windmill from the well and installed a solar-powered pumping system in the spring of 2000. Solar exposure is excellent at the site.

The ranching benefits of the project are substantial. First and foremost, the Ballards hope to reduce the maintenance time and cost of maintaining an unreliable windmill, as well as avoiding frequent - even daily - trips to check on water availability. Besides cost and convenience, the Ballards like their solar system for other reasons: some of the hottest days of summer are calm, drastically limiting windmill output. Also, it had always bothered them that their windmill would continue pumping after the tanks were filled, spilling water out onto the ground. Their new PV system uses a float switch to turn off the

water when the tanks are filled, preventing any spillage or waste.

The project has some limited environmental benefits, such as providing drinking water for wildlife and eliminating the wasteful spilling of water onto the ground. The project has also contributed at least indirectly to the efforts of the Painted Robe Watershed Group. The group is trying to develop off-stream water sources as part of a long-term strategy to cope with water quantity and quality problems in Painted Robe Creek. Although the pastures watered by the Ballards' PV system lie just outside the geographical boundaries of the Painted Robe watershed, their system furthers the goals of the watershed group and creates additional local interest in solar pumping.

Equipment Description

(equipment ordered from Midland Implement, Billings, Montana)

Solar panels: Four 60-Watt photovoltaic modules were installed originally. Later these were replaced by four 80-Watt Kyocera panels, wired in series to produce 48 volts direct current.

Pump: SunRise P-SR 5230 submersible piston pump, with a maximum flow rate of 5.5 gallons per minute at 75 feet of head or 6.2 gallons per minute at 50 feet of head. The pump is set at 62 feet below ground level.

Controller: SunRise SC1PV pump controller includes linear current booster. The voltage output is internally adjustable for both the three-speed pump motor and the controls for the float switch installed in the first watering tank.

Mounting structure: Fixed mounting rack, mounted on a six-inch diameter galvanized steel pipe set in concrete. The mounting structure is located close to the well. This mounting rack is being replaced with a Zomeworks UTR-040 Universal track rack.
Expected Output: The system is expected to produce average flows of 2000 to 3000 gallons per day during the summer months.

Problems encountered

During installation, the Ballards discovered that their panels did not fit the rack that was provided. They had to have another rack sent from Billings. Once the system was up and running, it provided disappointing peak flows of only about 4 gallons per minute. The dealer agreed to upgrade the panels, at no charge, from four 60-Watt panels to four 80-Watt panels. Flows improved to about 5 gallons per minute but still remain below the levels promised in the project design. The Ballards have decided that their next step will be to replace the fixed mounting rack with a tracking rack. When the tracker is installed in the spring of 2001 it should push the pump close to its maximum flow rate of about six gallons per minute and allow the pump to operate at a peak rate for a longer period each day.

Economics

Since the site is one and one-half miles from the nearest power line, the estimated cost of a line extension would be $30,000.

The Ballards had priced all new hardware for a windmill at over $5000, including $1300 for the head and $200 for the pump. Since the tower on the old windmill was defunct, a new tower was also necessary, contributing to the overall higher cost. Salvaged parts would have lowered the first cost. The Ballards would have installed the windmill themselves with ranch-owned heavy equipment, resulting in labor and equipment rental savings.
The cost of solar components was $5500, similar to the cost of a windmill. Windmills generally require more maintenance, such as replacing the oil in the gearbox regularly.

Windmill maintenance requirements also increase with the age of the system.

We're pumping water with the sun.

Based on first cost of the solar pumping system and estimated annual maintenance costs, the present value of the life cycle cost of the solar system over a ten-year period is $5,567. Assuming a four-month period of use each year and 100 cattle, the average cost of solar-pumped water per cow per day is less than $0.05 (a nickel per day) over a period of ten years. The cost per gallon of water pumped is $0.002 over the ten-year period, or $4.64 per day or $139.17 per month for 100 cow/calf pairs drinking 25 gallons per day.

Ueland Ranch, Anaconda, Montana

- *Location:* Anaconda, Montana
- *Season of Use:* February to April
- *Solar Modules:* 12 64-Watt panels
- *Pump:* Submersible centrifugal (DC)
- *Cost of Solar Components:* $7700
- *Primary Benefits:* Fisheries benefits from reduced pressure on riparian areas, drinking water for cattle at feeding area

Background

Don and Dan Ueland own and operate a large cattle ranch near Anaconda, Montana. In late February of each year, after calving season, the ranch begins moving cows and calves into a feeding area where a stack yard lies in the center of six lots, covering the better part of two sections. About 500 cow/calf pairs are in the lots by the end of the April, and cattle remain in the feeding area until May 1. At that time they are moved out to summer pasture.

The Uelands were looking for a way to provide water for cattle in the feeding area. The nearest water is at least one half mile away, and the nearest utility line is also over one half mile away. Solar pumping was an appealing option because of the high cost of a power line extension to the site. On the other hand, the project poses a challenge because of the large number of cattle and because pumping will take place in the late winter and early spring. At that time of year, sunlight is less abundant than it would be in summer, and the site will also be subject to freezing temperatures.

Project

The Uelands drilled a 50-foot deep well at the stack yard, with a static water level of 28 feet below ground surface and capacity of 15 to 20 gallons per minute. Working with NCAT, the ranch installed a large track-mounted solar array. Twelve 64-Watt photovoltaic modules, all mounted on a single passive tracking rack, are wired to produce 45 nominal volts direct current. A one half horsepower submersible multi-stage centrifugal pump should provide a maximum flow rate of 17.5 gallons per minute during the season of use. The ranch may remove the tracker and panels during hunting season to avoid vandalism.

Besides the strictly ranching benefits of this project, the Uelands were also interested in relieving pressure on Lost Creek and Warm Springs Creek, two streams that flow through the property. In order to distribute cattle better over the property and improve riparian areas and range conditions, the ranch has been developing several off-stream watering sites with the assistance of Montana Fish, Wildlife, & Parks, the Natural Resources Conservation Service, and other agencies.

Equipment Description

(equipment ordered from Sunelco, Hamilton, MT.)

Solar panels: Twelve Uni-Solar 64-Watt amorphous solar modules, wired to produce 45 nominal volts direct current. Each group of three modules is wired in series; the groups of three are then wired to each other in parallel.

Pump: Solarjack SCS 14-70 1/2 horsepower multi-stage centrifugal submersible pump, designed to produce a maximum flow rate of 17 gallons per minute in March and 17.5 gallon per minute in April. The pump is set at 43 feet below ground surface and connected to low water cutoff electrodes.

Controller: Solarjack PCA 8-60B pump controller with linear current booster and adjustable voltage output. No float switch is used in this system.

Mounting structure: Zomeworks F-series 168 square foot universal passive tracking rack, mounted on a 14-foot long, 6 inch diameter black steel pipe, set seven feet in the ground with concrete. The mounting structure is located close to the well.

Expected Output: The system is expected to produce average flows of 7836 gallons per day (GPD) in March, 9539 GPD in April, and 10,517 GPD in May.

Problems encountered

- The submersible cable that goes to the pump had been cut far too short and needed to be replaced.
- The plastic junction boxes attached to the underside of the panels proved to be quite fragile. A number of boxes cracked or broke when the knockout plugs were tapped out.

Economics

Since this site is about one half mile from the nearest power line, a line extension would cost around $10,000.

The Uelands considered a gas or propane-powered generator but decided that this was a worse option than a line extension. A generator-based system would leave them with fuel issues and costs, reliability issues, and freeze-up problems. A line-extension, while expensive, would have been highly reliable and would have given them the option of including heated waterers to solve their freeze-up problems. The present value of the life cycle cost over ten years of a grid-connected electric pumping system is estimated to be $14,043. The life cycle cost for the Uelands' solar pumping system is $8,137, a savings of $5,906 for the solar system.

The average cost of solar-pumped water per cow per day is $0.03, assuming an average of 400 cows and a two-month period of use per year over a ten-year period. Over the same ten-year period, the cost per gallon of water pumped would be $0.002.

Partners

Montana Fish, Wildlife, and Parks; the Natural Resources Conservation Service; Montana Power Company; and the Montana Department of Environmental Quality.

Hirsch Ranch, Racetrack, Montana

- *Location:* Racetrack, Montana
- *Season of Use:* May to October
- *Solar Modules:* Two 64-Watt panels
- *Pump:* Submersible diaphragm (DC)
- *Cost of Solar Components:* $2400
- *Primary Benefits:* Fisheries benefits from reduced pressure on riparian area

Background

Rick and Pam Hirsch graze 36 cow/calf pairs on a pasture near Racetrack, Montana. Cattle use the pasture four to five months a year, usually from May through September or October. Occasionally the Hirsches also keep a few horses or bulls in the pasture during the winter months. The cattle drink from Racetrack Creek and the riparian area shows heavy use. The Hirsches are interested in improving fish and wildlife habitat along the creek, and Montana Fish, Wildlife, and Parks [MFWP] has proposed fencing the cattle away from the creek. This would increase vegetation in the riparian area, stabilize and deepen the stream channel, and improve fish habitat. Racetrack Creek is shallow and braided as it runs through the Hirsches' pasture, and goes dry most summers — only a couple miles upstream from its confluence with the Clark Fork River.

Project

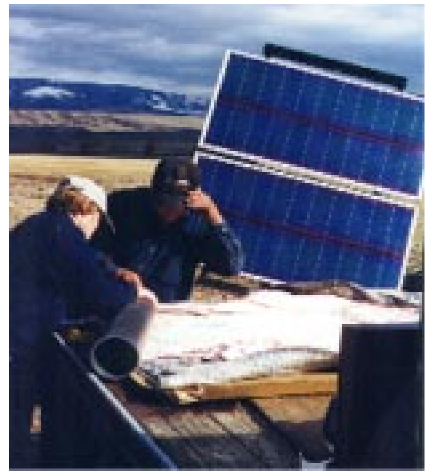
Working with NCAT, the Hirsches installed a solar-powered pumping system this October. The nearest utility line is about one third of a mile away, and solar exposure is excellent. Since the Hirsches knew from experience that the water table on their property was close to the surface, they started digging with a backhoe and found water at less than eight feet below the ground surface. Their pumping system uses two 64-Watt PV modules, a passive tracking rack, and a submersible diaphragm pump.

The pump is set at about 10 feet deep in the well and equipped with low water cut-off electrodes. Water quality at the site is good although the soil is very sandy. A sand shroud was installed to keep sand from entering and damaging the pump.

Anticipated environmental benefits from this project are excellent. MFWP believes that Racetrack Creek has the potential to be an important brown trout spawning stream. The Hirsches' project should also reduce nutrient inputs into the creek and the Clark Fork River, since it will move cattle away from the stream and create a healthy wet meadow that will absorb nitrates. Bull trout, a rare and threatened native fish species, are found in the headwaters of Racetrack Creek. As habitat improves, MFWP hopes that bull trout will eventually colonize downstream.

Ranching benefits from this project are less significant than the environmental benefits, although the Hirsches hope to see some improvement in the distribution of cattle across the pasture. They plan to install at least two watering tanks to encourage this. Should MFWP eventually fence the riparian area, the agency has agreed to provide a water gap so that livestock will continue to have access to drinking water from the stream.

Equipment Description



(equipment ordered from Sunelco, Hamilton, MT.)

Solar Panels: Two Uni-Solar US-64 64-Watt amorphous photovoltaic modules, wired to produce 24 volts direct current.

Pump: Solarjack SDS-Q-128 quad submersible positive displacement diaphragm pump, with a maximum flow rate of 3.5 to 3.7 gallons per minute during the summer months.

Pump Controller: Solarjack PCA 10-30B pump controller includes linear current booster, adjustable voltage output and controls for the float switch installed in the watering tank.

Mounting Structure: Zomeworks 20 square foot universal passive tracking rack, mounted on an eight foot long, 2 ½ inch diameter black steel pipe, set 36 inches in the ground in concrete. The mounting structure is located close to the pump.

Expected Output: The system is expected to produce average flows of 2604 gallons per day (GPD) in May, 2753 GPD in June, 2807 GPD in July, and 2640 GPD in August.

Problems Encountered

- One cable received had been cut almost too short and the other one had been cut far too long.
- The tracking rack had a piece of steel welded in a position that prevented the panels from being installed as close together as recommended. Since the predrilled holes were not close enough together, it was necessary to drill new holes in the panel frames.
- No wiring diagram was sent with the components.
- The hole for the threaded rod that holds the counterweights hadbeen drilled at a crooked angle, causing the weights to hang slightly off-center.
- The Zomeworks frame was slightly out of square, making itimpossible to center the panels precisely on the frame.

Economics

Since this site is about one third mile from the nearest power line, a line extension would cost around $8,000. A line extension appeared to be the most feasible alternative to a solar powered pumping system. The present value of the life cycle cost over ten years of a grid-connected electric pumping system is estimated to be $11,717. The solar alternative life cycle cost over ten years is $2,942, a savings of $8,775 for the solar system.

The average cost of solar-pumped water per cow per day is $0.09, for 36 cow/calf pairs and a three-month period of use per year over a ten year period. Over the same ten-year period, the cost per gallon of water pumped would be $0.005.

Leo Schraudner Ranch, Lavina, Montana

- *Location:* Lavina, Montana
- *Season of Use:* June to November
- *Solar Modules:* Seven 60-Watt panels
- *Pump:* Submersible centrifugal (AC)
- *Cost of Solar Components:* $10,650
- *Primary Benefits:* Reduced pressure on riparian areas, increased forage base that will allow extended grazing season, improved range conditions from better distribution of cattle.

Background

Leo Schraudner pastures about 150 cattle on one and a half sections of land south of Lavina, Montana. The property is located along Painted Robe Creek, a tributary to the Musselshell River with severe water quality problems, including salinity problems. The Painted Robe Watershed Group has been working to develop off-stream sources of drinking water for cattle. The group is also interested in improving riparian vegetation along the creek.

Ordinarily, Schraudner's cattle use these pastures near the creek during the summer months and until late October or early November. One of Schraudner's main objectives is to give his cattle increased use of nearby pastures, possibly extending their grazing until later in the fall. At present his use of these pastures is limited because of the scarcity of water. Painted Robe Creek frequently goes dry in late summer, as it did this year.

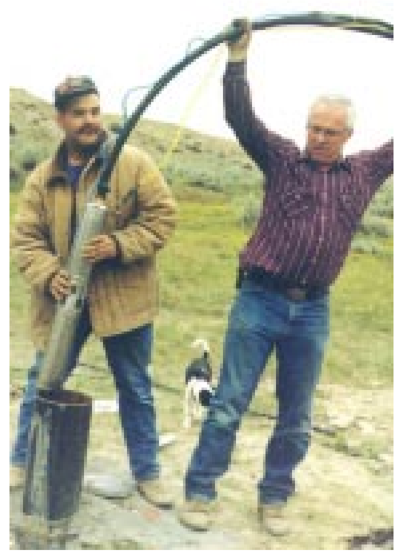
Project

The drought of 2000 made it more urgent for Schraudner to develop an additional water source for his cattle. He drilled a well near Painted Robe Creek early in the summer. The site is over a mile from the nearest accessible power line, so the cost of a power line extension would have been prohibitive. Schraudner has long used solar energy to power some of his electrical fencing, and he called NCAT in mid-summer to inquire about the possibility of installing a solar pumping system.

In turn, NCAT made contact with the Montana Department of Environmental Quality (DEQ), to see if one of DEQ's trailer-mounted solar systems might be available. Not only was a trailer-mounted system available from DEQ, but the system appeared to be a good match for Schraudner's pumping requirements. DEQ was eager to help out, especially given the urgency of the drought situation. The installation took place in late August.

The DEQ system is somewhat unusual in its use of an alternating current (AC) pump. The system includes an inverter to convert the DC electricity produced by the solar panels into the AC power required by the pump. The inverter is mounted, along with the pump controller, on the trailer. The well produces 6.5 gallons per minute and is 65 feet deep, with static water level at 12 feet. The pump was located 60 feet deep. Schraudner installed two 1100-gallon tanks about 100 feet from the well. There is an elevation gain of about eight feet from the well to the tanks. A one and one-half inch plastic water line connects the well to a frost-free hydrant.

Both the ranching and environmental benefits of this project are significant. The project supports the efforts of the Painted Robe Watershed Group, as the organization tries to cope with water quantity and quality problems in Painted Robe Creek. Besides giving his cattle a reliable and clean source of drinking water and extending the grazing season, Schraudner is also interested in eventually installing a more ambitious solar pumping system, one that would pump water up a large hill and enable him to give his cattle access to high quality forage far from the stream.



DEQ retains ownership of the trailer-mounted system but is making it available on a long-term loan basis to the local conservation district. Over the next few years the conservation district hopes to rotate the system among local ranches, giving a large number of area ranchers the chance to experience solar pumping.

Equipment Description

DEQ's mobile unit was built by Applied Power of Washington.

Pump: Grundfos SP3A-10 alternating current centrifugal submersible pump.

Solar Panels: Seven 60-Watt Kyocera modules, wired to produce 105 volts direct current.

Pump Controller/Inverter: Groundfos Solartronic SA 1500.

Mounting Structure: Two fixed racks with adjustable tilt angle, mounted on a flat bed trailer.

Expected Output: The system is expected to produce average flows of 3600 gallons per day (GPD) in June, 4000 GPD in July, 3000-3600 GPD in August, and 2880 GPD in September.

Problems Encountered

- Although the system was designed to produce 6.5 gallons per minute, it originally produced only a disappointing 2.5 gallons per minute.
- A leak was discovered and repaired at the pitless adapter, where an O-ring had been deformed during installation. After this repair, flows appeared to be at or near expected levels.

Economics

Since the site is over a mile from the nearest accessible power line, a line extension would cost around $25,000. Life cycle costs were not calculated for this project for two reasons. First, Schraudner installed this system on a temporary basis and the economic benefits are not easy to quantify. He does not yet know exactly how — or even whether — he wants to use solar energy at this site. Second, the trailer-mounted system on loan to Schraudner was not specifically designed for this location. Schraudner may well find that a smaller and less expensive system will ultimately meet his needs.

Partners

Natural Resources Conservation Service, USDA Farm Service Agency, Montana Department of Environmental Quality, Painted Robe Watershed Group, Lower Musselshell Conservation District.

Sauerbier Ranch, Sweetwater Basin
between Sheridan and Dillon, Montana

- *Location:* Sweetwater Basin, between Sheridan and Dillon, Montana
- *Season of Use:* May to July
- *Solar Modules:* 24 120-Watt panels
- *Pump:* Surface Piston Pump (DC)
- *Cost of Solar Components:* $24,500
- *Primary Benefits:* Increased forage base that will allow increased herd size, improved range conditions from better distribution of cattle, fisheries benefits from reduced pressure on riparian areas.

Background

Every summer Dan Doornbos pastures about 300 cow/calf pairs on a remote pasture in the Sweetwater Basin, about an hour from Alder, Montana. Sweetwater Creek, a tributary of the Ruby River, runs year-round most years. The terrain is hilly with rock outcroppings on the ridgetops. The riparian area along the stream does not extend far from the water's edge except in a few areas, mainly where beavers have moved in.

The riparian area and the hills around the stream are heavily grazed. Forage at the northern end of the pasture, approximately two miles uphill from the water source, is only lightly grazed. The distance from water and the rugged terrain preclude the cattle from using the abundant grass on this end of the pasture.

With the stream as the only water source in this eight-section pasture, about half of the pasture is not used by the cows. Cattle are brought in about May 21 and removed July 1; heifers may be brought in later in the summer. If the rest of the pasture could be completely utilized, the Sauerbier Ranch could increase the number of animals from the current 300 pairs to 350 pairs and see increased weight gains.

Project

The Natural Resources Conservation Service [NRCS] has been planning to install an approximately two-mile long pipeline to pump water from the creek up to a 10,000 gallon water storage tank at a high point in the northeast corner of the pasture. Out of this large tank, gravity lines would bring water down to three or four other tanks located to the west. Originally, NRCS planned to use a hydraulic ram to pump the water but that turned out to be unfeasible since a booster pump would have been necessary partway up the line.

NRCS also considered a water wheel-driven piston pump, but rejected this approach because of high cost, the need for a long (one half mile) supply ditch, and likely harm to fish in the stream. Finally, NRCS considered and rejected a propane generator or propane-powered pump, which would have cost approximately $15,000.

After conversations between NCAT and NRCS, a solar-powered pumping system began to look like an attractive option. The nearest utility line is about five miles away, and solar exposure is excellent at the site. NRCS designed an intake structure to direct relatively

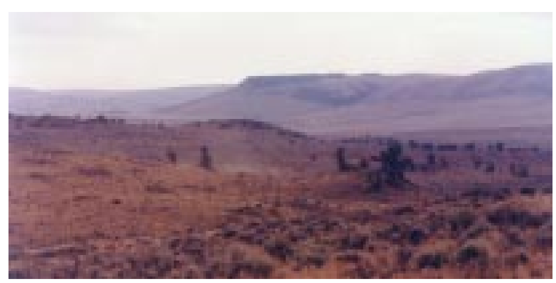
clean water from the stream into a culvert set vertically to act as a stilling well. The solar-powered piston pump is set on a frame within the culvert, and the culvert is equipped with a lid to protect the pump from the elements. The pump site is located on the stream bank away from flooding hazards (both from spring runoff and the local beavers). NRCS also designed the pipeline. Doornbos will install the pipes himself or contract the installation. He will also install a 10,000-gallon storage tank at the upper end of the pipeline

The system will require 24 120-Watt solar panels mounted on two tracking racks. NCAT hopes that this project will demonstrate the full potential of solar pumping, since the piston pump will push a substantial volume of water over a long distance (almost two miles) and also push it up a significant elevation gain of over 200 feet. This project should help dispel the common but mistaken impression that solar energy is limited to small-scale or low-energy applications.

Besides the obvious ranching benefits of the project, moving cattle away from the stream will provide environmental benefits by improving water quality and reducing the grazing pressure along the stream. Sweetwater Creek contains a population of native West Slope cutthroat trout, recently petitioned for listing as an endangered species. Because the area is so remote the population is relatively undisturbed, with a high degree of genetic purity. These fish are especially valuable and important because of their location on the east side of the Continental Divide, where the species is especially rare. The riparian area will not be fenced, but with an additional water source on the top of the ridge the grazing pressure on the stream should be reduced considerably, improving fish habitat. The presence of West Slope cutthroat trout is one reason why the U. S. Fish and Wildlife Service has decided to become involved in the project and provide funding. Montana Fish, Wildlife, and Parks has also been actively involved in planning the project.

Equipment Description

(equipment ordered from Sunelco, Hamilton, MT.)



Solar Panels: 24 Kyocera KC120-1 120-Watt multi-crystalline solar modules, wired to produce 190 volts direct current.

Pump: 3 horsepower Solarjack SJPP-10-16C surface piston pump with a 180-volt DC motor. The system should have a flow rate of 11 gallons per minute during the summer months when it will be in operation. The pump is set in a sump near the stream and equipped with low water cut-off electrodes. Total dynamic head is 421 feet. The pipe used to convey water nearly two miles to the storage tank is 2 inches in diameter.

Pump Controller: Solarjack pump controller, model PC-1808T. No float switch is used in this system

Mounting Structure: Two Zomeworks 100 square foot universal passive tracking racks. Each rack holds twelve panels and is mounted on an 11-foot long, 6 inch diameter black steel pipe, set 52 inches in the ground with concrete. The mounting structures are located close to the pump.

Expected Output: The system is expected to produce average flows of 6600 to 7000 gallons per day (GPD) in June, 7500 GPD in July, and 6600 to 7000 GPD in August.

Problems Encountered

- Because of dry conditions andextremely high fire danger, travel restrictions were imposed in the area throughout the second half of the summer. Installation hadbeen scheduled for August, but the landowner could not bring in heavy equipment to install the piping or even access the property to install equipment. When travel restrictions were lifted in October, the owner was unable to find a local contractor to do the necessary digging and trenching.

- As this report is being written (in November 2000), early snows and bitterly cold temperatures have delayed the installation further and will probably require postponing construction until early spring.

Economics

Since the site is about five miles from the nearest power line, a line extension would cost around $100,000.

For this project, the only feasible alternative to solar power was a propane generator or propane-powered pump. NRCS estimated the cost of such a system at $15,000. The present value of the life cycle cost over a ten-year period for the generator is estimated to be $24,618. This estimate includes the initial cost of the system, regular maintenance, two major mechanical costs, propane fuel costs, and estimated escalation values for propane fuel. Over the same ten-year period, the life cycle cost for the solar pumping system would be $24,602. In other words, the solar and propane alternatives were quite similar in cost.

Nonetheless, the solar option looked preferable to a propane system for several reasons: NRCS was uncertain about the reliability of propane pumps and generators. The system would have required a timer and could not have included a float switch, raising installation complications. Finally, delivering propane to such a remote site would have been extremely difficult, beyond the capability of a normal propane truck. The life cycle cost comparison in the preceding paragraph does not include the additional trips to the site or extra delivery charges that might have been required for a propane system.

The average cost of solar-pumped water is about ten cents per cow per day, assuming 350 cows and a two-month period of use per year over a ten year period. Over the same ten year period, the cost per gallon of water pumped would be $0.005.

Partners

NRCS has done the majority of the design work on the pipeline and intake structure. Other agencies involved are the Montana Department of Natural Resources Conservation; the Bureau of Land Management; Montana Fish, Wildlife, & Parks; the Ruby Valley Conservation District; and The US Fish and Wildlife Service.

C. Lessons Learned

Choosing sites and situations that are well-suited to solar

For someone considering the feasibility of a solar pumping project, the first and most important question is likely to be the distance from existing power lines. At current energy prices, solar power costs more per kilowatt hour than conventional power from the utility grid. The cost comparison tips in favor of solar, however, when a significant power line extension would be required to deliver energy to the pumping site. Power line extension costs vary significantly from one utility to another, but one rule of thumb is that solar is often worth considering when a line extension would be longer than about one third of a mile.

Season of use is another critical factor when looking at the suitability of solar power. The simplest applications in Montana tend to be for pumping between late spring and early fall, while animals are on summer pastures. Solar pumping is certainly possible at other times of the year. Far less sunlight is available during the cold months, however, and freezing water also becomes a problem.

The most striking advantage of remote or off-grid pumping (including solar, windmill, and generator-power) is that it allows the cost-effective creation of drinking water sources that are far from the utility grid. In NCAT's conversations with producers and agency staff, two benefits of solar pumping were mentioned repeatedly: giving livestock greater access to forage and reducing livestock pressure on riparian areas.

Especially in hot weather, cattle and other animals are reluctant to roam very far from water. By creating new sources of drinking water, solar pumping allows animals to move and graze in new places. In effect, solar pumping increases the forage available to livestock. By increasing the forage base available to livestock, solar pumping can extend the number of grazing days, reducing the period when animals must be fed costly hay or grain. By allowing animals to range farther and move more freely, solar pumping can also encourage livestock to spread themselves more uniformly, reducing intense pressure near water sources and improving the overall condition of the range.

Establishing new sources of drinking water can also help draw cattle and other animals away from riparian areas, reducing nutrient loading, damage to streamside vegetation, and associated erosion and water quality problems. These problems, especially erosion, are as much a concern to landowners as they are to conservationists and recreationists. Demands for riparian protection are growing in Montana, and many ranchers welcome the opportunity to avoid environmental controversies. In a few locations in Montana, most notably the upper Big Hole, stock-watering wells have also been used to add critically important stream flows, allowing the temporary closure of diversions that are needed only for stock watering.

The economics of solar pumping: looking beyond initial cost

Many who consider solar power as an energy source reject the idea immediately upon finding out about the cost of the system. However, looking beyond the first cost to other factors frequently will show that the solar alternative is cost effective.

DEMONSTRATION

In addition to providing a reliable source of energy for water pumping, a solar system can extend the grazing season and can allow cattle access to high quality forage far from existing water sources. Following are factors to consider when comparing a solar pumping system to another alternative:

- ***Cost of line extensions.*** This cost has increased dramatically for some utilities and will continue to rise. Utilities are sometimes reluctant to extend a power line to service only one well, especially if the distance is great, because the utility bears the cost of maintaining the line.
- ***Maintenance costs*** of solar versus windmill, gasoline, propane, or diesel generator
- ***The life span of solar equipment compared to a generator.***
- ***Utility deregulation*** and the ***uncertainty of electricity prices*** under deregulation. Those prices are anticipated to rise.
- ***Rising costs of propane, gasoline, and diesel fuel.***

The cost of a solar pumping installation can be viewed over a period of ten years to get a better idea of the actual cost. By comparing the installation costs (including labor), fuel costs over ten years, maintenance costs over ten years, and the cost and frequency of site visits, one often finds that solar is the more economical choice.

Compared with windmills, solar systems tend to be more reliable and require less maintenance. For summer use, when wind speeds are generally lower, solar is more effective since when the sun is shining and the weather is warm and cattle need more warm water and the system pumps more water. The initial cost of a solar pumping system is in the same range as a new windmill pumping system. Solar systems are generally easier to install because windmills require a tower. Installing a windmill tower may require special equipment.

SOLAR PUMPS VS. GAS-FIRED GENERATORS & WINDMILLS*

PUMP TYPE	ADVANTAGES	DISADVANTAGES
Solar Electric Power Systems	• Low maintenance • Clean • No fuel needed • Easy to install • Reliable long life • Unattended operation • Low recurrent costs • System is modular and can be matched closely to need	• Relatively high initial cost • Lower output in cloudy weather
Diesel (or gas) power system	• Moderate capital costs • Can be portable • Extensive experience available • Easy to install	• Needs maintenance and replacement • Maintenance often inadequate, reducing life • Fuel often expensive and supply intermittent • Noise, dirt and fume problem • Site visits necessary
Windmill	• Potentially long-lasting • Works well in windy site	• High maintenance • Costly repair • Difficult to find parts • Seasonal disadvantages • Need special tools for installation • Labor intensive • No wind, no power

* *Table courtesy of Sunelco*

A project report entitled Using Solar Energy to Pump Water for Livestock in Remote Areas, from the California Energy Commission and Extension Service, compares several solar pumping systems to alternatives ranging from generators to windmills. One of the sections compares the operating costs of two gasoline powered jack pump to two solar pumps over a period of 299 days. The cost per day, including labor, of operating the gasoline systems was $10.90. The cost per day of operating the solar systems was $5.01, a savings of $5.88 per day.

In 1989 Sandia National Laboratories noted that photovoltaic pumping systems in remote locations would often be cost effective compared to generators, even with five times the initial capital cost. Low-end generators, which are initially inexpensive, require consistent maintenance and have a design life of approximately 1500 hours. Small to medium-sized solar pumping systems often cost less initially than a durable slow speed engine-driven generator.

Sizing and designing systems

The average consumer is likely to be intimidated by the prospect of sizing and designing a solar pumping system, and most people who lack strong background or experience in this area will need the help of a qualified solar dealer. On the other hand, consumers should understand that dealers are eager to help. The design process is usually quick and painless. Many dealers will provide a no-cost proposal based on a few simple questions that can be asked over the phone.

In order to size and design a system correctly, the dealer will want to know

- how much water is needed by livestock which can be estimated based on the number and type of animals);
- when the water is needed (season of use);
- whether the water source is a stream, pond, spring, or well;
- how much water is available (estimated gallons per minute);
- how deep the well is;
- how far the water needs to be pumped, and with what elevation gain;
- whether there are water quality problems such as silt or high mineral content that may damage the pump; and
- how much storage volume is available, and how tanks are arranged.

Based on these factors, the dealer will recommend a system, putting together a list of suitable components. The main components of a solar pumping system are the solar panels, pump, pump controller, and mounting structure for the panels. All of these are discussed in Appendix A, Technical Overview. The components need to be compatible, working and fitting properly together. Here is one place where the dealer's experience and familiarity with systems becomes essential. The dealer also saves the consumer time and aggravation by providing the correct hardware: clips, screws, nuts, bolts, washers, cable (cut to correct lengths), and assorted wiring and connectors.

It should be obvious from the above that consumers who are new to solar pumping will find it very worthwhile to work with an experienced solar dealer. A list of Montana solar dealers and installers is included in Appendix B.

Another excellent source of technical assistance is the Natural Resources Conservation Service (NRCS). NRCS may be able to provide help with designing and installing stock-watering systems. This advice can prove invaluable, especially where projects require extensive piping or complicated arrangement of storage tanks.

In Montana most small pumping projects – whether solar or otherwise – raise few if any legal or regulatory complications. Landowners should consult local officials, though, to

make sure that they are meeting all legal requirements. For example, the local conservation district must be consulted for any project that involves disturbing a streambed, and the Department of Natural Resources and Conservation must be consulted for any project that may affect water rights.

Installing systems

Designing a solar pumping system from scratch is generally beyond the ability of the average consumer, but installing a system may not be. Montana's ranchers and farmers are handy and resourceful people. Most have good collections of tools and some experience with pumps and electrical wiring. Many of these people are eminently capable of installing a solar pumping system.

A few words of caution are necessary, however. Installing a solar pumping system is a complex task, combining elements of electrical work, plumbing, and heavy construction (often including earthmoving, pouring concrete, and welding). A backhoe, tractor, or front-end loader is almost a necessity for some larger projects.

The customer usually provides peripheral material such as water piping and fittings, tanks, mounting structure support post, concrete, and grounding materials. Almost by definition, a person installing a solar pumping system is in a remote location. This has the effect of compounding the penalty for forgetfulness or bad instructions, since these may necessitate a trip home or into town. It's a good idea to err on the side of excess, bringing an ample collection of tools to the job site.

Some useful items are:

- stepladders
- post pounder
- hammer
- sledgehamer
- shovel
- digging bar
- hacksaw
- cordless drill
- level
- compass
- measuring tape
- teflon tape
- electrical tape
- cable ties
- wrenches and sockets
- allen wrenches
- screwdrivers
- multimeter
- tarps
- pliers and sidecutters
- wire crimping tool
- wire nut connectors
- cable stripper
- hose clamps
- silicone caulk or glue
- propane torch

NCAT encountered minor problems in almost all of its demonstration projects. For example:

- Instructions were sometimes inaccurate or out of date.
- Diagrams were sometimes unclear or of poor quality.
- One participant received no installation instructions at all. Another person received no wiring diagram.
- Equipment sometimes arrived that was the wrong size, length or type. In some cases there were missing hardware items, such as screws, clips, and washers.
- There were some compatibility problems. For example, two trackers had pieces of steel welded as a stop for the shock absorber that prevented panels from being installed the recommended distance apart. In another case, pre-drilled holes in panels didn't line up with holes in the tracker.
- A number of systems initially yielded disappointing flows of water, requiring some troubleshooting to find and correct problems.

More than anything, assembling and installing a solar pumping system calls for good preparation, patience, common sense, and a basic understanding of wiring and pumping. The process is not as straightforward or "plug and play" as one might like, but it is probably no more difficult than some other common farm and ranch projects. The potential complexities of the installation further underscore the importance of a good relationship with a solar dealer, preferably a local one. A cell phone at the job site comes in very handy.

Another option, of course, is to hire a qualified installer. See Appendix B for a list of Montana solar installers.

A Note about Vandalism and Portability

Nearly every rancher or farmer approached about a possible solar demonstration project raised concerns about vandalism. The most common concern was that panels would be shot during hunting season. This issue came up so frequently and was voiced so strongly that NCAT believes it to be a very legitimate and serious problem in Montana's rural areas.

Solar advocates like to point out that pumping systems can be made portable, suggesting that they can be moved from one well to another following pasture rotations or that panels can be removed from an area during hunting season. This is true, but perhaps not as easy as one might think.

There are essentially three ways that installed solar panels can be moved from one place to another: If the panels are mounted on a trailer they can simply be driven from one location to another. The panels can be unbolted from the frame and removed. The third possibility is that a small array on a rack could be unbolted from the pole or other mounting structure, and the whole rack could be lifted off and carried away.

Each of these approaches has its limitations and complications. For one thing, trailer-mounting panels adds considerable cost. For another thing, while it is possible to install a tracking rack on a trailer, typical trailer-mounted systems use a fixed mounting rack, foregoing the power-generating advantages of a tracking rack. (See the discussion in Appendix A: Technical Overview.)

In most cases, removing panels from the frame may be the best option, although electrical connections are not always easy to work with. NCAT staff found that junction boxes were sometimes easily damaged and required awkward finger movements in tight corners. Disassembling large arrays would generally require working on a stepladder and would ordinarily require at least two people. Moreover, aligning the panels carefully on the frame is fairly time-consuming. This task would need to be repeated each time the panels were replaced.

Removing the whole frame – with panels attached – from a mounting pole may be a good solution for small arrays. In general, pole-mounted racks are attached to the pole by just one or two bolts. With larger arrays, the major problems are likely to be weight and awkwardness. Solar panels themselves are not very heavy, weighing 15 to 30 pounds apiece. But a top-of-pole mounting rack can weigh anywhere from 10 to 350 pounds. Even a four-panel array on a tracking rack can be extremely awkward to handle. Finally, whether one plans to remove the panels or remove the entire rack, one must seriously consider – and take precautions to prevent — the possibility of damage to the panels or rack during transportation from one site to another.

D. Solar-Powered Electric Fencing

Electric fencing systems, powered by batteries or alternating current, have been in use for several decades. Livestock producers have been the primary users. Electric fencing has become more popular as energizing units have become more reliable and a wider variety of units have become available. Solar-powered energizers are now common and available in most farm and ranch supply stores and catalogs.

Solar-powered electric fencing units consist of one or more solar panels, a battery, and a controller, also known as the fence charger. The panels provide direct current (DC) electricity to the battery and the battery operates the controller. The solar-powered unit is connected to a fencing system and a grounding system to complete the electric fence.

The solar panel, battery, and controller can be all in one portable unit for smaller systems or can consist of several solar panels mounted on a rack, with the controller and batteries installed nearby. These larger systems are powerful, able to energize many miles of multiple wire fencing. They are not portable, however. In order to be effective, the larger systems require individualized design based on length of fence, types of soil, type of livestock, how wet or dry the range conditions are, and time of year when the system is used. Most electric fencing dealers have enough technical support from their suppliers so that the design of the larger systems is not difficult.

In Montana, solar-powered electric fencing is in widespread use. Livestock producers, particularly those following intensive grazing rotation schemes, have found that they can reduce maintenance of the energizing system by using solar panels to charge the batteries.

Small portable systems, able to energize up to 25 miles of clean (no vegetation touching the wire) single wire fence line, are available for under $200, not including the fencing and grounding systems. Larger systems can cost much more.

See Appendix B for several manufacturers' web sites, as well as sites containing general electric fencing information from land grant university research.

Jim Tomlinson has been using a solar-powered electric fence for three summers to keep his cattle grazing up on a bench area. Before installing the fence, the cows did not use much of the forage on the bench, preferring to stay down along the creek. Tomlinson installed about one-half mile of two-wire fencing, using high tensile smooth wire. The area through which he built the fence has some brush but is relatively clean of vegetation along the fenceline.

When purchasing the solar panel and charger, Tomlinson followed manufacturer recommendations for the length of fencing he has and the amount of vegetation. He installed the fencing system to allow one wire to be hot and the other wire to be a ground wire. The charger is grounded to earth with three six-foot long ground rods, installed ten feet apart. Three ground rods were necessary because the charger is located in a dry area. The grounded fence wire is connected to the earth ground system. If a cow touches the hot wire, the circuit is completed either by the earth or the grounded wire. This is a preferred installation in dry country and during dry weather. Tomlinson said, "the fence worked well even in the very dry summer we had this year." He has not had any problems with either cows or wildlife taking the fence down. Some loose horses did take a section of fence down in the spring.

The charger's solar panel charges a battery so that the fence will work at night and during cloudy weather. Tomlinson uses both a 12-volt deep cycle battery and a smaller battery (not deep cycle) with the charger.

PART II: MARKET RESEARCH

A. Methodology

In order to understand the commercial potential of solar-electric technology in Montana's agricultural community, NCAT chose to employ an interview-based market research strategy rather than a written questionnaire or a telephone survey. This decision was made for several reasons:

Questionnaires received unannounced through the mail tend to be assigned very low priority by most respondents, unless the subject matter is something of personal interest. With solar-electric technology being a relatively new topic, NCAT believed the target audience – farmers and ranchers within Montana Power Company's service region – would too often not have enough interest to complete and return a questionnaire, resulting in a low response rate. Written questionnaires also tend to be restrictive in the information that can be collected effectively. Questionnaires can always include open-ended queries, but these types of questions are also the ones respondents frequently choose to leave blank or, at best, answer with very brief responses.

Telephone surveys can overcome some of the limitations of the written questionnaires, because they allow the surveyor to ask follow-on, probing questions in order to ferret out more details. Even better are personal and telephone interviews, including focus groups. These tend to be more fluid and free flowing than other market research tools. NCAT's experience has been that respondents are typically inclined to spend more time in the discussion once they understand the dialogue will be part of an interview, rather than a survey.

With respondents being more willing to enter and contribute to a discussion, the interviewer has more flexibility to probe different topics as they arise. Such probing was particularly helpful in the focus groups and personal interviews in this study. Indeed, it was this give-and-take between the interviewer and the interviewee that led to many significant research results.

NCAT interviewed nearly sixty stakeholder representatives. Most interviews were conducted by phone, but whenever possible the interviews were performed in person. NCAT chose to concentrate on the content of the interviews, rather than the number. Thus, this study is not claimed to be a statistically valid research product. However, NCAT interviewed enough farmers and ranchers and representatives of each of the ancillary groups to see clear patterns and duplication in the responses. For this reason, NCAT is confident that the study's results are accurate and provide more and better information than if the same study had employed a written or telephonic questionnaire.

B. Targeted Audiences

NCAT's primary objective in the market-research component of this study was to explore the commercial potential of solar-electric technology in the agricultural sector of Montana Power Company's service region. To meet this objective, NCAT focused first and foremost on farmers and ranchers in the targeted region, completing over twenty formal interviews.

Among these were a number of members of the Alternative Energy Resource Organization (AERO), including members of Farm and Ranch Improvement Clubs (FRICs). In order to obtain the broadest and most accurate perspective possible, however, NCAT also sought input from several ancillary groups whose opinions are considered important because of the relationships these groups have to either the agricultural community or the solar-electric industry. These additional groups included:

- County Extension and Natural Resource Conservation Service (NRCS) agents (11 interviews)
- Montana Power Company's regional new-construction managers (7 interviews)
- vendors of solar electric technology and systems (14 interviews)

C. Results

Overall, the research results support an optimistic picture of the potential for solar electric technologies in the agricultural community. Interviewees who have solar-electric experience gave the technology high marks for its ease of use, reliability, and cost effectiveness. Most of those without solar-electric experience seemed intrigued by others' successes with the technology, and many indicated that they will be revisiting the issue of solar electric and considering how it might be employed in their own farming and ranching operations.

Overall, the research supports an optimistic picture of the potential for solar electric technologies in the agricultural community.

Despite these promising results, the study highlights ways in which many in the agricultural community continue to labor under inaccurate perceptions regarding solar electric's cost, application, reliability, and availability. Although cost was identified most frequently as the single greatest barrier confronting solar-electric technology, a review of the research results confirms that what farmers and ranchers want even more than reduced prices is current information on the technology: how it is being employed in agriculture settings, how dependable it is, who to contact for more details, and how its costs compare to alternative practices.

The research findings also revealed how important it is to agriculture producers for their information sources to be credible. Friends and neighbors, County Extension and NRCS staff, and long-time suppliers are key among the small circle of resources producers typically turn to for information and advice. This finding is particularly helpful in developing effective marketing and information dissemination strategies.

D. Detailed Interview Descriptions

The research for this study employed interviews – sometimes in person, but usually by telephone – with representatives of several key stakeholder groups, including County Extension and NRCS agents, Montana Power Company's regional new-construction managers, vendors of solar-electric technology and systems, and members of AERO and its Farm and Ranch Improvement Clubs (FRICs). The following discussion presents more detail on the information obtained from each of these groups of interviewees.

What farmers and ranchers want even more than lower cost is current information on the technology.

1. County Extension and NRCS Agents

County Extension and NRCS agents represent an excellent resource for this study because of their long-standing reputation as an informed and reliable source of information and assistance to the farmers and ranchers. All of the agents contacted acknowledged receiving at least some calls about solar-electric technology.

Frequency of inquiries regarding solar electric

Agents in and around more-heavily populated areas, such as Ravalli and Missoula counties, generally reported receiving only a few inquiries throughout the course of the year. They attribute this low number of calls to the increasing urbanization of these counties, characterized by the strong trend away from traditional agriculture and toward smaller and more numerous plots, often just 10 to 20 acres in size. Another contributing factor is that these "gentleman" farmers and ranchers generally want to be close to the region's electrical grid, and this increased ratepayer base makes it more cost effective for the utilities to extend power lines. As the grid is extended, solar-electric applications become less cost effective compared to tying into the grid. The result is fewer opportunities for solar electric installations.

Agents in less-populated areas, however, including Jefferson, Granite, Broadwater, Powell, and parts of Lewis and Clark counties, continue to deal with traditional agricultural producers. Electric grids are still often a mile or more away from farming and ranching operations that require some form of power. Not surprisingly, agents in these counties receive more inquiries from producers interested in electrical power-generation alternatives.

Familiarity with solar-electric technology

A few of the agents in the less-populated counties indicated they are familiar enough with solar-electric technology to be able to suggest it as an alternative when appropriate. Most of the agents, however, while not ignorant of the technology, admitted they were not as well versed about it as they could be for applications other than solar fencing. Solar fencing has been around long enough that producers can turn to several reliable resources, including their County Extension and NRCS agents. The research indicated, however, that most County Extension and NRCS agents are not as experienced with applications beyond fencing. There was a general feeling that having more information available on solar-electric applications would be useful to both the agents and their clients.

Perspective on opportunity for solar electric

Interviews with County Extension and NRCS agents confirmed that there may be numerous opportunities to employ solar-electric technology – particularly in the more rural areas – based only on the number of known remote water-pumping projects for which producers are already hauling water to a site or using a generator. Beyond these obvious sites are other opportunities for solar applications, including not-yet-developed water-pumping sites. Solar power can also be used to open valves on irrigation pumps and operate remote ditch gates. Several agents emphasized that farmers and ranchers are ideal candidates for solar-energy systems because of their strong mechanical skills.

Perceived barriers to solar

While there appear to be ample opportunities for solar electric in agricultural operations, there are also barriers to be overcome. According to some agents, the high cost of solar electric – or at least the perception of high cost – is the most significant issue to be addressed, especially over the last 10 to 20 years of lower prices to producers of agricultural products. Other agents acknowledged that cost is an issue, but they focused more on the shortage of current information as being the major obstacle. Additionally, agents raised concerns about vandalism and weather effects, noting that producers will be less inclined to adopt a technology if they believe it can be easily damaged.

Extension and NRCS contacts clarified that if agriculture producers embrace solar-electric technology it will be because they regard it as the best tool for accomplishing a certain task, not because it is a renewable-energy alternative. As such, they will evaluate it in the same way any other tool is evaluated, drawing information from trusted sources and using similar risk/reward factors to reach a decision.

Recommendation on how to expand solar-electric use

Despite the barriers confronting solar electric, all agents agreed that there are ways to expand the number of solar-electric applications in the agricultural community. Farm tours were repeatedly cited as the best way to get producers to consider alternative approaches. Farmers and ranchers rely heavily on the experiences of friends and neighbors, and farm tours offer the opportunity to showcase one producer's approach. Other means of information dissemination cited by agents included workshops and seminars, especially when timed during the off-season; articles in several agricultural-industry periodicals, such as *Prairie Star*, the *Montana Farmer-Stockman*, *Agri-News*, and *Farm Journal*; promotions by long-time trusted suppliers; and displays at regional trade shows and expositions.

2. Montana Power Company's Regional New-Construction Managers

MPC's regionally based new-construction managers were also considered an excellent resource for this study. New-construction offices are typically the first point-of-contact for individuals seeking line extensions. Thus, these offices have firsthand knowledge of the number and type of requests coming in for line extensions. They also work with prospective ratepayers to help them understand the cost of a proposed line extension and what options might be available.

Frequency of line-extension requests and how they are handled

NCAT contacted seven of the new-construction offices operating in MPC's service region. Their responses varied significantly, depending on their location and function. The Kalispell office, for instance, reported receiving no calls for line extensions, because that office deals only with natural-gas distribution, not electricity. This office also offered the opinion that the Kalispell region gets too little direct sunlight to make any but the smallest applications feasible.

Extending that Power Line: Factors to Consider

From the customer's perspective …

Pros

- Customers experience greater control over lifestyle choice.
- Line extension enhance property values.
- Customers are protected by MPC for up to five years against new users tapping into the line without sharing in the cost of the extension. After five years, customers are no longer protected, but new users then must usually seek an easement from the original customer to access the line.

Cons

- Costs average three to five dollars per foot for overhead lines and five to seven dollars per foot for buried lines. This includes about one dollar per foot for the line; one to two dollars per foot for preparation of the land and about two dollars per foot for the hardware. Economies-of-scale are possible, but costs generally range $20,000-$25,000/mile.
- Will the path of the line cross other public or private land? If so, easements are needed and there will be additional costs. Easements crossing private land are usually easy, but involve negotiating an agreement with the landowner. Easements for crossing public land (e.g., Forest Service; BLM) are much more complicated, costly, and time consuming (often 6-9 months).
- Installation can be time-consuming – from a mile or more each day to a mile or less each week, depending on terrain, obstacles, available equipment.
- There is potential for damage caused by natural elements and vandals, possibly resulting in damage to the owner's electricity-powered equipment.
- When maintenance or repair is needed, line extensions may not be the utility's highest priority.

… and from the utility's perspective

Pros

- Adds to the ratepayer base;
- Opens the door for additional ratepayers who might later tap into the extended line; and
- Expands reach of infrastructure.

Cons

- Considerable resource expended to plan, design, install, and maintain the extension, especially in the case of remote sites;
- Revenues often fall far short of meeting expenses; and
- Liability issues if owner's electrical equipment is damaged by weather, falling trees, or other hazards.

The Billings office, on the other hand, reported responding to an estimated 700 to 800 line-extension requests in 1999. The majority of these requests involved extending lines to groups of homes or other population centers. Because these costs are shared among many ratepayers, the financial impact on any single ratepayer does not warrant consideration of alternative means of providing power.

In the remaining cases – estimated to be less than 20 throughout the Billings region in 1999 – MPC representatives always took time to discuss options other than a line extension to supply power to the designated site. Some customers – typically upscale homeowners – still opt for a line extension and end up paying "outlandish amounts of money" to have power lines extended to their sites. Most others, however, tend to choose generators. Other MPC new-construction offices described similar situations in their own regions and, like the Billings region, consider each case on its own merit to determine whether a line extension is feasible. This process benefits both the customer and MPC. The customer can usually select a less costly and more reliable source of power. The utility benefits from not having to install new infrastructure that is costly to maintain relative to the revenues generated by that line over time.

Most vendors agreed that nothing will be more effective than farm tours and demonstrations of the technology.

When line-extension cost projections suggest that other options should be considered, MPC's new-construction offices do their best to steer the customer toward proven power-generation systems and those systems with which the office is most familiar. Some of the new-construction managers indicated they have sometimes included solar-electric systems as one of the options for consideration. In most cases, however, the major option suggested is for gas- or diesel-powered generators.

Solar Electric as an Option?

When asked why solar electric wasn't a more common suggestion, the answer in every case was quick and straightforward – the utility representatives simply do not know enough about the technology to feel comfortable recommending it. Moreover, they are either uncomfortable or unfamiliar with the companies that sell solar-electric systems. Under these circumstances, it is not at all surprising that solar-electric systems are not usually among the options presented to line-extension customers.

Without exception, the new-construction offices were willing to revisit the idea of solar-electric systems as an alternative to some line extensions. The key, they indicated, will be access to updated, credible information, both for themselves and the customer. They also want to have the opportunity to see, discuss, and learn from working systems, so they can better understand when solar electric is viable and when it is not.

It seems ironic to label agricultural producers as conservative and risk averse, considering that they are in a high-risk venture.

As important as the technology itself is information on the companies that will sell and service the system. Currently, the new-construction offices are unaware of what solar-electric dealers are operating in the state, what systems and services they provide, and what kind of track record they have. A point made by more than one of the new-construction offices is that they will refrain from suggesting solar as an option unless they can feel comfortable about the companies that would actually sell, install, and service the system.

3. Vendors

Example of Solar-Electric's Potential

A recent discussion with Rodney Rogers at Bighorn Electric Coop in Hardin, Montana, provided an excellent example of the potential of solar-electric technology when surrounded by a properly supported environment.

Q: How did Bighorn Electric Coop get involved with solar-electric technology?

A: Bighorn became involved with solar electricity five to six years ago, when one of our managers developed an interest in it as an alternative to some of the line extension requests we were receiving. We figure ¾ to 1 mile over normal terrain was the maximum distance a line extension could be before solar electricity became a cost-effective alternative. Rougher terrain can quickly shorten this distance.

Q: How many solar-electric systems has Bighorn Electric installed and how are they being used?

A: At least 30 by now. We're beginning to receive fewer calls about them from within Bighorn County, but interestingly, we're now receiving a fair number of inquiries from other counties. Nearly all of the systems in Bighorn County are being used for water pumping. Many of the systems are on trailers, intended to be hauled around to different sites on a ranch. Other landowners have acquired multiple systems, with one landowner having purchased six.

Q: How are the systems sized?

A: Every system is uniquely designed to meet the expected demands placed on it. However, the typical system has involved eight to 15 Siemens 53-watt Alice panels designed to pump about 10 gallons per minute. The depth of the well is a major factor in determining the final number of panels to use. We have also been staying exclusively with submersible pumps, but in the spring we'll be installing an above-ground pump in a system, a change that should reduce the cost of the system significantly.

Q: Has Bighorn Electric actively marketed these systems?

A: We have never needed to do any marketing. The first couple of systems worked very well, and then word-of-mouth took over. In such a heavily agricultural county, it wasn't long before we had lots of inquiries about the technology. If we were to market the systems, the best way would be to use the existing installations as examples of how the technology can be employed reliably and cost-effectively. Farmers and ranchers often like to see their friends and neighbors using a new, innovative tool before they decide to adopt it. Hauling a sample system around to trade shows and conferences is another effective way to promote a new tool or practice.

Q: If other utilities were interested in exploring the potential for solar electricity in their own service regions, what is the single best piece of advice you could offer from Bighorn's experiences?

A: What made the difference for Bighorn was that we had an internal champion for the technology, someone who recognized solar energy as a tool we could use in dealing with line extensions, which can be a real problem in highly rural areas.

Vendors – the individuals and companies that design, create, sell, install, and service solar-electric systems – represent a critical segment of the solar-electric industry in Montana. The state is home to at least 16 vendors of solar-electric systems, most of whom sell more systems out of state – and in some cases, overseas – than they do in-state. NCAT attempted to identify and interview all of these vendors to learn more about their unique perspective on the market potential for solar-electric systems in Montana's agricultural community.

Solar business in general

NCAT succeeded in contacting the large majority of the vendors serving Montana. With few exceptions, these vendors described a strong upswing in business over the last few years, driven jointly by Y2K concerns, the growing number of remote home sites, and the ever-increasing array of new technological developments, such as grid-intertie capability. Some of the vendors reported they have never been busier. Moreover, the general feeling is that this upswing will stay with the industry for several more years, especially if the economy remains strong.

Solar electric in the agricultural sector

Vendors reported that little of their activity is in the agriculture sector. The majority opinion was that the agriculture sector is a difficult market to enter on something other than a small scale. Some vendors reported having previously made concerted efforts to reach farmers and ranchers at their major tradeshows and expositions and through the press, but with relatively few sales being generated. In short, there tends to be initial interest in the technology but little follow-through.

Perceived barriers to selling into the agriculture market

Vendors recognize they are battling a number of barriers to increased sales in Montana's agricultural community. According to the interviews, memories left over from the high-cost, low-output systems of the '70s and '80s represent the greatest barrier. Even in those cases when the vendor has the opportunity to update the potential buyer regarding the significant improvements in today's systems and their costs relative to alternatives, the decision to buy is difficult for producers who are still trying to weather the effects of the prolonged slump in agricultural prices.

The agricultural sector's traditionally conservative nature is seen as another major barrier. Interestingly, it was a vendor who first commented on the irony of labeling agriculture producers as "conservative" and "risk adverse," noting that agriculture is an inherently high-risk venture. Whether labeled as conservative, risk adverse, prudent, cautious, or some other description, the fact remains that farmers and ranchers are not perceived as being impulsive buyers. They generally want to be assured that something new to them is going to perform as claimed. After all, in the case of a solar water-pumping system, the well being of a producer's herd may rest on the system's reliability and performance.

Being conservative is not by itself a condemnation of agriculture producers. What it signals to vendors, however, is the likelihood of an extended and sometimes resource-draining sales period. As small-business owners themselves, solar-electric vendors are understandably reluctant to commit the level of resource needed to pursue the sale, especially in times like the current business upcycle, when sales from non-agricultural sectors are much easier and less expensive to close.

Overcoming the barriers

Those vendors having experience in marketing to the agricultural sector tended to agree that there is no quick way to overcome the sector's cautiousness. As a group, however, virtually all the vendors interviewed for this study agreed that the best way to proceed is by expanding the agricultural sector's access to current information on solar-electric technology and its relative costs, capabilities and applications, availability, and maintenance. Print media and workshops are two methods of disseminating this information, but in the end, most vendors agreed that nothing will be more effective than farm tours and demonstrations of the technology. Several of the vendors noted, too, that today's agriculture producers are better educated than those of a generation ago, and thus are better able to understand and assimilate technological information presented to them. As noted previously by Extension and NRCS agents, today's producers are also likely to feel comfortable with the mechanics of solar-electric systems, suggesting that the systems are more likely to receive proper maintenance.

4. Farmers and Ranchers, including AERO and FRIC Members

The final stakeholder group interviewed comprised farmers and ranchers. NCAT initially regarded members of the Alternative Energy Resource Organization (AERO) and its Farm and Ranch Clubs (FRICs) as a separate ancillary group, but in fact the large majority of these members are also practicing agricultural producers. For this reason, the interview summary includes NCAT's discussions with the AERO and FRIC members as well.

Setting the stage

The farmers and ranchers interviewed for this study represented a diverse sampling. Operators of both large and small operations were included, with one participant managing a ranch in excess of 50,000 acres. Many of the respondents are primarily livestock producers (cattle, horses, and buffalo), while others raise both livestock and grain (primarily wheat and hay).

> Each of the stakeholder groups interviewed for this study added a unique perspective to the research findings, and the group of farmers and ranchers was no exception. Producers risk their livelihoods when they choose new technologies. As such, more than one interviewee challenged the negative connotations often assigned to the "conservative" and "risk averse" labels, arguing that agriculture is itself a high-risk enterprise. Producers asserted that anyone taking the risks that farmers and ranchers do is likely to be equally "conservative" and "risk averse" in their buying habits.

Level of awareness and comfort with solar electric

> ***Low agriculture prices make it difficult for producers to afford any project costing $5,000 to $10,000.***

Virtually all of the interviewees were already aware of solar-electric technology, either directly from their own experience or indirectly through the experiences of friends and neighbors. Everyone agreed that the most common application is electric fencing, but several participants were unaware of the possibilities for water pumping. Participants offered other intriguing applications for solar electricity as well – for example, charging cell phones when the user is in the field and powering small LEDs that have been shown to scare coyotes away from sheep. Regardless of the application, most producers expressed comfort with the technical and mechanical aspects of solar electric, underscoring comments from the other interview groups about farmers and ranchers generally being good candidates because of their mechanical skills.

Likelihood of expanded use of solar electric

On the topic of expanding the use of solar-electric technology within the agricultural arena, reactions varied depending on the level of experience the respondents have had with solar-electricity. Producers who have employed solar electricity in their operations – whether for fencing, water pumping, or other applications – were generally positive about the technology and, in most instances, indicated that they were likely to apply solar-electric technology to other suitable applications as they arise. In comparison, producers who are only aware of the technology from some other person's experience indicated that their involvement in this research has made them more willing to consider solar, but are they remain unwilling to commit to a new technology until they are comfortable in knowing it is the right answer to a given problem.

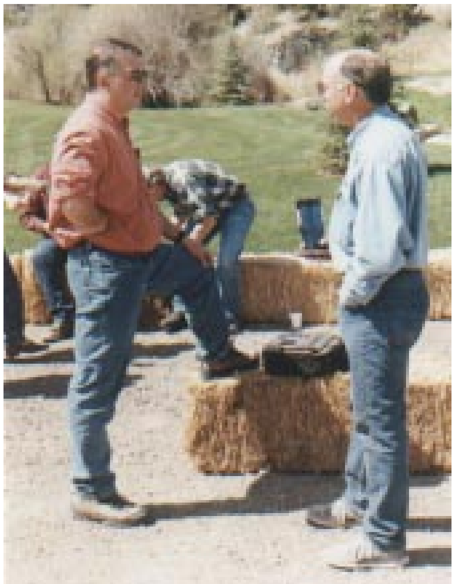
Identified barriers to expanded Use

> ***Lack of information, rather than perceived cost, seems to be the greatest single barrier confronting solar-electric technology in today's agricultural sector.***

Producers were questioned about what barriers they see that solar-electric technology will have to overcome. Most identified cost as a major barrier, though as discussions continued many acknowledged that the life-cycle cost of solar electric could be extremely competitive relative to conventional technology, especially in remote applications. At the same time, some producers continued to focus on the issue of absolute costs, saying the long run of low agriculture prices have made it difficult for them to afford any project costing $5,000 to $10,000, regardless of which technology might be most appropriate.

Throughout the interviews, information shortage was also frequently identified as a barrier. Nearly all of the producers acknowledged they have not stayed current on the development of solar-electric technology, so they are uninformed about the technology's capabilities, applications, cost, availability, and other related matters. As a result, many interviewees admitted they still imagine the high-price, low-reliability systems of the '70s and '80s when they think about solar. A few said they still regard solar as a failed technology, believing they would be seeing more of it if it were successful.

Other barriers – some less obvious, but no less noteworthy – were identified as well. For instance, several producers noted that an ongoing obstacle for all renewable-energy



technologies continues to be the general population's apathy toward the concept of energy efficiency. Memories of the 1970's oil embargo and its resulting high-priced fuel and long gas lines are now faded, aided by the slow, gradual rise to today's prices. Nothing better reflects this than the nation's love affair with sport-utility vehicles, large trucks, and other less-fuel efficient automobiles.

Another factor affecting the perception of solar is how the agricultural community typically looks at costs on a per-unit basis – for example, per acre or per head of livestock. Presented in this way, the energy requirements for an ongoing operation appear to be quite low. As an example, one producer noted he expects to use one to three gallons of diesel fuel, or $2 to $5, on each planted acre. These costs pale, however, in comparison to other inputs, such as fertilizer, which can run as high as $80 to $100 per acre. Such comparisons assign a low priority to energy issues.

Concern about vandalism was identified as still another barrier. At least two respondents offered anecdotes about how solar-electric panels used in remote areas of eastern Montana had been targeted by vandals. Having so little ability to protect the panels makes it difficult for producers to commit to them, especially if it means their investment in livestock or grain may be at risk if the system does not operate as expected.

Recommendations for overcoming the barriers

Producers agreed that there may not be much that can be done about the high absolute cost of solar-electric systems. It was acknowledged that this barrier is really tied more to national farm policy and is not a statement on whether solar-electric systems can compete with conventional means of accomplishing the same task. Still, several producers raised the idea of incentives as a way to reduce costs. Others, however, were quick to caution against tying the success of solar electric to incentives. If incentives are implemented, it was generally agreed that they should be offered by utilities or dealers, but not by the government.

In terms of the relative cost of solar electric, many of the producers realized that the issue is less about cost and more about not having the right information – and not knowing for sure where to get it – to enable an informed decision to be made. For this reason, many of the producers interviewed held that the lack of information, rather than high-perceived costs, is the greatest single barrier confronting solar-electric technology in today's agricultural sector. Overcoming the barrier will require up-to-date information on the technology and ready availability to producers.

Following up on this issue, producers were asked what sources they usually rely on for credible information about a new technology or practice. By and large, the responses repeatedly highlighted five major sources (in no order of importance):

- agency representatives (i.e., County Extension and NRCS agents), usually in person, but sometimes via workshops, seminars, and organized demonstrations;

- suppliers with whom the producer has a long-standing relationship;

- friends and neighbors;

- local, state, and sometimes national agricultural trade shows and similar events; and

- the agricultural press, with multiple recommendations for *Prairie Star*, *Farm Journal*, and *Montana Farmer-Stockman*.

When probed further to identify the single, most preferred way to reach the agricultural sector with a new technology, producers made clear they like to see it in use, preferably under normal operating conditions. Seeing it being used provides a better understanding of how the technology operates and of how it should be installed or applied. Additionally, seeing someone else employ the technology is evidence of it being a proven and accepted approach to the task it addresses, rather than still being in the experimental stage of development.

Visits to friends and neighbors, organized farm tours, demonstrations by agency staff or suppliers at workshops or seminars, and demonstrations at conferences are all opportunities to see a technology in use. Most of the producers with little or no solar-electric experience indicated they would be inclined to attend a demonstration of solar-electric technology other than for fencing purposes, assuming it is held within a reasonable distance from home and at a time that coincides with their work schedules.

PART III: CONCLUSIONS AND RECOMMENDATIONS

A. Barriers and Opportunities

Barriers

Summarized below are the barriers identified during the course of this research:

A shortage of objective, up-to-date, and easily accessed information regarding solar-electric technology, applications, and dealers/installers

As frequently as the cost issue was raised, an even greater barrier appears to be a shortage of information on the technology and its applications, installation, maintenance, reliability, and performance. As an illustration, producers having recent experience with solar-electric applications were overwhelmingly positive about the technology. Producers with little or no experience, however, were far less optimistic. Many of them indicated that their participation in this study, together with what they have learned about others' successful experiences, will likely cause them to re-think solar, but they admitted not knowing where to go for updated, reliable information. All producers interviewed agreed that making good literature resources more readily available would be a good first step in promoting solar electricity. Many producers requested a copy of this study's final report as a tool for determining how solar-electric technology might be employed in their operations.

"It's worth another look."

The shortage of information extends to other stakeholder groups as well. Several of the utility representatives and County Extension and NRCS agents also expressed interest in having a better understanding of solar-electric technology and the companies that sell and install systems.

The reality that solar-electric costs are higher than some producers can afford

The issue here is not whether solar-electric costs are higher than the cost of more conventional alternatives, but whether any alternative is affordable for producers during an extended period of depressed commodity prices. In these circumstances, producers may have exceptional opportunities to employ solar-electric technology but will not be able to address them, with solar or anything else.

The perception that solar-electric costs are higher than most other alternatives

Many producers still associate today's solar technologies with negative memories of solar from the late '70s and early '80s. First and foremost among these memories is a very high initial cost of the system.

The crucial importance of reliability

When it comes to providing the drinking water their cattle need to survive, agricultural producers cannot afford to gamble on anything they perceive to be experimental or unreliable. Most of them also cope with severe and stressful demands on their time. They can't afford to spend time checking on a pumping system every day to make sure it is working properly.

"The cost would be the first thing..."

Underestimation of solar's reliability in today's systems

Most interviewees with little experience with solar electricity still associate the technology with the high cost and poor performance of so many systems from the '70s and '80s. They have little understanding of the improvements in today's technology, especially in terms of day-to-day dependability and withstanding the rigors of severe weather conditions. Many people also confuse photovoltaics with solar hot water heating, and have heard negative stories about fly-by-night solar hot water installers during the 70's and 80's.

Uncertainty regarding the availability of solar-electric technologies

Most producers indicated that they would not know where to go if they did want to consider buying a solar-electric system. Those with solar-fencing experience noted that they don't think their solar-fencing suppliers also offer other solar-electric systems. Most producers asked to receive the list of solar-electric suppliers to be developed as part of this study.

Uncertainty about access to technical support

The interviews repeatedly underscored that agricultural producers are good candidates for solar applications because of their strong mechanical skills. These skills will be valuable in the event the owner needs to maintain or make minor repairs to a solar system, but they cannot fully replace the knowledge and experience of someone who has been designing, installing, and maintaining such systems for a matter of years.

Producers recognize the importance of having access to this kind of technical resource but they are also guarded about relying too much on an unfamiliar vendor, wondering whether the company will be around in a year or two. A major challenge to the solar industry will be to convince prospective buyers that today's companies are not like those that came and went in the '70s and '80s. Until that challenge can be met and agriculture producers are more comfortable with solar-equipment vendors, the issue of technical support is likely to continue being a drag on sales.

Concerns regarding the susceptibility of solar-electric system to damage from vandalism

Several interviewees repeated stories they had heard about system failure due to vandalism. Producers are understandably reluctant to install any mechanical system if there is a possibility of system failure, regardless of whether the failure is caused by vandalism, weather, or some other effect.

General perception that the issue of energy savings ranks very low on a producer's list of priorities

Solar advocates promote many different aspects of solar energy, including its energy savings relative to fossil fuels. It would be a mistake to emphasize energy savings too heavily with the agricultural sector, however, because energy inputs represent only a small portion of the inputs that go into a producer's product. As such, producers generally assign energy savings a lower priority than other operational costs.

Inconsistent quality of instructions, hardware, and packaging

It would be a mistake to emphasize energy savings too heavily with ranchers and farmers.

In four of its six demonstration projects, NCAT encountered missing or defective hardware, compatibility problems, or missing or erroneous instructions. One system arrived with no instructions at all. One arrived with no wiring diagram. One arrived with the wrong instructions for the pump controller. (These turned out to be instructions for an earlier model.) In one case a key diagram was incorrectly drawn. In another case, parts of a shock absorber had been pre-assembled incorrectly by the manufacturer. Some systems arrived with missing washers, clips, screws, or other hardware. In two cases electrical cables had been cut to incorrect lengths. In two cases the panels did not fit on the rack as recommended. Assuming that these experiences are typical, they raise an obvious concern about negative publicity, especially given the importance of word-of-mouth communication among ranchers and farmers.

A traditional reliance on surface water for agricultural purposes

Montana is blessed with an abundance of rivers and streams, and in many parts of Montana it is highly unusual to dig wells or pump water for livestock. Animals traditionally drink directly from streams, springs, ditches, or ponds, and agricultural producers are not accustomed to spending money or maintaining equipment for the purpose of providing stock water. In its conversations with agency staff, farmers, and ranchers, NCAT heard the comment more than once that the conceptual leap from surface water to pumped groundwater may be larger and more intimidating for ranchers and farmers than the conceptual leap from conventional energy to solar energy.

The generally conservative nature of the agricultural community

If businessmen and women already engaged in a high-risk venture can be labeled "conservative" if they are prudent and cautious about how they spend their money, then agricultural producers may well be called conservative. As such, they make buying decisions deliberately and sometimes slowly, often after checking with friends, neighbors, and other trusted sources. This customer profile represents a significant challenge to the solar industry, because it means dealers must often invest substantial resource into making each sale.

In several of the demonstration projects, NCAT encountered missing or defective hardware, compatibility problems, or missing or erroneous instructions.

Opportunities

Summarized below are some opportunities for expanding the market for agricultural uses of solar energy in Montana:

Opportunities to provide better information about costs

Farmers, ranchers, and agency personnel need current and realistic information about the costs of solar technology. This information should be couched in familiar terms of "payback period" or comparisons with familiar alternatives such as gas-powered generators or windmills. The information should help producers see the big picture and think beyond the relatively high initial cost of these systems. For example, comparisons might look at life-cycle (10-20 year) costs including labor savings.

Information should help producers see the big picture and think beyond the relatively ;high initial cost of these systems.

Opportunities to create alternative funding mechanisms

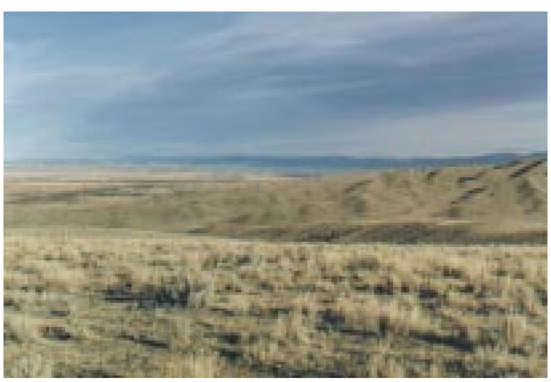
Co-ops and other utilities may be logical funding partners in some cases. Conservation and environmental groups and agencies may be logical funding partners in cases where significant environmental benefits are available. Leasing holds potential to reduce the high up-front cost of solar pumping systems.

Opportunities to provide better information about ranching benefits

Promotional efforts for solar technology are often based on energy savings or environmental concerns that are secondary to ranchers. Montana ranchers are most impressed with the ability of solar pumping to give their livestock greater access to forage. Once they see this possibility, many of them make the transition from being vaguely interested to being keenly interested.

Opportunities to provide better information about reliability

Farmers and ranchers are generally unaware that modern solar panels typically come with at least a 25-year warrantee and can withstand severe weather, including hail. Solar pumping systems compare very favorably to the usual alternatives (gas or propane-powered generators or windmills) in terms of maintenance, reliability, and longevity. In response to concerns about vandalism, a key point is that solar pumping systems can be made portable, so they can be removed during hunting season.



Opportunities to provide better information about availability

Montana has more solar dealers and installers than the average person might think, but NCAT's interviews suggest that these dealers and installers are still nearly invisible to the average farmer or rancher.

Opportunities for new dealers and installers

Given their lack of familiarity with PV installation and maintenance issues (as well as lingering memories of fly-by-night installers and shoddy systems from the 1970s and 1980s), many Montana ranchers and farmers strongly prefer to have a familiar local source of technical support. This preference creates a need for qualified dealers and installers who are locally-based.

Opportunities for utilities to save money

Montana's utilities have begun to realize that pumping systems for stock watering are often money-losers for them, since power bills do not cover line maintenance costs. Solar pumping enables utilities to reduce installation, operation, and maintenance costs, as well as solving operational and environmental problems for their customers who are agricultural producers. With these advantages in mind, some Montana utilities have begun aggressively promoting solar pumping. (For example, see the discussion of Bighorn Electric Co-op in "Detailed Interview Descriptions" above.) Montana's utilities have the potential to become the state's leading champions of solar technology in agricultural settings. Nonetheless, Montana utilities still lag behind utilities in North Dakota, Idaho, Nebraska, Colorado, and other states when it comes to promoting solar pumping.

Opportunities to develop marketing strategies appropriate to the way farmers and ranchers learn

These marketing efforts should be geared towards the information sources that agricultural producers trust most, including word of mouth from neighbors. For example, efforts might systematically identify and target "early adopters" and publicize these people to their neighbors. Educational and promotional efforts should involve Montana's traditional agriculture organizations and should target large and familiar agricultural trade shows and well-known agricultural publications. Training sessions should be aimed at Extension, NRCS, and other agency staff as well as individual producers. Meetings with youth clubs such as 4-H and Future Farmers of America (FFA) might also be very worthwhile.

Opportunities for realizing environmental benefits

Montana ranchers are most impressed with the ability of solar pumping to give their livestock greater access to forage.

Montana's ranchers and farmers are coming under increasing pressure to get livestock out of riparian areas, and many conservation-minded landowners are also highly motivated to do this in order to benefit fish and wildlife. Conservation groups and local, state, and federal agencies are often unaware that solar pumping has so much potential to solve these problems in a way that is also beneficial to producers. Promotional and marketing efforts should systematically explore opportunities for using solar pumping to achieve environmental goals, and should target and inform agencies and organizations that may be interested in these applications.

Opportunities for dealers and manufacturers to improve instructions, hardware, and packaging

Solar manufacturers and dealers should view every sale as an opportunity to build public trust, and they should be vividly aware of the potential for serious inconvenience and damaging publicity caused by poor instructions, hardware, or packaging. Many ranchers and farmers are willing to tackle the installation of a PV pumping system. Since they expect to do much of their own maintenance, they prefer to have as much hands-on familiarity as possible. They also prefer to avoid the cost of paying an installer to do the job. With this do-it-yourself scenario in mind, instructions should be as thorough and user-friendly as possible, aimed at a mechanically-inclined person who has no previous experience with solar equipment and is working in a remote location. Special care should be taken to ensure that the correct parts are all included and that these parts fit and work together.

Promotional and marketing efforts should explore opportunities for using solar pumping to achieve environmental as well as agri-cultural goals.

Opportunities to develop marketing strategies appropriate to Montana's traditional reliance on surface water

Many farmers and ranchers have heard of using solar energy to pump groundwater from a well, but fewer think about PV systems as a way to pump surface water. Properly designed surface water pumping projects can provide the same kinds of ranching and environmental benefits as groundwater projects, including giving livestock access to high quality forage and reducing pressure on riparian areas.

Opportunities to replace failed windmills

Montana's landscape is dotted with defunct windmills, and it has been said that many failed windmills are solar pumping projects waiting to happen. Most failed windmills are associated with

1) a well that has already been dug; 2) a past or present need for pumping; and 3) a location that is far from power lines.

Opportunities for alternatives to line extensions

Whenever a customer approaches a utility with a request for a long power line extension, there is an opportunity to provide information about solar power and to alert the customer to an option that may be more cost-effective, both for the customer and the utility. In fact, in some states utilities are *required* to provide this information whenever a line extension request exceeds a certain length.

Montana utilities have the potential to become the state's leading champions of solar technology in agriculture.

B. Conclusions

Overall, the results of the Montana AgSolar Project support a highly optimistic view of the potential for expanded application of solar-electric technology in Montana's agricultural sector. Virtually all of the interviewees were familiar with solar-electric technology, either through their own use or through a friend or neighbor's use. Interviewees with solar-electric experience gave the technology high marks for its ease of use, reliability, and cost effectiveness. Most of those without solar-electric experience seemed intrigued by others' successes with the technology, and many indicated that they would seriously consider how they might use solar energy in their farming and ranching operations.

Based on its research, NCAT believes that Montana's agricultural community is moving rapidly beyond the introductory stage, during which systems must be heavily subsidized to move them into the marketplace. Although cost was identified frequently as the greatest barrier confronting solar-electric technology, there appear to be many agricultural situations where solar pumping makes good economic sense at current retail prices. In fact, in a few parts of Montana solar pumping has already caught on and is expanding rapidly.

> ***One main conclusion of this study is that what farmers and ranchers want even more than lower costs is information: about current costs, applications, the reliability and dependability of solar electric, and its availability***.

Solar pumping appeals to a variety of stakeholder groups in Montana and for a variety of reasons. Just as ranchers and farmers are only beginning to appreciate the agricultural benefits of solar pumping, conservation organizations and conservation-minded landowners are only beginning to appreciate the environmental benefits.

> ***A second main conclusion of this report is that solar pumping for stock-watering makes possible a unique and valuable convergence of interests, allowing progress on some of Montana's most intractable land-use problems: improving ranch operations while at the same time relieving grazing pressure on riparian areas.***

A recurring theme in interviews was the difficulty of changing the buying habits of agricultural producers. Some interviewees attributed this to a cautious, conservative, or traditional outlook on the part of farmers and ranchers. Others characterized it as a reasonable prudence, especially given the critical importance of reliability and dependability when it comes to delivering drinking water to livestock. In any case,

> ***A third main conclusion of this report is that promotional efforts should not be aimed solely at individual farmers and ranchers. NCAT recommends a broad approach that seeks to motivate other stakeholder groups, such as solar dealers, utilities, conservation organizations, local watershed committees, conservation districts, and agencies.***

Toward this end, NCAT is proposing an ambitious strategic plan calling for the involvement of numerous stakeholder groups. The objectives and tasks in the plan are designed to address market-entry barriers and opportunities that are within reach of these stakeholders. The driving goal of the plan is to raise even further the consciousness of the state's agricultural sector regarding the possibilities for solar-electric technologies and ultimately to increase the number of solar-electric installations in agricultural settings throughout the state.

C. Strategic Plan

Overall Goal: To increase the number of solar-electric installations in the agricultural sector throughout Montana.

- **Objective 1: *To publicize completion of the Montana AgSolar project.***

Task 1A. Inventory every newspaper, major agricultural publication, radio station, and television station operating in Montana and develop them into a mail-merge friendly database.

Suggested Partners: NCAT; Montana Renewable Energy Association (MREA)

Task 1B. Develop a press package regarding the AgSolar project and distribute to every newspaper, major agricultural publication, radio station, and television station operating in Montana.

Suggested Partners: Montana Power Company (MPC), with NCAT's assistance

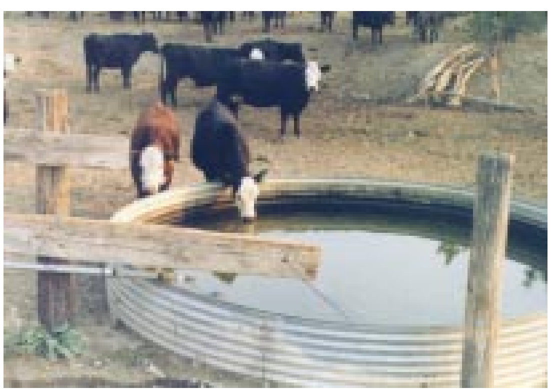
Task 1C. Distribute the completed Montana AgSolar Project Report to all interviewees who requested a copy.

Suggested Partners: MPC, with NCAT's assistance

- **Objective 2: *To identify and explore partnerships with stakeholders who stand to benefit from agricultural uses of solar energy.***

Task 2A. Target utilities statewide, including especially rural electric cooperatives. Promote the economic benefits of solar energy to utilities compared to line-extensions, in the form of lower installation, operation, and maintenance costs. Montana's utilities have the potential to become the state's leading champions of solar technology in agriculture, a role already being played by utilities in nearby states.

Suggested Partners: Montana Electric Cooperatives' Association, Generation and Transmission Cooperatives



Task 2B. Target large and influential agricultural organizations statewide. Promote the agricultural benefits of solar energy, especially the potential of solar-powered pumping to give livestock greater access to forage.

Suggested Partners: Montana Stockgrowers, Montana Woolgrowers, Farmers' Union, Farm Bureau, Alternative Energy Resources Organization (AERO), Northern Plains Resource Council (NPRC), Conservation Districts, Intertribal Ag Council, Women Involved in Farm Economics

Task 2C. Target conservation and environmental groups statewide. Seek cost-sharing opportunities on projects with strong environmental benefits.

Suggested Partners: The Audubon Society, Montana Land Reliance, Montana Wildlife Federation, The Nature Conservancy, Rocky Mountain Elk Foundation, Trout Unlimited, Ducks Unlimited

Task 2D. Target agencies statewide with responsibilities for managing public lands. Promote awareness of the environmental benefits of solar pumping, especially the options for moving livestock away from riparian areas.

Suggested Partners: Montana Department of Natural Resources Conservation, Montana Fish, Wildlife, & Parks, Bureau of Land Management, Bureau of Reclamation, U.S. Forest Service, U.S. Fish & Wildlife Service, Montana's tribal authorities

Task 2E. Target conservation-minded landowners statewide, promoting awareness of the environmental benefits of solar pumping.

Suggested Partners: AERO, NPRC, reservations, Conservation Districts with active Grazing Groups, tribal landowners

- **Objective 3: *To strengthen the new Montana Renewable Energy Association (MREA) and build support within the organization for agricultural uses of solar energy.***

Task 3A. Draw from the known network of dealers, utility representatives, and other stakeholders to arrive at a nucleus of interests sharing the same vision of expanded use of solar-electric technology in the agricultural sector.

Suggested Partners: Montana Solar Initiative partners, including MPC, Bonneville Power Administration (BPA), Montana-Dakota Utilities (MDU), Western Area Power Administration (WAPA), numerous rural electric co-ops, the Montana Environmental Information Center, Montana Department of Environmental Quality, NCAT, AERO, Sage Mountain Center, and numerous solar dealers & installers

Task 3B. Develop a specific plan for establishing broad political support for the new organization, initially by seeking recognition of and endorsement by the Governor's office and the Montana Department of Environmental Quality

Suggested Partners: *MREA*

- **Objective 4: *To identify and explore financing and incentive mechanisms.***

Task 4A. Explore the feasibility of *leasing* as a way to reduce the high initial cost of a solar pumping system.

Suggested Partners: MPC, BPA, MDU, WAPA, rural electric co-ops

Task 4B. Explore the feasibility of *incentives to solar dealers*.
Many vendors view the agricultural sector as difficult to enter and express reluctance to commit time and effort to this sector. In the case of other consumer goods such as cars or electronics, financial incentives to dealers (in the form of commissions or "spiffs") sometimes prove more effective than discounts to consumers.

Suggested Partners: MPC, BPA, MDU, WAPA, rural electric co-ops, dealers and installers

Task 4C. Explore the feasibility of *low-interest loans* or subsidies from utilities interested in reducing installation, operation, and maintenance costs associated with line extensions.

Suggested Partners: MPC, BPA, MDU, WAPA, rural electric co-ops

- **Objective 5: *To develop and implement a fresh marketing effort to disseminate current, factual, and objective information about solar-electric's applications in the agricultural sector.***

Task 5A. Increase the number of solar-electric demonstration projects, with a strong emphasis on geographical distribution.

This study suggests that demonstration projects will have the greatest impact on producers living nearby or at least within easy driving distance. Enough Montana ranchers and farmers are already interested in solar technology so that it should be possible to locate promising demonstration projects by providing only modest subsidies to participants.

Suggested Partners: MPC, BPA, MDU, WAPA, co-ops, DEQ, AERO, Conservation Districts, Extension, NRCS, local watershed groups

Task 5B. Develop and promote farm tours to focus attention on successful demonstrations.

This study repeatedly identified farm tours as the single most effective means of drawing the agricultural community's attention to innovative technologies, processes, and products. Tours will have the greatest impact on producers living nearby or at least within easy driving distance.

Suggested Partners: MREA, MPC, BPA, MDU, co-ops, NCAT, AERO (including AERO's Farm and Ranch Improvement Clubs), Conservation Districts, Extension, NRCS, local watershed groups

Task 5C. Develop and distribute a "Solar Applications in Agriculture" information packet containing brief case studies of successful demonstration sites and a Montana vendor/ installer list.

Finished case studies should be single-page, front-and-back presentations highlighting the site, the project's intended objective, anticipated benefits, system economics, and a source of further information.

Suggested Partners: MREA, NCAT, dealers & installers

Task 5D. Work cooperatively with the agricultural community and solar-electric vendors to develop and disseminate a solar-electric technology reference guide.

This guide should, at minimum:

- present a solar-electric technology tutorial;
- present case studies of the many different agricultural applications for solar electric;
- provide detailed "how to" plans – complete with sample diagrams;
- present objective discussions of key decision points in purchasing, installing, and maintaining solar-electric systems; and
- include the Montana vendor/installer list, complete with contact information.

Suggested Partners: MREA, NCAT

Task 5E. Seek a relationship with at least one major agricultural publication to print a series of articles on the use of solar-electric technology in agriculture. These articles should strongly emphasize ranching and agricultural benefits, especially the potential of solar-powered pumping to give livestock greater access to forage.

Suggested Partners: MREA

Task 5F. Develop and help distribute a high-quality video on agricultural applications of solar-electric technology.

The video would present different solar technologies, compare solar and petroleum-powered power-generating systems, work through the installation of a solar system, highlight decisions to be made and factors involved, and comment on how producers can approach dealers.

Suggested Partners: MREA, NCAT

Task 5G. Display an "AgSolar" booth at each of the coming year's major agricultural tradeshows and conferences.

Subtask 5Gi: Establish a schedule of ag shows and conferences.

Subtask 5Gii: Develop a portable, trailer-based solar water-pumping system capable of being displayed at tradeshows and conferences.

Suggested Partners: MREA, solar dealers and installers

Task 5H. Encourage and help support workshops promoting use of solar-electric technology in the agricultural sector.

Each workshop should ideally be tailored to a specific audience. Besides agricultural producers, some other likely groups would include utility representatives, Extension and NRCS agents, watershed groups, or Conservation District representatives. Workshops might also target youth organizations such as Future Farmers of America or 4-H clubs.

Suggested Partners: Sandia National Laboratories, WAPA, MPC, BPA, rural electric co-ops, Extension, NCAT, AERO

- **Objective 6:** ***To design and build a demonstration track-mounted solar pumping system that is significantly more portable and modular than current systems.***

The threat of vandalism poses a significant barrier to the acceptance of solar technology in Montana's rural areas, creating a need for a truly portable pumping system that can be removed during hunting season. Trailer-mounted systems address this problem, but only by adding significant expense. Most trailer mounted systems also forego the benefits of a track rack. It should be possible to design a tracking system and electrical connections that can be more easily disassembled and reassembled in the field.

Task 6A. Seek input from solar dealers and installers on current designs and options for making solar pumping systems more portable and modular.

Task 6B. Build a demonstration tracking system that is highly portable, easily disassembled, and yet easily and securely protected against theft.

Suggested Partners: NCAT, solar dealers, installers, and equipment manufacturers

- **Objective 7:** ***To seek two- to three-year funding from appropriate industry players, foundations, and government agencies to support at least one well-qualified, full-time employee to help implement this strategic plan.***

The primary purpose of this individual(s) would be to champion the expanded use of solar-electric technology within the agricultural sector. In this role, s/he would be expected to:

- Respond to requests for information and technical assistance;
- Work closely with farmers and ranchers on design and installation of systems;
- Refer interested consumers to solar-electric vendors and installers;
- Arrange workshops, farm tours, and displays at agricultural tradeshows;
- Work closely with the press to keep solar electricity in front of stakeholders; and
- Monitor and report progress toward this Strategic Plan's overall goal and objectives.

Suggested Partners: MREA, NCAT

D. Contacts

The following people and companies were contacted by NCAT staff during the course of the project.

Solar Equipment Dealers

Backwoods Solar, Sandpoint, ID

Michael & Lumarie Strickland, Dearborn Solar Electric Company, Cascade, MT

Bill Gross, Gross Electric, Great Falls, MT

Mountain Pass Wind Company, White Sulphur Springs, MT

Oasis Montana, Inc., Stevensville, MT

Planetary Systems, Ennis, MT

Powerline Solar Products (formerly Keep It Simple Systems), Helena, MT

Quality Solar, Yaak, MT

Mary Hamilton, Owner, Solar Plexus, Missoula, MT

Suncraft (now called Radiant Engineering), Bozeman, MT

Sunelco, Hamilton, MT

Sundance Solar, Red Lodge, MT

Solar Installers

Tony Boniface, Bozeman, MT

Gross Electric, Bill Gross, Columbia Falls, MT

Paradise Electric, Scott Jochim

Leisure Electric, David Haussler, in Lakeview, ID; (208) 222-2212, or
(208) 265-8669 in Sandpoint, ID

Natural Resource Co., Charles Woodward, Victor, ID 83455; (208) 787-2495
<IDPV@compuserve.com>

CONTACTS

County Extension Agents

Barb Andreozzi, Deer Lodge County Extension, Anaconda, MT

Larry Hoffman, Lewis and Clark County Extension, Helena, MT

Rob Johnson, Ravalli County Extension, Hamilton, MT

Virginia Knerr, Broadwater County Extension, Townsend, MT

Dan Lucas, Granite County Extension, Phillipsburg, MT

Jerry Marks, Missoula City Extension, Missoula, MT

Dave Phillips, Fergus County Extension, Lewistown, MT

Dave Streufert, Powell County Extension, Deer Lodge, MT

MPC Utility Representatives

Dave Boles, Havre office

Dale Ellison, New Construction Manager, MPC, Bozeman, MT

Mark Gonly, Kalispell office

Len Leveaux, Butte office

Sharla Thomas, Lewistown office

Agency Staff

Scott Mendenhall, Jefferson County Economic Development Agent, Whitehall, MT

Mike Odegard, District Conservationist, Natural Resources Conservation Service, USDA, Missoula, MT, (covers Missoula and Mineral Counties)

Other Contacts

Bob Boettcher, Big Sandy, MT

Mr. Connors, Advanced Composting Systems, Whitefish, MT; email phoenix@compostingtoilet.com , website www.compostingtoilet.com

Lil Erickson, Corporation for the Northern Rockies, Livingston, MT

Rod Minor, Lightfoot Cycles, Darby, MT

Dave Oien, AERO member, Conrad, MT

Andy Rahn, student, previously employed by Chico Hot Springs, Chico, MT

Jeff Schahczenski, Whitehall, MT

Bob Stoeckley, Alpenglow Lights, Eureka, MT

Mike Vogel, Director of Extension's Housing & Environmental Quality Program, Bozeman, MT

Mark Comfort, Engineering Estimator, formerly New Construction, MPC, Missoula, MT

Websites on Solar Electric Fencing

http://www.ibiblio.org/farming-connection/links/fecebld.htm

http://gallagherusa.com/

http://fishock.com/install/install.htm

http://parmakusa.com

Appendix A: Technical Overview

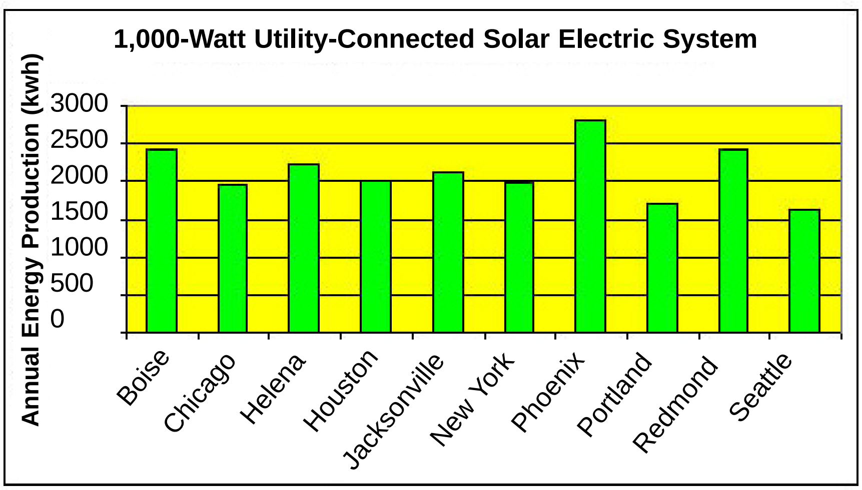
Solar electric systems are sometimes called photovoltaic systems, and the word "photovoltaic" is often abbreviated "PV." A solar cell produces a small amount of electricity when light strikes it. The wafer thin cells are constructed of a layer of silicon applied to a metal backing and covered with tempered glass. The sunlight strikes the silicon cell and bounces light particles, or photons, across a barrier within the cell. This creates a flow of electrons, or electricity, through the cell. This direct current electricity can be tapped and put to work.

Most PV cells produce about one-half volt; the amount of current produced is based on the size of the cell. The total amount of power produced depends on the number of modules and the amount of sunshine available at a given site.

Montana's Solar Resource

Although Montana is a northern state the available solar resource in the summer (when most livestock watering occurs) is good. The clear skies and dry air allow for a higher percentage of the sun's radiation to reach the surface of a solar panel. In addition, the long summer days allow a longer period of daily pump operation. Wintertime operation is hampered by short daylight length and cloudier weather.

This graph compares the annual energy produced from a 1,000 watt solar array in Helena with other cities in the country. Helena's solar resource compares well with southern cities since the longer summer days and cooler termperatues result in a higher performance of solar electric systems.



Solar Modules

Solar modules (or panels) have been in existence for over 40 years. 30 to 44 solar cells are built into a solar module. A group of modules, called an array, is usually mounted on a roof or a mounting structure. Most photovoltaic cells are composed of single-crystal silicon cells; two other types of crystalline cells are polycrystal silicon and ribbon silicon. Thin film amorphous silicon cells are much less efficient but also much cheaper than crystalline cells.

Sixty- to 120-Watt modules are commonly used in water-pumping applications, with costs ranging from $325 to $800 per panel. Module peak power amps and volts vary between manufacturers; the length of the warranty on the power output varies also. According to most solar equipment vendors, the life expectancy of a solar module is 30 years or more.

Mounting Structures

There are essentially two ways to mount solar modules: either on a fixed structure or on a tracking structure. Fixed mounts are less expensive and tolerate higher wind loading but have to be carefully oriented so that they face due south (not magnetic south). Solar modules will pump more water on a tracking array than they will on a fixed array. The tracking array follows the sun across the sky and allows 30 to 40 percent more water to be pumped in the summertime and 10 to 15 percent more in the winter. With more hours of available peak sun, a smaller pump and fewer modules may be used, reducing overall system cost. Sometimes, however, it may be less expensive to buy additional panels that to buy a tracker. Tracking works best in clear sunny weather. It is less effective in cloudy climates and on short winter days. Trackers are ideal for use with late spring, summer, and early fall livestock water pumping.

Trackers are now available that are completely passive. They use no power from the system, and rely instead on the sun's heat and gravity to move the rack. As the sun heats one side of the passive tracking system, a fluid contained in a cylinder expands in the heated side and condenses in the shaded side. The heavy condensed fluid pulls the shaded side downward, causing the tracker to tilt towards the sun and follow it across the sky.

Trackers are designed to function properly in wind. Most use piston-type shock absorbers and hanging weights for stability. Although a stiff breeze blows the panels temporarily off-track, they quickly return to the correct orientation. "High wind" versions are also available for locations experiencing consistently strong winds, although extremely windy conditions (over 90 miles per hour) can damage any tracker.

Fixed "top of pole" mounts, commonly used in water pumping applications, cost $130 to $600. Trackers must be mounted on a Schedule 40 steel pipe, and can cost anywhere from $400 to $1800. The cost is based on the size needed for the number of modules in the array.

Solar Pumping

As solar advocates and equipment vendors like to point out, solar power and water pumping are a natural combination. Generally, water is needed the most when the sun is shining the brightest. A solar module generates maximum power under full sun conditions when larger quantities of water are needed for irrigation or livestock watering. Stock-watering systems generally do not need batteries, thus reducing cost and maintenance while increasing longevity.

Direct Current (DC) Water Pumps

DC pumps in general use one-third to one-half the energy of conventional AC pumps, and eliminate high starting surges. Newcomers to solar pumping are likely to be surprised at the variety of DC pumps available. DC pumps can be either *submersible* or *surface*, and they move water using either *displacement* or *centrifugal force*. Submersible pumps are placed down a well or sump and are highly reliable because they are not exposed to freezing temperatures, do not need any special protection from the elements, and do not require priming. Surface pumps are located at or near the water's surface, usually on a stream or spring, and are used primarily for moving water through a pipeline. Some surface pumps can develop high heads and are suitable for moving water long distances or to high elevations. Positive displacement pumps use diaphragms, vanes or pistons to seal water in a chamber and force it through a discharge outlet by reducing the volume of the chamber. The lift capacity is maintained even while pumping water slowly. Centrifugal pumps are the type commonly used for domestic non-solar water systems. A spinning impeller adds energy to the water and pushes it into the system, similar to a water wheel. Centrifugal pumps are used where higher volumes are required.

Submersible Pumps

1. ***Submersible diaphragm pumps*** are a positive displacement type, reliable and easy to install because of their small size and light weight. They can be installed in shallow wells or in wells as deep as 230 feet. The higher capacity pumps need a minimum five-inch well casing. The diaphragms in these pumps require regular replacement, which can usually be performed by the owner, using a rebuild kit and a screwdriver. Depending on well depth and capacity, these pumps can provide 2,000 gallons per day. Costs range from $650 to $800.

2. A relatively new type of positive displacement pump, a *submersible sealed piston pump* can pump water from a 600 foot deep well but costs about three times as much as a diaphragm pump. Costs range from $1850 to $2200.

3. ***Submersible centrifugal pumps*** deliver water at higher volumes and over a wide range of well depths. In a shallow well, these pumps can be installed by hand; deeper wells require specialized equipment. Submersible centrifugal pumps can be used in wells as deep as 400 feet; in shallower wells they can pump up to 6,000 gallons per day. Larger pumps require a minimum five-inch well casing. Centrifugal pumps require more power than diaphragm pumps to develop the high rpm needed for acceptable water pumping efficiencies. Costs range from $1100 to $2400.

Surface Pumps

1. ***Surface centrifugal pumps*** can move large volumes of water but at lower heads than the submersible pumps. They are installed within 10 to 15 feet of the water surface. These pumps can pump dirty water with less difficulty than most other pumps. Costs range from $700 to $900.

2. ***Rotary vane pumps*** are positive displacement surface pumps and move lower volumes of water at high pressures. They are generally installed within 10 to 15 feet of the water surface. These pumps are more efficient than centrifugal pumps but have tight tolerances and work best with clean water. The pumps have a filter assembly; dirty water requires regular filter replacement. A one-quarter horsepower pump costs about $500.

3. ***Surface piston pumps***, another positive displacement type, can be used to pump water from a lake, cistern or shallow well. The suction lift capability is from 10 to 20 feet but it can provide a pumping head of up to 2,700 feet. In other words, set next to a spring, a piston pump can push water up a steep ridge to a stock watering tank on top. It can pump during periods of low sunlight. It is best used for low volumes and a high lift. Some models of piston pumps cannot tolerate dirty water. Costs vary from a one-quarter horsepower piston pump at $1000 to a three horsepower pump that costs over $5000.

4. Small ***two - and three-piston diaphragm pumps*** are installed at a maximum of ten feet above the water surface. They can pump at up to 4 gallons per minute but at higher pressures and can be used with a pressure tank. Diaphragms must be replaced regularly. Costs range from $100 to $250.

5. ***Jack pumps*** are positive displacement surface pumps that move water with every stroke. They look like the typical oil field pump and are similar to the type used in windmills. They are simple and reliable and operate at low light levels and low well capacities. They can be used with very deep wells and are available in sizes ranging from three-quarters horsepower to three horsepower. Jack pumps are custom designed and costs are specific to the system design.

Alternating Current (AC) Water Pumps

AC pumps require inverters and additional controls, which add to system cost and complexity. An inverter is an electronic component that converts DC electricity from the solar panels into AC electricity to operate the pump. Stand alone livestock water-pumping systems can generally use an inverter that produces a modified square wave (sometimes called a modified sine wave). Since these systems are not connected to the utility grid, they do not require a more expensive sine wave converter. AC pumping is best for some situations, particularly where wiring distances are greater than 200 feet or where it is difficult to replace AC wire with larger DC wire.

Alternating current submersible centrifugal pumps are similar to direct current submersible centrifugal pumps. Some equipment vendors consider the alternating current version to be more durable and longer lasting than the direct current version. Costs range from $400 to $750.

Batteries

Batteries are usually not recommended for use with solar-powered livestock watering systems for several reasons:

1. Batteries reduce the overall efficiency of the system;
2. Batteries require additional circuit protection;
3. Batteries require additional maintenance; and
4. Since batteries perform best in warm temperatures, they should be placed in an insulated enclosure.

Instead of storing electricity in batteries, it is simpler and more economical to store water in tanks. Three to tens days' storage may be required depending on climate and water usage.

Pump Controllers

The pump controller protects the pump from high or low voltage conditions and maximizes the amount of water pumped in less than ideal light conditions. The controller matches the pump motor load to the power available from the solar modules, allowing the pump to operate earlier and later in the day or on partially sunny days. The pump controller helps the pump to start up slowly and not stall out in low light conditions

Float Switches

A float switch is used to turn a pump on and off when filling, for example, a stock tank. A float switch is similar to the float in a toilet tank, but is wired to the pump controller. When the float is in the up position, the electric circuit is open and the pump does not run. As the water level in the tank lowers, so does the float. At a pre-set position, the contacts close in the switch and the pump turns on.

Low Water Cut-Off Electrodes

These safety devices protect the pump from low water conditions in the well or other water source. Three electrodes are installed in the well: the low water electrode, the high water electrode, and the common or ground electrode. If the water level drops below the low water electrode, the pump is shut off until the well recharges and the water level rises above the high water electrode.

Other Agricultural Uses of Solar Electric Energy

Solar generated electricity lends itself to a variety of other agricultural uses, beyond water pumping for livestock. Solar uses in aquaculture, or fish farming, range from using solar-powered pumps for aeration of ponds, circulation and transfer of water between ponds and de-icing during cold weather. Small-scale, low pressure, or drip irrigation systems can all be operated by solar-powered pumps. Solar-powered fans can ventilate greenhouses or livestock confinement buildings. Fans can also be used to move air for drying high-value crops, such as herbs.Remote lighting, powered by solar, can be used in off-grid calving or lambing facilities, for security lighting and for motion sensing lighting.

Appendix B: Montana Renewable Energy Dealers

Montana Businesses

Shawn Coggins
Advanced Composting Systems
195 Meadows Road
Whitefish, MT 59937
Phone: (406) 862-3854

Mark Gray
Alternative Energy Systems LLC
P. O. Box 83
1223 25th Ave. NE
Black Eagle MT 59404
Phone: 406-761-7200
alternativeeng@cs.com

Products and services: Authorized Onan Generator dealer, hybrid systems, solar modules, wind generators for electricity and water pumping, inverters, charge controllers. Solar lighting, batteries, solar-powered water pumps. Mail-order, design, installation, maintenance and troubleshooting.

Michael & Lumarie Strickland
Dearborn Solar Electric Co.
633 Dearborn River Rd
Cascade, MT 59421
Phone: (406) 788-0118
Products and Services: PV modules, wind generators for electricity and water pumping, inverters, charge controllers, high-efficiency refrigeration, AC and DC, high-efficiency fluorescent lights, solar-powered water pumps; mail order, design, installation, maintenance, troubleshooting.

William E Gross
Gross Electric
638 Badrock Drive
Columbia Falls, MT 59912
Phone: (406) 892-4940
Fax: (406) 892-4914
Products and Services: design, installation, maintenance, troubleshooting.

Tony Boniface
Independent Power Systems
1627 W. Main St
Bozeman, MT 59715
Phone: (406) 587-5295
Fax: (406) 587-5295
E-mail: tboniface@imt.net
Products and services: design, supply and install hydroelectric, solar, wind and generator/battery/inverter systems; design, installation, maintenance, troubleshooting.

Steve Hicks
Mountain Pass Wind Co.
P.O. Box 394
White Sulphur Springs, MT 59645
Phone: (406) 547-2266
e-mail: steveahicks@yahoo.com
Products and Services: design, install, repair wind generation systems; design, sell, install and service wind and solar systems; mail order, design, installation, maintenance, troubleshooting.

Glenn Nelson
195 Meadows Road
Whitefish, MT 59937
Phone: (406) 862-3854

Chris Daum
Oasis Montana, Inc.
436 Red Fox Lane
Stevensville, MT 59828
Phone: (877) 627-4768 or 4778
Fax: (406) 777-2632
e-mail: info@oasismontana.com
Products and Services: Alternative energy supplies, including solar panels (PV modules) regulators and controllers, inverters, batteries, wind generators, hydro turbines, energy-efficient and propane refrigerators; mail order, troubleshooting.
http://www.oasismontana.com

Larry & Annette Chain
Obadiah's Woodstoves & Alternative Energy
305 Silver Dr. N.
Troy, MT 59935
Phone: (800) 968-8604
E-mail: woodstoves@montanasky.net
Products and Services: Specializes in solar, wind, and small-scale hydro systems. Installation, service and maintenance. Also specializes in woodstoves, gas and oil stoves, and fireplace inserts.
http://www.alternativenergy.net

William Von Brethorst
Planetary Systems
Box 340
262 Badger Rd.
Ennis, MT 59729
Phone: (406) 682-5646
Fax: (406) 682-5644
brethors@3rivers.net
Products and Services: Designs, installs, services renewable energy systems, including solar, wind, and microhydro. Catalog available.
http://www.planetarysystems.com/

Bruce Bannister
Prairie Wind & Sun
P.O. Box 1296
Miles City, Montana 59301
Phone: (406) 232-4223
email: solarb@servco.com
Products and Services: Specializes in modules and power systems for large and small applications
http://www.sunenergy.com

Jimmy Martin
Quality Solar
31923 South Fork
Yaak River Rd
Troy, MT 59935
Phone: (406) 295-5072

Dale Picard
Radiant Engineering, Inc.
501 E Peach Suite C
Bozeman, MT 59715
Phone: (406) 587-3442
Email: radiant@mcn.net
Products and Services: Radiant Engineering is experienced with the modern hydronic heating technology. Provides advice, design, equipment and labor to complete systems incorporating hydronic radiant floor heating, hot water baseboard and radiators, hydronic fan convectors, snow melting, high performance boilers, advanced controls and monitors. Company also specializes in geothermal systems and active solar water heating.
http://www.radiantengineering.com

Lee Tavenner
Solar Plexus
130 West Front Street
Missoula, MT 59802
Phone/Fax: 406-721-1130
e-mail: solplex@montana.com
Products and Services: design, supply and install hydroelectric, solar, wind and generator/battery/inverter systems; design, installation, maintenance, troubleshooting.
http://www.montana.com/solplex

Dale Picard
Suncraft Inc.
501 E Peach Suite C
Bozeman, MT 59715
Phone: (406) 587-3442

APPENDIX B

Henry & Barbara Dykema
Sundance Solar Systems
P.O. Box 4404
Luther, MT 59051
Phone: (406) 425-1153
Products and Services: design, sell and install residential PV systems; PV pumping systems; mail order, design, installation, maintenance, troubleshooting.

Dan Healy - Systems Engineer
Sunelco - A Division of Kyocera Solar
100 Skeels Street
Hamilton, MT 59840
Phone: (800) 338-6844
Fax: (406) 363-6046
E-mail: dhealy@kyocerasolar.com
Products and Services: Solar electric, back-up power, photovoltaics, solar power, AC and DC power systems.
http://www.sunelco.com

Joanne Smith
Sunwize Technologies, Inc.
108 Rosewood Court
Hamilton, MT 59840
Phone: (406) 375-9195
Fax: (406) 375-9194
E-mail: sunwise@montana.com
www.sunwize.com

Appendix C: Incentives and Financing

Financial incentives have long been a tool used by both the federal government and many state governments to facilitate the adoption of renewable and alternate energy technologies. These incentives can take many forms, including traditional tax incentives, system buy downs, and other subsidies. In addition, the mortgage-lending community is responding to increased interest from borrowers to include renewable-energy systems in their loans. Still another variation involves "green pricing" and end-user "buy ups," in which the consumer often agrees to pay more for the opportunity to user environmentally friendly renewable energy. Each of these tools is explored further in the following sections.

Tax Incentives – Federal

INVESTMENT TAX CREDIT FOR SOLAR ENERGY PROPERTY

After years of on-again, off-again uncertainty, the federal government's **10% business energy tax credit** has been permanently extended as part of the passage of the Energy Policy Act of 1992. (U.S. Code Citation: 26 USC Sec. 48) This investment tax credit is not available to homeowners, but does allow commercial entities a credit of up to 10% of the investment or purchase and installation cost of qualified solar energy property. (The residential tax credit expired permanently in 1985.) The credit cannot be claimed for property (1) used mainly outside the United States, (2) used by governmental units and foreign persons and entities, or (3) used by a tax-exempt organization (unless the property is used mainly in an unrelated trade or business).

"Qualified solar energy property" includes equipment that uses solar energy to generate electricity, including storage devices, power-conditioning equipment, transfer equipment, and related parts. Qualifying equipment also includes equipment up to, but not including, the stage that transmits or uses electricity, as well as "dual-use equipment" that uses both solar and non-solar energy, such as pipes and hot water tanks, but only if its use of energy from non-solar sources does not exceed 25% of its total energy input in an annual measuring period, and only to the extent of its basis or cost allocable to its use of solar energy.

In addition, solar energy property MUST BE –

- completely installed and operational in the year in which the credit is first taken;
- constructed, reconstructed, or erected by (or at the request of) the taxpayer;
- originally used by the taxpayer, if acquired by the taxpayer;
- in conformance with any performance or quality standards prescribed by regulation; and
- subject to depreciation or amortization.

It is noteworthy that the investment tax credit does NOT apply to:

- public utility property
- the material and components of "passive solar systems" (i.e., systems based on the use of conductive, convective, or radiant heat transfer), even if combined with "active solar systems" (i.e., systems based on the use of mechanically forced energy transfer)
- equipment used for most swimming pools, and

- equipment that uses solar energy to generate steam at high temperatures for use in industrial or commercial processes.

In addition, there are situations in which the full 10% credit cannot be taken. If the solar energy property is financed in whole or in part by subsidized energy financing or by tax- exempt private activity bonds, the credit may taken only on the portion of the investment or purchase which is not subsidized. For example, if $20,000 of a $100,000 investment (the cost or basis) is allocable to subsidized financing or tax-exempt private activity bonds, the credit would amount to 10% of $80,000. In addition, the cost or basis of property for investment-credit purposes may be limited if the taxpayer borrows against the property and is protected against loss, or if the money is borrowed from a person who is related or who has other than a creditor interest in the business activity. In these cases, the cost or basis must be reduced by the amount of this “nonqualified nonrecourse financing” as of the close of the tax year in which it is placed in service.

There are also limitations on the amount of credit that can be taken. In any one year, the taxpayer may not take any tax credit that exceeds the total tax owed. The allowable tax credit for any one year is also limited to $25,000, plus 25% of the total tax remaining after the credit is taken. For example, if the taxpayer is allowed the full 10% credit for an investment of $500,000, which is $50,000, and owes $100,000 in taxes, the maximum credit would be $25,000 plus 25% of the remaining $75,000 ($18,750), for a total of $43,750.

Credit not allowable in one year may be carried back to each of the three preceding years, beginning with the earliest. Any unused credit after the carry back may be carried forward to each of the 15 years after the year of the credit. Taxpayers interested in taking advantage of the **business energy tax credit** will need Form 3486 (Investment Credit) and possibly Form 3800 (General Business Credit), together with their corresponding instruction forms.

[***Disclaimer:*** *This information is presented only as an information guide and is not intended to serve as tax advice or direction. Taxpayers should seek professional tax advice before acting on decisions relating to the **business energy tax credit**.*]

FEDERAL 5-YEAR DEPRECIATION SCHEDULE FOR SOLAR ENERGY PROPERTY

Commercial entities that invest in or purchase qualified solar energy property may also take advantage of the federal **five-year accelerated-depreciation schedule**. (U.S. Code Citation: 26 USC Sec. 168) Use of the accelerated-depreciation schedule is restricted by the same qualifications and conditions that apply to the **business energy tax credit** above.

The Modified Accelerated Cost Recovery System (MACRS) uses a 200-percent declining balance method according to the following five-year depreciation schedule:

Year 1 ... 20.00%
Year 2 ... 32.00%
Year 3 ... 19.20%
Year 4 ... 11.52%
Year 5 ... 11.52%
Year 6 ... 5.76%

Without this legal provision, depreciation of solar equipment would be done over the standard 20-year period. Note that taxpayers who take advantage of the **business energy tax credit** for solar equipment should use 95 percent of the original value of the solar equipment as the basis for depreciation, not 90 percent. If the tax credit is not taken, the full 100 percent of the system's value can be used as the basis for depreciation.

As an example:
Total Job Cost for Solar Equipment Installation = $100,000
First Year 10% Business Energy Tax Credit for Solar Equipment =$10,000
Basis for Depreciation is $95,000 (95% of $100,000)

Year	% Deduction	Business Tax Bracket	% of Depreciation Basis	Savings
1	20	34	6.8	$6,460.00
2	32	34	10.88	10,336.00
3	19	34	6.528	6,201.60
4	11.52	34	3.9168	3,720.96
5	11.52	34	3.9168	3,720.96
6	5.76	34	1.9584	1,860.48
Total	**100.00**	**n.a.**	**34.3717**	**$32,300.00**

Total Tax Incentive Recovery (10% credit + 5-year depreciation) = $42,300 (Percent Total of Job Paid for by the Federal Government = 42.3%)

APPENDIX C

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Tax Incentives – State of Montana

RENEWABLE ENERGY SYSTEMS EXEMPTION

Montana is one of many – but not all – states that currently offer a financial incentive to promote expanded use of renewable energy technologies. The incentive in Montana is a **10-year exemption** from personal property taxes for qualifying technologies. Specifically, the statute [MCA 15-6-201(b)(3)] exempts from property taxes the value of the qualified energy system.

Unlike the federal incentive, Montana property tax exemption is open to residential and commercial applications. Qualifying equipment includes active and passive solar; geothermal; wind; and low-emission wood or other biomass combustion devices. The exemption applies to systems up to $20,000 in value for single-family residential dwellings and $100,000 for multi-family or nonresidential structures. There is no maximum limit.

> Taxpayers interested in taking advantage of Montana's property tax exemption should visit their County Assessor's office and request Form AB14 (Application for Tax Incentive Assessment of Energy Generating Property), together with any instruction forms.

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