ENERGY AT DAVID WEST FIELD STATION

CONSERVATION & GENERATION

Prepared and Assembled for the Allan Savory Center by

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CHALLENGE OF CONSERVATION

Attempts to conserve energy are often complicated by the ease of applying prevailing technologies and, because energy costs money, by our judgments regarding the deployment of income and capital. The easiest approach is to simply consume less (aligning use with income) and to rely on the utility providers to supply us with power made "affordable" by means of broadly shared capital outlays for generation and distribution. Government subsidy of power generators sweetens that approach. But the era of cheap power draws to a close as natural resources are depleted and the environmental costs of extraction deepen. We are able to balance consumption with income with less assurance as each month passes. Accordingly, capital plays a larger role now for those with access. And improved alternatives to conventional fossil-fuel conversion of energy offer broader possibilities to them.

Conventional generation squanders significant energy resources (as much as 90% lost in the form of heat by the time the light bulb filament glows.) Newer technologies and improved manufacturing processes reducing embodied energy bring environmental payback (in the case of photovoltaics) to a matter of three to five years when balanced against improved efficiencies in power generation.

Buying one's own generation facility and enjoying lower unit costs stabilized for the life of the facility is feasible now to a point beyond which much reduced environmental cost becomes merely one positive side effect.

AT THE DAVID WEST FIELD STATION

The West Ranch is an all-electric installation operating on the grid at current a current utility rate of $0.135 per kilowatt hour (kWh). That means that each and every task requiring energy is accomplished by utilizing the single most expensive and environmentally costly resource. Monthly utility bills for 2002 when the rate was $0.087 kWh ranged from a low of 4581 kWh / $443.32 (November, 2002) to 9361 kWh / $821.03 (August, 2003). Adjusted for the current rate, those charges would be $618.44 for November and $1,263.74 for August.

MAJOR CONSUMERS:

1. Surface pond fed by seepage from Stock Tank #2 (Constant pumping at Wells # 2 and # 3)
2. Electric Air-Source Heating and Cooling
3. Domestic Line Pressure Pump
4. Electric Hot Water

CONSERVATION MEASURES

1. Abandon Stock Tank # 2; feed stock trough (at pond's present location) by float valve from Domestic Tank adjacent to Well # 2
2. Abandon Well # 2, the lesser producing, deeper bore
3. Adopt wood-fired heat for Winter and maintain thermostatic controls at residences at 75° F during Summer
4. Abandon Domestic Line Pressure Pump in favor of hydraulic head pressure from Domestic Tank;
5. Substitute thermoconvective hot water source for domestic hot water at Main residence and Casita
6. Adopt wood-fired hot water for Hot Tub

Overall, consumption needs to be reduced by a range of 50% (in November) to 66% (in August) for any energy plan to succeed. Annual consumption should hover around 36,000 kWh (3,000 kWh per month; household averages range from 400 kWh to 1,500 kWh). Conservation measures 1, 2, and 4 should reduce the consumption at Meter "Ranch" from 46% of total consumption to a figure more in line with East Indian Well at 2%. Measure 3 should reduce consumption at Meter "Main House" by 15%. Measures 5 and 6 should reduce consumption at Meter Main House by 16%.

Total conservation measure reductions could amount to 3,500 < 6,500 kWh, depending on the month, and bring consumption into line with potential generation capacity.

GENERATION

Net Metering law in Texas is not particularly helpful to grid-tied power generation systems. Compensation for power generated is strictly tied to energy-costs-avoided at a current rate of $0.035 per kWh. Stand- alone systems do make economic sense if the natural potential exists.

Climatic conditions at West Ranch argue for photovoltaic power generation. Wind generation is marginal to poor but solar insolation is high at 6 solar hours per day. This proposal assumes building-integrated photovoltaic arrays. Building integration generally makes for tidier surrounds in a working landscape context. The southern exposures on the roofs of the Main House / Barn and the Shed adjacent to Well # 3 fall within industry standards for optimal power generation. See the PV Watts calculations (page 5).

The following financial pro-forma suggest that although monthly loan service may exceed current utility bills (in two scenarios) the unit cost per kWh is halved (potentially) and the net benefit across the design life of the system is positive and substantial.

PV COSTS & OUTPUT CALCULATIONS

Borrowed Principal	
KW system (125 ea. BP SX 160)	20
Hours of sun / day	6
kWh's / day	120
kWh's / year	43,800
kWh's required / year	36,000
Installation cost per KW	$5,500.00
Overall system cost	$110,000.00
Tax Credits: % of System Cost	20%
Less tax credits	($22,000.00)
Maintenance	$11,000.00
Total expenditure	$99,000.00
Loan amount	$88,000.00
Interest rate (annual)	7.00%
Loan length (years)	10
Monthly payment	($1,021.75)
Total Loan pmts.	($122,610.00)
Annual output (kWh's)	43,800
Design life (years)	30
kWh's excess	7,800
Avoided cost per kWh + CPI	$0.07
Excess production annual income	$546.00
PV rate (kWh)	$0.08
Current utility rates (kWh)	$0.13
Actual pv rate (Current pv rate less excess production)	$0.06
Avg. Monthly to SWTEC @ current rate + CPI increases	$663.00
Total paid to SWTEC over Design Life	$238,680.00
Net benefit over Design Life	$116,070.00

Capital Out-of Pocket	
KW system (125 ea. BP SX 160)	20
Hours of sun / day	6
kWh's / day	120
kWh's / year	43,800
kWh's required / year	36,000
Installation cost per KW	$5,500.00
Overall system cost	$110,000.00
Tax Credits: % of System Cost	20%
Less tax credits	($22,000.00)
Maintenance	$11,000.00
Total expenditure	$99,000.00
Principal amount required	$88,000.00
Investment rate (annual income foregone)	4.00%
Length of Investment (years)	10
Monthly Income foregone	($359.94)
Total Out-of-PocketCost	($131,193.27)
Annual output (kWh's)	43,800
Design life (years)	30
kWh's excess	7,800
Avoided cost per kWh + CPI	$0.07
Excess production annual income	$546.00
PV rate (kWh)	$0.08
Current utility rates (kWh)	$0.13
Actual pv rate (Current pv rate less excess production)	$0.06
Avg. Monthly to SWTEC @ current rate + CPI increases	$663.00
Total paid to SWTEC over Design Life	$238,680.00
Net benefit over Design Life	$107,486.73

PV COSTS & OUTPUT CALCULATIONS Cont.

Loan hedged by Capital Investment*

KW system (125 ea. BP SX 160)	20
Hours of sun / day	6
kWh's / day	120
kWh's / year	43,800
kWh's required / year	36,000
Installation cost per KW	$5,500.00
Overall system cost	$110,000.00
Tax Credits: % of System Cost	20%
Less tax credits	($22,000.00)
Maintenance	$11,000.00
Total expenditure	$99,000.00
Loan amount	$88,000.00
***Net Interest Rate (Annual)**	3.00%
Loan length (years)	10
Monthly payment	($849.73)
Total Loan pmts.	($101,967.60)
Annual output (kWh's)	43,800
Design life (years)	30
kWh's excess	7,800
Avoided cost per kWh + CPI	$0.07
Excess production annual income	$546.00
PV rate (kWh)	$0.08
Current utility rates (kWh)	$0.13
Actual pv rate (Current pv rate less excess production)	$0.06
Avg. Monthly to SWTEC @ current rate + CPI increases	$663.00
Total paid to SWTEC over Design Life	$238,680.00
Net benefit over Design Life	$136,712.40

NATIONAL MUNICIPAL BOND YIELDS:
TRIPLE-A RATED, TAX-EXEMPT INSURED REVENUE BONDS

Updated: **New York:** Nov 19 12:	1 DAY PRIOR YIELD	2 DAY PRIOR YIELD	CHANGE IN YIELD	31% EQ YIELD	1 WEEK PRIOR YIELD	1 MONTH PRIOR YIELD	6 MONTH PRIOR YIELD
2-Year	1.46%	1.42%	0.04%	2.09%	1.51%	1.34%	1.29%
5-Year	2.60%	2.52%	0.08%	3.71%	2.63%	2.38%	2.32%
7-Year	3.21%	3.14%	0.07%	4.59%	3.25%	3.09%	2.92%
10-Year	3.84%	3.78%	0.06%	5.49%	3.91%	3.78%	3.48%
15-Year	4.40%	4.38%	0.02%	6.29%	4.53%	4.46%	4.17%
20-Year	4.74%	4.72%	0.02%	6.77%	4.89%	4.94%	4.53%
30-Year	4.88%	4.86%	0.02%	6.97%	5.01%	5.07%	4.63%

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Net interest rate equals loan rate at 7.0% (current prevailing for loans of this size) less income on secured bond investment at 4% (see bond rates above.)

In fact, lenders presently charge income (on security) plus 2%, or 2.5%, in such cases. Although sequestered capital is often considered to have a crippling effect on cash flow, the lower (secured) rate can enhance the net benefit significantly and is often chosen as the wisest option in the presence of adequate cash flows.

The following tables show power generation calculations for each array at its individual tilt and azimuth (degrees left or right of true south at 180°.) See next page for notes.

AC ENERGY AND COST SAVINGS

MAIN

STATION IDENTIFICATION

City: San Angelo TX

Latitude: 31.37 ° N
Longitude: 100.50 ° W
Elevation: 582 m

PV SYSTEM SPECIFICATIONS

AC Rating: 18.0 kW
Array Type: Fixed Tilt
Array Tilt : 14.0 °
Array Azimuth: 161.0 °

ENERGY SPECIFICATIONS

Cost of Electricity: 13.5 ¢

ENERGY PRODUCTION

Month	kWh	Value($)
1	2184	294.84
2	2283	308.20
3	2874	387.99
4	2961	399.74
5	3078	415.53
6	3106	419.31
7	3184	429.84
8	3081	415.94
9	2744	370.44
10	2653	358.16
11	2002	270.27
12	1990	268.65
Year	32143	4339.31

WELL

STATION IDENTIFICATION

City: San Angelo TX

Latitude: 31.37 ° N
Longitude: 100.50 ° W
Elevation: 582 m

PV SYSTEM SPECIFICATIONS

AC Rating: 2.0 kW
Array Type: Fixed Tilt
Array Tilt : 21.0 °
Array Azimuth: 202.0 °

ENERGY SPECIFICATIONS

Cost of Electricity: 13.5 ¢

ENERGY PRODUCTION

Month	kWh	Value($)
1	260	35.10
2	265	35.77
3	327	44.15
4	329	44.41
5	337	45.49
6	337	45.49
7	345	46.58
8	340	45.90
9	310	41.85
10	307	41.45
11	237	32.00
12	238	32.13
Year	3630	490.05

ENERGY PRODUCTION TOTAL

Month	kWh	Value($)
1	2444	329.94
2	2584	343.97
3	3201	432.14
4	3290	444.15
5	3415	461.02
6	3443	464.80
7	3529	476.42
8	3421	461.84
9	3054	412.29
10	2960	399.61
11	2239	302.27
12	2228	300.78
Year	35773	4,829.36

Variables notwithstanding, the calculations confirm that the 20 kW (total) array proposed should generate the annual target of 36,000 kWh at the tilt and azimuth of the existing roofs. Winter increases at a tilt equal to 30° N are insignificant enough to justify Summer (high AC requirements) increases at the tilts specified. Some capital savings (foregoing more elaborate racking mounts to achieve tilt equal to latitude) result from using existing roof slopes. Moreover, integrating arrays with existing structures minimizes costs associated with ranch operations and security.

INTERPRETING THE RESULTS

The monthly and yearly energy production are modeled using the PV system parameters you selected and weather data that are typical or representative of long-term averages during the 1961-1990 time frame. Because weather patterns vary from year-to-year, the values in the tables are better indicators of long-term performance than performance for a particular month or year.

PV performance is largely proportional to the amount of solar radiation received, which may vary from the long-term average by 30% for monthly values and 10% for yearly values. How the solar radiation might vary for your location may be evaluated by examining the tables in the *Solar Radiation Data Manual for Flat-Plate and Concentrating Collectors* (*http://rredc.nrel.gov/solar/old_data/nsrdb/redbook/*).

For these variations and the uncertainties associated with the weather data and the model used to model the PV performance, future months and years may be encountered where the actual PV performance is less than or greater than the values shown in the table. The variations may be as much as 40% for individual months and up to 20% for individual years. Compared to long-term performance over many years, the values in the table are accurate to within 10% to 12%.

The values in the table assume that the PV array has an unobstructed view of the sky. If trees, buildings, mountains, or other obstacles block the sun, the values in the table should be reduced.

Results for one- and two-axis tracking systems assume continuous tracking of the sun throughout the day. For passive and other non-optimum tracking schemes, consult the manufacturer for an appropriate factor for reducing the PVWATTS results.

The PV system size is an AC rating for Standard Reporting Conditions (SRC). The energy production values in the table are valid only for crystalline silicon PV systems rated at SRC.

The cost savings are determined as the product of the number of kilowatt hours (kWh) and the cost of electricity per kWh. These cost savings occur if the owner uses all the electricity produced by the PV system, or if the owner has a net-metering agreement with the utility. With net-metering, the utility bills the owner for the net electricity consumed. When electricity flows from the utility to the owner, the meter spins forward. When electricity flows from the PV system to the utility, the meter spins backwards.

If net-metering isn't available and the PV system sends surplus electricity to the utility grid, the utility generally buys the electricity from the owner at a lower price than the owner pays the utility for electricity. In this case, the cost savings shown in the table should be reduced.

Besides the cost savings shown in the table, other benefits of PV systems include greater energy independence and a reduction in fossil fuel usage and air pollution. For commercial customers, additional cost savings may come from reducing demand charges. Homeowners can often include the cost of the PV system in their home mortgage as a way of accommodating the PV system's initial cost.

To accelerate the use of PV systems, many state and local governments offer financial incentives and programs. Go to http://www.nrel.gov/stateandlocal for more information.

FUTURE ADAPTIVE REUSE

The systems and conservation measures outlined here in no way eliminate options for the adaptive re-design of the Main House / Barn. The pv panels can be temporarily relocated should the re-design involve alterations to the roof structure. The experienced gained from conservative operations can be expected to positively inform all efforts at adaptive re-use.

Such a project will offer the opportunity to incorporate passive architectural elements that will complement these systems and result in even greater economic and environmental savings.

ENGINEERING

Field experience and improved products designed specifically for the context described here are readily available. Several reputable and competent design/build companies operate in Texas and are capable of providing the engineering necessary to implement.

Southwest Texas Electric Coop cannot be expected to display any enthusiasm inasmuch as implementation will deprive them of one of their better sources of income. Fortunately, their enthusiasm is not required although we will want to maintain good relations.

EXHIBITS

Net Metering in Texas

Texas Incentives for Renewable Energy

Electricity in Texas

BP Solar BP 3160 Photovoltaic Panels

How Does a Thermosiphon System Work?

SunEarth SunSiphon

QuadraFire 2100 Millennium Wood Stove (Main Residence)

QuadraFire 400 Millennium Wood Stove (Casita)

EREC Fact Sheet (Excerpted): Solar Water Heating

Solar Water Pumping Makes Sense

PHASING

	COST ESTIMATES			ACTIVITY
	% CURRENT USE	ACTIVATION COST	ANTICIPATED SAVINGS AVG. MONTHLY @ CURRENT RATES	
PHASE ONE				
Deactivate Well #2	5	500.00	47.25	*Disconnect power; pull pump and sucker rod*
Abandon Stock Tank #2*		300.00	0.00	*Drain & Redirect Well #3 to Domestic Tank @ Well #2*
*Convert leak-fed pond to Float Valve trough fed by Well #3	30	1,000.00	283.50	*Purchase Trough & Float Valve or Nose Pumps*
Deactivate Domestic Line-pressure pump	10	750.00	94.50	*Disconnect pump & bypass piping; gravity feed from Domestic Tank*
Abandon Hot Tub	2	—	18.90	*Disconnect*
PHASE TWO				
Wood-fired heating @ residences; 2 ea. @ Main & Casita	5	3,000.00	47.25	*Purchase & Install*
Install Sun Siphons @ residences; 2 ea. @ Avg. 1500	15	3,000.00	141.75	*Purchase & Install; Reroute Domestic Plumbing*
Convert Well #3 to Photovoltaic power	10	5,500.00	94.50	*Purchase & Install new pump & PV Array*
PHASE THREE				
Convert remaining loads to 18kW PV	33	88,000.00	311.85	*Purchase & Install*