McKinleyville Community Services District Waste Water Treatment Facility Renewable Energy Project

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Engr492 Capstone Design

Background and Objective

The McKinleyville Community Services District (MCSD) wastewater treatment facility (WWTF) will soon be upgraded in anticipation of a future population increase. System upgrades to components, operations and capacity will substantially increase the energy consumption when the new facility comes online in the fall of 2016, and MCSD management would like to offset the energy demand with renewable sources. Given the facility setting at Hiller Park and adjacent to the Hammond Trail, potential renewable sources should minimize impacts to aesthetics, noise, air quality, recreation and biological systems. Renewable Energy Consultants (REC) was tasked with evaluating options and designing the most favorable and economically preferable renewable energy system.

Constraints

- Comply with Laws and Regulations
- 5% < Renewable Energy System < 100% Demand
- Use available resources (spatial and temporal)
- Fit within MCSD space, near its PG&E meters
- Renewable technology must be commercially tested

Criteria

REC has identified 6 weighted criteria with which to evaluate initial alternatives that pass constraints, as described in Table 1 below. Criteria and respective weights were chosen in a collaborative process with client feedback, to represent priorities with relative values.

Table 1: Initial Alternative Criteria & Weights

Criterion	Description	Weight
Net Present Value (NPV)	The net accounting of cumulative costs and benefits over the project lifetime, with consideration to discount, loan, insurance and inflation rates	7
Payback Period/ Expected Life (PP/EL)	The ratio of (simple) payback period – the time for the costs to be repaid by project benefits– to the project design life	8
Dependability and Expected Life (Dep)	Technology should be: durable enough to withstand conditions at the WWTF; have an expected life of reliable duration; be relatively easy to operate and maintain	6
Maintenance Labor (Labor)	Renewable energy systems will need some sort of maintenance labor to maintain efficiency	8
Ease of Implementation (EOI)	Permits required from local, regional, state or federal agencies for legal compliance; intensity of pre-construction and development work; licensing of technologies. EOI is calculated as weighted sums for each category	8
Energy Offset (%)	The overall annualized energy offset percentage relative to expected WWTF energy demand, accounting for losses	10

Initial Alternatives

- Anaerobic Digester (AD), methane capture and microturbine cogeneration or engine system. Since the digester has a longer lifetime than the engine or turbine components, both 20 and 40-year lifetimes were evaluated
- Biomass- local wood waste feedstock used to run a combined heat and power system
- Solar Panels – Grid-tied, ground-mounted PV system
- Wind Turbines – small wind farm of 100 kW turbines
- No Design Alternative – baseline design with no renewable technologies added

Design Assumptions

•$0.15/kW
•5.5% Discount Rate
•5% Loan Rate
•2.5% Inflation rate
•0.25% Annual Insurance Rate
•Expected Annual Energy Demand: 1.1388 GW-hr

Decision Matrix

Applying available information about capital and maintenance costs over the project lifetime, labor involved with weekly system operations, energy offset, permitting, the ease of implementation, the payback period, alternatives were evaluated in a Delphi decision matrix, shown in Table 2. It is clear that solar power is the most feasible option.

Table 2: Delphi Decision Matrix

Criteria	Weight	AD (20yr)	AD (40yr)	Biomass	Solar	Wind	No Alt
NPV	7	(2749)	(2600)	(394)	70	(103)	0
PP/EL	8	14	14	14	80	44	44
Dep	6	5	5	23	45	30	60
Labor	8	24	24	0	12	18	80
EOI	8	6	6	7	19	11	80
Energy Offset %	10	31	31	100	100	90	0
Total	-	(2669)	(2520)	(251)	**325**	91	264

Preliminary Solar Design Alternatives

National Renewable Energy Laboratory (NREL) has published a free software, System Advisory Model (SAM), for designing and comparing performance of renewable energy systems. SAM was used heuristically to compare performance of preliminary design alternatives with nearly equal conditions. Databases of solar radiation, solar PV modules, and inverters were used in combination with a design tool on the IronRidge website for compatible PV modules to determine feasible solar alternatives. See Table 3 for results.

Table 3: Simplified Preliminary Solar Alternatives Analysis in SAM

Metric	ET Solar	EcoSolargy	Suniva	Kyocera
Annual Energy (kWh)	1,138,399	1,138,605	1,130,632	1,138,195
Capacity factor (%)	15.7	15.5	15.6	15.5
First year (kWhAC/kWDC)	1,374	1,359	1,370	1,356
Performance ratio	0.87	0.86	0.87	0.86
Levelized cost (nominal), (¢/kWh)	12.78	11.69	14.00	14.21
Levelized cost (real), (¢/kWh)	10.13	9.26	11.09	11.26
Electricity cost without system	$ 162,118	$ 162,118	$ 162,118	$ 162,118
Electricity cost with system	$ 20,049	$ 20,063	$ 20,329	$ 20,047
Net savings with system	$ 142,069	$ 142,055	$ 141,789	$ 142,071
Net present value	$ 356,069	$ 480,865	$ 223,337	$ 193,848
Payback period (years)	13.3	12.2	14.5	14.8
Initial cost	$2,747,832	**$ 2,489,264**	$ 3,011,440	$ 3,083,758

Preferred Alternative Description

Photovoltaic Ground-Mount System

- Iron Ridge PV Ground Mounting System for 35 degree tilt
  - 54 arrays (5x10)
- Solar Panels-ET Solar 310W
  - 2700 count
- Inverters-Chint 100kW
  - 8 count; 20 over project lifetime
- Area including ground cover ratio: 2.6 acres
- Proposed Rate Schedule: A-10
- 30% Federal Investment Tax Credit
- "True-up" date is optimally March 1st to maximize net energy metering (NEM) credit value

Preferred Alternative Performance

After further refining inputs to the SAM software model to most closely match available information and informed assumptions, REC determined these system performance characteristics:

•System DesignOutput: 828.3 kW
•Annual Energy (first year): 1,138,605 kWh
•Levelized Cost (nominal): 11.69 ¢/kWh
•Net Savings with System: $142,055
•Net Present Value: $480,865
•Payback Period (simple): 12.2 years
•Initial Cost: $2.489 Million

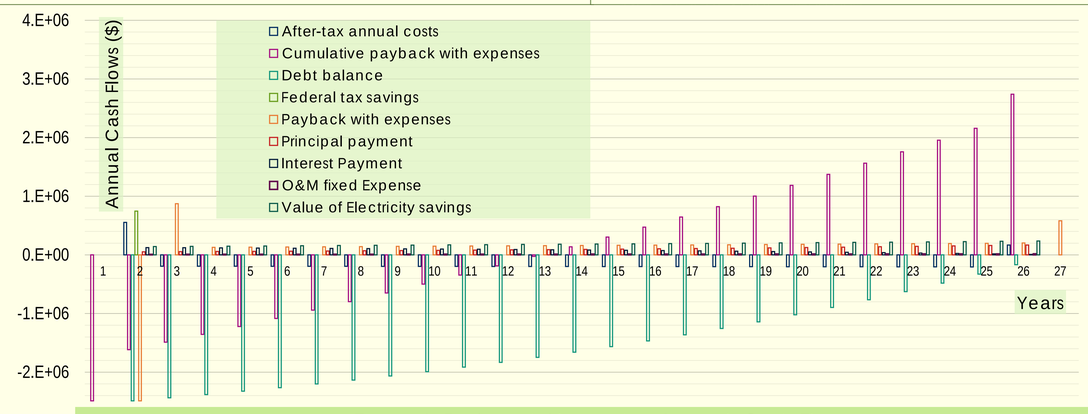

Figure 1: Preferred Alternative Annual Cash Flow

Table 4: Costs and Benefits

Initial Costs

Description	Cost
2700 EcoSolargy Panels	$569,659
20 Chint Inverters (over lifetime)	$350,649
Wire & Conduit	$55,000
Mounting Hardware	$252,261
Cement Pilings (materials & labor)	$55,940
Fence Replacement	$66,985
Engineering Cost	$144,000
Construction & Margin	$500,000
Land Clearing and Auger Boring	$103,582
Grid Interconnection Fee	$5,000
Contingency (10% direct)	$197,245
Freight (PV modules, inverters, mounting hardware)	$89,274
Sales tax on components	$99,668
Approximate Total	$2,489,000

Additional Costs / Benefits

Description	Cost/Benefit
O&M annual costs	$(10,000)
PG&E supplemental bill	$(20,063)
Salvage Value	$373,390
Federal Investment Tax Credit	$746,779

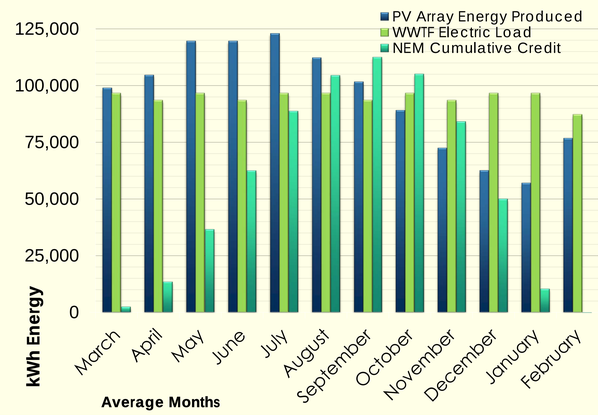

Figure 2: Preferred Alternative Performance

Figure 3: Preferred Alternative site at MCSD WWTF

References:

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