A Rural Electric Co-op's Experience with Photovoltaic Systems for Livestock Water Pumping

Rolland Skinner
Northwest Rural Public Power District
Hay Springs, Nebraska

Larry Moore and Len Malczynski
Sandia National Laboratories

Introduction

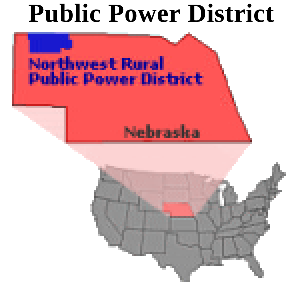
As energy costs continue to increase, renewable energy sources such as photovoltaic (PV) systems increasingly find themselves being considered for the value they provide and, in some cases, because they have become cost competitive. Since more than 2000 co-ops and public power districts maintain nearly 45 percent of the electric distribution lines in the U.S., these aging and geographically widespread distribution lines represent an opportunity for photovoltaic applications as an advanced method for rural electrification. The topic for this paper is such an application---livestock water pumping in remote areas.

Rural electric systems represent an aging infrastructure in many areas with some distribution lines that are 50+ years old. Replacement costs for these overhead lines vary greatly and range from $12,000 per mile in open country to greater than $60,000 in rugged mountain terrain. At these replacement costs, well sites that are greater than half a mile from a distribution line may be economic candidates to use a PV system for providing water for livestock.

Northwest Rural Public Power District (*Northwest*)

Northwest Rural Public Power District is located in the northern part of the Nebraska Panhandle. The District provides electricity and many other quality products and services to customers in Northwest Nebraska. The service area borders Fort Robinson on its western edge and the Pine Ridge Indian Reservation on the north. The terrain is diverse including the nearby national forest, the dry land wheat areas in the West, rugged rock terrain in the North, the sand hills and cattle ranches to the East as well as the irrigated farmland to the South. The area served by *Northwest* covers approximately 4000 square miles with about 1.35 customers/mile.

Northwest Rural Public Power District



Northwest follows the model that was used when Co-ops were created in the 1940s--enhance the quality of life in rural America. The foundation of the co-op service is to provide financing; organizations to construct, operate, and maintain facilities that provide electric service; and a set of standards for the installation of reliable electric power facilities. As the co-ops evolve to provide services to their customers, distributed generation using technology such as photovoltaic systems is becoming the next step.

Photovoltaic Systems as a Business – Financial Feasibility

Photovoltaic water pumping systems can be considered a business initiative that may provide a new revenue stream for the co-ops. *Northwest* installed its first PV system in 1990 and additional opportunities are expected to arise as windmills and distribution lines currently in service reach their end-of-life. As this choice of using PV systems continues, a critical question that needs to be addressed is the cost of operations and maintenance for these renewable systems. This paper documents the first steps taken in studying the costs in these PV-powered water pumping systems.

Northwest installed it first system in the fall of 1990—a 100-watt pumping system bringing water from a depth of 20 feet. Since that time nine systems have been sold and twenty systems are being leased. These pumping systems group naturally into three categories of size (100-200 watts, 300-400 watts, and 800-1200 watts) with an average system lifetime of about 6.3 years. In addition, there is one off-grid home in the service area and a grid-tied system is being installed.

There are other opportunities for the installation of PV stock water systems. An informal survey of the number of windmills in the service area indicates 1000+ of these aging units exist. As these systems reach their end-of-life, PV systems may be considered as a replacement. This option also exists for the 50- to 70-year-old distribution lines that exist in the service area at this time. *Northwest*'s experience enables them to understand the cost of line extension, line replacement, line maintenance and the yearly income that is expected from a site. Work must now continue to identify the costs and income that is to be expected with the fielding of these PV systems for water pumping.

Photovoltaic Systems as a Business – Service and Knowledge Base

Rural electric co-op areas have always been provided a very high level of service. As PV systems evolve into use in this community, that same level of service must be maintained for PV to be successful and remain in use. This support by a local co-op may be in the form of financing and knowledge of the needs of the customer (a system engineering role), as well as providing the infrastructure needed to be the energy provider.

Northwest can continue its traditional role of financing systems when needed. Their low interest rates and longer depreciation schedule allow them to provide the service of leasing PV power systems at this time. The infrastructure that supports installation as well as maintenance needs to be improved and extended. When problems occur at a well site there is still the issue of identifying the customer or utility equipment as the problem. This identification of the cause of the breakdown sometimes prompts unnecessary trips by either the driller or *Northwest* to diagnose and correct the problem. One approach being discussed to minimize this overlap of responsibility at the well site is to involve the driller more in the installation and maintenance of the PV system.

Northwest is working to extend the role of 'system engineer' that has evolved as a responsibility over the many years of its existence. Knowledge of the business of its customer base (livestock), its experience with wells and providing water, and its core business of being an energy provider has made it a natural point of contact for the renewable energy needs of the community. The historical role of *Northwest* has been in partnership with the Rural Utility Service (RUS). This technical role required knowledge of equipment characteristics that satisfied RUS requirements as well as safety and connection standards for installing and maintaining the distribution lines in the service area. The system engineering support may require interaction with Natural Resources Conservation Service (NRCS is formerly the USDA Soil Conservation Service). In this case, NRCS provides range evaluation (type and quality of grass in an area) as well as pipeline design and water storage needs at a site. Additional work in the development of a pumping project may find *Northwest* being the middle man as state and other federal agencies become involved. The support for the end-user, the rancher, may be varied and includes such questions as:

- What storage tank size and quality should be chosen?
- Should PV or wind be used?
- Are batteries needed to extend pumping time?
- Is a trailer system needed for pasture rotation?

Northwest has invested many hours of time in study and telephone conversation with PV suppliers to become a reliable source of knowledge for the ranching community. This effort is considered to be an investment for the future in terms of service to be provided.

Photovoltaic Systems as a Business – RUS as a Partner

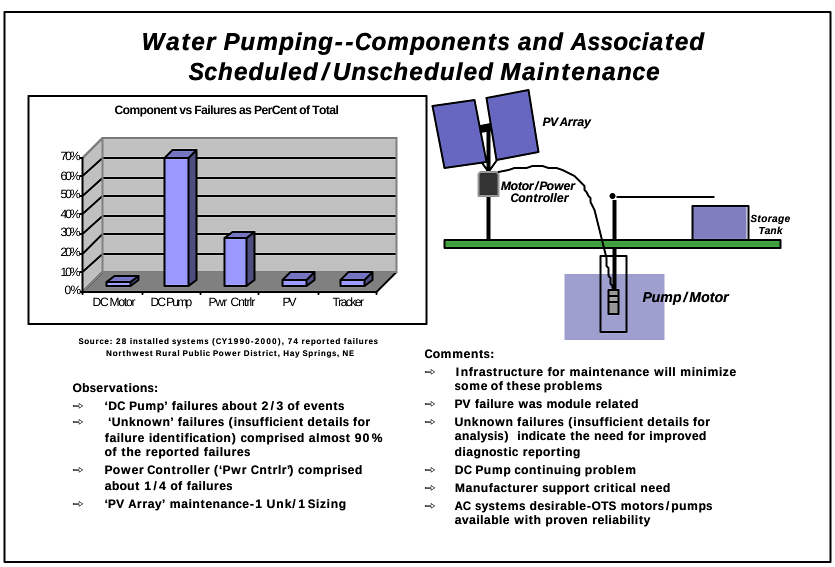
The Rural Utility Service has been a reliable partner for the co-ops for many years. Northwest is now proposing to RUS that the organization carry the relationship a step further in the use of renewables. RUS has been already working to simplify its loan process regarding renewables. To complement this loan process, *Northwest* is asking that PV equipment be placed on the approved equipment list and that O&M data be collected and shared as part of this process. This ability to bring information from various co-ops together will provide statistical significance to the data and results being developed at this time from data provided by *Northwest*.

Analysis

In the spring of 2000 *Northwest* and Sandia National Laboratories (SNL) began a cooperative effort to study the cost of the livestock water pumping systems fielded by *Northwest*. The immediate goal is to better understand the costs in these fielded systems. Eventually data with other co-ops is desired so the analysis can be extended. With this additional data, confidence in the results of the analysis increases and the information can be shared with a larger population of users of PV systems.

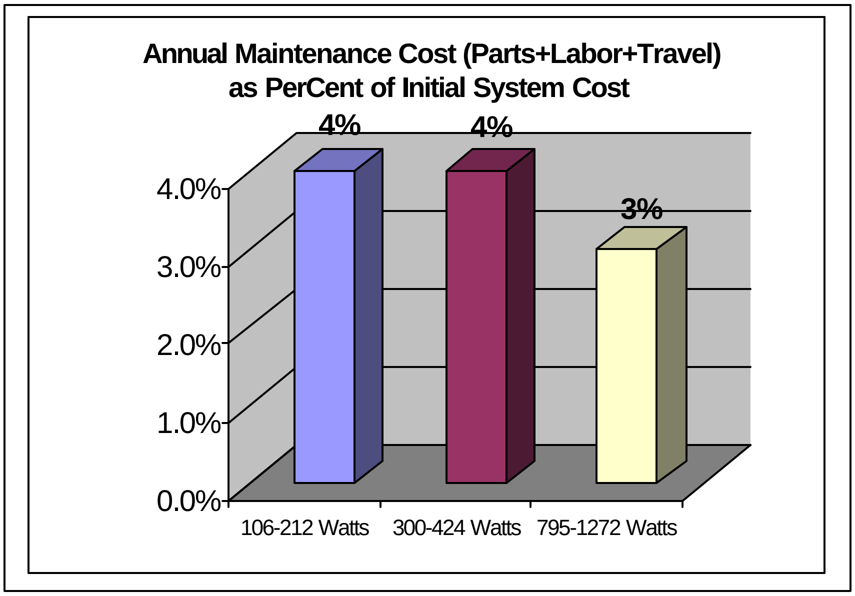
At this time *Northwest* has system, component, and maintenance information on 28 PV water pumping systems. The initial work focused on Jerry Anderson reviewing the written records of the co-op to extract the system, component and O&M information needed for the study. At the same time SNL continued the development of a Microsoft Access database that is the tool used to store and format the data for both internal and external analysis. This laborious process continued on a part-time basis as data was identified and verified as it was entered into the database. As expected, this process of entering and editing data from these fielded systems was invaluable in the development of the database as an analytical tool. The data entry is considered complete but additions to the database will occur as new systems are installed and systems failures occur.

An initial analysis of the data has been completed. This work consists of a system-level view of unscheduled maintenance events, annual total maintenance (parts plus labor plus travel) cost as a percent of the initial system cost and the annual total maintenance cost broken into categories. The data was entered into the database in stages. The first round of work captured the basic O&M information that is summarized in the nearby figure. As part of the database design, a set of failure modes was created to document system failures. As each maintenance record was entered in the database, a failure mode was assigned to the resulting record. The results are tabulated so that the failures associated with each component are represented as a percent of the total number of system

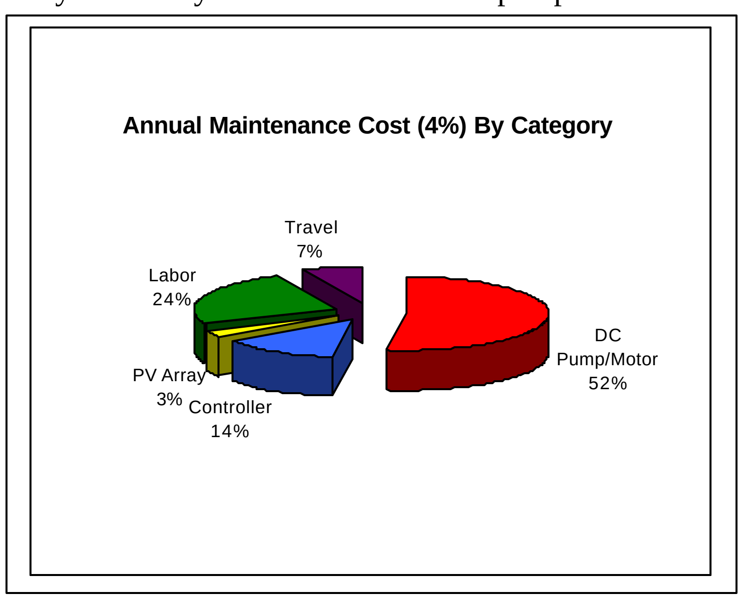


failures. Here the dc pump and the power controller are shown to be the most common problems with the system, which is certainly consistent with the field experience. A further look at the pump failures revealed no correlation with the manufacturer of the pump or the static well depth (the only metric available for the well). In the preceding chart the DC Pump represents a pump/motor unit because of the uncertainty in identifying specific causes of failures.

The next step in the analysis was the calculation of the annual maintenance cost as a percent of the initial system cost. The *Northwest* systems group naturally into three categories determined by the PV array size. For each system, the initial system cost was compounded to 2001 dollars using a discount rate of 5%. In addition, each system failure was compounded to 2001 dollars using the same discount rate. The total maintenance cost is the sum of these individual costs. The final step was to take the ratio the total maintenance cost to the initial system cost and divide this result by the current lifetime. Averages for the maintenance cost for the systems in each size category were then calculated. At this time we can plan for an average annual maintenance cost of approximately 4% of the initial system cost.



Although field experience and early data analysis have identified the pump/motor as the cost driver in the system, a break-down of the 4% annual maintenance cost is still of interest. In the accompanying figure, the DC Pump/Motor (52%) and the Power Controller (14%) represent about two-thirds of the system maintenance costs. Here there appear to be opportunities for reducing cost through design changes and



implementation of routine maintenance such as diaphragm replacement in volumetric pumps. Travel and Labor costs in this figure represent those costs for all of the system components.

Summary

Work continues in the installation, operation and maintenance of these water pumping systems. The initial results of the cost analysis indicate that PV power may be an economically viable option for sites greater than a half mile from the distribution system. The expected annual maintenance cost for these systems will be about 4% of the initial system cost. Additionally, PV may offer a distributed energy resource for applications other than water pumping for livestock. In choosing PV as the energy source, it is important to consider the value the system provides in addition to traditional cost metrics.

Co-Ops Biggest Pitfall Is To Not Engage In the Renewable Energy Discussions In Progress

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.

Water Pumping for Livestock Using Photovoltaic Power Systems

Rolland Skinner, Manager
Northwest Rural Public Power District

Larry Moore
Len Malczynski
Sandia National Laboratories

NRPPD

Sandia National Laboratories

PV Water Pumping for Livestock *as a Business*

- Site Specific
- Not replace grid
- Sound addition to co-ops line extension and line replacement program
- Cost effective when used properly
- Asset when co-ops guide its use

NRPPD

Sandia National Laboratories

PV Water Pumping for Livestock *as a Business*

- Need to be proactive to address PV community concerns on utility acceptance
- Application problems can be solved
- Negative effects to not engage

Co-ops Biggest Pitfall
Not To Engage

NRPPD

Sandia National Laboratories

Who is Northwest Public Power District?

- Provides electrical power, financing, other services to Northwest Nebraska
- Serves 4000 square miles/5 different terrain
- 2186 miles of line / 1.35 customers/mile
- New *revenue* streams attractive
  - .6% growth in electric income
  - 2-3% escalation in cost

NRPPD

Sandia National Laboratories

Who is Northwest Rural Public Power District (NRPPD)

- Improve the living standards rural America
  - Financing
    - 1 1/2 - 2% available long-term
    - Organization
    - Electric Lines
    - Knowledge
  - Next…Distributed Generation - PV

NRPPD

Sandia National Laboratories

Service Through Knowledge

- Electric Lines
  - RUS specification guide
  - RUS material list
  - RUS personnel
- Energy Efficiency
  - Irrigation
  - Audits-residential

NRPPD

Sandia National Laboratories

Service Through Knowledge

- Distribution Generation
  - What to do
  - What not to do
- Properly Designed & Integrated PV provides
  - Value to the electric system
  - Value to the customer

NRPPD

Sandia National Laboratories

PV As A Business

Stock Water Pumping

- Stock water pumping
  - 9 systems sold
  - 20 systems leased
  - 5% stockwells PV
  - 1 off-grid home
  - 1 grid-connected home
- NRPPD role
  - Point of contact-Knowledge base
  - Hours invested by phone
- 1000+ windmills
- Existing lines
  - 50-70 years old
  - 30-40 miles @ $12,000/mile
- $*500K* long term value
- Yearly maintenance
  - $150 newer lines/older ↑
  - $?? PV

NRPPD

Sandia National Laboratories

PV Is Business
What is Needed?

- Co-ops are energy providers
  - Line Extension
  - Line Replacement
- PV - Financial Feasibility
  - 1/2 mile line needed
  - PV may be option

NRPPD

Sandia National Laboratories

What Is Needed?
Service

- Reliable Service(If it doesn’t work we fix it)
- Infrastructure
  - Driller
  - Inventory
- Financing
  - Low interest rates
  - Longer depreciation
  - Revenue

NRPPD

Sandia National Laboratories

What Is Needed?
Co-op Knowledge Base

- Equipment- RUS
  - Specifications
  - Safety
- Capacity
  - Electric Lines/Overload
  - PV/No Reserve
    - Factory/Dealer
    - Co-op/Customer
- Project Knowledge
  - NRCS - pipeline
  - PV Design/Sales
- Efficiency
  - DC vs AC
  - Single Phase vs 3 Phase

What Is Needed?
Co-op Knowledge Base

- Customer Value
  - Tank Size & Quality
  - Batteries
  - Wind + PV
  - Trailers pasture rotation
- Safety-Interconnect Standards
  - IEEE, UL, NEC
  - Distribution Safety Committees-Lineman Credibility
- Net Metering/Avoided Cost

NRPPD
Sandia National Laboratories

What Is Needed? RUS As A Partner

- RUS Material List Needs to include PV
  - Dealer/Factory Information
    - Place equipment on List
  - Co-op Experience
    - Add/Remove Components/Systems
  - New Products
    - Example - Thin Film Modules
      - Cost/Life
      - Long term field test by co-ops

NRPPD

Sandia National Laboratories

What Is Needed? Understand Costs

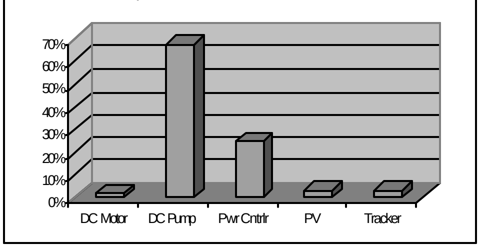
- Maintenance - RUS requires O&M records
  - Records Kept/Shared ➔ Knowledge
    - What Last?
    - What Does Not?
    - Who's?
    - Cost?

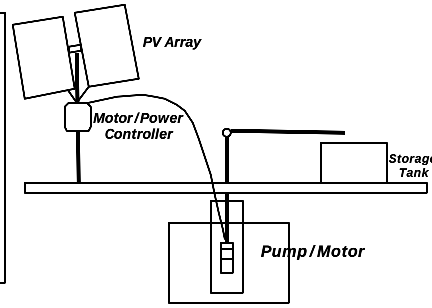
NRPPD

Sandia National Laboratories

15

Water Pumping--Components and Associated Unscheduled Maintenance





Source: 28 installed systems (CY1990-2000), 61 reported failures
Northwest Rural Public Power District, Hay Springs, NE

Observations:

- 'DC Pump' failures about 2/3 of events
- 'Unknown' failures (insufficient details for failure identification) comprised almost 90% of the reported failures
- Power Controller ('Pwr Cntrlr') comprised about 1/4 of failures
- 'PV Array' maintenance-1 Unk/1 Sizing

Comments:

- Infrastructure for maintenance will minimize some of these problems
- PV failure was module related
- Unknown failures (insufficient details for analysis) indicate the need for improved diagnostic reporting
- DC Pump continuing problem
- Manufacturer support critical need
- AC systems desirable-OTS motors/pumps available with proven reliability

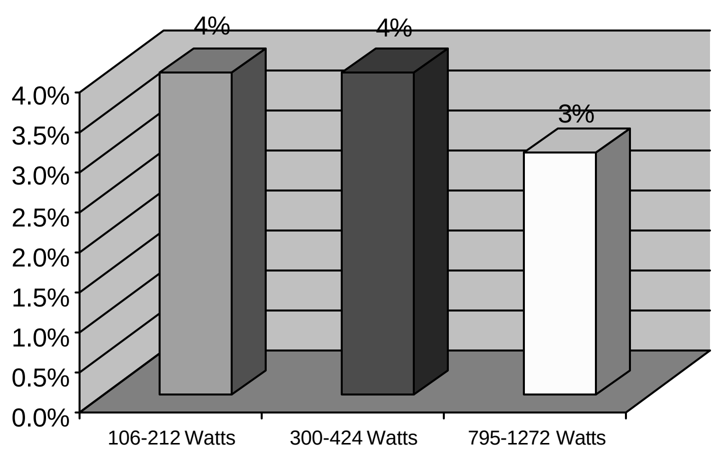
NRPPD Rolland Skinner
rskinner@gpcom.net
308-638-4491

4May01

Larry Moore
lmmoore@sandia.gov
505-845-9191
Sandia National Laboratories

16

Maintenance Cost (Parts+Labor+Travel) as PerCent of Initial System Cost

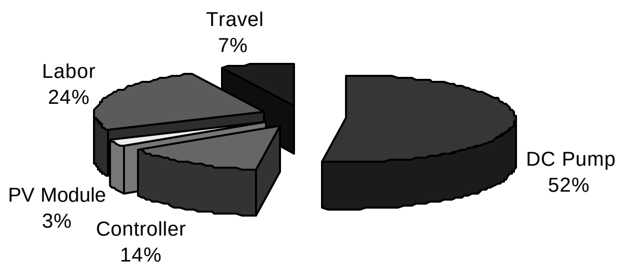


NRPPD Rolland Skinner
rskinner@gpcom.net
308-638-4491

Source: 28 installed systems (CY1990-2000), 74 reported failures
Northwest Rural Public Power District, Hay Springs, NE

Larry Moore
lmmoore@sandia.gov
505-845-9191
Sandia National Laboratories

Maintenance Cost (4%) By Category



NRPPD
Rolland Skinner
rskinner@gpcom.net
308-638-4491

Source: 28 installed systems (CY1990-2000), 74 reported failures
Northwest Rural Public Power District, Hay Springs, NE

Larry Moore
lmmoore@sandia.gov
505-845-9191
Sandia National Laboratories

What Is Needed?
Financial Feasibility

- Co-ops as energy providers
  - Line extension/Line replacement
- Financial Feasibility ➔ 1/2 mile line

	PV	Commercial
Avg Income/yr	$307.21	$195.72
Power Costs	$0.00	$97.86
Available NW	$307.21	$97.86
Depreciation Yrs	10-20	30

NRPPD

Sandia National Laboratories

Distribution Lines

1. Construction Cost

$12,000	Construction cost per mile
$200	O&M per mile per year

2. Financing Criteria

5%	Per Cent Loan
30	Year Loan

Distance (miles)	Total Line Cost	Monthly Recovery Cost	Yearly Recovery Cost
3	$36,000	$193	$2,319
2	$24,000	$129	$1,546
1	$12,000	$64	$773
0.5	$6,000	$32	$387

4. Summary

Distance (miles)	Est Monthly Recovery Rate
3	$243.22
2	$162.15
1	$81.07
0.5	$40.54

Est Monthly Recovery Rate		($243.22)
	Annual	$2,919

input this data
intermediate calculated values

3. What Monthly Payment Is Required to Break Even?

Enter Distance	3	miles
Enter Yearly Recovery Cost	$2,319	

Year	Annual O&M	Annual Financing Cost	Misc	Total System Cost	Est Recovery Rate
1	$600	$2,319		$2,919	$2,919
2	$600	$2,319		$2,919	$2,919
3	$600	$2,319		$2,919	$2,919
4	$600	$2,319		$2,919	$2,919
5	$600	$2,319		$2,919	$2,919
6	$600	$2,319		$2,919	$2,919
7	$600	$2,319		$2,919	$2,919
8	$600	$2,319		$2,919	$2,919
9	$600	$2,319		$2,919	$2,919
10	$600	$2,319		$2,919	$2,919
11	$600	$2,319		$2,919	$2,919
12	$600	$2,319		$2,919	$2,919
13	$600	$2,319		$2,919	$2,919
14	$600	$2,319		$2,919	$2,919
15	$600	$2,319		$2,919	$2,919
16	$600	$2,319		$2,919	$2,919
17	$600	$2,319		$2,919	$2,919
18	$600	$2,319		$2,919	$2,919
19	$600	$2,319		$2,919	$2,919
20	$600	$2,319		$2,919	$2,919
21	$600	$2,319		$2,919	$2,919
22	$600	$2,319		$2,919	$2,919
23	$600	$2,319		$2,919	$2,919
24	$600	$2,319		$2,919	$2,919
25	$600	$2,319		$2,919	$2,919
26	$600	$2,319		$2,919	$2,919
27	$600	$2,319		$2,919	$2,919
28	$600	$2,319		$2,919	$2,919
29	$600	$2,319		$2,919	$2,919
30	$600	$2,319		$2,919	$2,919
				$54,367	$54,359
				NPV (3.4%)	

NRPPD
Rolland Skinner
rskinner@gpcom.net
308-638-4491

Larry Moore
lmmoore@sandia.gov
505-845-9191
Sandia National Laboratories

1024W Water Pumping System

Pump/Motor, Power Controller, PV, Travel & Labor included

input this data
intermediate calculated values

1024 W System Cost		$11,589
Annual O&M cost		4%
	O&M Yearly	$464
Financing 5%, 15 years		
	Monthly Payment	$92
	Finance Yearly	$1,100
NRPPD Monthly Fee		$145
	Annual Recovery	$1,735

Costs: O&M Yearly	Finance Yearly	Misc	Total	NRPPD Recovery
$464	$1,100		$1,563	$1,735
$464	$1,100		$1,563	$1,735
$464	$1,100		$1,563	$1,735
$464	$1,100		$1,563	$1,735
$464	$1,100		$1,563	$1,735
$464	$1,100		$1,563	$1,735
$464	$1,100		$1,563	$1,735
$464	$1,100		$1,563	$1,735
$464	$1,100		$1,563	$1,735
$464	$1,100		$1,563	$1,735
$464	$1,100		$1,563	$1,735
$464	$1,100		$1,563	$1,735
$464	$1,100		$1,563	$1,735
$464	$1,100		$1,563	$1,735
$464	$1,100		$1,563	$1,735
			$18,134	$20,128
			NPV (3.4%)	
			Difference	$1,994

Power Controller, PV, Travel & Labor included

1024 W System Cost		$10,051
Annual O&M cost		1.4%
	O&M Yearly	$141
Financing 5%, 15 years		
	Monthly Payment	$79
	Finance Yearly	$954
NRPPD Monthly Fee		$116
	Annual Recovery	$1,390

Costs: O&M Yearly	Finance Yearly	Misc	Total	NRPPD Recovery
$141	$954		$1,095	$1,390
$141	$954		$1,095	$1,390
$141	$954		$1,095	$1,390
$141	$954		$1,095	$1,390
$141	$954		$1,095	$1,390
$141	$954		$1,095	$1,390
$141	$954		$1,095	$1,390
$141	$954		$1,095	$1,390
$141	$954		$1,095	$1,390
$141	$954		$1,095	$1,390
$141	$954		$1,095	$1,390
$141	$954		$1,095	$1,390
$141	$954		$1,095	$1,390
$141	$954		$1,095	$1,390
$141	$954		$1,095	$1,390
			$12,696	$16,127
			NPV (3.4%)	
			Difference	$3,431

NRPPD
Rolland Skinner
rskinner@gpcom.net
308-638-4491

Larry Moore
lmmoore@sandia.gov
505-845-9191
Sandia National Laboratories

300W Water Pumping System

Pump/Motor, Power Controller, PV, Travel & Labor included

	input this data
	intermediate calculated values

300 W System Cost		$4,182
Annual O&M cost		4%
	O&M Yearly	$167
Financing 5%, 15 years		
	Monthly Payment	$33
	Finance Yearly	$397
NRPPD Monthly Fee		$66
	Annual Recovery	$791

Costs				NRPPD
O&M Yearly	Finance Yearly	Misc	Total	Recovery
$167	$397		$564	$791
$167	$397		$564	$791
$167	$397		$564	$791
$167	$397		$564	$791
$167	$397		$564	$791
$167	$397		$564	$791
$167	$397		$564	$791
$167	$397		$564	$791
$167	$397		$564	$791
$167	$397		$564	$791
$167	$397		$564	$791
$167	$397		$564	$791
$167	$397		$564	$791
$167	$397		$564	$791
$167	$397		$564	$791
			$6,544	$9,176
			NPV (3.4%)	
			Difference	$2,632

Power Controller, PV, Travel & Labor included

300 W System Cost		$3,456
Annual O&M cost		1.4%
	O&M Yearly	$48
Financing 5%, 15 years		
	Monthly Payment	$27
	Finance Yearly	$328
NRPPD Monthly Fee		$45
	Annual Recovery	$541

Costs				NRPPD
O&M Yearly	Finance Yearly	Misc	Total	Recovery
$48	$328		$376	$541
$48	$328		$376	$541
$48	$328		$376	$541
$48	$328		$376	$541
$48	$328		$376	$541
$48	$328		$376	$541
$48	$328		$376	$541
$48	$328		$376	$541
$48	$328		$376	$541
$48	$328		$376	$541
$48	$328		$376	$541
$48	$328		$376	$541
$48	$328		$376	$541
$48	$328		$376	$541
$48	$328		$376	$541
			$4,365	$6,278
			NPV (3.4%)	
			Difference	$1,912

NRPPD
Rolland Skinner
rskinner@gpcom.net
308-638-4491

Larry Moore
lmmoore@sandia.gov
505-845-9191
Sandia National Laboratories

150W Water Pumping System

Pump/Motor, Power Controller, PV, Travel & Labor included

	input this data
	intermediate calculated values

150 W System Cost		$1,530
Annual O&M cost		4%
	O&M Yearly	$61
Financing 5%, 15 years		
	Monthly Payment	$12
	Finance Yearly	$145
NRPPD Monthly Fee		$35
	Annual Recovery	$415

Costs				NRPPD
O&M Yearly	Finance Yearly	Misc	Total	Recovery
$61	$145		$206	$415
$61	$145		$206	$415
$61	$145		$206	$415
$61	$145		$206	$415
$61	$145		$206	$415
$61	$145		$206	$415
$61	$145		$206	$415
$61	$145		$206	$415
$61	$145		$206	$415
$61	$145		$206	$415
$61	$145		$206	$415
$61	$145		$206	$415
$61	$145		$206	$415
$61	$145		$206	$415
$61	$145		$206	$415
			$2,394	$4,811
			NPV (3.4%)	
			Difference	$2,417

Power Controller, PV, Travel & Labor included

150 W System Cost		$1,150
Annual O&M cost		1.4%
	O&M Yearly	$16
Financing 5%, 15 years		
	Monthly Payment	$9
	Finance Yearly	$109
NRPPD Monthly Fee		$17
	Annual Recovery	$205

Costs				NRPPD
O&M Yearly	Finance Yearly	Misc	Total	Recovery
$16	$109		$125	$205
$16	$109		$125	$205
$16	$109		$125	$205
$16	$109		$125	$205
$16	$109		$125	$205
$16	$109		$125	$205
$16	$109		$125	$205
$16	$109		$125	$205
$16	$109		$125	$205
$16	$109		$125	$205
$16	$109		$125	$205
$16	$109		$125	$205
$16	$109		$125	$205
$16	$109		$125	$205
$16	$109		$125	$205
			$1,453	$2,382
			NPV (3.4%)	
			Difference	$929

NRPPD
Rolland Skinner
rskinner@gpcom.net
308-638-4491

Larry Moore
lmmoore@sandia.gov
505-845-9191
Sandia National Laboratories

Summary

✓ PV can be a *positive* and valuable addition to a utilities portfolio of options for service to their customers.

✓ PV is *cost effective* at site specific locations today, with many additional opportunities created by energy price spikes.

✓ Utilities are a *critical partner* in renewable energy applications.

As Partners, We Can Continue to Improve the Quality of Life in Rural America