UNION MINE DISPOSAL SITE
Renewable Energy Project
Feasibility and Economic Analysis

Final Report
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1.0 Executive Summary

The Renewable Energy Development Institute (REDI) has completed a 6 month wind and solar resource assessment for the Union Mine site. Based upon the site data recorded from 1/9/02 to 7/16/02 the wind resource has been found to be minimal while the solar resource is excellent. Environmental and site specific constraints are negligible.

The economic analysis indicates that a wind energy system will not be economically viable while a solar electric photovoltaic (PV) system can provide up to 100% of the site's electricity at an affordable cost roughly equal to (15% more) the rates being paid to the utility company. Monetary incentives are available to reduce the initial cost of the system by up to 50%. Financing for the installation is available to the County through several tax-exempt loan funds.

Tax incentives are also available that can further reduce the costs through the involvement of a "third party" investor. The "third party" financing option can provide savings to the County without having to invest in the system directly. The "third party" financing mechanism can be combined with the tax-exempt financing to provide a maximum benefit to the County. The final recommendation is for the County to consider soliciting investors for "third party" financing of an Energy Purchase Agreement for a five year term and then buy the system from the investors with funds from a long-term low-interest rate tax-exempt loan.

For the County to consider the purchase of a 602 kW photovoltaic (PV) system to supply 100% of the site electrical load we first consider the future cost for electricity over the next 20 years on both a total cost and a per unit basis. Using the Net Present Value of this expense shows the time value of the electricity cost. We next compare this cost to the Life Cycle Cost of the PV system on both a Cash purchase and with Financing.

20 Year Cost Projections

	Cost of Doing Nothing	Cash for PV System	Finance PV System
Simple Cost ($)	$3,764,838	$2,270,935	$3,949,818
Simple Unit ($/kWh)	$.1790	$.1080	$.1878
NPV Cost ($)	$1,464,227	$2,057,498	$1,680,858
NPV Cost ($/kWh)	$.0696	$.0978	$.0799

The Cost of Electricity assumes actual cost from 2001 with annual average escalation of 3%. Net Present Value calculations assume a 10% Discount Rate. Cash and Financing cases assume 3% inflation, O&M costs of $500/yr and annual PV output loss of .5%. The Financing rate used is 6% over a 20-year term.

As can be seen from the table above a PV system can be comparable to future electricity costs if financed over a long term and at a low interest rate. If electricity rates rise more than 3% per year PV could be a better investment. From a monthly cash flow perspective the monthly loan payment becomes in essence a “long-term fixed price” electric supply contract for the power produced. After the system is paid for all energy generated for the rest of the life of the system is virtually free.

The “third party financing” mechanism can offer the PV system at no initial cost to the County with an agreement to purchase the electricity generated at a discount for the term of the contract. Assuming a 20% discount off of current (2001) utility rates this represents and annual savings of approximately $28,000. Over a 5-year term this would total $140,000. At the end of the 5-year term the County could purchase the system at a reduced cost with at least a 15-year life remaining in the system. The “third party” installs the system, operates and maintains it and takes the tax incentives offered for business use of solar equipment.

2.0 Site Survey and Monitoring Equipment

2.1 General Meteorology

REDI provided County staff with detailed specifications for wind, solar and meteorological monitoring systems. The County staff assumed the responsibility for the general meteorological equipment and REDI assumed responsibility for the wind and solar monitoring equipment. REDI recommended a range of standard met stations available from Kinemetrics, Qualimetrics and Davis Instruments.

Annual average rainfall for the site is 39.6 inches. Average low temperature is 38°F and average high 91°F with the maximum high recorded for Placerville of 109°F and a maximum low of 11°F.[1] These conditions are within the operating range of available solar and wind energy equipment. Data used in analyzing solar energy availability contains historic weather data for the Sacramento weather station from the TMY2 weather database.[2]

2.2 Wind / Solar Monitoring

REDI installed a 20 meter NRG-NOW System (NRG Systems) consisting of a 20 meter (~66 feet) single pole tower, 2 NRG #40 Maximum Anemometers (wind speed), 2 NRG 200P Wind Direction Vanes (wind direction), 1 Li-Cor LI200SA Solar Radiation Sensor and a 9200-PLUS Data Logger (see Attachment A). The initial site survey identified two potential locations for the monitoring equipment – one on the high ground located near the spray field area and the other on top of the covered landfill area. Due to vegetation

[1] Weather.com historical data
[2] TMY2 Weather Data

and proximity to weapons firing range at the site near the spray areas the decision was made to install the monitoring system on top of the covered landfill. Large concrete blocks available at the site were used as guy wire anchors to avoid any penetration of the landfill liner / cover.

The data generated by the wind and solar instruments was recorded at hourly intervals on a 32-kilobyte data chip for downloading into a data chip reader on a periodic basis. The system is self-powered and self-contained. While there was a potential to connect the data system to a telephone line for remote access it was decided that this was unnecessary. Data chips were collected by REDI staff and read in February, April and July with raw data reports sent to County staff.

The total six month data stream has been analyzed for the potential of wind and solar electric generation resources. (See Attachment B)

3.0 Data

3.1 Utility

County staff provided REDI with Pacific Gas and Electric utility bills from the Union Mine facility for the annual periods covering 2000 to 2001. The rate tariff for the account is E19S – a "time-of-use" rate schedule. Annual electricity consumption was 604,960 kWh's in 2000 and 1,177,120 in 2001. For the purposes of this study the 2001 electric load data was used. The total paid for electricity in 2001 was $139,230.94 for an average kWh cost of $.1183. Approximately 8.9% (105,125 kWh) of annual consumption occurs during Peak periods, 27.6% (325,200 kWh) during Partial Peak and 62.5% (746,795 kWh) during Off Peak.

Using the current rates for the E19S tariff the annual cost for 2002 is projected to be $148,527 or $.1265 per kWh representing a 6.9% increase in one year. Future prices for electricity are unknown at the present time as rate caps are scheduled to come off this year and new rates will be "market driven". For purposes of the economic analysis electric costs will be estimated for a 20-year period at current rates and with a 3% annual escalation. This would result in a 20 year "cost of doing nothing" of $2,488,176 at current rates and $3,764,838 ($.1790 per kWh average) with a 3% annual escalation.

3.2 Wind

The wind speed needed for most wind electric generators is at least 10 miles per hour (mph) for start-up and for good production needs to be above 20 mph for long-periods. Wind energy potential is directly related to wind speed. A Wind Energy Resource Atlas of the United States was developed by the Pacific Northwest Laboratory[3] showing wind potential rated by "Power Class" ranging from Class 1 – unsuitable – to Class 7 - maximum potential. Class 3 areas (12.5 to 15.7 mph average) are considered marginal for existing wind turbine technology, Class 2 areas (11.5 to 14.3 mph average) less than marginal and Class 1 areas (9.8 to 12.5 mph average) unsuitable. The Sierra Foothills is designated a Class 1 to 2 range in most areas. (see Attachment C)

[3] Elliot, D.L. and Schwartz, M.N. – NTIS no. DE94001667 – Wind Energy Potential in the United States

The wind data recorded at the Union Mine site shows an average of 4.4 mph with only an occasional speed above 10 mph recorded during the 6-month monitoring period. Further site monitoring is not warranted as the site is considerably under even the lowest Class 1 designation.

3.3 Solar

The solar resource (insolation) available at the Union Mine site is suitable and is on par with the average for Northern California of 5 hours “peak sun equivalent”. This data correlates with the TMY2 weather data for the Sacramento area used by most solar electric software programs. REDI uses the Maui Software "Solar Design Studio ver 5.0" (developed with Sandia National Labs) for estimating solar electric power system outputs. This software uses actual weather data to incorporate temperature, wind speed, cloud cover, rainfall and sunlight availability into the calculations.

3.4 Site

The Union Mine Disposal Site consists of a closed landfill with an existing methane gas capture and disposal facility adjacent to a wastewater treatment facility. The existing facility covers approximately 33 acres of the 271-acre county-owned property. The area surrounding the site to the north, east and west rises steeply in elevation and features a variety of ridges, canyons and hillsides while to the south the land generally decreases in elevation but also features a variety of ridges, canyons and hillsides. The existing Environmental Impact Report and associated documents were provided by County staff to REDI for review of general site data, past activities and for the potential of any environmental concerns related to a wind or solar energy system.

4.0 Feasibility

Given the data from above REDI evaluated the potential for a variety of system locations and sizes for wind and solar electric systems.

4.1 Wind

Even though the wind resource is unsuitable there is a diurnal pattern of wind through the valley at the Union Mine site. Using the data gathered REDI performed an analysis of the estimated output for a 10 kW wind turbine using the MicroSite™ software provided with the NRG monitoring system (see Attachment D) The estimated annual output from a 10 kW Bergey BWC Excel turbine is 5,040 kWh for a capacity factor (percent of annual availability) of .14%. This is negligible. A wind system for this site is **not recommended**.

4.2 Solar

The solar resource is good for the Union Mine site and there is sufficient area for the mounting of a large array capable of providing all of the facility’s electrical needs. Several approaches to system sizing were analyzed to determine the optimum economic and energy benefits (see Attachment E).

A 624 kW (AC) solar electric system would be capable of providing 100% of the annual electrical consumption. Further analysis of the economics reveal that a smaller system

of 602 kW (AC) will provide 100% of the annual electric bill due to the value of the kilowatt-hours produced on a “time of use” rate schedule. For more details see the Economic Analysis section below. The system would need approximately 65,000 square feet of land area with a southern exposure. The solar electric array (grouping of individual solar modules) should be tilted up to a 30° angle from the horizontal for optimum annual output.

The south slope of the landfill area would be an ideal location for this solar electric system and would also be relatively close to the electrical interconnection location at the main facility. A ground-mounted array could be installed without penetrating the landfill membrane using concrete ballast blocks on the southern slope if necessary.

4.3 Environmental

Data provided in the Environmental Impact Report (EIR) for the Union Mine Landfill closure was reviewed for geologic, vegetation, wildlife and other environmental factors that could be impacted by the installation of a solar electric system (wind turbine impacts were not evaluated as wind was determined to be unsuitable for the site).

A solar electric system has no moving parts, makes no noise (the inverter mounted away from the array makes a very slight 60 cycle buzzing sound that would be inaudible from outside of the electrical room) and has no chemical “exhaust”. While the EIR discusses potential underground cavities from past mining there is little chance of impact resulting from geological considerations. The main concern would be maintaining the integrity of the gas capture and landfill membrane structures. Ground mounting the array away from the membrane or without penetrating the ground can address this concern.

A slight impact that should be evaluated further would be the potential for “glare” resulting from low-angle early morning and late afternoon sun affecting the residences to the east and west of the Union Mine facility. In general solar electric modules use “anti-reflective” coatings to absorb as much sunlight as possible. However, at obtuse incident angles there is the potential for glare. Should it be determined that a solar electric system is desirable further analysis would be required based upon the proposed system size and location.

5.0 Economic Analysis

5.1 Wind

Even though this site is not suitable for a wind turbine the data gathered was input to determine a quantitative value for comparison purposes. Using the average value for current power costs of $.1183 this results in $596. The installed cost for the 10 kW wind turbine used for this example would be approximately $40,000, less the CPUC Self Generation Incentive of 50% or $20,000, for a net cost of $20,000. Even assuming 3% electricity cost escalation the payback for this system would exceed the useful life of the equipment. Wind equipment is not recommended for this site.

5.2 Solar

The solar electric system sizing was analyzed using several approaches. The first approach is to consider a system that would provide 100% of the site's **annual electrical needs**. Another approach is to determine the system size for providing 100% of the **annual electricity cost**. A third approach looks at the system size needed to provide the maximum peak power without exporting. (This could be important for evaluating a solar electric system used in conjunction with a cogeneration system as "net metering" of a solar electric system is not allowed when used together with cogeneration and exporting power would not be economic.

Using the electricity consumption from 2001 – 1,177,120 kWh – a 642 kW (AC) system could provide 100% of the annual consumption. The system would need to be "net metered" (see "Section 5.3 – Net Metering" below) as during the sunny summer months the solar electric system would provide over 100% of the daily electrical loads at the site. This over-production is credited at the time of generation for use against electricity consumed at a later time. Assuming an installed cost of $7,500 per kW the total system cost would be $4,815,000 less the CPUC Self Generation Incentive of $2,407,500 for a net cost of $2,407,500.

Note that this system produces 100% of the electricity needed but due to time-of-use pricing it generates a savings greater than the current electric bill. This illustrates one of the advantages of "time-of-use" net metering where the full retail value of the electricity is credited at the time it is generated. Because so much of the solar electricity is generated during "on peak" and "partial peak" times this value ends up being more than the annual electric bill.

Because net metering law does not require the utility company to purchase any excess generation on an annual basis the system needs to be sized to provide 100% of the annual **electric bill** rather than the annual kilowatt-hours consumed.

The second approach looks at the "time of use" value for the kWh's generated during Peak, Partial Peak and Off Peak times to provide a system that offers 100% of the **cost of electricity** through Net Metering. This system size is reduced to 602 kW (AC), a reduction of 40 kW, for a total cost after CPUC incentives of $2,257,500. The life cycle cost over 20 years for this system would be $.1080 and the total system cost would be reduced by $150,000. The time to recover the costs would then be 16.1 years at current rates and 10.2 years with 3% annual electricity cost escalation.

A third approach assumes that the system will provide no more than 100% of any daily electrical need – the "non-exporting" model. This results in a 162 kW system producing $35,920 in first year savings at an installed cost of $607,500 after CPUC Self Generation incentives. This results in a simple payback of 16.9 years at current rates and 11.7 years with 3% annual electricity escalation. The life cycle cost for power is the same for all three systems as the installed costs are assumed to be the same.

5.3 Incentives

5.3.1 CEC Buydown Funds / CPUC Self Generation Grant

Financial incentives for installing solar electric systems are offered by both the California Energy Commission (CEC) and the California Public Utilities Commission (CPUC). The amount of the incentive currently offered is $4,500 per kilowatt up to 50% of the system's total installed cost. Information about the programs can be obtained at the CEC website www.consumerenergycenter.org and at PG&E's website www.pge.com. At the time of this report the CEC program only has funding for systems under 10 kilowatts and the legislature is processing a bill to extend the program for another 5 years. The CPUC program has funds available and will continue to obtain additional funds next year.

5.3.2 Federal and State Tax Incentives

Tax incentives are available to businesses that utilize solar energy systems. While these incentives are of no use directly to the County they may be utilized through a "tax leveraged" financing program such as "third party financing" as described below. The Federal incentive is 10% of installed system costs plus a 5 year accelerated depreciation deduction. The State of California offers an additional 15% credit but this will probably not be available due to restrictions on the use of the credit in a "third party financing" scenario. The State also offers a depreciation deduction. There may be other tax related incentives made available on both Federal and State levels resulting from proposed legislation currently being considered. The tax incentives are considered in the "third party financing" approach discussed below.

5.3.3 Net Metering and Interconnection

Existing law in California allows for the production of renewable electricity to be credited at the full avoided cost of the electricity had it been purchased from the utility. This means that the "time of use" pricing structure used in the existing E19S tariff at the Union Mine facility will apply to electricity generated by the proposed solar electric system. In addition, any electricity generated in excess of site load requirements may be "exported" into the utility grid and credited at the full retail price. The solar electric system must be interconnected to the utility grid through a standard "interconnection agreement". Up to 100% of the site's electrical consumption may be produced on an annual basis resulting in a "zero" energy bill.[4]

The California legislature has approved a revision to the net metering law to extend the availability of net metering above 10 kW beyond the present planned sunset date of 12/30/02. If net metering is not extended the benefits of a solar electric system would be reduced to a system that did not export. The overall cost and benefit of the system would be considerably lower while the economics of the system would remain similar in terms of projected payback and life cycle costs per kWh. (see Financing section below for details)

[4] There is still a per meter basic service fee charged monthly

5.4 Financing (see Attachment E for details)

While solar energy is delivered free to the site each day the equipment needed to convert sunlight into electricity is expensive. Just as with conventional electric utility costs the generation systems must be financed over a long term in order to achieve affordable monthly rates. Several financing approaches are considered below showing the benefits of both long-term financing and potential for leveraging tax incentives for additional economic benefits.

5.4.1 Cost of Doing Nothing

In 2001 El Dorado County paid $139,228 for 1,177,120 kilowatt-hours (kWh) at an average per unit cost of $.1183. Continuing to purchase electricity over the next 20 years the County will be spending at least $2,488,000, assuming that rates stay at the current price, or $3,765,000 if rates increase an average of 3% each year. While there is no “initial cost” associated with continuing to purchase electricity there is also no “payback” associated with this long-term commitment to buy power at whatever the future prices are. Note that using a 10% “Discount Rate” brings the overall Net Present Value for the costs of electricity to $.0696 per kWh. However, there is no way to determine what the future price of electricity will be so there may be large variations from year to year. Purchasing a solar electric system can serve to “fix” the cost of power over a long term in that the cost for the equipment is known as well as the output from the system. With long-term low-interest rate financing this can make the annual power expenses affordable and predictable.

Cost of Doing Nothing	
Cost of doing nothing	-$2,488,176
Cost of doing nothing Life Cycle Cost $/kWh	-$0.1183
Cost with 3% escalation	-$3,764,838
Cost of doing nothing with escalation $/kWh	-$0.1790
NPV Cost with 3% escalation	**-$1,464,227**
NPV Life Cycle Cost with escalation $/kWh	**-$0.0696**

5.4.2 Cash purchase

The simple approach to financing is to purchase the system with cash. While the simple cash approach appears to have the least overall cost in terms of total dollars spent over the life of the system in fact it is the most costly in terms of the “time value of money” or Net Present Value. Assuming an installed cost of $4,515,000 for a 602 kW (AC) solar electric system the Life Cycle unit cost for electricity produced over a 20-year period would be $.1080 per kWh. Using the same 10% Discount Rate the Net Present Value of this investment will bring the total cost to $2,057,498 for a Life Cycle unit cost of $.0978 per kWh. Note that this assumes additional costs of $500 per year for Operating and Maintenance, annual inflation of 3% and a loss of .5% output from the solar electric system each year over the 20-year system life.

Cash Cost Analysis	
Cost of System On Cash Basis	-$2,270,935
Life Cycle Cost $/kWh	-$0.1080
NPV of System Cost	**-$2,057,498**
NPV Life Cycle Cost $/kWh	**-$0.0978**

5.4.3 Tax-exempt Financing

The County is eligible for tax-exempt financing from a number of sources. One new program being offered by the California Power Authority is particularly interesting for solar energy systems. The new Public Leadership Solutions for Energy (PULSE) financing program (see attachment F) will offer long-terms (up to the useful life of the equipment) and low interest rates (current rates estimated between 4.5% to 5% fixed). Using a rate of 6% and a 20-year term the total of all payments including expenses is $3,949,818 or $.1878 per kWh. Using the same Discount Rate of 10% the Net Present Value for the financing approach results in a total cost of $1,680,858 or $.0799 per kWh.

Financed Cost Analysis	
Total Financed Cost	-$3,949,818
Life Cycle Cost $/kWh	-$0.1878
NPV of System Cost	**-$1,680,858**
NPV Life Cycle Cost $/kWh	**-$0.0799**

5.4.4 Third Party Financing

Because the County is exempt from paying income taxes there is no way to directly take advantage of the Federal and State tax incentives that exist for solar electric systems. However, there are several methods of involving tax-paying investors in a “public-private” partnership where the taxable entity can utilize the tax incentives and pass some of the savings along to the tax-exempt entity. The most common form of this arrangement is the Energy Purchase Agreement where the County would receive a guaranteed savings with no up-front or operating costs.

The basic requirements for an Energy Purchase Agreement are to have 1) an end-user that agrees to purchase the electricity generated by the system at a negotiated price, 2) an investor group that pays for the installation and operations of the solar electric system and receives the tax incentives as well as most of the energy generation revenues, and 3) a contractor that is responsible for the installation and maintenance of the system. A typical arrangement would be for the end-user to purchase the electricity generated by the solar electricity system at a set discount off of what the utility price for electricity is during the same billing period. Based upon the current cost for electricity the County could save approximately $25,000 the first year with a 20% discount rate.

Assuming the same costs for the solar electric system the investor can offset most of the costs of the energy system through “tax shelter” benefits. Additional income needed to reach a targeted rate of return comes from the sale of the electricity generated. Ideally, at the end of the depreciation period, the investor can be bought out by the end-user at a then determined “fair market value” that results in a lower cost system than if

the end-user had purchased the system without the tax incentives. (See Attachment E) for more details on the Investor's cash flows)

Cash Cost Analysis	
Cost of System On Cash Basis	-$888,712
Life Cycle Cost $/kWh	-$0.0422
NPV of System Cost	**-$911,423**
NPV Life Cycle Cost $/kWh	**-$0.0433**

The table above indicates that the net cost for a commercial entity such as a third party energy service provider is significantly reduced with the utilization of state and federal tax incentives. This is what allows the investor to offer discount prices on energy generated and can also lower the system cost should the County decide to purchase the system after five years.

6.0 Recommendations

6.1 Wind

As discussed earlier the wind resource at the Union Mine site is unsuitable for any type of wind turbine installation. **No further investigation of this resource is recommended.**

6.2 Solar

A solar electric system could provide 100% of the Union Mine facilities' annual electrical loads. Through the Net Metering tariff electricity is credited at the full retail value at the time of production. Excess generation can be "stored" in the utility grid for use later. The direct purchase of the solar electric system will pay for itself over the life of the system. **Use of a solar electric system is recommended.**

6.3 Financing

As shown above the County will be spending money on electricity at the Union Mine facility for decades to come. Rather than simply expense these funds with nothing to show for the costs the County could instead invest these funds into a solar electric on-site generation system. In addition to providing clean power the ability to fix the costs of power to a dependable number for annual budgets provides an additional benefit. With the future prices of electricity uncertain the benefits could be even greater should prices continue to rise. In the mean time cash incentives are being used up on a first come first serve basis and may not be available in the future. REDI recommends investing in a solar electric system and offers two options for how to finance the system.

6.3.1 County Finance

The County could finance the solar electric system with a tax-exempt lease available from the California Power Authority's new PULSE program. With no money down the monthly payments are higher than current electric utility costs for the first 12 years. The system will pay for itself by the end of the financing term. The table below shows the annual cash flows for a 20-year lease at a 6% fixed interest rate. This process may

incur additional staff time and expenses should a competitive bid be needed to meet County capital improvement project requirements.

Year	Expenses	Savings	Credits	Net Savings	Balance
1	-$2,454,820	$140,111	$2,257,500	-$57,208	-$57,208
2	-$197,334	$144,314	$0	-$53,020	-$110,228
3	-$197,350	$148,644	$0	-$48,706	-$158,934
4	-$197,366	$153,103	$0	-$44,262	-$203,196
5	-$197,382	$157,696	$0	-$39,686	-$242,882
6	-$197,399	$162,427	$0	-$34,972	-$277,853
7	-$197,416	$167,300	$0	-$30,116	-$307,969
8	-$197,434	$172,319	$0	-$25,115	-$333,084
9	-$197,453	$177,489	$0	-$19,964	-$353,048
10	-$197,472	$182,813	$0	-$14,658	-$367,707
11	-$197,491	$188,298	$0	-$9,193	-$376,900
12	-$197,511	$193,947	$0	-$3,565	-$380,465
13	-$197,532	$199,765	$0	$2,233	-$378,232
14	-$197,532	$205,758	$0	$8,226	-$370,006
15	-$197,575	$211,931	$0	$14,355	-$355,651
16	-$197,598	$218,289	$0	$20,690	-$334,960
17	-$197,621	$224,837	$0	$27,216	-$307,744
18	-$197,646	$231,582	$0	$33,937	-$273,808
19	-$197,670	$238,530	$0	$40,859	-$232,948
20	-$197,696	$245,686	$0	$47,990	-$184,958

6.3.2 Third Party Finance

Third party financing could be an attractive option to the ownership of the system. Annual savings would be guaranteed with no capital outlay needed and no operating expenses or maintenance costs incurred. The third party contract could also specify options for the County to purchase the system at a future date for a fair market value. The California Department of General Services is in the process of soliciting for third party investments in state projects and is developing a standardized contracting mechanism for these types of projects. The County could follow the State's process and use the same contracts and bidders in order to comply with competitive bid requirements.

The Energy Purchase Agreement contract can provide for the actual discount rate offered and also offer options for the County to purchase the system in the future at a "fair market value". This method allows for the system to be installed and operated for at least 5 years (minimum term for investors to avoid any recapture of tax incentives) providing a track record of actual system generation and operations. REDI has experience with this type of contracting and can offer further services in developing a third party financing solicitation if needed.