Appendix A. Detailed Methodology

A.1 Scope of Study

The objective of this REO Study is to identify LPOE sites within GSA's portfolio that present the best opportunity for cost-effective implementation of RE technologies. The Study found for each LPOE site the combination of RE technologies that achieves minimum life-cycle costs, with and without financial incentives.

The technologies evaluated include:

- Daylighting,
- Wind energy,
- Biomass energy, including thermal steam and biomass electric (combustion, gasification, anaerobic digestion),
- Solar ventilation air preheating (SVP),
- Solar Water Heating,
- Solar Electric Photovoltaics (PV),
- Solar Industrial Process Heat Technology, including thermal steam and solar thermal electric.

The analysis used geographic information system (GIS) software, databases, Excel spreadsheet calculations, and an optimization software called "Premium Solver."

Site Factors

The Study used site information from multiple sources. For each LPOE facility, GSA provided the following data:

- Site address,
- Site latitude/longitude,
- Total facility square footage, and when available, building loads, building sizes, building primary use,
- FY 2007-2008 annual utility energy use and cost, including gas, electric, oil, propane, and steam.

For information not provided by GSA, the Study used values typical of the building type: cubic-feet-per-minute of ventilation air per ASHRAE Std 62 [ref. 3]; gallons per day of hot water from Commercial Building Energy Consumption Survey (CBECS) [ref. 4]; and lighting levels per IESNA standard [ref. 5].

NREL provided site-specific resource and incentive information from its GIS database of solar, wind, weather, and biomass resources [ref. 1]. Platts, Inc. databases detailed local energy costs and wholesale power costs.

The Study employed simple annual-average algorithms to calculate energy delivery as a function of RE resources based on efficiency models. It calculated associated energy cost savings based on energy use and cost information for each site. Energy performance and cost savings were also based on NREL's experience with the technologies gained through other analyses.

It used DOE's multipliers for CO_2 emissions per kWh of electricity-use for each location, and it used a standard multiplier for CO_2 emissions per therm of natural gas consumption for all locations.

The Study estimated the installed cost, including incentive timeframe and tax depreciation, by using the Database of State Incentives for Renewables & Efficiency (DSIRE) database maintained by the University of North Carolina. It incorporated the effects of incentives that may be available at each location from state governments, utilities, and others.

It assumes a typical corporate tax liability structure in the 35 percent tax bracket for estimating the effects of business investment tax credit and accelerated depreciation. It makes these assumptions because GSA cannot directly utilize tax incentives but can benefit indirectly from pass-through cost savings.

Economic Factors

In the life-cycle cost analysis, NREL used a discount rate of 4.6 percent to represent the time-value of money, consistent with rates published by the National Institute of Standards and Technology (NIST) for federal analysis [ref. 2]. It used the same publication, *Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis*, for other parameters used in the economic analysis, such as fuel escalation rate and general inflation rate.

The life-cycle analysis time period is 25 years because that is the maximum allowed by 10CFR436 for electrical and mechanical measures, and we expect these systems to last that long. In order to model costs which are not constant from year to year, such as accelerated depreciation, the Study used a 25-year cash flow analysis.

The Study calculated a life-cycle cost of all RE technologies combined at a site, but also reports payback period as figures-of-merit to assess cost-effectiveness of each individual technology. Other results include ROI and RE use as percentage of total energy use for each site.

Initial cost, efficiency, and operation and maintenance cost for each of the renewable energy technologies is characterized according to the cost and performance data reported in edition four of the *Power Technologies Energy Data Book* [ref. 8] and also from *Renewable Energy Technology Characterizations* [ref. 10]. Other sources were incorporated to establish the economic parameters for costing. The *RS Means Green Building: Project Planning and Cost Estimating* [ref. 7] was used for installed cost estimates with regional adjustment factors according to the City Cost Adjustments for the closest city location. However, costs vary widely for remote sites, which may introduce some error.

The study estimated the size, cost, savings, and payback period for each technology at each location. For sites identified as most promising in this analysis and prior to any implementation, GSA must conduct a detailed engineering technical and economic feasibility study.

A.2 Technology Characterizations

Initial cost, efficiency, and operation and maintenance cost for each of the renewable energy technologies is characterized according to the cost and performance data reported in edition four of the Power Technologies Energy Data Book [ref. 8] and also from Renewable Energy Technology Characterizations [ref. 10].

Daylighting

The term “daylighting” refers to consciously adding natural light to reduce the need for artificial light, a big user of electricity in today’s commercial buildings. A complete daylighting system consists of apertures (skylights, light shelves, and windows) to admit and distribute sunlight and a controller to modulate artificial light as needed to maintain the desired level of light for the building space. It reduces electricity use for lighting, and it requires no scheduled maintenance. However, skylights may increase roof maintenance.

Figure 1 is a photograph of skylights in an application similar to the configuration modeled for the LPOE study. While this single-story industrial model is not accurate for LPOE buildings, we consider this configuration as proxy for savings available from an architectural treatment of the daylighting and controls.

Daylighting was considered in the office, utility, and warehouse areas of each LPOE. Utilization of daylighting can enhance the quality of both light and comfort for the people working in these buildings. It can also contribute to lower overall cooling loads by reducing waste or by-product heat from electric lighting.

Figure A-1: Daylighting applicable to LPOE sites

Table A-1 lists the characteristics of daylighting technology used in the analysis. Table A-2 shows seasonal illuminance information used for daylighting calculations for each site. Table B-12 lists the details of the daylighting analysis including skylight area, cost, annual energy delivery, annual cost savings, and payback period.

Note that the skylight costs used in the analysis do not include costs for special security features as described in the *LPOE Design Guide*.

Table A-1: Characteristics of Daylighting Technology Used for Analysis

	Lighting Levels	
Office	30	Fc
Warehouse	15	Fc
Utility	30	Fc
Skylight Transmittance	0.7	
Lightwell Transmittance	0.8	
Coefficient of Utilization Daylight	0.55	
Coefficient of Utilization Elec Light	0.55	
Luminous Efficacy Elec Light	75	Lumens/watt
Roof U-value	0.1	btu/hr/F
Skylight U-value	0.5	btu/hr/F
Cooling COP	3.5	
Heating Efficiency	0.8	
Skylight Cost	25	$/sf
Controls cost	0.25	$/sf floor area

Table A-2: Illuminance Information for Daylighting Calculation (Daily Profile by Season in kLux-Hour/sf)

	Spring					Summer					Fall					Winter				
Name	**9am**	**11am**	**1pm**	**3pm**	**5pm**	**9am**	**11am**	**1pm**	**3pm**	**5pm**	**9am**	**11am**	**1pm**	**3pm**	**5pm**	**9am**	**11am**	**1pm**	**3pm**	**5pm**
Dalton Cache, AK	13	29	34	27	13	26	40	46	50	40	10	24	30	30	21	0	4	7	2	0
Alcan, AK	10	26	35	31	16	28	46	56	57	48	7	22	32	33	24	0	0	3	0	0
Skagway, AK	13	29	34	27	13	26	40	46	50	40	10	24	30	30	21	0	4	7	2	0
Lukeville, AZ	31	69	83	71	36	60	94	108	95	58	42	78	91	75	35	13	42	54	40	9
Nogales, AZ	35	72	84	71	35	61	95	105	89	54	45	80	89	71	33	16	46	55	41	10
Sasabe, AZ	31	69	83	71	36	60	94	108	95	58	42	78	91	75	35	13	42	54	40	9
Douglas, AZ	43	77	87	69	30	44	85	105	99	67	27	68	87	80	48	21	50	56	37	6
San Luis, AZ	31	69	83	71	36	60	94	108	95	58	42	78	91	75	35	13	42	54	40	9
Naco, AZ	35	72	84	71	35	61	95	105	89	54	45	80	89	71	33	16	46	55	41	10
San Luis AZ (not built yet)	31	69	83	71	36	60	94	108	95	58	42	78	91	75	35	13	42	54	40	9
Nogales, AZ	35	72	84	71	35	61	95	105	89	54	45	80	89	71	33	16	46	55	41	10
Calexico West, CA	31	69	83	71	36	60	94	108	95	58	42	78	91	75	35	13	42	54	40	9
San Ysidro, CA	38	68	77	58	21	33	68	91	86	56	26	64	85	76	42	22	47	50	31	3
Andrade, CA	31	69	83	71	36	60	94	108	95	58	42	78	91	75	35	13	42	54	40	9
Otay Mesa, CA	38	68	77	58	21	33	68	91	86	56	26	64	85	76	42	22	47	50	31	3
Tecate, CA	38	68	77	58	21	33	68	91	86	56	26	64	85	76	42	22	47	50	31	3
Calexico, CA	31	69	83	71	36	60	94	108	95	58	42	78	91	75	35	13	42	54	40	9
Eastport, ID	16	37	48	42	22	29	57	73	71	58	12	40	57	56	40	1	14	20	15	1
Porthill, ID	16	37	48	42	22	29	57	73	71	58	12	40	57	56	40	1	14	20	15	1
Ferry Point, ME	35	56	56	40	11	42	62	72	65	42	25	44	53	45	24	10	24	23	9	0
Coburn Gore, ME	33	55	57	42	14	43	66	78	71	47	26	52	63	55	30	11	28	28	14	0
Fort Fairfield, ME	35	56	56	40	11	42	62	72	65	42	25	44	53	45	24	10	24	23	9	0
Houlton, ME	35	56	56	40	11	42	62	72	65	42	25	44	53	45	24	10	24	23	9	0
Jackman, ME	33	55	57	42	14	43	66	78	71	47	26	52	63	55	30	11	28	28	14	0
Limestone, ME	35	56	56	40	11	42	62	72	65	42	25	44	53	45	24	10	24	23	9	0
Orient, ME	35	56	56	40	11	42	62	72	65	42	25	44	53	45	24	10	24	23	9	0
Vanceboro, ME	35	56	56	40	11	42	62	72	65	42	25	44	53	45	24	10	24	23	9	0
VanBuren, ME	35	56	56	40	11	42	62	72	65	42	25	44	53	45	24	10	24	23	9	0
Milltown ME	35	56	56	40	11	42	62	72	65	42	25	44	53	45	24	10	24	23	9	0
St. Francis, ME	35	56	56	40	11	42	62	72	65	42	25	44	53	45	24	10	24	23	9	0
Madawaska, ME	35	56	56	40	11	42	62	72	65	42	25	44	53	45	24	10	24	23	9	0
Fort Kent, ME	35	56	56	40	11	42	62	72	65	42	25	44	53	45	24	10	24	23	9	0
St. Francis, ME	35	56	56	40	11	42	62	72	65	42	25	44	53	45	24	10	24	23	9	0
Detroit Cargo, MI	18	43	53	46	23	29	61	78	77	59	13	42	60	59	40	3	19	26	19	3
Intl Bridge, MI	19	47	59	52	28	28	55	73	74	58	10	34	50	51	37	2	17	24	17	3
Amb. Bridge, MI	19	47	59	52	28	28	55	73	74	58	10	34	50	51	37	2	17	24	17	3

Table A-2: Illuminance Information for Daylighting Calculation (Daily Profile by Season in kLux-Hour/sf)

	Spring					Summer					Fall					Winter				
Name	9am	11am	1pm	3pm	5pm	9am	11am	1pm	3pm	5pm	9am	11am	1pm	3pm	5pm	9am	11am	1pm	3pm	5pm
Grand Portage, MN	23	48	56	46	20	34	58	68	67	52	15	39	50	49	31	3	18	23	14	0
Noyes, MN	23	48	56	46	20	34	58	68	67	52	15	39	50	49	31	3	18	23	14	0
Roseau, MN	23	48	56	46	20	34	58	68	67	52	15	39	50	49	31	3	18	23	14	0
Intl Falls, MN	23	48	56	46	20	34	58	68	67	52	15	39	50	49	31	3	18	23	14	0
Baudette, MN	24	49	58	47	21	36	63	77	75	55	18	45	59	57	36	6	22	28	17	0
Chief Mt, MT	19	43	54	45	23	34	62	77	75	61	14	43	59	57	40	1	17	24	16	0
Piegan, MT	19	43	54	45	23	34	62	77	75	61	14	43	59	57	40	1	17	24	16	0
Raymond, MT	25	47	55	44	19	39	66	79	74	55	19	46	59	54	34	4	20	24	13	0
Rooseville, MT	25	47	55	44	19	39	66	79	74	55	19	46	59	54	34	4	20	24	13	0
Sweetgrass, MT	19	43	54	45	23	34	62	77	75	61	14	43	59	57	40	1	17	24	16	0
Turner, MT	25	47	55	44	19	39	66	79	74	55	19	46	59	54	34	4	20	24	13	0
Ambrose, ND	25	47	55	44	19	39	66	79	74	55	19	46	59	54	34	4	20	24	13	0
Dunseith, ND	16	42	55	49	28	29	57	73	77	62	10	37	55	56	42	0	16	25	18	3
Portal, ND	16	42	55	49	28	29	57	73	77	62	10	37	55	56	42	0	16	25	18	3
St. John ND	16	42	55	49	28	29	57	73	77	62	10	37	55	56	42	0	16	25	18	3
Pembina, ND	23	48	56	46	20	34	58	68	67	52	15	39	50	49	31	3	18	23	14	0
Columbus, NM	43	77	87	69	30	44	85	105	99	67	27	68	87	80	48	21	50	56	37	6
Santa Teresa, NM	43	77	87	69	30	44	85	105	99	67	27	68	87	80	48	21	50	56	37	6
Alexandria Bay, NY	27	50	55	44	17	38	62	75	71	52	21	45	58	52	31	8	22	25	14	0
Champlain, NY	27	50	55	44	17	38	62	75	71	52	21	45	58	52	31	8	22	25	14	0
Massena, NY	27	50	55	44	17	38	62	75	71	52	21	45	58	52	31	8	22	25	14	0
Fort Covington, NY	27	50	55	44	17	38	62	75	71	52	21	45	58	52	31	8	22	25	14	0
Rouses Pt. NY	29	50	55	43	15	39	64	77	70	49	21	48	60	54	30	7	22	24	13	0
St John Hwy, NY	29	50	55	43	15	39	64	77	70	49	21	48	60	54	30	7	22	24	13	0
Trout, River, NY	27	50	55	44	17	38	62	75	71	52	21	45	58	52	31	8	22	25	14	0
Chateaugay, NY	27	50	55	44	17	38	62	75	71	52	21	45	58	52	31	8	22	25	14	0
Mooers, NY	29	50	55	43	15	39	64	77	70	49	21	48	60	54	30	7	22	24	13	0
Jamieson, NY	29	51	55	42	15	38	64	77	71	47	23	50	62	56	30	11	26	28	15	0
Niagra Falls, NY	22	45	52	43	20	33	61	77	75	56	16	42	58	55	35	5	20	25	16	2
Ogdensburg NY	27	50	55	44	17	38	62	75	71	52	21	45	58	52	31	8	22	25	14	0
Brownsville/Matamoros TX	24	56	72	62	32	26	62	85	88	67	17	56	75	76	51	14	38	49	38	12
Gateway, TX	24	56	72	62	32	26	62	85	88	67	17	56	75	76	51	14	38	49	38	12
Columbia, TX	23	54	69	62	32	25	59	80	85	65	16	52	73	75	52	12	37	47	37	12
Convent, TX	23	54	69	62	32	25	59	80	85	65	16	52	73	75	52	12	37	47	37	12
Del Rio, TX	23	57	75	66	36	24	63	89	93	70	15	53	79	81	56	12	39	50	40	14
Donna TX (not built yet)	24	56	72	62	32	26	62	85	88	67	17	56	75	76	51	14	38	49	38	12

Table A-2: Illuminance Information for Daylighting Calculation (Daily Profile by Season in kLux-Hour/sf)

	Spring					Summer					Fall					Winter				
Name	**9am**	**11am**	**1pm**	**3pm**	**5pm**	**9am**	**11am**	**1pm**	**3pm**	**5pm**	**9am**	**11am**	**1pm**	**3pm**	**5pm**	**9am**	**11am**	**1pm**	**3pm**	**5pm**
Bridge of the Americas, TX	43	77	87	69	30	44	85	105	99	67	27	68	87	80	48	21	50	56	37	6
Eagle Pass, TX	23	57	75	66	36	24	63	89	93	70	15	53	79	81	56	12	39	50	40	14
Fabens, TX	43	77	87	69	30	44	85	105	99	67	27	68	87	80	48	21	50	56	37	6
Fort Hancock, TX	43	77	87	69	30	44	85	105	99	67	27	68	87	80	48	21	50	56	37	6
El Paso, TX (out leased)	43	77	87	69	30	44	85	105	99	67	27	68	87	80	48	21	50	56	37	6
Juarez-Lincoln, TX	23	54	69	62	32	25	59	80	85	65	16	52	73	75	52	12	37	47	37	12
Los Indios, TX	24	56	72	62	32	26	62	85	88	67	17	56	75	76	51	14	38	49	38	12
Laredo TX	23	54	69	62	32	25	59	80	85	65	16	52	73	75	52	12	37	47	37	12
Los Tomates, TX	24	56	72	62	32	26	62	85	88	67	17	56	75	76	51	14	38	49	38	12
McAllen, TX	24	56	72	62	32	26	62	85	88	67	17	56	75	76	51	14	38	49	38	12
McAllen TX (not built yet)	24	56	72	62	32	26	62	85	88	67	17	56	75	76	51	14	38	49	38	12
Marfa, TX	43	77	87	69	30	44	85	105	99	67	27	68	87	80	48	21	50	56	37	6
Kika de la Garza, TX	24	56	72	62	32	26	62	85	88	67	17	56	75	76	51	14	38	49	38	12
Paso Del Norte, TX	43	77	87	69	30	44	85	105	99	67	27	68	87	80	48	21	50	56	37	6
Progreso, TX	24	56	72	62	32	26	62	85	88	67	17	56	75	76	51	14	38	49	38	12
Roma, TX	24	56	72	62	32	26	62	85	88	67	17	56	75	76	51	14	38	49	38	12
Rio Grande City, TX	24	56	72	62	32	26	62	85	88	67	17	56	75	76	51	14	38	49	38	12
Ysleta, TX	43	77	87	69	30	44	85	105	99	67	27	68	87	80	48	21	50	56	37	6
RR Inspection, TX	23	54	69	62	32	25	59	80	85	65	16	52	73	75	52	12	37	47	37	12
Admin, TX (leased)	24	56	72	62	32	26	62	85	88	67	17	56	75	76	51	14	38	49	38	12
El Paso, TX (Leased)	43	77	87	69	30	44	85	105	99	67	27	68	87	80	48	21	50	56	37	6
DOT, TX (leased)	23	57	75	66	36	24	63	89	93	70	15	53	79	81	56	12	39	50	40	14
Derby Line, VT	29	50	55	43	15	39	64	77	70	49	21	48	60	54	30	7	22	24	13	0
Norton, VT	29	50	55	43	15	39	64	77	70	49	21	48	60	54	30	7	22	24	13	0
Beebe Plain, VT	29	50	55	43	15	39	64	77	70	49	21	48	60	54	30	7	22	24	13	0
Alburg Springs, VT	29	50	55	43	15	39	64	77	70	49	21	48	60	54	30	7	22	24	13	0
North Troy VT	29	50	55	43	15	39	64	77	70	49	21	48	60	54	30	7	22	24	13	0
West Berkshire,VT	29	50	55	43	15	39	64	77	70	49	21	48	60	54	30	7	22	24	13	0
Derby Line, VT	29	50	55	43	15	39	64	77	70	49	21	48	60	54	30	7	22	24	13	0
Beecher Falls, VT	29	50	55	43	15	39	64	77	70	49	21	48	60	54	30	7	22	24	13	0
Canaan, VT	29	50	55	43	15	39	64	77	70	49	21	48	60	54	30	7	22	24	13	0
East Richford, VT	29	50	55	43	15	39	64	77	70	49	21	48	60	54	30	7	22	24	13	0
Richford, VT	29	50	55	43	15	39	64	77	70	49	21	48	60	54	30	7	22	24	13	0
Alburg, VT (Joint ownership)	29	50	55	43	15	39	64	77	70	49	21	48	60	54	30	7	22	24	13	0
Highgate Springs 1, VT	29	50	55	43	15	39	64	77	70	49	21	48	60	54	30	7	22	24	13	0

Table A-2: Illuminance Information for Daylighting Calculation
(Daily Profile by Season in kLux-Hour/sf)

	Spring					Summer					Fall					Winter				
Name	**9am**	**11am**	**1pm**	**3pm**	**5pm**	**9am**	**11am**	**1pm**	**3pm**	**5pm**	**9am**	**11am**	**1pm**	**3pm**	**5pm**	**9am**	**11am**	**1pm**	**3pm**	**5pm**
Highgate Springs 2, VT	29	50	55	43	15	39	64	77	70	49	21	48	60	54	30	7	22	24	13	0
Highgate Springs 3, VT	29	50	55	43	15	39	64	77	70	49	21	48	60	54	30	7	22	24	13	0
Blaine, WA	17	34	39	35	16	26	46	63	64	48	14	37	52	50	32	2	14	16	11	0
Danville, WA	27	46	48	37	14	43	68	79	73	52	25	52	64	57	32	6	20	21	11	0
Laurier, WA	27	46	48	37	14	43	68	79	73	52	25	52	64	57	32	6	20	21	11	0
Mataline Falls. WA	27	46	48	37	14	43	68	79	73	52	25	52	64	57	32	6	20	21	11	0
Oroville, WA	27	46	48	37	14	43	68	79	73	52	25	52	64	57	32	6	20	21	11	0
Point Robert, WA	27	46	48	37	14	43	68	79	73	52	25	52	64	57	32	6	20	21	11	0
Sumas, WA	17	34	39	35	16	26	46	63	64	48	14	37	52	50	32	2	14	16	11	0
Blaine, WA	17	34	39	35	16	26	46	63	64	48	14	37	52	50	32	2	14	16	11	0
Danville, WA	17	34	39	35	16	26	46	63	64	48	14	37	52	50	32	2	14	16	11	0
Kenneth Ward, WA	17	34	39	35	16	26	46	63	64	48	14	37	52	50	32	2	14	16	11	0

Wind Energy

Uneven heating of the earth's surface creates wind. Variation in heating and factors such as surface orientation or slope, rate of reflectivity, absorptivity, and transmissivity also affect the wind resource. Furthermore, the wind resource can be affected (accelerated, decelerated, made turbulent) by factors, such as terrain, bodies of water, buildings, and vegetative cover.

Wind is air with high kinetic energy that can be transformed into useful work via wind turbine blades and a generator. Overall, wind is a diffuse resource that can generate electricity cost effectively and competitively in many regions.

Wind Characteristics

Windiness varies with the season and time of day and, of course, weather events. Collected wind data focuses on two primary considerations – average annual wind speed and a frequency distribution of the wind at various speeds. The wind speed at any given time determines the amount of power available in the wind.

The power available in the wind is given by:
$P = A \rho V^3/2$
where
P = power of the wind [Watts]
A = windswept area of the rotor (blades) = $\pi D^2/4 = \pi r^2$ [m^2]
ρ = density of the air [kg/m^3] (at sea level at 15°C)
V = velocity of the wind [m/s]

As shown, wind power is proportional to velocity cubed (V^3). If wind velocity doubles, wind power increases by a factor of eight ($2^3 = 8$). Consequently, small differences in average speed cause significant differences in energy production. Examining ways to increase the wind velocity at a particular site should be considered. Normally, the easiest way to accomplish this is to increase the height of the tower. The wind industry has been moving towards ever higher towers and the industry norm has increased from 30 m to 80 m over that last 15-20 years.

Wind turbines are typically cost effective where the average wind speed is high, where the competing energy costs are high or a combination of both. Large wind farms of 100–500 MW have been driving the industry due to lower installed costs and lower cost of energy. Only 1 or 2 turbines would be considered for LPOE sites due to load and land constraints resulting in significantly higher installed costs than the wind farm industry norms.

Wind turbines require regular maintenance. Manufacturer warranties cover the first two to five years. Professional wind turbine maintenance contractors (a.k.a.

windsmiths) are recommended after the warranty period. Figure 2 shows large wind turbines that may be considered for a GSA LPOE site with sufficient land.

Wind maps can give a visual approximation of the wind resource in an area, but do not provide enough data for estimating annual electricity output at a particular site. On-site wind data collected for a period of one to three years is necessary to estimate wind turbine performance. This study used the best available data for its estimates, but in the case of wind, site specific data should be collected before making wind turbine purchase decisions.

Figure A-2: Modern wind turbines

In the United States, there have been about 11,699 MW of wind power installed with another 4,500 MW under construction. Wind turbines consist of rotating blades that convert the momentum of the wind to electric power. They have several moving parts and require regularly scheduled and unscheduled maintenance. Turbines are available from as small as 250 W to as large as 5 MW. For the size of the wind plants considered here, large turbines in the range of 800 kW to 1500 kW per turbine would be the optimal size. A 15 MW plant could consist of ten 1.5 MW turbines. Figure 13 shows the relation of cost to project size.

Table A-3 lists the characteristics of wind technology. Figure A-3 is a map of the national wind resource. Table A-4 lists details of the wind power analysis including size of the wind energy system for each LPOE site (kW), cost, annual energy delivery, annual cost savings, and payback period.

Table A-3: Characteristics of Wind Energy Technology Used for Analysis

Tower Height	80	M
Wind Shear Exponent	0.115	
Acres per MW	60	
Wind Turbine Efficiency	35%	
Capital Cost	$2,200	$/kW, maximum
O&M Cost	7.9	$/year/kW
Power/Area	0.46	kW/m^2

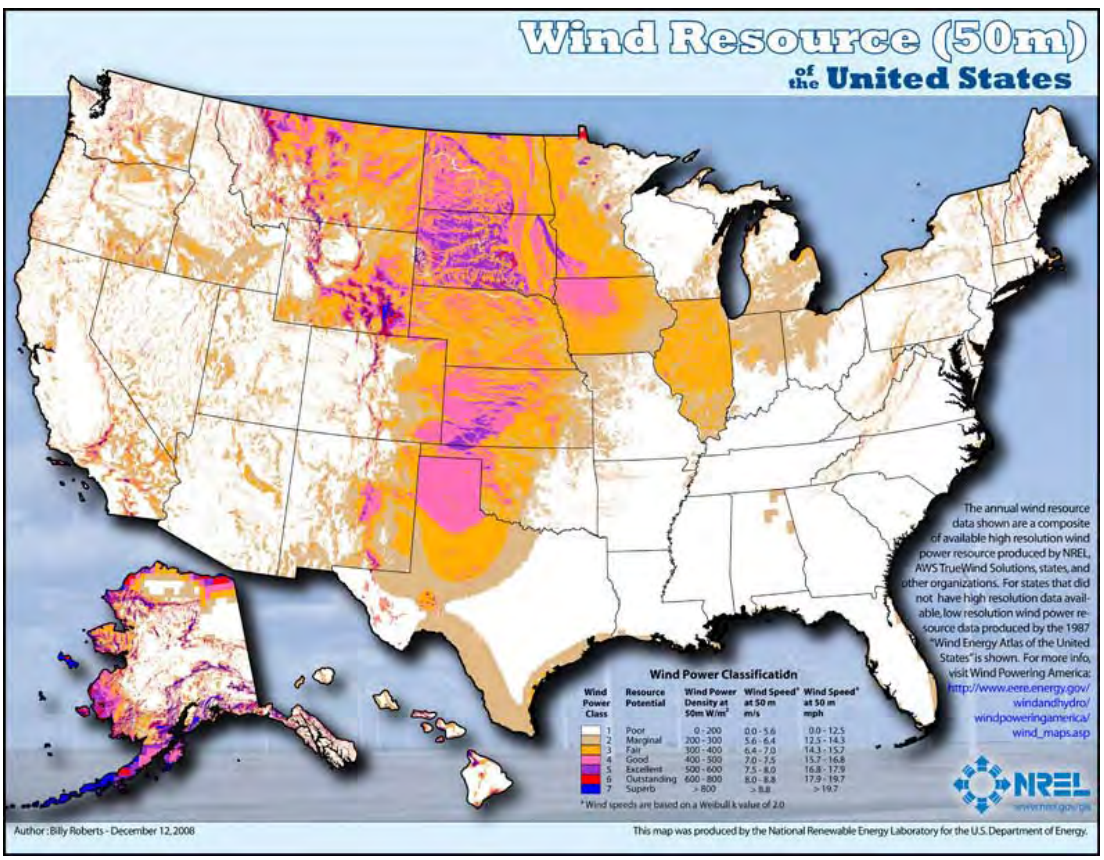

Figure A-3: Map of U.S. Wind Resources

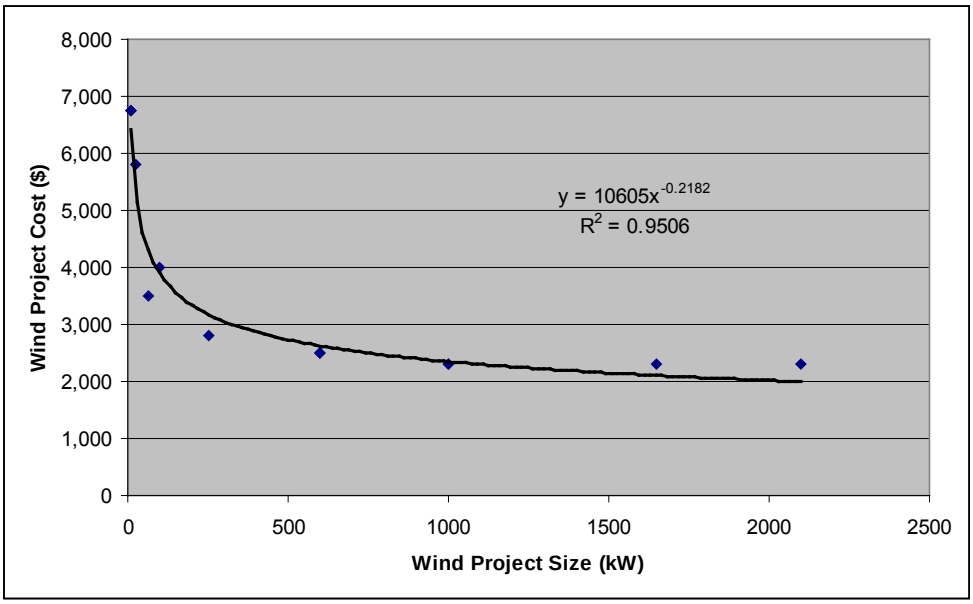

Figure A-4: Wind project cost as a function of size

Land Use Requirements

Land use requirements are established for solar PV, wind energy, solar thermal and solar thermal electric technologies. Land use requirements of the other technologies are not included, but many of these fit within the building or on the building shell. Many locations with cost-effective applications of solar or wind are constrained by the size of the site. Table A-4 shows land required and available for wind energy development.

Table A-4: Land Required and Land Available for Wind Energy

LPOE Site Name	Land Required (acres)	Land Available (acres)
St John Hwy, NY	0	95
Ysleta, TX	0	91
Calexico, CA	0	87
Los Tomates, TX	18	75
Columbia, TX	0	70
Piegan, MT	0	63
Tecate, CA	0	60
Del Rio, TX	0	60
Alcan, AK	0	55
Kika de la Garza, TX	16	55
Los Indios, TX	0	50
Nogales, AZ	0	40
Pembina, ND	0	40
Champlain, NY	0	35
Otay Mesa, CA	28	31
Bridge of the Americas, TX	0	27
Rooseville, MT	0	25
Detroit Cargo, MI	0	22
Juarez-Lincoln, TX	0	20
Dalton Cache, AK	0	18
Massena, NY	0	18
Highgate Springs 2, VT	0	16
Eagle Pass, TX	0	13
Blaine, WA	0	12
Paso Del Norte, TX	0	11
Columbus, NM	0	10
Brownsville/Matamoros,TX	6	10
Laredo TX	0	10
McAllen, TX	0	10
San Luis, AZ (not built)	0	9
Raymond, MT	0	9
Skagway, AK	0	8
Nogales, AZ	0	8
Dunseith, ND	0	8
Fabens, TX	0	8
Marfa, TX	2	8

Table A-4: Land Required and Land Available for Wind Energy

LPOE Site Name	Land Required (acres)	Land Available (acres)
Rio Grande City, TX	0	8
Oroville, WA	0	8
Ambrose, ND	0	7
Derby Line, VT	0	7
Blaine, WA	0	7
Lukeville, AZ	0	6
Houlton, ME	0	6
Santa Teresa, NM	0	6
Mataline Falls. WA	0	6
Calexico West, CA	0	5
St. John ND	0	5
Alexandria Bay, NY	8	5
Fort Covington, NY	0	5
Convent, TX	0	5
Fort Hancock, TX	0	5
Kenneth Ward, WA	0	5
San Ysidro, CA	47	4
Andrade, CA	2	4
Coburn Gore, ME	0	4
Jackman, ME	0	4
Grand Portage, MN	0	4
Mooers, NY	0	4
Sumas, WA	0	4
Douglas, AZ	0	3
Derby Line, VT	0	3
Blaine, WA	0	3
Point Robert, WA	0	3
Sasabe, AZ	0	2
San Luis, AZ	0	2
Eastport, ID	0	2
Vanceboro, ME	0	2
Noyes, MN	0	2
Intl Falls, MN	0	2
Trout, River, NY	0	2
West Berkshire,VT	0	2
Laurier, WA	0	2
Naco, AZ	0	1
Porthill, ID	0	1

Table A-4: Land Required and Land Available for Wind Energy

LPOE Site Name	Land Required (acres)	Land Available (acres)
Ferry Point, ME	0	1
Fort Fairfield, ME	0	1
Limestone, ME	0	1
Orient, ME	0	1
VanBuren, ME	0	1
Madawaska, ME	0	1
Fort Kent, ME	0	1
Chief Mt, MT	0	1
Portal, ND	0	1
Rouses Pt. NY	0	1
Chateaugay, NY	0	1
RR Inspection, TX	0	1
Norton, VT	0	1
Alburg Springs, VT	0	1
North Troy VT	0	1
Beecher Falls, VT	0	1
Canaan, VT	0	1
East Richford, VT	0	1
Richford, VT	0	1
Alburg, VT (Joint ownership)	0	1
Highgate Springs 3, VT	0	1
Danville, WA	0	1
Milltown ME	0	0
St. Francis, ME	0	0
St. Francis, ME	0	0
Intl Bridge, MI	0	0
Amb. Bridge, MI	0	0
Roseau, MN	0	0
Baudette, MN	0	0
Sweetgrass, MT	0	0
Turner, MT	0	0
Jamieson, NY	0	0
Niagra Falls, NY	9	0
Ogdensburg NY	0	0
Gateway, TX	13	0
Donna TX (not built)	0	0
El Paso, TX (out leased)	0	0

Table A-4: Land Required and Land Available for Wind Energy

LPOE Site Name	Land Required (acres)	Land Available (acres)
McAllen TX (not built)	0	0
Progreso, TX	0	0
Roma, TX	0	0
Admin, TX (leased)	0	0
El Paso, TX (Leased)	0	0
DOT, TX (leased)	0	0
Beebe Plain, VT	0	0
Highgate Springs 1, VT	0	0

Biomass Energy

Biomass energy is fuel, heat, or electricity produced from organic materials such as plants, agricultural residues, forestry by-products, and municipal or industrial wastes. Biomass has its energy stored within the chemical structure of the organic substance itself. Solid or liquid biomass feedstocks from surrounding areas can be acquired (at low cost) and converted to heat or electricity for buildings. Much of the plant-based biomass resource is already in a form that is readily transportable and dispatchable, with no energy transformation necessary, though ensuring the fuel has the required moisture content if often critical. There are costs associated with moisture removal/regulation, storage and transport. And, maintaining the energy quality (i.e., moisture content) of the fuel may require some environmental controls and consideration for a shelf life that is not indefinite.

This analysis considered 10 configurations of systems for LPOE sites using biomass, such as wood mill waste from surrounding areas. Sources from the LPOE site activity itself such as waste pallets or tree trimmings could also be used. Combustion of solid biomass can be used to generate steam and topping cycle for steam co-generation of heat and power at a facility. Some of the heat output of the boiler may be converted to electricity by a steam turbine in a cogeneration topping cycle. Boiler fuel may be wood chips or bio-oil. Bio-oil could also be used by existing boilers and storage tanks with minimal modifications. Gasification of solid biomass produces a fuel gas by heating the feed material in a vessel, sometimes with the addition oxygen and or water (Figure A-5). Decomposition reactions take place that produce a mixture of hydrogen and CO, along with water, methane, and CO_2. Anaerobic digestion of wet feedstocks to produce methane gas was considered, but no cost-effective systems were identified for LPOE sites.

Unlike the other renewable energy technologies considered in this report, on-site use of biomass resources involves atmospheric emissions, solid waste residues (ash), and possible water-borne wastes. It may be expected, however, that emissions from a gasification operation could be no worse than those of a direct-burn operation.

Figure A-5: Biomass-fueled gasifier and boiler

Several technologies are available to convert biomass feedstocks into heat and electricity. These include direct combustion, gasification, and liquefaction of solid biomass and anaerobic digestion of liquid biomass. In this study, we considered combustion or gasification and combustion of dry biomass feedstocks such as wood mill waste available in the area. Dry sources of waste from the LPOE site itself may also be considered if the site were to include an inventory of waste streams, such as waste pallets or tree trimmings. Anaerobic digestion of wet feedstocks is considered in this analysis to produce methane gas. Wet waste streams include confined animal waste from surrounding areas.

A.2.3.1 Biomass Resource Data

Biomass fuel resources available at each LPOE site were not provided by GSA. Biomass resources considered from surrounding areas include:

Crop Residues (Dry Tonnes/Year)

The following crops were included in this analysis: corn, wheat, soybeans, cotton, sorghum, barley, oats, rice, rye, canola, dry edible beans, dry edible peas, peanuts, potatoes, safflower, sunflower, sugarcane, and flaxseed. The quantities of crop residues that can be available in each county are estimated using total grain production, crop to residue ratio, moisture content, and taking into consideration the amount of residue left on the field for soil protection, grazing, and other agricultural activities from USDA, National Agricultural Statistics Service, 2002 data. [ref. 1]

Orchard and Grape (Dry Tonnes/Year)

Pruning from orchards and vineyards were estimated for California only from USDA, 2002 data. [ref. 1]

Forest Residues (Dry Tonnes/Year)

Forest residues are logging residues and other removable material left after carrying out silviculture operations and site conversions. Logging residue comprises unused portions of trees, cut or killed by logging and left in the woods. Other removable materials are the unutilized volume of trees cut or killed during logging operations from USDA, Forest Service's Timber Product Output database, 2002. [ref. 1]

Primary Mill Residues (Dry Tonnes/Year)

Primary mill residues include wood materials (coarse and fine) and bark generated at manufacturing plants (primary wood-using mills) when round wood products are processed into primary wood products, like slabs, edgings, trimmings, sawdust, veneer clippings and cores, and pulp screenings from USDA, Forest Service's Timber Product Output database, 2002. [ref. 1]

Secondary Mill Residues (Dry Tonnes/Year)

Secondary mill residues include wood scraps and sawdust from woodworking shops — furniture factories, wood container and pallet mills, and wholesale lumberyards.

Urban Wood Waste (Dry Tonnes/Year)

This analysis includes wood residues from municipal solid waste (MSW) (wood chips and pallets), utility tree trimming and/or private tree companies, and construction and demolition sites from U.S. Census Bureau, 2000 Population data, BioCycle Journal, State of Garbage in America, January 2004; County Business Patterns 2002. [ref. 1]

Methane Emissions from Landfills (Tonnes/Year)

Three key factors were considered for this study: total waste in place, landfill size, and geographic location (arid or non-arid climate) from EPA, Landfill Methane Outreach Program (LMOP), 2003. [ref. 1]

Methane Emissions from Manure Management (Tonnes/Year)

The following animal types were included in this analysis: dairy cows, beef cows, hogs and pigs, sheep, chickens and layers, broilers, and turkey. The methane emissions were calculated by animal type and manure management system from USDA, National Agricultural Statistics Service, 2002 data. [ref. 1]

Methane Emissions from Domestic Wastewater Treatment (Tonnes/Year)

The methane generation is estimated using the methodology from the EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2003 and from U.S. Census Bureau, 2000 Population data http://www.nrel.gov/docs/fy06osti/39181.pdf. [ref. 1]

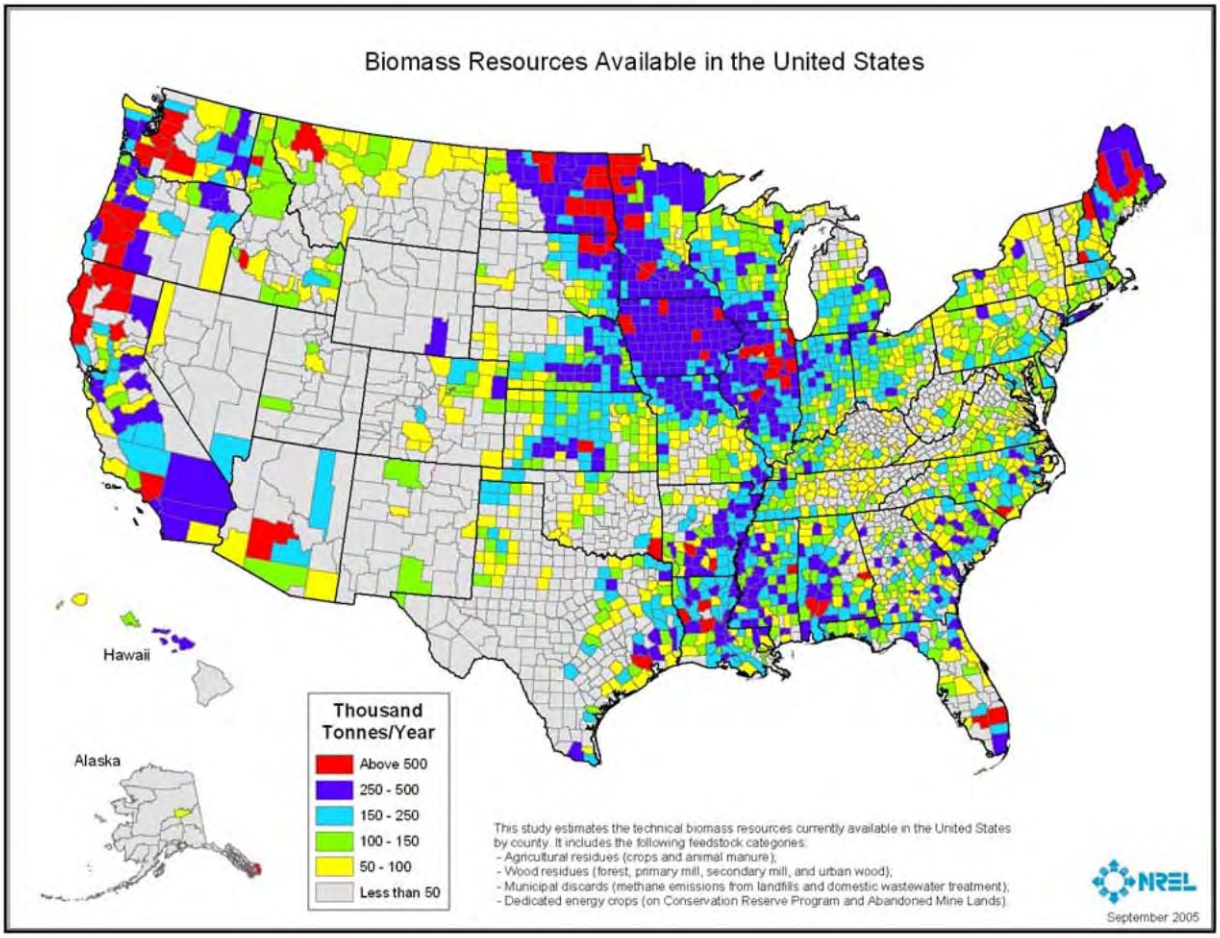

Figure A-6: Biomass resources in the U.S. by tonnage

A.2.3.2 Technology Characteristics of Biomass Energy Conversion Configurations

The emerging biomass energy sector is focusing on increasing the conversion efficiency of solid biomass-based fuels compared to the standard boiler and steam-cycle configuration. The technology platforms considered in this analysis are:

1. Thermochemical means of converting biomass via gasification;
2. Pyrolysis; and
3. Anaerobic digestion (AD).

These technologies convert solid fuel into liquid and gaseous intermediaries suitable for conventional and advanced power generation systems. While further R&D is needed to increase reliability, reduce maintenance costs, and reduce capital costs, they are already penetrating the biomass energy sector in a number of countries. Within these technology platforms, several different prime movers have been considered for conversion of the intermediate fuels to heat and power. While any combination of these configurations may be possible, gasification and anaerobic digestion with conventional steam cycle are selected to be included in the optimization. Ten configurations in four platforms in all have been considered and are described as follows:

Combustion Platform

Combustion of biomass to generate steam, and topping cycle for steam co-generation of heat and power

Biomass heat is provided by a boiler of a capacity determined as a result of the optimization. Cost and combustion efficiency of the boiler are specified. Some of the heat output of the boiler may be converted to electricity by a steam turbine in a cogeneration topping cycle. Boiler fuel may be wood chips or bio-oil. Bio-oil use could be used by existing boilers and storage tanks with minimal modifications.

Gasification Platform

Gasification is a high-temperature process that is optimized to produce a fuel gas with a minimum of liquids and solids. Gasification consists of heating the feed material in a vessel with or without the addition of oxygen. Water may or may not be added. Decomposition reactions take place, and a mixture of hydrogen and CO are the predominant gas products, along with water, methane, and CO_2.

- Configuration 1A Biomass Gasification /Steam Cycle: This configuration is a biomass gasification system fueling a steam cycle. The system gasifies biomass and immediately burns the syngas in a heat-recovery

steam generator (HRSG) to produce steam for the steam turbine. The combined gasification and boiler efficiency is about 64 percent. The steam-to-electricity conversion efficiency of a standard steam cycle is taken as 50 percent while heat can be recovered at about 80 percent effectiveness. O&M costs should be very similar to a conventional biomass fired boiler.

- Configuration 1B Biomass Gasification / Spark Ignition Reciprocating Engine: This configuration considers a slightly more advanced biomass gasification process called pyrolytic gasification whereby a high-Btu content syngas is produced by externally heating biomass. The syngas generated in this process then has sufficient energy content to run spark-ignition reciprocating engines. Typically these engines are de-rated to account for the reduced energy content of the syngas when compared with natural gas. Hence the engine combined heat and power (CHP) costs on a $/kW basis are higher than for a natural gas system. The fuel-to-electricity conversion efficiency of a gas engine operating on syngas is roughly 37 percent based on Lower Heating Value, and heat recovery effectiveness is typically around 80 percent. The O&M cost reflected here represents the O&M cost for the gasification plant and the gas engines; roughly $18/MWh.

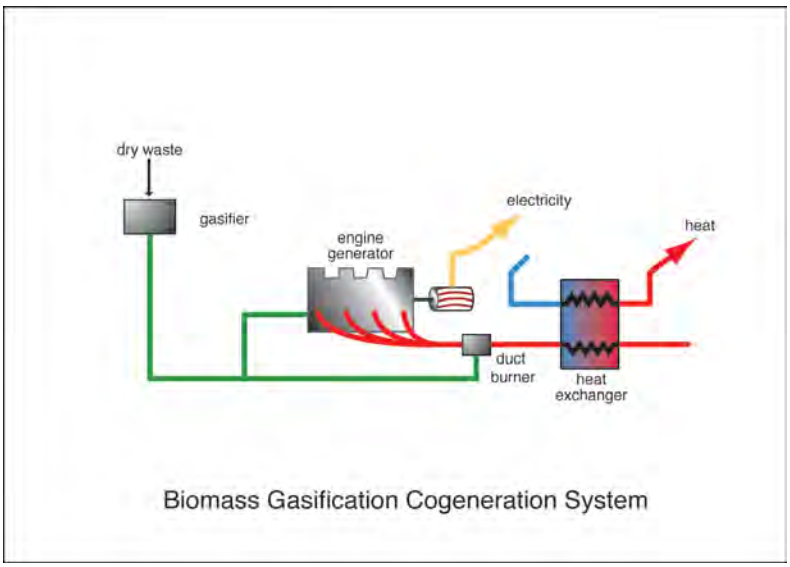

Figure A-7: Platform 1B biomass gasification with syngas utilization via spark-ignition reciprocating engines

- Configuration 1C Biomass Gasification / Combustion Turbine Combined Cycle: The last configuration considered for gasification systems is the combined cycle. This is the least commercialized configuration of the

three systems and costs are, therefore, less certain. The gasification system cost has been assumed to be equal to Configuration 1B; however it may actually require more gas-cleanup systems and could likely be higher in reality. The combined-cycle cost is indicative of natural gas combined-cycle costs with a slight power output de-rating for the syngas. The same gasification efficiency has been assumed as for Configuration 1B and the combined cycle will see a decreased efficiency relative to the natural gas baseline. However, future improvements in process design should be able to bring the efficiency up considerably. Heat recovery has been assumed at zero because the system would likely be at utility-scale and would use a condensing steam turbine for maximum electrical generation. The system has a lower O&M cost compared to the gas engine configuration but higher O&M cost than the steam cycle. Future integrated gasification and combined cycle (IGCC) configurations utilizing pressurized oxygen-blown gasification would have higher plant efficiencies than what is shown here.

Pyrolysis Platform

- Configuration 2A Pyrolysis / Steam Cycle: Configuration 2A is fast pyrolysis followed by a conventional steam cycle. The efficiency of biomass pyrolysis-to-bio-oil is about 77 percent while the boiler efficiency would be roughly 80 percent, resulting in a total efficiency of 61 percent. The cost for the pyrolysis plant is given in $ per hourly million Btu of bio-oil production. The steam-to-electricity conversion efficiency of a standard steam cycle is taken as 50 percent and heat recovery around 70 percent. O&M cost includes the O&M for the steam cycle and the pyrolysis plant in terms of hourly million Btu of bio-oil utilization.

- Configuration 2B Pyrolysis / Compression Ignition Engine: The second pyrolysis configuration considers a fast-pyrolysis plant fueling modified compression ignition engines. This system has an advantage over 1B because liquid-fueled compression-ignition engines have higher efficiencies. Published literature indicates that diesel engines burning bio-oil achieve comparable efficiencies to those using diesel fuels, although modifications to the fuel handling system for preheating the bio-oil are required. Heat recovery effectiveness is assumed to be 80 percent.

- Configuration 2C Pyrolysis / Combustion Turbine Combined Cycle: The final configuration for a fast-pyrolysis plant is to fire the bio-oil in a combustion turbine combined cycle. Research on the subject indicates that modified simple-cycle combustion turbines can easily reach 28 percent fuel-to-electricity conversion efficiency with an expected combined-cycle efficiency of 35 percent. However, they have been shown to operate at or above rated turbine power output; thus the combined cycle is not de-rated and the cost is shown for a conventional natural gas

combined cycle. It is likely that the first commercial system using this configuration will have much higher combined-cycle efficiencies but this probably represents the current state-of-the-art. As in Configuration 1C, it is assumed that a bio-oil-fired combined cycle will not have heat recovery for district heating applications.

Anaerobic Digestion Platform

- Configuration 3A Anaerobic Digestion / Spark Ignition Engine: This configuration involves anaerobic digestion of mixed energy crops and manure which would be typical for farm-based applications in the 100 kW to 500 kW scale. These smaller-scale gas engines operating on digester gas are typically not de-rated as much as for syngas and have lower installed costs. The digester efficiency has been assumed to be 57 percent which is an average efficiency for different types of energy crop and manure feedstocks. The efficiency for AD systems is lower because they can only utilize the volatile solids content while the lignocellulosic material is removed and sold as fiber. The efficiency of smaller-scale gas engines is slightly lower at 35 percent, compared to larger engines, while heat recovery is also less efficient. Plant capacity factors are dependant mainly on the AD systems and 92 percent is the goal for many applications.

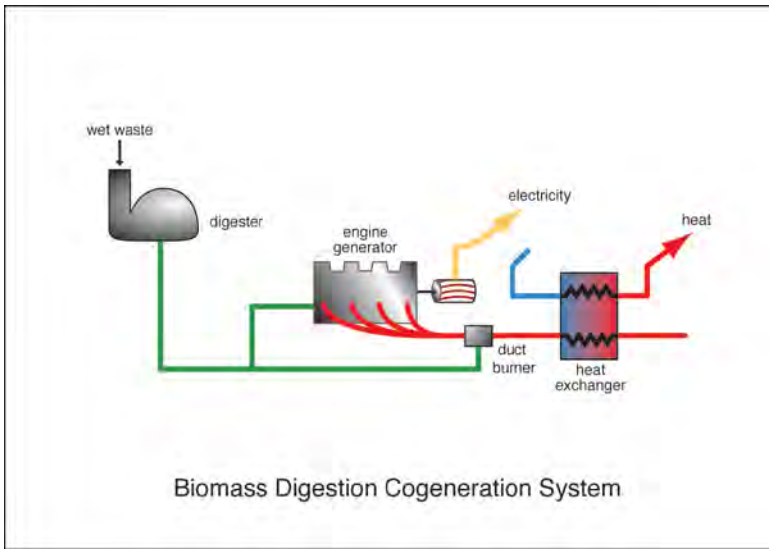

Figure A-8: Platform 3A anaerobic digester and spark-ignition engine with heat recovery

- Configuration 3B Anaerobic Digestion / Microturbine: Microturbines can also be used with digester gas and offer a good fit at these small scales.

These systems offer lower electrical efficiency but higher heat recovery because of the higher-temperature flue gases.

- Configuration 3C Anaerobic Digestion / Molten Caronate Fuel Cell: The final configuration considers an anaerobic digester supplying by a molten carbonate fuel cell (MCFC). The MCFC is the only commercialized CHP fuel cell and has been proven on biogas. This configuration has the highest electrical efficiency but lower heat recovery efficiency because heat is consumed by the internal-reforming process of the fuel cell. Capacity factor for MCFC running on biogas has been observed at around 85 percent but can be expected to increase as their commercial use increases. This system is also the most expensive of the 3 platforms considered here but could qualify for incentives for both the AD system and the fuel cell.

Energy savings consist of savings in natural gas and electricity. Natural gas savings are limited to the minimum of:

1. Base case natural gas use; or
2. Renewable energy heat generating capacity.

Electric savings are limited to the minimum of electric peak, then renewable energy generation above that is treated as wholesale power to the utility. Electric savings are limited to:

1. The minimum of cogeneration size (kW) or
2. Heat generating capacity of the plant times heat-to-electric cogeneration efficiency.

Thermal energy as a by-product of electric generation is added back into the gas savings but multiplied by a heat exchanger effectiveness.

$$E_{s,\ gas} = C_{boiler} * \eta_{biomass\ boiler} * 8760 * CFboiler\ (1-\underline{\eta}_{cogeneration} + (1-\underline{\eta}_{cogeneration}) * e_{hx} / \eta_{gas\ boiler}$$

$$E_{s,\ electric} = Cboiler * \eta_{biomass\ boiler} * 8760 * CFboiler * \underline{\eta}_{cogeneration}$$

where

- C_{boiler} = biomass boiler size (M Btu/h)= variable determined by the optimization
- CF_{boiler} = capacity factor (% of time operational)
- $\underline{\eta}_{cogeneration}$ is the efficiency of the electric generator
- e_{hx} is the effectiveness of the heat recovery heat exchanger
- η_{boiler} = auxiliary heater efficiency.

Boiler heat delivery (therms)=boiler size * capacity factor

Biomass initial cost ($)=boiler size * cost per MBH + electric cogen size * kW of cogen * city cost adjustment factor from RS Means cost estimating manuals

Biomass cogeneration size (kW)=variable determined by optimization

Biomass gas savings (therms/year)=minimum of site gas use and thermal energy provided by boiler minus that converted to electricity divided by heat recovery steam generator effectiveness

Biomass electric delivery (kWh/year)=minimum of electric energy generation as calculated by cogen capacity times capacity factor or as limited by boiler capacity, boiler efficiency, and boiler capacity factor

Biomass capacity factor=electric delivery divided by cogen capacity and 8760 h/y

Biomass annual utility cost savings ($/year)=minimum of cogen capacity or demand (kW) credited at retail rate plus any generation in excess of that credited at avoided cost plus federal production incentive times electric generation plus gas savings times gas rate

Tons of fuel used=boiler heat delivered for both process heat and cogen divided by boiler efficiency and divided by heating value of fuel

Radius to collect fuel (miles)=radius calculated from area quotient of fuel required (tons) and density (tons/square mile)

per ton fuel cost ($/ton)=fixed cost ($/ton) plus trucking cost ($/ton/mile)
Fuel cost ($) =fuel used minus fuel available onsite times fuel cost ($/ton)

State tax credit (%)=variable to be input by user
Federal tax credit (%)=variable to be input by user
Rebate ($)=variable to be input by user

Biomass cost w/incentives ($)=boiler cost above minus any rebates or tax credits
Biomass O&M cost ($/year)=$ per MBH of boiler capacity per year

Biomass payback period (years)=cost with incentives subtracted divided by cost savings minus O&M costs and minus fuel costs.

NREL's consultant, Econergy International, has assembled indicative metrics for energy efficiency, equipment capital costs, and plant operation and maintenance costs. [ref. 13]. While some of these numbers have come from specific projects that Econergy has been involved with, others are representative estimates provided to Econergy by technology providers active in the space. Other costs

not accounted for in this analysis include development cost, land, enclosure buildings, and balance-of-plant. [ref. 17]

Table A-5: Characteristics of Biomass Heat and Power Technologies Used for Analysis

	Combustion with steam topping cycle cogeneration	Biomass gasification with syngas utilization via conven-tional steam cycle	Biomass gasification with syngas utilization via spark-ignition reciprocating engines	1C Biomass gasifica-tion with syngas utiliza-tion via combus-tion turbine combined cycle	Biomass fast pyrolysis with bio-oil utilization via conventional steam cycle	Biomass fast pyrolysis with bio-oil utilization via compression-ignition reciprocating engines	Biomass fast pyrolysis with bio-oil utilization via combustion turbine combined cycle	Anae-robic Diges-tion of biomass with biogas utilization via sparkignition reciprocating engines	AD of biomass with biogas utilization via micro-turbine	AD of biomass with biogas utilization via molten carbonate fuel cell
Gasifier/Boiler /Digester Cost ($/MBH)	500,000	195,802	195,802	195,802	223,590	223,590	223,590	419,918	419,918	419,918
Cogen Cost ($/Kw)	1,650	700	1,300	815	700	1,300	747	1,000	1,225	4,500
Fuel Storage and Handling ($/MBH)	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000	250,000
Boiler Efficiency	0.75	0.64	0.75	0.75	0.61	0.77	0.9	0.57	0.57	0.57
Cogen Efficiency	0.3	0.5	0.37	0.47	0.33	0.45	0.35	0.35	0.3	0.45
Boiler Capacity Factor	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.92	0.92	0.85
Hx effectiveness	0.7	0.8	0.8	0	0.8	0.8	0	0.6	0.66	0.38
Fixed Cost Per Ton	20	20	20	20	20	20	20	20	20	20
Trucking Cost ($/sqmi/ton)	1	1	1	1	1	1	1	1	1	1
Federal Production Tax Credit ($/kWh)	0.01	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
Biomass O&M Cost ($/yr-MBH)	15,000	25,079	57,518	43,139	25,079	31,452	24,913	43,377	44,372	42,669

A.2.3.3 Air Quality Concerns

Unlike the other renewable energy technologies considered in this report, on-site use of biomass resources involves atmospheric emissions, solid waste residues (ash) and possibly water-borne wastes. While the decomposition of waste into simpler compounds by gasification should reduce emissions, detailed data for gasification could not be found in the literature (except for coal and clean wood). It may be expected, however, that emissions from a gasification operation could be no worse than those of a direct-burn operation which may be found in the

literature. The following values of lbs/ton for direct combustion of refuse-derived-fuel are from Emissions From Integrated MSW Strategies [ref. 13]:

- Particulates 0.05;
- CO 2.06;
- Hydrocarbons 0.08;
- NO_x 2.64;
- Methane 2.29;
- CO_2 1460;
- Water 970;
- NMOC 0.12;
- Dioxin/furan 0.0038;
- Sulfur 1.1;
- Hydrogen 0.26.

Also, the following values are for the same publication for anaerobic digestion:

- Particulates 0.02;
- CO 0.79;
- Hydrocarbons 0.08;
- NO_x 0.32;
- Methane 14.34;
- CO_2 437;
- Water 188;
- NMOC 0.75;
- Dioxin/furan NA;
- Sulfur NA;
- Hydrogen NA.

In addition to these air emissions, ash from a gasifier using waste as fuel may contain metals which could leach out in a landfill, depending on the nature of the waste. Office paper, cardboard, and waste from convenience food operations have been found to be very uniform and free of metals, PVC, and other materials which may be of special concern (according to a phone conversation with Robb Walt of Community Power Systems).

Table A-6: Selected Emissions Data for Each Biomass Conversion Considered

Fuel	CO_2 emissions (kg/TJ)	N_2O emissions (kg/TJ)
Natural Gas	56,100	0.1
Wood	112,000	4.0
Bio-diesel	70,800	0.6
Bio-gas	54,600	0.1

Table A-7: Additional Information for Biomass Energy Resources by (in tons per 50 mile radius of site)

LPOE Site Name	Crops	Manure	Forest	Prim-Mill	SecMill	Urban	Landfill	DWWT	Energy crops on CRP land	Total
Dalton Cache, AK	0	0	0	0	8	644	0	9	0	**662**
Alcan, AK	0	0	0	0	0	235	0	3	0	**238**
Skagway, AK	0	0	0	0	8	644	0	9	0	**662**
Lukeville, AZ	10,839	166	0	0	1,840	40,094	11,753	650	0	**65,343**
Nogales, AZ	18,478	125	0	0	311	9,101	3,211	140	0	**31,369**
Sasabe, AZ	5,187	70	0	0	1,458	30,734	9,355	496	0	**47,302**
Douglas, AZ	19,333	122	0	0	11	7,024	2,313	107	0	**28,912**
San Luis, AZ	42,987	45	0	0	776	11,511	2,649	174	0	**58,144**
Naco, AZ	18,478	125	0	0	311	9,101	3,211	140	0	**31,369**
San Luis AZ (not built yet)	42,987	45	0	0	776	11,511	2,649	174	0	**58,144**
Nogales, AZ	7,490	86	0	0	1,473	26,678	8,481	428	0	**44,637**
Calexico West, CA	44,208	346	0	0	3,499	58,405	14,892	841	0	**122,194**
San Ysidro, CA	1	0	0	0	0	0	0	0	0	**0**
Andrade, CA	64,727	3,249	0	0	2,766	49,500	15,931	715	0	**136,890**
Otay Mesa, CA	285	1,177	0	0	12,032	200,957	57,099	2,901	0	**274,453**
Tecate, CA	285	1,177	0	0	12,032	200,957	57,099	2,901	0	**274,453**
Calexico, CA	50,090	167	0	0	1,699	28,173	6,195	406	0	**86,732**
Eastport, ID	18,539	27	138,394	0	503	4,398	0	62	0	**161,925**
Porthill, ID	18,620	32	127,789	5,044	479	4,604	0	66	0	**156,636**
Ferry Point, ME	1	0	350,172	7,368	393	5,153	454	81	0	**363,624**
Coburn Gore, ME	1	10	653,116	279,746	862	10,903	4,546	167	0	**949,353**
Fort Fairfield, ME	1	5	159,679	15,386	794	4,617	1,432	67	0	**181,984**
Houlton, ME	1	4	326,377	36,170	1,099	8,799	3,590	136	0	**376,179**
Jackman, ME	1	11	518,031	97,495	470	6,347	5,320	96	0	**627,773**
Limestone, ME	1	4	133,923	12,394	687	3,849	1,124	55	0	**152,040**
Orient, ME	1	3	412,738	43,305	1,152	10,703	4,552	168	0	**472,623**
Vanceboro, ME	1	1	346,071	18,865	670	6,819	1,797	107	0	**374,333**
VanBuren, ME	1	3	113,408	10,470	583	3,258	948	47	0	**128,720**
Milltown ME	1	0	350,172	7,368	393	5,153	454	81	0	**363,624**
St. Francis, ME	1	6	206,653	21,745	930	5,220	1,483	75	0	**236,116**
Madawaska, ME	1	4	117,956	10,890	606	3,389	986	49	0	**133,883**
Fort Kent, ME	1	5	152,688	14,097	785	4,386	1,276	63	0	**173,304**
St. Francis, ME	1	5	152,688	14,097	785	4,386	1,276	63	0	**173,304**
Detroit Cargo, MI	318,256	719	20,936	4,296	29,694	570,671	222,425	7,934	49,513	**1,224,448**
Intl Bridge, MI	1	0	0	0	0	0	0	0	0	**0**

Table A-7: Additional Information for Biomass Energy Resources by (in tons per 50 mile radius of site)

LPOE Site Name	Crops	Manure	Forest	Prim-Mill	SecMill	Urban	Landfill	DWWT	Energy crops on CRP land	Total
Amb. Bridge, MI	1	0	0	0	0	0	0	0	0	**0**
Grand Portage, MN	1	0	38,311	13,536	1	507	0	7	32	**52,397**
Noyes, MN	500,070	226	35,204	44	76	2,930	1,359	45	1,199,699	**1,739,657**
Roseau, MN	229,076	217	177,475	54,870	1,098	6,726	5,401	105	1,449,773	**1,924,744**
Intl Falls, MN	1,048	14	269,852	128,794	330	4,370	0	69	905	**405,385**
Baudette, MN	1,311,918	5,392	86,651	12,945	36,953	300,613	107,005	4,984	504,133	**2,370,597**
Chief Mt, MT	66,556	222	36,882	646,384	453	4,385	630	60	0	**755,575**
Piegan, MT	88,032	269	50,559	890,254	625	5,663	868	78	0	**1,036,352**
Raymond, MT	209,297	98	0	0	23	1,323	0	19	0	**210,761**
Rooseville, MT	209,297	98	0	0	23	1,323	0	19	0	**210,761**
Sweetgrass, MT	144,351	288	357	0	2	1,750	0	20	0	**146,770**
Turner, MT	42,720	68	712	0	0	757	0	9	0	**44,267**
Ambrose, ND	276,612	125	0	0	174	2,034	0	31	118,177	**397,155**
Dunseith, ND	528,104	92	1,464	0	153	3,105	0	49	1,393,480	**1,926,450**
Portal, ND	333,750	90	1,704	0	129	2,139	0	33	334,545	**672,393**
St. John ND	475,296	64	1,434	0	120	2,705	0	42	1,133,945	**1,613,610**
Pembina, ND	508,960	216	30,362	25	49	2,738	785	42	1,094,219	**1,637,400**
Columbus, NM	7,122	3,487	0	0	89	7,917	0	124	0	**18,740**
Santa Teresa, NM	13,704	9,564	2,657	10,079	6,766	87,290	20,094	1,328	0	**151,484**
Alexandria Bay, NY	9,909	982	74,346	229,213	2,219	22,439	11,394	338	11,356	**362,200**
Champlain, NY	9,909	982	74,346	229,213	2,219	22,439	11,394	338	11,356	**362,200**
Massena, NY	2,910	627	78,415	8,150	510	14,896	946	226	2,886	**109,570**
Fort Covington, NY	4,797	698	82,863	7,995	846	17,886	4,848	270	2,300	**122,505**
Rouses Pt. NY	4,295	1,391	115,712	17,478	3,281	32,784	10,935	519	483	**186,883**
St John Hwy, NY	4,295	1,391	115,712	17,478	3,281	32,784	10,935	519	483	**186,883**
Trout, River, NY	5,631	733	85,629	8,786	1,043	19,376	6,612	292	2,068	**130,174**
Chateaugay, NY	1	0	0	0	0	0	0	0	0	**0**
Mooers, NY	4,711	1,302	103,458	16,168	3,040	31,305	8,659	494	475	**169,616**
Jamieson, NY	13,557	392	116,429	95,781	23,417	362,000	88,491	5,498	5,636	**711,206**
Niagra Falls, NY	90,845	1,040	36,964	25,654	9,249	139,058	64,351	2,139	27,983	**397,286**
Ogdensburg NY	1	0	0	0	0	0	0	0	0	**0**
Brownsville/Matamoros TX	318,924	19	0	0	2,377	59,237	3,284	897	0	**384,739**

Table A-7: Additional Information for Biomass Energy Resources by (in tons per 50 mile radius of site)

LPOE Site Name	Crops	Manure	Forest	Prim-Mill	SecMill	Urban	Landfill	DWWT	Energy crops on CRP land	Total
Gateway, TX	1	0	0	0	0	0	0	0	0	**0**
Columbia, TX	433	126	0	0	1,200	21,920	6,748	324	0	**30,754**
Convent, TX	433	126	0	0	1,200	21,920	6,748	324	0	**30,754**
Del Rio, TX	176	124	0	0	0	5,259	0	75	0	**5,637**
Donna TX (not built yet)	461,937	63	0	0	3,492	101,686	9,927	1,540	0	**578,647**
Bridge of the Americas, TX	12,926	7,598	3,335	12,655	6,732	84,556	20,140	1,284	0	**149,230**
Eagle Pass, TX	10,155	78	0	0	50	7,794	115	112	0	**18,308**
Fabens, TX	11,946	2,774	1,806	6,852	6,612	77,110	20,140	1,166	0	**128,410**
Fort Hancock, TX	12,137	1,236	2,779	10,545	5,516	63,683	16,884	960	0	**113,744**
El Paso, TX (out leased)	12,848	7,570	2,956	11,216	6,731	84,400	20,140	1,282	0	**147,146**
Juarez-Lincoln, TX	433	126	0	0	1,200	21,920	6,748	324	0	**30,754**
Los Indios, TX	428,516	38	0	0	3,234	88,741	7,972	1,345	0	**529,847**
Laredo TX	433	126	0	0	1,200	21,920	6,748	324	0	**30,754**
Los Tomates, TX	292,937	17	0	0	2,214	53,500	2,398	810	0	**351,878**
McAllen, TX	392,098	68	0	0	2,907	90,877	9,927	1,376	0	**497,254**
McAllen TX (not built yet)	392,283	74	0	0	2,886	90,829	9,927	1,375	0	**497,377**
Marfa, TX	1	59	0	0	0	1,439	0	15	0	**1,515**
Kika de la Garza, TX	410,588	62	0	0	3,062	93,524	9,927	1,417	0	**518,581**
Paso Del Norte, TX	12,852	7,627	2,883	10,938	6,732	84,465	20,140	1,283	0	**146,924**
Progreso, TX	467,013	48	0	0	3,556	101,139	9,837	1,532	0	**583,127**
Roma, TX	90,235	111	0	0	738	32,561	3,970	488	0	**128,105**
Rio Grande City, TX	201,640	120	0	0	1,591	62,374	8,631	941	0	**275,298**
Ysleta, TX	1	0	0	0	0	0	0	0	0	**0**
RR Inspection, TX	326	123	0	0	1,191	21,689	6,698	321	0	**30,350**
Admin, TX (leased)	377,598	54	0	0	2,855	88,856	9,927	1,346	0	**480,638**
El Paso, TX (Leased)	12,896	7,687	3,031	11,499	6,734	84,595	20,140	1,285	0	**147,869**
DOT, TX (leased)	9,866	77	0	0	51	7,795	127	112	0	**18,030**
Derby Line, VT	1	1,260	378,065	297,948	1,704	17,215	11,673	271	4	**708,143**
Norton, VT	1	886	445,498	422,762	1,445	15,018	10,868	235	0	**896,715**
Beebe Plain, VT	1	1,310	362,100	255,794	1,739	17,320	11,575	274	6	**650,122**
Alburg Springs, VT	4,167	1,495	133,093	19,508	3,517	34,727	13,325	551	567	**210,955**
North Troy VT	276	1,572	314,146	77,379	3,152	26,878	14,750	431	76	**438,665**
West Berkshire,VT	2,807	1,683	185,553	21,079	3,710	34,972	19,363	558	421	**270,150**
Derby Line, VT	1	1,276	374,885	287,784	1,724	17,356	11,701	274	5	**695,009**
Beecher Falls, VT	1	523	486,527	448,182	1,273	11,666	8,980	182	0	**957,337**

Table A-7: Additional Information for Biomass Energy Resources by (in tons per 50 mile radius of site)

LPOE Site Name	Crops	Manure	Forest	Prim-Mill	SecMill	Urban	Landfill	DWWT	Energy crops on CRP land	Total
Canaan, VT	1	552	491,613	454,474	1,318	12,063	9,470	188	0	**969,680**
East Richford, VT	1,202	1,632	258,410	33,475	3,564	31,299	16,972	501	195	**347,254**
Richford, VT	1,202	1,632	258,410	33,475	3,564	31,299	16,972	501	195	**347,254**
Alburg, VT (Joint ownership)	4,167	1,495	133,093	19,508	3,517	34,727	13,325	551	567	**210,955**
Highgate Springs 1, VT	3,770	1,600	151,290	18,655	3,613	35,077	17,219	558	527	**232,311**
Highgate Springs 2, VT	3,770	1,600	151,290	18,655	3,613	35,077	17,219	558	527	**232,311**
Highgate Springs 3, VT	3,770	1,600	151,290	18,655	3,613	35,077	17,219	558	527	**232,311**
Blaine, WA	11,507	6,326	5,157	58,802	2,176	19,757	373	281	0	**104,384**
Danville, WA	3,326	143	61,789	230,098	287	4,798	0	54	0	**300,499**
Laurier, WA	3,206	167	66,047	257,850	306	5,041	0	57	0	**332,676**
Mataline Falls. WA	3,206	167	66,047	257,850	306	5,041	0	57	0	**332,676**
Oroville, WA	3,018	29	31,011	58,813	157	4,029	0	46	0	**97,106**
Point Robert, WA	3,018	29	31,011	58,813	157	4,029	0	46	0	**97,106**
Sumas, WA	11,507	6,326	5,157	58,802	2,176	19,757	373	281	0	**104,384**
Blaine, WA	11,507	6,326	5,157	58,802	2,176	19,757	373	281	0	**104,384**
Blaine, WA	11,507	6,326	5,157	58,802	2,176	19,757	373	281	0	**104,384**
Kenneth Ward, WA	11,507	6,326	5,157	58,802	2,176	19,757	373	281	0	**104,384**

Solar Resources

The solar resource available outside the Earth's atmosphere is immense and always available. The solar radiation that gets filtered through the atmosphere with its accompanying clouds, moisture, pollution, etc. is still enormous, though availability follows daily and seasonal patterns occasionally interrupted by weather events. The challenge in working with the solar resource for electricity generating applications is that the resource is relatively diffuse and unconcentrated.

For making electricity, only bands of the solar spectrum within the visible light wavelengths are utilized and the objective for PV manufacturers is to utilize as much of that available energy as possible. For heating applications, whether for space (air) or materials (mass), the light energy is transformed into heat energy as it strikes a surface and is absorbed.

In the continental U.S., the intensity of solar radiation during the middle 6-8 hours of the day is usually in the 500-1000 W/m^2 range. A daily pattern of insolation intensity can be seen in the graph below.

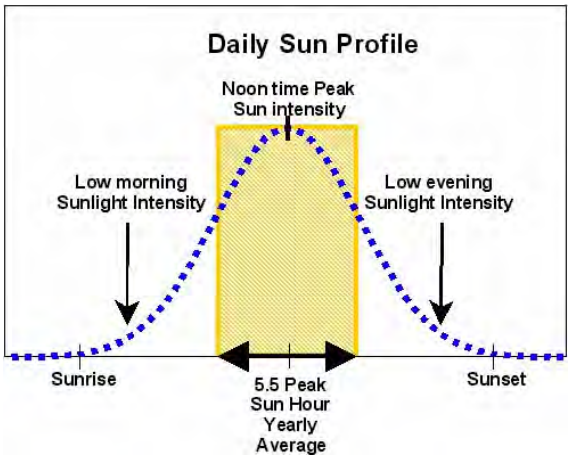

Figure A-9: Daily insolation pattern integrated into a yearly average of 5.5 sun-hours/day

Source: http://www.solarexpert.com/grid-tie/system-performance-factors.html

To facilitate climate comparison and predict system performance, the amount of solar radiation that falls on a collector throughout the day has been integrated to determine the area under the curve. The conventional level of intensity is 1,000 W/m2 (1kW/m2) termed peak sun-hours. The solar resource at a site is often reported in sun-hours/day which equates to kWh/ m^2/day. There have been extensive weather data collection efforts throughout the U.S. for number of years and with a wide variety of data collectors, end users and end uses in mind.

The solar radiation resource data that was selected for resource analysis for USCG with particular solar technology applications in mind were chosen for three primary application purposes:

- Solar hot water or photovoltaic (PV) systems that are most commonly operated at a fixed tilt angle that corresponds to the local latitude
- Transpired solar collectors that mostly commonly are added on to or affixed in front of vertical south-facing exterior walls
- Horizontal roof-mounted PV systems that have gained popularity due to relative installation simplicity

An important point to note, and an advantage of solar compared to other renewable resources, is the fact that the variation of the solar resource from best-to-worst locations varies by roughly a factor of 2.5. This means that a solar project can be done essentially anywhere, though 2.5 times as many square feet of PV or solar collector might be needed for a location with a low solar resource vs. a location with a high solar resource. The key parameters for determining cost effective applications will be highly influenced by other site specific factors beyond solar resource alone.

A.2.4.1 Solar Ventilation Air Preheat

Solar ventilation air preheating (SVP) systems use the sun's heat to warm air before it is brought into the building's HVAC system. Adding inexpensive hot air generated on cold sunny days to the supply air of an HVAC system can lower heating bills.

The system consists of metal siding perforated with small holes. The sun heats the special metal siding (a metal sheathing perforated with small holes) that covers a portion of the south-facing exterior wall of a building. The sheathing leaves an 8 to 10 cm plenum into which heat is drawn through the holes. Solar radiation heats the plate, which loses heat to the air, but the air is drawn into a small hole before the thin "boundary layer" can mix with the ambient air. The warm air is added to ventilation air by means of a fan.

SVP systems use a "transpired collector" with holes about 1 mm in diameter and about 9 mm apart in a metal absorber sheet painted black or other dark, light-absorbing color. At this small scale, heat transfer is by conduction rather than convection and air flow is by viscosity rather than momentum.

The transpired collector plate is held about six inches away from the south wall by supports to create a plenum. Air is drawn through the wall by power of a fan. The perimeter is sealed with flashing. It is only for preheating ventilation air; there is no recirculation to the inlet for reheating. A by-pass damper on the face

of the wall admits fresh air without heating in summer. Figure A-11 illustrates how an SVP system works.

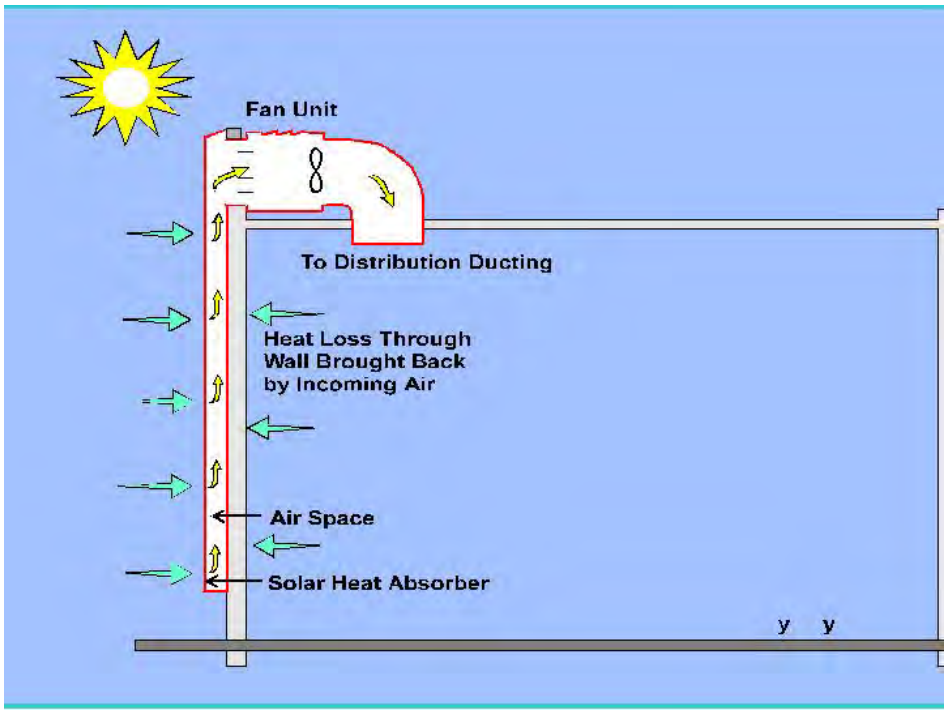

Figure A-10: Solar ventilation air preheating system schematic

SVP are very low maintenance systems as there is only one moving part, the fan. Due to the low cost of this simple technology (about $20/sf installed) and its high efficiency, over 2 million sf have been installed, mostly in manufacturing plants in the Northeast and in Canada.

Savings at each site depend on both the solar resource and the heating degree days for that site. Solar ventilation preheat is generally cost effective at the northern sites that can use the heat through much of the year. A site with a heating season of 4 months or longer could consider this technology. The SVP system on a US Bureau of Reclamation water treatment plant in Leadville, Colorado cost $28,000 and saves $4,000 per year. Figure 15 shows the distribution of the solar resource.

Figure A-11: Solar ventilation air preheating system in Leadville, Colorado

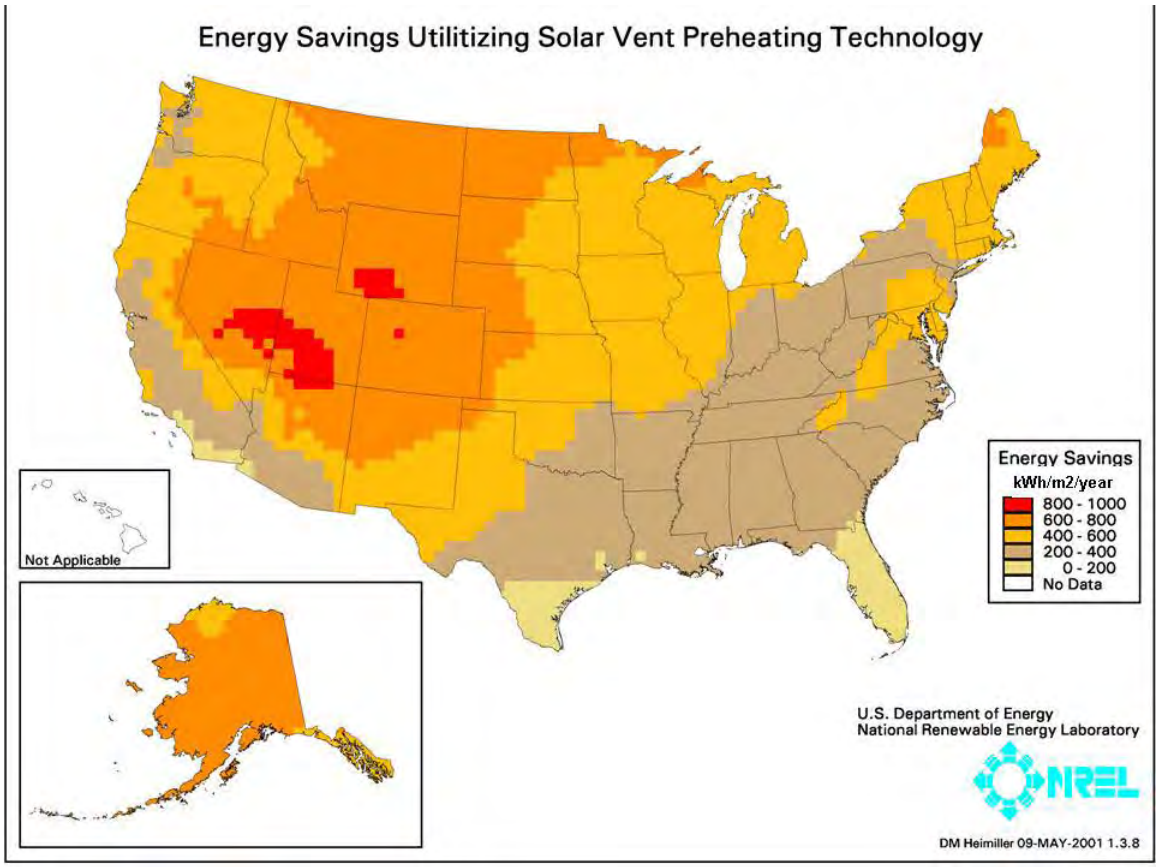

Figure A-12: Map of energy savings from solar ventilation preheating technology

The size of a solar ventilation air preheating system is determined by the optimization, but there are some constraints. For a given amount of ventilation air the suggested size is given by the equation

$A_C = V_{bldg} / v_{wall}$

where

- A_C = solar collector area (ft^2 or m^2), might be limited by available wall area.
- V_{bldg} = building outside air flow rate (CFM or l/min)
- v_{wall} = per-unit-area airflow through wall (CFM/ft^2 or l/min/m^2, typically 4 to 8 CFM/ft^2. If wall area is sufficient, use the lower value of 4 CFM/ft^2.

The size of the south-facing wall is a constraint. CFM/ft^2 is also a constraint, so that the boundary-layer effect that leads to the high efficiency is valid.

Energy delivered by the solar ventilation air preheating system and fuel energy saved are calculated by the equations

$Q_{solar} = A_c\, q_{useful} * (\#days/week/7) / \eta_{heating}$

and

$Q_{saved} = Q_{solar} / \eta_{heating}$

where

- Q_{solar} = annual heat delivery of solar system (kWh/yr or Mbtu/yr)
- Q_{saved} = annual fuel energy saved (kWh/yr)$\eta_{heating}$ = heating system efficiency

Additional fan power required to pull the ventilation air through the solar ventilation preheat system is calculated by the equation

$Q_{fan} = A_c\, q_{fan} * (\#hours/day * \#days/week * \#weeks/year)$

where

- q_{fan} = fan energy required to pull air through collector (taken to be 1 W/ft^2 for this analysis).

Solar ventilation air preheating system cost is estimated as per the total installed cost in Table A-8.

Table A-8: Characteristics of Solar Ventilation Preheat Technology Used for Analysis

Material Cost	$14.00/ft^2
Installation Cost	$14.00/ft^2
Ductwork	$4.00/ft^2
Other	$4.00/ft^2
Initial Cost	$36.00/ft^2
O&M Cost	$0

Table A-9 lists the ventilation rates required for each type of space at each LPOE. Often the size is limited by the south wall area which was estimated from the LPOE site layouts provided. The GIS resource data of Table A-17 lists the resource information for the SVP technology (which combines both solar resource and heating degree day information) used in the estimation of annual energy delivery. Table B-16 lists the details of the solar ventilation preheating analysis including size of the transpired collector, cost, annual energy delivery, annual cost savings, and payback period.

Table A-9: Ventilation Rates Used for Analysis

	Warehouse	Office	Lab	Residence	Other
Ventilation Rate (cfm//ft^2)	0.02	0.14	1.00	0.00	0.34

A.2.4.2 Solar Water Heating

Solar water heating systems use the sun to heat water that is stored in tanks for later use. Operation is similar to a hydronic heating system, with the solar collectors as heat sources, heat exchangers to heat potable water, pumps to circulate the fluid, expansion tanks, pressure relief valves, flush and fill valves, and controls. The conventional hot water heating system is used as a back-up to the solar system. Buildings at LPOE sites that use expensive electricity or propane to heat water will benefit from adding solar water heating systems when expanding or remodeling.

There are three types of solar water heating collectors:

1. Unglazed plastic collectors for low temperatures such as swimming pool heating;
2. Glazed, insulated flat plate collectors for mid-temperature service hot water; and
3. Evacuated tube collectors with reflectors for high temperature applications.

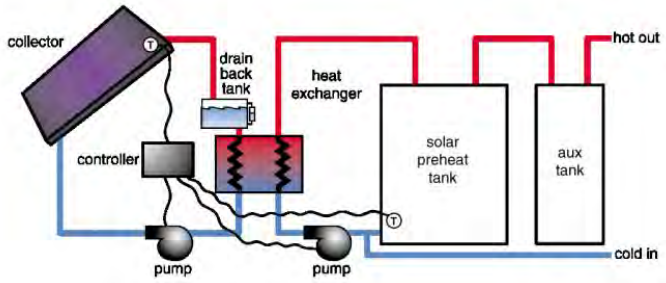

Figure A-13: Typical solar water heating system schematic

Typical solar water-heating systems are sized to provide 40 percent to 70 percent of water-heating requirements. Typical solar pool-heating systems use unglazed polymer collectors to provide 50 percent to 100 percent of swimming pool heating requirements. Typical systems generate 1,600 therms or 46,000 kWh of energy per year and cost $0.30 to $0.50/Watt (of peak capacity). Typical flat plate collectors deliver about 900 kWh/m^2/year and cost $1/Watt to $2/Watt, or 8¢/kWh. The energy costs of solar thermal systems have declined by more than 50 percent due to technology improvements. Parabolic trough collectors with evacuated tubes cost about $1/Watt and deliver about 900 kWh/m^2/year. Key companies developing or selling solar water heaters include: Alternative Energy Technologies; Harter Industries; Aquatherm; Duke Solar; FAFCO; Heliodyne, Inc.; Radco Products; Sun Earth; Sun Systems; ThermoTechnologies; Industrial Solar Technology and Thermal Conversion Technologies. [ref. 5]

About 1.2 million solar water-heating systems have been installed in the United States, mostly from 1981 to 1986 when federal and state tax credits were in effect. Many of these buildings use expensive electricity or propane to heat water and sites should consider solar hot water when ports are expanding or remodeling.

Figure A-14: Solar water heating system at Chickasaw National Recreation Area, Oklahoma

Water heating load (gallons per day) is estimated according to the statistics available in reference [ref. 9] and listed in Table A-10.

Table A-10: Information for Water Heating Load Used for Analysis

Hot Water as Fraction of Total Building Energy		
Office	0.089506	
Education	0.21942	
Health Care	0.262063	
lodging	0.403771	
public assembly	0.153914	
food service	0.112016	
food sales	0.042623	
warehouse	0.052219	
other 15.3	0.08885	
all	0.152486	
source: DOE/OBT Energy Databook		

SDHW Efficiency	0.4	
Cost	73	$/sf
O&M Cost	0.005	% of initial cost
Aux efficiency	0.8	

Suggested size for the solar water heating system is estimated using the equation

$$A_c = \frac{L}{(\eta_{solar}\, I_{max})}.$$

where

- A_c = collector area (m^2)
- L = daily load (kWh/day)
- η_{solar}= efficiency of solar system (typically 0.429 for all locations from reference [ref. 12])
- I_{max} = maximum daily solar radiation (kWh/m^2/day)

Using I_{max} in the above equation means the system is designed to meet the load on the sunniest days of the year. This sizing strategy optimizes economic performance since there is no excess capacity. Annual Energy Savings (kWh/year) is estimated by the equation

$$E_s = \frac{A_c\, I_{ave}\, \eta_{solar}\, 365}{\eta_{boiler}}$$

where

- I_{ave} = average solar radiation (kWh/m^2/day)
- η_{boiler} = auxiliary heater efficiency.

Auxiliary water heater efficiency is taken from reference [ref. 16] for different types of water heaters:

- gas 0.43 to 0.86, assume 0.57;
- electric 0.77 to 0.97, assume 0.88;
- heat pump assume 2.0;
- propane 0.42 to 0.86, assume 0.57;
- oil 0.51 to 0.66, assume 0.52.
- If fuel use was not provided electricity was assumed to be used for water heating.

Solar system cost is estimated according to the formula

$$C = (c_{solar}\, A_c\text{-rebate})*(1\text{-federal tax credit})*(1\text{-state tax credit})$$

where

- C = installed cost of solar system ($)
- c_{solar} = per-unit-area cost of installed solar system ($/$m^2$), typically $400/$m^2$ for large systems up to $1200/$m^2$ for small systems. $73/sf ($800/m^2)

is the value used in this analysis. Any incentives, in terms of %-of-cost rebate or $ per m^2 rebate are subtracted from the installed cost.

Annual cost savings is estimated by the equation

$S = E_S C_e - C_{O\&M} + Es * C_{production\ incentive}$

where

- S = annual cost savings ($/year)
- Ce = cost of auxiliary energy ($/kWh).
- Cproduction incentive = payments or credits for delivered energy ($/kWh). The cost of energy is calculated for the water heating fuel type from use and cost data provided for each center.

Any other annual costs or revenues, such as O&M costs or production incentives, are added or subtracted from the annual cost savings.

A.2.4.3 Solar Electric Photovoltaics (PV)

Figure A-15: PV System of the type considered in report

PV modules convert sunlight directly into electricity with no moving parts, no noise, no pollution, and very little maintenance. They are highly reliable and last 20 years or longer. Solar cells are fabricated from thin semi-conductor wafers with an electric field applied to the cell to make one side positive and one side negative. When the sun's light strikes the solar cell, electrons are knocked loose from one side of the wafer and conducted from one side of the solar cell to the

other with an embedded conductor wire. This movement of electrons along the conductor wire is an electric current or electricity, which is collected and used to power any electrical device.

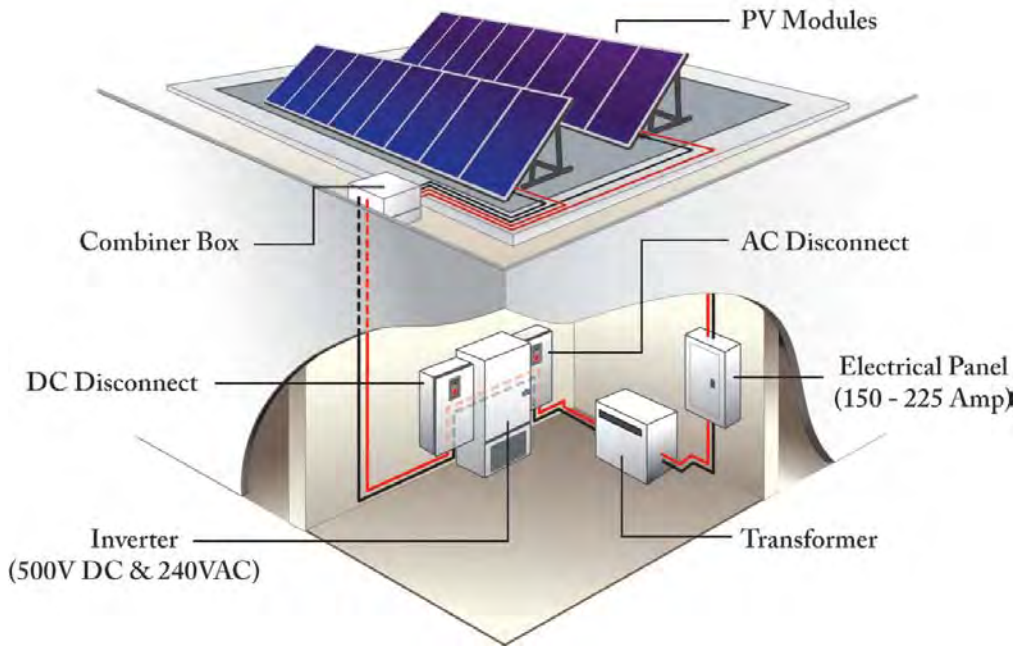

Figure A-16: Photovotaic system schematic

Over the past two decades, significant improvements have been made in the efficiency of PV materials and manufacturing costs have been driven down, yet PV is still more expensive than conventional grid electricity in the U.S. The cost of PV-generated electricity has dropped 15- to 20-fold in the last 40 years; and grid-connected PV systems currently sell for about $5/Wp to $8/Wp (20¢/kWh to 32¢/kWh), including support structures, and power conditioning. Complete system cost is reported at $8,500/kW in reference [ref. 7.]

In this analysis we represent cost as a function of size as $9.8065 multiplied by the system size in kW raised to an exponent of -0.0576. Operation and maintenance (O&M) costs are reported at 0.008 $/kWh produced in *Factors Associated with Photovoltaic System Costs*. [ref. 11]

PV's cost effectiveness is dependent to a large degree on the local, state or utility incentive programs coupled with tax-based incentives. Since the incentives are included in the model, the results point directly to locations GSA should consider PV.

About 288 MW of PV were sold in 2000, and 2,521 MW of PV were sold in 2006, indicating the growth of this industry. Annual market growth for PV has been about 25 percent as a result of reduced prices, government incentives and successful global marketing. Hundreds of applications are cost-effective for off-grid needs. Almost two-thirds of U.S.-manufactured PV is exported. However, the fastest growing segment of the market is grid-connected PV, such as roof-mounted arrays on homes and commercial buildings in the United States. California is subsidizing PV systems because it is considered cost-effective to reduce their dependence on natural gas, especially for peak daytime loads for air-conditioning, which matches PV output. [ref. 6]

Current leading PV companies in the U.S. include: Shell Solar; BP Solar; RWE (ASE); AstroPower (now GE); USSC; Global Solar; First Solar; Evergreen Solar; and others totaling 104 MW of rated power production manufactured per year. [ref. 15]

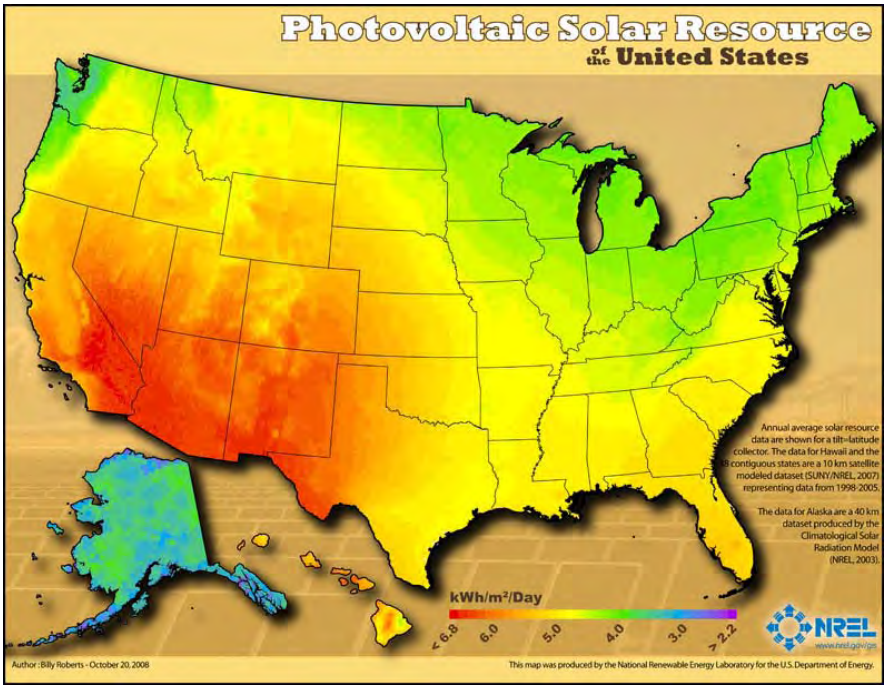

Figure A-17: Solar Resource across the U.S.

The size of the PV system in kW of rated output is determined by the optimization. In the analysis below, note that units of I, solar radiation, are (sunhours/day). This unit has the same value as (kWh/m^2/day) in the data because photovoltaic devices are rated at 1 kW/m^2 radiation. Solar System Size is:

P_{rated} = rated PV power (kW)

System efficiency is taken to be 77 percent to represent mismatch losses in the array, losses in the inverter and transformer. Annual Electric Energy Savings are estimated as

$E_s = 0.77*P_{rated}\ I_{ave}\ 365$

where
I_{ave} = average solar radiation (sun hours/day or kWh/m^2/day)

PV system cost is estimated by the equation

$C = (c_{solar}\ P_{rated}\text{-rebate})*(1\text{-federal tax credit})*(1\text{-state tax credit})$

where

- C = installed cost of solar system ($)
- c_{solar} = per-unit cost of installed solar system typically $5.1 to $9.1/watt. For this analysis we use the value $7.10/watt DC installed cost.

Annual cost savings are estimated by the equation

$S = E_s\ C_e - C_{O\&M}$

where

- S = annual cost savings ($/year)
- C_e = cost of utility energy ($/kWh)
- $C_{O\&M}$ = annual cost of operation and maintenance, taken as 0.143 percent of installed cost.

Table A-11: Characteristics of PV Technology Used for Analysis

Initial Cost	$8,500.00	$/kW	RS Means Green Building Project Planning and Cost Estimating, 2006
O&M	0.006	$/kWh	Renewable Energy Technology Characterizations, EPRI TR-109496, 1997.C185
BOS Efficiency	0.77		PVWatts documentation www.nrel.gov
Acres per MW	6.5		

A.2.4.4 Solar Industrial Process Heat and Solar Thermal Electric

Solar industrial process heat systems achieve higher temperatures at a faster speed than do other solar heat collectors. This intensity and speed make solar industrial process heat systems more suitable for various industrial applications.

The application modeled in this study is hot water heating. It is not cost effective for several reasons.

Solar industrial process heat systems use parabolic trough solar collectors to focus the sun's rays onto a receiver pipe running down the focal line of the trough. The receiver pipe is surrounded by a glass cover pipe to prevent heat loss. Motors and controls track the azimuth of the sun from east-to-west in a north-south oriented trough for maximum gain. The concentrating collectors require direct sun with minimal clouds, moisture or dust. The desert southwest, which has many clear sunny days every year, is considered the most viable region for these concentrating systems.

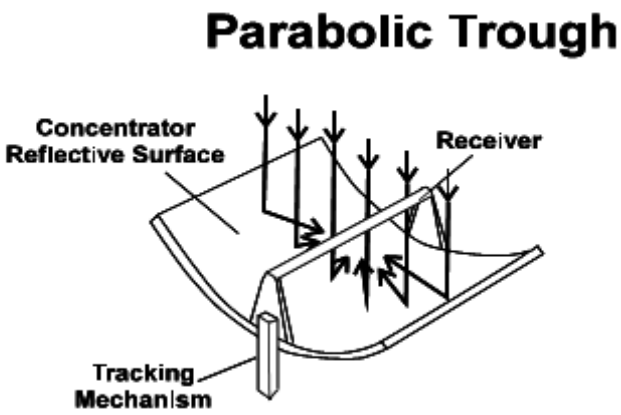

Figure A-18: Illustration of a parabolic trough solar collector

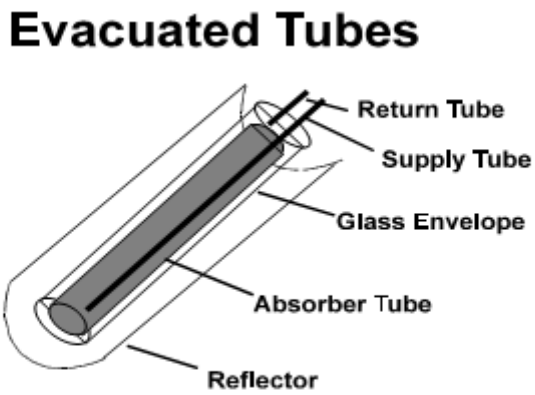

Figure A-19: Illustration of a receiver pipe

Since the system has moving parts, it requires preventative and unscheduled maintenance. In order to displace natural gas (to get to net zero), on-site thermal storage is required. Thermal storage may consist of fluid tank, tubes in sand, or tubes in concrete.

An advantage of these systems over PV is that energy storage is part of the system. The industrial process heat system, depending upon design parameters and intent, can typically perform well for several hours after sunset adding a degree of 'dispatchability' not normally associated with solar systems.

Energy savings consist of savings in natural gas and electricity. Natural gas savings are limited to the minimum of:

1. Base Case natural gas use; or
2. Renewable energy heat generating capacity.

Electric savings are limited to the minimum of electric peak, then renewable energy generation above that is treated as wholesale power to the utility. Electric savings are limited to:

1. The minimum of cogeneration size (kW); or
2. Heat generating capacity of the plant times heat-to-electric cogeneration efficiency.

Thermal energy as a by-product of electric generation is added back into the gas savings but multiplied by a heat exchanger effectiveness.

$$E_{s,\ gas} = \frac{A_c\ I_{ave}\ \eta_{solar}}{365} *(1-\eta_{cogeneration})*e_{hx}/\ \eta_{boiler}$$

$$E_{s,\ electric} = \frac{A_c\ I_{ave}\ \eta_{solar}}{365} *\eta_{cogeneration}$$

where

- I_{ave} = average solar radiation (kWh/m^2/day)
- $\eta_{cogeneration}$ is the efficiency of the electric generator
- e_{hx} is the effectiveness of the heat recovery heat exchanger
- η_{boiler} = auxiliary heater efficiency.

Solar thermal or solar thermal electric was not found to be cost effective at any of the LPOE sites. GSA's LPOE sites have limited hot water loads and do not require the intensity and speed offered by solar industrial process heat systems.

Table A-12: Characteristics of Solar Industrial Process Heat Technology Used for Analysis

Solar Thermal Cost	60	$/sf
O&M Cost	$0.127	$/therm/yr
Efficiency	0.33	
Cost of Thermal Storage	$1,465	$/therm
Hours Per Day of Solar Collection	6	
Cogen Cost	1650	$/kW
Cogen Efficiency	0.2	
Boiler Capacity Factor	0.85	
Hx Effectiveness	0.7	
Federal Production tax Credit	0.01	$/kwh

A.3 Site-Specific Information

GSA staff provided utility use and cost information for each LPOE. GSA also provided details regarding the square footages of different types of space in each LPOE. GSA did not provide an inventory of waste streams for use in the biomass fuel assessment, so only feedstocks from the surrounding area were considered. Table A-13 presents a summary of data provided for each site.

Sites considered in San Luis AZ, Donna TX, and McAllen TX had not been built yet at the time of the analysis. In these cases a 10,000 square foot building was considered and energy use and cost were estimated by the square-footage average of other sites in that state. The titles for these sites in the following tables have “not built” in the name.

Table A-14, A-15, and A-16 provide the base case consumption and cost information for electricity, oil, and natural gas, respectively.

Table A-13: Location and Size of the 119 LPOE Sites

	Address	City	State	Bldg Size (ft^2)	Warehouse Area (ft^2)	Office Area (ft^2)	Laboratory Area (ft^2)	Residential Area (ft^2)	All Other Area (ft^2)	Land Size (acres)
Dalton Cache, AK			AK	14,942	300	0	0	5,820	8,822	18
Alcan, AK	M 1221 8 Tenths Ak Highway	Tok	AK	54,972	894	0	18,420	26,072	9,586	55
Skagway, AK	Klondike Highway	Skagway	AK	6,565	0	0	0	0	6,565	8
Lukeville, AZ	190 North Highway	Lukeville	AZ	35,775	0	17,157	7,118	11,500	0	6
Nogales, AZ	International and Grand	Nogales	AZ	107,344	0	106,182	442	0	720	40
Sasabe, AZ	International Boundary	Sasabe	AZ	15,502	0	7,764	639	0	7,099	2
Douglas, AZ	FMCSA Modular Inspection Facility	Douglas	AZ	67,317	0	66,311	1,006	0	0	3
San Luis, AZ	FMCSA Inspection Facility	San Luis	AZ	54,773	0	38,443	0	0	16,330	2
Naco, AZ	FMCSA Vehicle Inspection Facility	Naco	AZ	23,181	0	22,701	0	0	480	1
San Luis AZ, not built	County 25th Street and	San Luis	AZ	10,000	0	0	0	0	10,000	9
Nogales, AZ	New Site Border Station	Nogales	AZ	99,955	0	99,955	0	0	0	8
Calexico West, CA		Calexico	CA	138,180	0	137,549	631	0	0	5
San Ysidro, CA		San Ysidro	CA	223,847	0	223,847	0	0	0	4
Andrade, CA		Adrnade	CA	9,397	0	4,617	0	4,780	0	4
Otay Mesa, CA		Otay Mesa	CA	326,899	2,384	321,462	3,053	0	0	31
Tecate, CA	US Border Station	Tecate	CA	53,684	0	48,848	0	4,836	0	60
Calexico, CA			CA	209,197	0	202,977	6,220	0	0	87
Eastport, ID	US Highway 95	Eastport	ID	12,335	570	1,200	1,310	0	9,255	2
Porthill, ID	US Border Station	Porthill	ID	4,750	505	0	0	0	4,245	1
Ferry Point, ME	Ferry Point	Calais	ME	14,710	0	12,910	1,800	0	0	1
Coburn Gore, ME	State Route 27	Coburn Gore	ME	14,291	0	5,897	0	8,394	0	4

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	Address	City	State	Bldg Size (ft^2)	Warehouse Area (ft^2)	Office Area (ft^2)	Laboratory Area (ft^2)	Residential Area (ft^2)	All Other Area (ft^2)	Land Size (acres)
Fort Fairfield, ME	Boundaryline Road	Fort Fairfield	ME	6,133	0	6,133	0	0	0	1
Houlton, ME	Interstate 95	Houlton	ME	31,844	0	29,534	2,310	0	0	6
Jackman, ME	Interboundary Line	Jackman	ME	10,881	0	9,386	1,495	0	0	4
Limestone, ME	Route 229	Limestone	ME	4,662	0	4,662	0	0	0	1
Orient, ME	US Route 1	Orient	ME	4,857	414	4,443	0	0	0	1
Vanceboro, ME	State Route 6 Water Street	Vanceboro	ME	7,364	0	6,620	744	0	0	2
VanBuren, ME	Bridge Street	Van Buren	ME	8,117	0	7,373	744	0	0	1
Milltown ME	Milltown	Calais	ME	1,136	0	1,136	0	0	0	0
St. Francis, ME	St. Francis, ME Township	Saint Francis	ME	2,098	0	2,098	0	0	0	0
Madawaska, ME	Bridge Road	Madawaska	ME	9,250	0	9,250	0	0	0	1
Fort Kent, ME	U.S. Route 1	Fort Kent	ME	9,829	0	9,829	0	0	0	1
St. Francis, ME	Usbs, Street Pamphile	St. Francis	ME	940	0	940	0	0	0	
Detroit Cargo, MI	2810 W Fort Street	Detroit	MI	78,664	0	78,664	0	0	0	22
Intl Bridge, MI	International Bridge Plaza	Sault Ste Marie	MI	73,557	0	0	0	0	73,557	
Amb. Bridge, MI			MI	387,677	0	0	0	0	387,677	
Grand Portage, MN	Highway 61 North	Grand Portage	MN	15,852	0	13,266	1,994	0	592	4
Noyes, MN	Route 1, Box 112	Noyes	MN	17,032	0	17,032	0	0	0	2
Roseau, MN	State Highway 310	Roseau	MN	25,927	0	0	0	0	25,927	
Intl Falls, MN	2nd Avenue	International Falls	MN	11,954	0	11,954	0	0	0	2
Baudette, MN	International Bridge, Highway 72	Baudette	MN	8,758	0	8,758	0	0	0	0
Chief Mt, MT	Main Port Building	Babb	MT	9,409	0	7,682	237	0	1,490	1
Piegan, MT	Apartments House	Babb	MT	95,638	3,779	17,894	0	69,643	4,322	63
Raymond, MT	Main Port Building	Raymond	MT	35,409	0	35,409	0	0	0	9
Rooseville, MT	Main Port Building	Eureka	MT	28,131	9,513	12,220	0	0	6,398	25
Sweetgrass, MT	Main Port Building	Sweetgrass	MT	42,147	0	0	0	0	42,147	

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Turner, MT	Main Port Building	Turner	MT	7,695	243	6,564	0	0	888	0
Ambrose, ND	Main Port Building	Ambrose	ND	6,705	0	6,705	0	0	0	7
Dunseith, ND	Main Port Building	Dunseith	ND	11,606	0	11,606	0	0	0	8
Portal, ND	Main Port Building	Portal	ND	14,710	0	13,680	0	0	1,030	1
St. John ND	Main Port Building	St John	ND	5,801	0	5,801	0	0	0	5
Pembina, ND	Import Broker's Pads	Pembina	ND	45,302	0	19,841	0	0	25,461	40
Columbus, NM	Palomas & 2nd Street	Columbus	NM	21,370	0	963	0	0	20,407	10
Santa Teresa, NM	104 Santa Teresa	Santa Teresa	NM	57,418	1,252	11,510	0	0	44,656	6
Alexandria Bay, NY	Int-81	Alexandria Bay	NY	54,800	0	51,722	0	0	3,078	5
Champlain, NY	198 West Service Road	Champlain	NY	140,167	0	93,247	6,782	0	40,138	35
Massena, NY	Cornwall Bridge	Massena	NY	10,000	0	0	0	0	10,000	18
Fort Covington, NY	NYS Route 37	Fort Covington	NY	5,978	0	5,978	0	0	0	5
Rouses Pt. NY	Nys Route 276	Rouses Point	NY	10,571	0	10,571	0	0	0	1
St John Hwy, NY	Nys Route 9b	Rouses Point	NY	18,948	0	18,948	0	0	0	95
Trout, River, NY	Nys Route 30	Trout River	NY	11,427	0	11,427	0	0	0	2
Chateaugay, NY	Nys Route 374	Chateaugay	NY	6,340	0	6,340	0	0	0	1
Mooers, NY	Nys Route 22	Mooers	NY	5,504	0	5,504	0	0	0	4
Jamieson, NY			NY	1,044	0	0	0	0	1,044	
Niagra Falls, NY			NY	220,074	0	0	0	0	220,074	
Ogdensburg NY			NY	97,278	0	0	0	0	97,278	
Brownsville/Matamoros TX	1300 Mexico Blvd.	Brownsville	TX	44,348	0	415	0	0	43,933	10
Gateway, TX			TX	79,138	1,313	23,359	0	0	54,466	
Columbia, TX			TX	163,863	2,350	2,069	0	0	159,444	70
Convent, TX	100 Zaragoza Street	Laredo	TX	59,599	0	59,599	0	0	0	5
Del Rio, TX	Rio Grande	Del Rio	TX	91,914	1,102	27,170	0	0	63,642	60

Table A-13: Location and Size of the 119 LPOE Sites

	Address	City	State	Bldg Size (ft^2)	Warehouse Area (ft^2)	Office Area (ft^2)	Laboratory Area (ft^2)	Residential Area (ft^2)	All Other Area (ft^2)	Land Size (acres)
	Road									
Donna TX (not built yet)	Us Hwy 281 And Fm 493	Donna	TX	10,000	0	0	0	0	10,000	
Bridge of the Americas, TX	3600 Paisano Drive	El Paso	TX	155,333	0	61,870	0	0	93,463	27
Eagle Pass, TX	160 Garrison Street	Eagle Pass	TX	84,140	0	15,850	0	0	68,290	13
Fabens, TX	Term of Fm1109 Po 728	Fabens	TX	10,891	0	3,665	0	0	7,226	8
Fort Hancock, TX	Termination of Fm1088	Ft Hancock	TX	5,197	0	2,329	0	0	2,868	5
El Paso, TX (out leased)	1009 Stanton Street	El Paso	TX	10,000	0	0	0	0	10,000	
Juarez-Lincoln, TX	Termination I-35	Laredo	TX	214,917	0	49,697	0	0	165,220	20
Los Indios, TX	100 Los Indios Blvd.	Los Indios	TX	106,145	935	21,377	0	0	83,833	50
Laredo TX	Del Mar Blvd.	Laredo	TX	27,989	0	9,730	18,259	0	0	10
Los Tomates, TX	3300 S. Expressway 77/83	Brownsville	TX	123,720	7,054	22,743	0	0	93,923	75
McAllen, TX	2301 S. Main	McAllen	TX	30,260	0	8,756	21,504	0	0	10
McAllen TX, not built	New US Port of Entry	McAllen	TX	10,000	0	0	0	0	10,000	
Marfa, TX	300 Madrid Street	Marfa	TX	26,740	0	8,969	13,991	0	3,780	8
Kika de la Garza, TX	9901 S Cage Street	Pharr	TX	132,076	1,347	20,217	0	0	110,512	55
Paso Del Norte, TX	1000 S El Paso Street	El Paso	TX	88,179	0	50,063	0	0	38,116	11
Progreso, TX	American End Intl Bridg	Progreso	TX	31,291	0	31,291	0	0	0	
Roma, TX	405 N Estrella, Suite B	Roma	TX	41,259	0	41,259	0	0	0	
Rio Grande City, TX	313 Pete Diaz Jr.	Rio Grande City	TX	49,654	0	49,654	0	0	0	8
Ysleta, TX	797 S Zaragoza Road	El Paso	TX	165,955	11,226	39,185	0	0	115,544	91
RR Inspection, TX	2119 W Zaragosa Street	Laredo	TX	2,016	0	2,016	0	0	0	1

Table A-13: Location and Size of the 119 LPOE Sites

	Address	City	State	Bldg Size (ft^2)	Warehouse Area (ft^2)	Office Area (ft^2)	Laboratory Area (ft^2)	Residential Area (ft^2)	All Other Area (ft^2)	Land Size (acres)
Admin, TX, leased	Term of Intl Toll Bridge	Hidalgo	TX	74,401	0	74,401	0	0	0	
El Paso, TX, leased	1090 Mesa	El Paso	TX	8,698	0	8,698	0	0	0	
DOT, TX, leased	500 Adams Street	Eagle Pass	TX	73,000	0	73,000	0	0	0	
Derby Line, VT	Interstate Route 91	Derby Line	VT	11,778	0	11,778	0	0	0	7
Norton, VT	State Route 114	Norton	VT	8,031	0	8,031	0	0	0	1
Beebe Plain, VT	Main Street	Beebe Plain	VT	3,522	0	3,522	0	0	0	0
Alburg Springs, VT	US Highway	Alburg Springs	VT	3,679	440	3,239	0	0	0	1
North Troy VT			VT	6,136	0	6,136	0	0	0	1
West Berkshire,VT	State Route 118	West Berkshire	VT	7,679	0	7,679	0	0	0	2
Derby Line, VT	US Route 5	Derby Line	VT	21,135	926	17,737	2,472	0	0	3
Beecher Falls, VT	State Route 102	Beecher Falls	VT	9,730	0	9,730	0	0	0	1
Canaan, VT	State Route 102	Canaan	VT	5,005	0	5,005	0	0	0	1
East Richford, VT	357 Glen Sutton Road	Richford	VT	8,751	0	8,751	0	0	0	1
Richford, VT	705 Province Street	Richford	VT	8,148	0	8,148	0	0	0	1
Alburg, VT, joint ownership	US Border Station	Alburg	VT	3,671	0	0	0	0	3,671	1
Highgate Springs 1, VT	517 Welcome Center Road	Highgate Springs	VT	2,306	0	2,306	0	0	0	0
Highgate Springs 2, VT	482 Welcome Center Road	Highgate Springs	VT	33,776	0	33,776	0	0	0	16
Highgate Springs 3, VT	525 Welcome Center Road	Highgate Springs	VT	4,568	0	4,568	0	0	0	1
Blaine, WA	Peace Arch Border Station	Blaine	WA	33,941	0	0	0	0	33,941	3
Danville, WA	Rural Route 21	Danville	WA	8,205	750	0	0	0	7,455	1
Laurier, WA	US Border Station	Laurier	WA	9,718	0	0	0	4,780	4,938	2
Mataline Falls. WA			WA	5,830	0	0	0	1,280	4,550	6
Oroville, WA	33643 Hwy 97 N	Oroville	WA	63,665	0	0	3,999	0	59,666	8
Point Robert, WA			WA	32,555	0	0	0	0	32,555	3

Table A-13: Location and Size of the 119 LPOE Sites

	Address	City	State	Bldg Size (ft^2)	Warehouse Area (ft^2)	Office Area (ft^2)	Laboratory Area (ft^2)	Residential Area (ft^2)	All Other Area (ft^2)	Land Size (acres)
Sumas, WA	Cherry and Boundary	Sumas	WA	23,251	2,065	15,922	0	0	5,264	4
Blaine, WA	Peace Arch Border Station		WA	33,941	0	0	0	0	33,941	7
Blaine, WA	Pacific Highway Border Street	Blaine	WA	96,444	0	0	0	0	96,444	12
Kenneth Ward, WA	Lynden Border Station	Lynden	WA	17,362	0	0	0	0	17,362	5

Table A-14: Base Case Electricity Consumption and Cost

LPOE Site Name	Annual Electric Consumption (kWh)	Annual Electric Cost ($)
Champlain, NY	5,196,517	$575,518
San Ysidro, CA	4,455,623	$571,987
Otay Mesa, CA	3,396,801	$464,896
Calexico, CA	3,788,400	$459,637
Calexico West, CA	3,429,170	$415,762
Juarez-Lincoln, TX	3,930,912	$357,506
Nogales, AZ	2,888,787	$259,075
Kika de la Garza, TX	2,426,988	$255,192
Bridge of the Americas, TX	2,561,849	$253,723
Niagra Falls, NY	1,948,130	$243,753
Los Tomates, TX	2,469,400	$230,768
Blaine, WA	2,877,160	$223,828
Columbia, TX	2,132,128	$215,937
Ysleta, TX	2,114,686	$212,465
Nogales, AZ	1,862,437	$202,955
Admin, TX (leased)	2,137,357	$200,931
Los Indios, TX	2,049,130	$181,178
Gateway, TX	1,830,160	$180,637
Alexandria Bay, NY	1,152,072	$172,539
Detroit Cargo, MI	1,916,640	$165,242
San Luis, AZ	1,785,280	$159,603
Del Rio, TX	1,607,224	$156,124
Tecate, CA	1,151,457	$154,040
Paso Del Norte, TX	1,423,360	$153,678
Santa Teresa, NM	1,431,100	$153,091
Convent, TX	1,495,840	$133,657
Ogdensburg NY	861,120	$128,638
DOT, TX (leased)	1,267,873	$122,248
Pembina, ND	1,638,840	$112,108
Douglas, AZ	1,153,684	$111,917
Rio Grande City, TX	936,746	$94,218
Highgate Springs 2, VT	986,304	$94,129
Roma, TX	1,045,534	$93,707
Eagle Pass, TX	990,240	$89,082
Alcan, AK	609,740	$84,767
Brownsville/Matamoros TX	893,247	$84,724

Table A-14: Base Case Electricity Consumption and Cost

LPOE Site Name	Annual Electric Consumption (kWh)	Annual Electric Cost ($)
McAllen, TX	797,990	$77,871
Lukeville, AZ	738,760	$75,140
Sweetgrass, MT	729,244	$73,605
Oroville, WA	1,394,664	$73,310
Amb. Bridge, MI	654,160	$69,616
Blaine, WA	912,240	$67,712
Columbus, NM	540,691	$63,556
Laredo TX	681,250	$63,345
Dalton Cache, AK	165,440	$62,672
Houlton, ME	568,192	$58,709
Intl Bridge, MI	1,872,966	$58,425
Progreso, TX	616,320	$53,784
Fabens, TX	293,220	$50,598
Andrade, CA	340,940	$45,404
Blaine, WA	728,673	$45,285
Chief Mt, MT	740,893	$45,252
Point Robert, WA	698,917	$43,436
Ferry Point, ME	309,360	$42,895
Piegan, MT	546,320	$42,286
Sumas, WA	610,920	$41,519
El Paso, TX (Leased)	411,700	$41,272
Raymond, MT	824,080	$41,166
Naco, AZ	388,880	$38,150
Eastport, ID	555,761	$35,007
Skagway, AK	169,640	$34,092
Roseau, MN	479,760	$32,618
Rooseville, MT	571,200	$31,546
Derby Line, VT	269,760	$31,284
Fort Hancock, TX	259,760	$29,846
Sasabe, AZ	227,120	$29,673
Marfa, TX	320,920	$29,257
Massena, NY	443,440	$26,804
Kenneth Ward, WA	324,160	$26,165
Grand Portage, MN	265,600	$26,130
Madawaska, ME	144,158	$23,025
Fort Kent, ME	143,810	$22,591
Portal, ND	308,435	$20,460
Norton, VT	126,700	$18,329

Table A-14: Base Case Electricity Consumption and Cost

LPOE Site Name	Annual Electric Consumption (kWh)	Annual Electric Cost ($)
Derby Line, VT	133,120	$17,842
Trout, River, NY	129,392	$17,797
San Luis AZ (not built yet)	173,025	$17,464
Donna TX (not built yet)	173,025	$17,464
El Paso, TX (out leased)	173,025	$17,464
McAllen TX (not built yet)	173,025	$17,464
Beecher Falls, VT	118,794	$17,348
Jackman, ME	206,520	$16,512
Vanceboro, ME	105,591	$15,998
Rouses Pt. NY	130,276	$15,865
Coburn Gore, ME	123,802	$15,739
Noyes, MN	190,041	$15,246
Fort Covington, NY	101,040	$14,343
Richford, VT	97,268	$14,312
Intl Falls, MN	171,760	$13,193
Fort Fairfield, ME	67,164	$12,888
VanBuren, ME	111,215	$12,718
Canaan, VT	82,488	$11,820
East Richford, VT	80,263	$11,591
Chateaugay, NY	104,797	$11,382
Dunseith, ND	163,357	$10,854
Danville, WA	141,720	$10,513
Mooers, NY	86,960	$10,273
West Berkshire,VT	73,002	$9,883
Porthill, ID	142,712	$9,854
Baudette, MN	77,572	$9,583
Milltown ME	67,260	$9,576
St John Hwy, NY	191,440	$8,715
Limestone, ME	46,288	$8,546
Laurier, WA	71,210	$7,494
Highgate Springs 3, VT	48,400	$6,722
St. John ND	76,221	$6,029
Alburg, VT (Joint ownership)	41,549.40	$5,663
Beebe Plain, VT	36,354	$5,546
Alburg Springs, VT	37,186	$5,463
Ambrose, ND	58,875	$4,723
Orient, ME	26,953	$4,528
Turner, MT	15,400	$3,879

Table A-14: Base Case Electricity Consumption and Cost

LPOE Site Name	Annual Electric Consumption (kWh)	Annual Electric Cost ($)
St. Francis, ME	42,040	$3,838
St. Francis, ME	36,715	$3,279
Mataline Falls. WA	85,600	$2,893
Jamieson, NY	9,241	$1,549
North Troy VT	4,388	$957
RR Inspection, TX	8,143	$938
Highgate Springs 1, VT	2,887	$403

Table A-15: Base Case Oil Consumption and Cost

LPOE Site Name	#2 Oil Annual Consumption (therms)	#2 Oil Annual Cost ($/year)
Alcan, AK	115,330	$289,188
Highgate Springs 2, VT	58,789	$118,441
Pembina, ND	71,317	$110,407
Champlain, NY	41,277	$102,259
Raymond, MT	50,542	$97,873
Piegan, MT	34,569	$64,107
Dalton Cache, AK	14,399	$37,042
Houlton, ME	15,767	$32,300
Skagway, AK	10,717	$29,184
Coburn Gore, ME	11,088	$27,354
Derby Line, VT	13,208	$27,118
Grand Portage, MN	14,591	$22,260
Fort Kent, ME	11,180	$20,835
Derby Line, VT	8,418	$18,074
St John Hwy, NY	7,064	$17,819
Vanceboro, ME	6,252	$13,640
Rouses Pt. NY	5,557	$13,536
Noyes, MN	7,475	$13,510
Massena, NY	5,326	$13,269
Madawaska, ME	5,574	$12,116
Ferry Point, ME	5,185	$11,295
Alexandria Bay, NY	7,720	$11,017
Norton, VT	5,432	$10,819
VanBuren, ME	5,129	$10,775
Fort Hancock, TX	3,774	$9,735
Fort Fairfield, ME	4,146	$9,210
Chateaugay, NY	3,449	$9,023
Trout, River, NY	3,404	$8,227
Beecher Falls, VT	3,119	$7,125
Limestone, ME	2,884	$7,102
Richford, VT	3,239	$7,102
North Troy VT	3,379	$6,990
Fort Covington, NY	2,370	$6,073
Highgate Springs 3, VT	2,830	$5,679
Ambrose, ND	3,273	$5,628
Mooers, NY	1,999	$5,128
Jackman, ME	2,720	$5,108

Table A-15: Base Case Oil Consumption and Cost

LPOE Site Name	#2 Oil Annual Consumption (therms)	#2 Oil Annual Cost ($/year)
Canaan, VT	2,274	$5,079
East Richford, VT	2,463	$5,067
St. John ND	2,677	$4,344
West Berkshire,VT	1,877	$4,171
Dunseith, ND	3,083	$4,079
Alburg Springs, VT	1,733	$3,979
Beebe Plain, VT	1,836	$3,487
Jamieson, NY	624	$1,547
Orient, ME	670	$1,537
Milltown ME	651	$1,348

Table A-16: Base Case Natural Gas Consumption and Cost

LPOE Site Name	Annual Natural Gas Consumption (therms)	Annual Natural Gas Cost ($)
Champlain, NY	137,957	$163,698
San Ysidro, CA	145,016	$152,424
Bridge of the Americas, TX	110,012	$97,904
Detroit Cargo, MI	83,084	$84,977
Otay Mesa, CA	60,035	$71,399
Del Rio, TX	26,297	$48,259
Intl Bridge, MI	46,127	$46,947
Ysleta, TX	52,230	$46,891
Ogdensburg NY	25,392	$35,303
Chief Mt, MT	33,570	$29,852
Eagle Pass, TX	21,161	$28,561
Juarez-Lincoln, TX	21,080	$24,763
Nogales, AZ	19,476	$23,835
Roseau, MN	17,603	$21,192
Nogales, AZ	16,846	$20,639
Calexico West, CA	18,667	$18,861
Sumas, WA	15,779	$16,633
Paso Del Norte, TX	17,385	$15,795
Douglas, AZ	8,989	$15,779
Marfa, TX	10,028	$14,357
Kika de la Garza, TX	9,165	$10,526
Admin, TX (leased)	8,038	$9,553
Blaine, WA	7,749	$8,639
Santa Teresa, NM	7,386	$7,790
Kenneth Ward, WA	7,237	$7,646
Los Indios, TX	6,737	$7,463
Convent, TX	6,274	$6,867
Intl Falls, MN	5,578	$6,710
Portal, ND	6,722	$6,587
Naco, AZ	2,997	$5,669
Roma, TX	1,716	$4,715
Oroville, WA	592	$4,668
Amb. Bridge, MI	3,828	$3,970
Brownsville/Matamoros TX	3,289	$3,823
Gateway, TX	2,936	$3,553
Danville, WA	2,263	$3,336
Los Tomates, TX	2,480	$3,033
El Paso, TX (Leased)	2,305	$2,382

Table A-16: Base Case Natural Gas Consumption and Cost

LPOE Site Name	Annual Natural Gas Consumption (therms)	Annual Natural Gas Cost ($)
Rio Grande City, TX	1,497	$2,283
McAllen, TX	869	$1,806
San Luis AZ (not built yet)	1,748	$1,748
Donna TX (not built yet)	1,748	$1,748
El Paso, TX (out leased)	1,748	$1,748
McAllen TX (not built yet)	1,748	$1,748
Laredo TX	1,449	$1,738

Geographical Information System (GIS) Data on Renewable Energy Resources

NREL evaluated renewable energy technologies using GIS database of renewable energy resource information (www.nrel.gov/GIS) [ref. 1], to represent the magnitude of a renewable energy resource in the area.

NREL Datasets used in the analysis include:

- Solar radiation 40x40 km grid
- Horizontal, south-facing vertical, tilt=latitude
- Wind energy 200mx1000m grid
- Biomass resources
- Illuminance for daylighting
- Temperature and heating degree days
- State and utility incentives and utility policy [ref. 6]
- Temperature and heating degree day [ref. 1]
- City cost adjustments [ref. 7]
- Installed hardware costs [ref. 9]
- Economic parameters (discount rate, inflation rate) [ref. 2]

Information on the renewable energy resources available at each site is listed in Table A-17.

Table A-17: RE Resource Information from NREL's GIS System

LPOE Site Name	Heating Degree Days (65F)	Cooling Degree Days (65F)	Annual Average Solar tilt=lat (kWh/m^2/day)	Wind Power Density 50 m (W/m^2)	Annual Solar Vent Preheat Delivery (kWh/m^2/yr)	Annual Direct Solar on E/W 1-axis tracker (kWh/m^2/day)	Biomass total residues within 50 miles (tons/yr)
Dalton Cache, AK	8,953	0	3.5	155	575	0.0	662
Alcan, AK	12,890	34	3.9	64	728	0.0	238
Skagway, AK	8,953	0	3.5	55	670	0.0	662
Lukeville, AZ	938	4,522	6.6	95	273	5.5	65,343
Nogales, AZ	1,456	3,247	6.5	144	370	5.4	31,369
Sasabe, AZ	938	4,522	6.5	132	332	5.5	47,302
Douglas, AZ	2,380	2,462	6.5	152	411	5.3	28,912
San Luis, AZ	938	4,522	6.5	102	165	5.3	58,144
Naco, AZ	1,456	3,247	6.5	144	370	5.4	31,369
San Luis AZ (not built yet)	938	4,522	6.5	102	165	5.3	58,144
Nogales, AZ	1,456	3,247	6.5	101	357	5.4	44,637
Calexico West, CA	938	4,522	6.5	117	186	5.3	122,194
San Ysidro, CA	1,186	657	5.9	132	145	4.3	0
Andrade, CA	938	4,522	6.5	374	171	5.4	136,890
Otay Mesa, CA	1,186	657	5.9	117	145	4.3	274,453
Tecate, CA	1,186	657	5.9	117	145	4.3	274,453
Calexico, CA	938	4,522	6.5	136	177	5.4	86,732
Eastport, ID	8,068	142	4.4	31	640	3.2	161,925
Porthill, ID	8,068	142	4.3	87	640	3.0	156,636
Ferry Point, ME	9,436	180	4.1	140	588	2.7	363,624
Coburn Gore, ME	7,141	362	4.3	137	597	2.8	949,353
Fort Fairfield, ME	9,436	180	3.9	244	585	2.5	181,984
Houlton, ME	9,436	180	4.2	227	585	2.9	376,179
Jackman, ME	7,141	362	4.1	177	597	2.6	627,773
Limestone, ME	9,436	180	3.8	285	587	2.4	152,040
Orient, ME	9,436	180	4.2	164	585	2.9	472,623
Vanceboro, ME	9,436	180	4.1	174	586	2.7	374,333
VanBuren, ME	9,436	180	4.0	100	587	2.7	128,720
Milltown ME	9,436	180	4.1	140	588	2.7	363,624
St. Francis, ME	9,436	180	4.2	271	649	2.9	236,116
Madawaska, ME	9,436	180	3.9	100	608	2.6	133,883
Fort Kent, ME	9,436	180	4.0	100	608	2.7	173,304
St. Francis, ME	9,436	180	4.0	100	608	2.7	173,304
Detroit Cargo, MI	6,160	792	4.1	192	414	2.4	1,224,450

Table A-17: RE Resource Information from NREL's GIS System

LPOE Site Name	Heating Degree Days (65F)	Cooling Degree Days (65F)	Annual Average Solar tilt=lat (kWh/m^2/day)	Wind Power Density 50 m (W/m^2)	Annual Solar Vent Preheat Delivery (kWh/m^2/yr)	Annual Direct Solar on E/W 1-axis tracker (kWh/m^2/day)	Biomass total residues within 50 miles (tons/yr)
Intl Bridge, MI	8,842	173	4.0	0	508	2.6	0
Amb. Bridge, MI	8,842	173	4.0	0	508	2.6	0
Grand Portage, MN	10,019	209	4.4	350	718	3.1	52,397
Noyes, MN	10,019	209	4.2	450	722	2.8	1,739,660
Roseau, MN	10,019	209	4.3	350	671	3.0	1,924,740
Intl Falls, MN	10,019	209	3.9	250	593	2.5	405,385
Baudette, MN	7,580	700	4.4	250	526	3.0	2,370,600
Chief Mt, MT	8,631	140	4.6	378	729	3.4	755,575
Piegan, MT	8,631	140	4.6	312	729	3.3	1,036,350
Raymond, MT	8,494	481	4.5	355	738	3.3	210,761
Rooseville, MT	8,494	481	4.5	355	738	3.3	210,761
Sweetgrass, MT	8,631	140	4.7	440	729	3.5	146,770
Turner, MT	8,494	481	4.7	412	725	3.5	44,267
Ambrose, ND	8,494	481	4.4	467	766	3.1	397,155
Dunseith, ND	8,816	418	4.5	283	726	3.2	1,926,450
Portal, ND	8,816	418	4.4	425	755	3.1	672,393
St. John ND	8,816	418	4.5	532	726	3.2	1,613,610
Pembina, ND	10,019	209	4.1	315	722	2.8	1,637,400
Columbus, NM	2,380	2,462	6.5	215	521	5.4	18,740
Santa Teresa, NM	2,380	2,462	6.6	191	511	5.3	151,484
Alexandria Bay, NY	8,044	427	4.1	250	499	2.7	362,200
Champlain, NY	8,044	427	4.1	250	499	2.7	362,200
Massena, NY	8,044	427	4.2	250	458	2.8	109,570
Fort Covington, NY	8,044	427	4.1	250	458	2.7	122,505
Rouses Pt. NY	7,452	500	4.0	100	460	2.5	186,883
St John Hwy, NY	7,452	500	4.0	100	460	2.5	186,883
Trout, River, NY	8,044	427	4.1	250	474	2.7	130,174
Chateaugay, NY	8,044	427	4.0	0	488	2.6	0
Mooers, NY	7,452	500	4.1	100	460	2.7	169,616
Jamieson, NY	6,021	742	4.3	250	403	2.7	711,206
Niagra Falls, NY	6,602	547	4.0	250	391	2.4	397,286
Ogdensburg, NY	8,044	427	4.0	0	488	2.6	0
Brownsville/ Matamoros, TX	526	4,000	5.1	350	29	3.2	384,739
Gateway, TX	526	4,000	5.1	350	29	3.2	0
Columbia, TX	848	3,505	5.3	250	95	3.8	30,754

Table A-17: RE Resource Information from NREL's GIS System

LPOE Site Name	Heating Degree Days (65F)	Cooling Degree Days (65F)	Annual Average Solar tilt=lat (kWh/m^2/day)	Wind Power Density 50 m (W/m^2)	Annual Solar Vent Preheat Delivery (kWh/m^2/yr)	Annual Direct Solar on E/W 1-axis tracker (kWh/m^2/day)	Biomass total residues within 50 miles (tons/yr)
Convent, TX	848	3,505	5.3	250	95	3.8	30,754
Del Rio, TX	1,445	3,094	5.3	250	238	3.7	5,637
Donna TX (not built yet)	526	4,000	5.2	250	34	3.5	578,647
Bridge of the Americas, TX	2,380	2,462	6.5	250	511	5.2	149,230
Eagle Pass, TX	1,445	3,094	5.3	250	213	3.7	18,308
Fabens, TX	2,380	2,462	6.4	100	512	5.0	128,410
Fort Hancock, TX	2,380	2,462	6.5	100	515	5.3	113,744
El Paso, TX (out leased)	2,380	2,462	6.5	250	511	5.2	147,146
Juarez-Lincoln, TX	848	3,505	5.3	250	95	3.8	30,754
Los Indios, TX	526	4,000	5.1	250	34	3.3	529,847
Laredo TX	848	3,505	5.3	250	95	3.8	30,754
Los Tomates, TX	526	4,000	5.0	350	29	3.2	351,878
McAllen, TX	526	4,000	5.2	250	48	3.5	497,254
McAllen TX (not built yet)	526	4,000	5.2	250	48	3.5	497,377
Marfa, TX	2,380	2,462	6.4	550	457	5.2	1,515
Kika de la Garza, TX	526	4,000	5.2	250	48	3.5	518,581
Paso Del Norte, TX	2,380	2,462	6.5	250	511	5.2	146,924
Progreso, TX	526	4,000	5.2	250	34	3.4	583,127
Roma, TX	526	4,000	5.4	250	73	3.8	128,105
Rio Grande City, TX	526	4,000	5.3	250	73	3.7	275,298
Ysleta, TX	2,380	2,462	6.5	100	512	5.2	0
RR Inspection, TX	848	3,505	5.3	250	95	3.8	30,350
Admin, TX (leased)	526	4,000	5.2	250	48	3.5	480,638
El Paso, TX (Leased)	2,380	2,462	6.5	250	511	5.2	147,869
DOT, TX (leased)	1,445	3,094	5.3	250	213	3.8	18,030
Derby Line, VT	7,452	500	3.9	135	582	2.5	708,143
Norton, VT	7,452	500	3.9	235	582	2.4	896,715
Beebe Plain, VT	7,452	500	3.8	122	582	2.3	650,122
Alburg Springs, VT	7,452	500	4.0	225	460	2.5	210,955
North Troy VT	7,452	500	3.9	154	527	2.5	438,665
West Berkshire,VT	7,452	500	4.0	198	454	2.6	270,150
Derby Line, VT	7,452	500	3.9	135	582	2.5	695,009
Beecher Falls, VT	7,452	500	4.0	59	571	2.4	957,337
Canaan, VT	7,452	500	4.0	86	571	2.5	969,680

Table A-17: RE Resource Information from NREL's GIS System

LPOE Site Name	Heating Degree Days (65F)	Cooling Degree Days (65F)	Annual Average Solar tilt=lat ($kWh/m^2/day$)	Wind Power Density 50 m (W/m^2)	Annual Solar Vent Preheat Delivery ($kWh/m^2/yr$)	Annual Direct Solar on E/W 1-axis tracker ($kWh/m^2/day$)	Biomass total residues within 50 miles (tons/yr)
East Richford, VT	7,452	500	3.9	184	527	2.5	347,254
Richford, VT	7,452	500	3.9	184	527	2.5	347,254
Alburg, VT (Joint ownership)	7,452	500	4.0	225	460	2.5	210,955
Highgate Springs 1, VT	7,452	500	4.0	182	460	2.5	232,311
Highgate Springs 2, VT	7,452	500	4.0	182	460	2.5	232,311
Highgate Springs 3, VT	7,452	500	4.0	182	460	2.5	232,311
Blaine, WA	5,659	18	3.9	156	460	2.5	104,384
Danville, WA	6,664	416	4.4	33	552	3.1	300,499
Laurier, WA	6,664	416	4.3	30	552	3.0	332,676
Mataline Falls. WA	6,664	416	4.3	30	552	3.0	332,676
Oroville, WA	6,664	416	4.6	37	516	3.2	97,106
Point Robert, WA	6,664	416	4.6	37	516	3.2	97,106
Sumas, WA	5,659	18	3.9	156	460	2.5	104,384
Blaine, WA	5,659	18	3.9	156	460	2.5	104,384
Blaine, WA	5,659	18	3.9	156	460	2.5	104,384
Kenneth Ward, WA	5,659	18	3.9	156	460	2.5	104,384

Cost Adjustment Factors

The initial cost of each technology is estimated from the technology characterizations adjusted for the city cost adjustment factors for each location from RS Means and Co. The city cost adjustments are for composite project cost including both materials and labor and are listed in Table A-18.

Table A-18: City Cost Adjustments for Composite Project Cost – Materials and Labor

LPOE Site Name	Nearest City for Which Cost Adjustment Factor is Published	RS Means & Co. City Cost Adjustment Factor
Dalton Cache, AK	Juneau AK	1.192
Alcan, AK	Juneau AK	1.192
Skagway, AK	Juneau AK	1.192
Lukeville, AZ	Tucson AZ	0.865
Nogales, AZ	Tucson AZ	0.865
Sasabe, AZ	Tucson AZ	0.865
Douglas, AZ	Tucson AZ	0.865
San Luis, AZ	Tucson AZ	0.865
Naco, AZ	Tucson AZ	0.865
San Luis AZ (not built)	Tucson AZ	0.865
Nogales, AZ	Tucson AZ	0.865
Calexico West, CA	San Diego CA	1.051
San Ysidro, CA	San Diego CA	1.051
Andrade, CA	San Diego CA	1.051
Otay Mesa, CA	San Diego CA	1.051
Tecate, CA	San Diego CA	1.051
Calexico, CA	San Diego CA	1.051
Eastport, ID	Couer D/Alene ID	0.97
Porthill, ID	Couer D/Alene ID	0.97
Ferry Point, ME	Machias ME	0.865
Coburn Gore, ME	Machias ME	0.865
Fort Fairfield, ME	Machias ME	0.865
Houlton, ME	Machias ME	0.865
Jackman, ME	Machias ME	0.865
Limestone, ME	Machias ME	0.865
Orient, ME	Machias ME	0.865
Vanceboro, ME	Machias ME	0.865
VanBuren, ME	Machias ME	0.865
Milltown ME	Machias ME	0.865

Table A-18: City Cost Adjustments for Composite Project Cost – Materials and Labor

LPOE Site Name	Nearest City for Which Cost Adjustment Factor is Published	RS Means & Co. City Cost Adjustment Factor
St. Francis, ME	Machias ME	0.865
Madawaska, ME	Machias ME	0.865
Fort Kent, ME	Machias ME	0.865
St. Francis, ME	Machias ME	0.865
Detroit Cargo, MI	Detroit MI	0.982
Intl Bridge, MI	Detroit MI	0.982
Amb. Bridge, MI	Detroit MI	0.982
Grand Portage, MN	Duluth MN	1.049
Noyes, MN	Duluth MN	1.049
Roseau, MN	Duluth MN	1.049
Intl Falls, MN	Duluth MN	1.049
Baudette, MN	Duluth MN	1.049
Chief Mt, MT	Havre MT	0.904
Piegan, MT	Havre MT	0.904
Raymond, MT	Havre MT	0.904
Rooseville, MT	Havre MT	0.904
Sweetgrass, MT	Havre MT	0.904
Turner, MT	Havre MT	0.904
Ambrose, ND	Minot ND	0.868
Dunseith, ND	Minot ND	0.868
Portal, ND	Minot ND	0.868
St. John ND	Minot ND	0.868
Pembina, ND	Minot ND	0.868
Columbus, NM	Las Cruces NM	0.893
Santa Teresa, NM	Las Cruces NM	0.893
Alexandria Bay, NY	Niagara Falls NY	1.015
Champlain, NY	Niagara Falls NY	1.015
Massena, NY	Niagara Falls NY	1.015
Fort Covington, NY	Niagara Falls NY	1.015
Rouses Pt. NY	Niagara Falls NY	1.015
St John Hwy, NY	Niagara Falls NY	1.015
Trout, River, NY	Niagara Falls NY	1.015
Chateaugay, NY	Niagara Falls NY	1.015
Mooers, NY	Niagara Falls NY	1.015
Jamieson, NY	Niagara Falls NY	1.015
Niagra Falls, NY	Niagara Falls NY	1.015

Table A-18: City Cost Adjustments for Composite Project Cost – Materials and Labor

LPOE Site Name	Nearest City for Which Cost Adjustment Factor is Published	RS Means & Co. City Cost Adjustment Factor
Ogdensburg, NY	Niagara Falls NY	1.015
Brownsville/ Matamoros, TX	McAllen TX	0.833
Gateway, TX	McAllen TX	0.833
Columbia, TX	McAllen TX	0.833
Convent, TX	McAllen TX	0.833
Del Rio, TX	McAllen TX	0.833
Donna TX (not built)	McAllen TX	0.833
Bridge of the Americas, TX	McAllen TX	0.833
Eagle Pass, TX	McAllen TX	0.833
Fabens, TX	McAllen TX	0.833
Fort Hancock, TX	McAllen TX	0.833
El Paso, TX (out leased)	McAllen TX	0.833
Juarez-Lincoln, TX	McAllen TX	0.833
Los Indios, TX	McAllen TX	0.833
Laredo TX	McAllen TX	0.833
Los Tomates, TX	McAllen TX	0.833
McAllen, TX	McAllen TX	0.833
McAllen TX (not built)	McAllen TX	0.833
Marfa, TX	McAllen TX	0.833
Kika de la Garza, TX	McAllen TX	0.833
Paso Del Norte, TX	McAllen TX	0.833
Progreso, TX	McAllen TX	0.833
Roma, TX	McAllen TX	0.833
Rio Grande City, TX	McAllen TX	0.833
Ysleta, TX	McAllen TX	0.833
RR Inspection, TX	McAllen TX	0.833
Admin, TX (leased)	McAllen TX	0.833
El Paso, TX (Leased)	McAllen TX	0.833
DOT, TX (leased)	McAllen TX	0.833
Derby Line, VT	Burlington VT	0.861
Norton, VT	Burlington VT	0.861
Beebe Plain, VT	Burlington VT	0.861
Alburg Springs, VT	Burlington VT	0.861
North Troy VT	Burlington VT	0.861
West Berkshire,VT	Burlington VT	0.861
Derby Line, VT	Burlington VT	0.861

Table A-18: City Cost Adjustments for Composite Project Cost – Materials and Labor

LPOE Site Name	Nearest City for Which Cost Adjustment Factor is Published	RS Means & Co. City Cost Adjustment Factor
Beecher Falls, VT	Burlington VT	0.861
Canaan, VT	Burlington VT	0.861
East Richford, VT	Burlington VT	0.861
Richford, VT	Burlington VT	0.861
Alburg, VT (Joint ownership)	Burlington VT	0.861
Highgate Springs 1, VT	Burlington VT	0.861
Highgate Springs 2, VT	Burlington VT	0.861
Highgate Springs 3, VT	Burlington VT	0.861
Blaine, WA	Everett WA	1.011
Danville, WA	Everett WA	1.011
Laurier, WA	Everett WA	1.011
Mataline Falls. WA	Everett WA	1.011
Oroville, WA	Everett WA	1.011
Point Robert, WA	Everett WA	1.011
Sumas, WA	Everett WA	1.011
Blaine, WA	Everett WA	1.011
Blaine, WA	Everett WA	1.011

A.4 Optimization Technique

The objective of the optimization problem is to minimize life-cycle cost. An excel spreadsheet was prepared to estimate the cost and savings associated with each renewable energy measure and the life-cycle cost for energy use at each LPOE. A computer program named “Premium Solver” from Frontline Systems was then used to adjust each of the following variables to minimize life-cycle cost:

- kW of PV
- kW of wind power
- Square feet of Solar ventilation air preheating
- Square feet of solar water heating
- Square feet of solar thermal (parabolic troughs) and kW of solar thermal electric
- BTU/hour of biomass boiler capacity and kW of biomass electric using:
  - Combustion

    - Gasification
    - Anaerobic Digestion
- Percentage of office, packaging and warehouse roofs to be occupied by daylighting skylights.

Life-cycle cost was calculated for the RE Solutions Case and for the Base Case by adding initial cost to any annual costs inflated over time and discounted to their present value. Initial cost used for the Base Case was zero. Initial costs for the RE Solutions Case were taken from NREL assessments and data of each RE industry. Annual costs for both the RE Solutions Case and the Base Case include maintenance, fuel, standby charges from the utility, payments to the utility associated with the difference between retail and delivered power, any production incentives, or other cash flows.

The discount rate (4.6 percent) and energy cost escalation rates were used according to regulation 10CFR436. [2] The regulation specifies a maximum analysis period of 25 years for mechanical and electrical equipment, and the renewable energy measures considered here may be expected to last that long. In order to model costs which are not constant from year to year, such as accelerated depreciation, a 25-year cash flow analysis was prepared.

The life-cycle cost analysis discounted all costs over a 25-year analysis period to their present worth. RE projects with life-cycle costs lower than the Base Case are good options. Life-cycle cost results were used to calculate return on investment. Cost-effective RE projects have rates of return higher than the discount rate used in the life-cycle analysis (4.6 percent).

The solver routine calculates the change in life-cycle cost associated with a change in the size of each of the renewable energy technologies and then moves in the direction of LCC by an amount determined by a quadratic approximation (Figure A-20).

The solver routine finds the minimum life-cycle cost in 13 variables, but only two variables can be illustrated in this two-dimensional figure. An increase and decrease in the size of each RE component is used to indicate direction of reducing life-cycle cost. The solver routine involved the following parameters—precision: value of energy use 0.0 +/- 0.0001; convergence: change in life-cycle cost less than $0.0001 for five iterations; quadratic extrapolation to obtain initial estimates of the variables in one-dimensional search; central derivatives used to estimate partial derivatives of the objective and constraint functions; and Newtonian Search Algorithm used at each iteration to determine the direction to search.

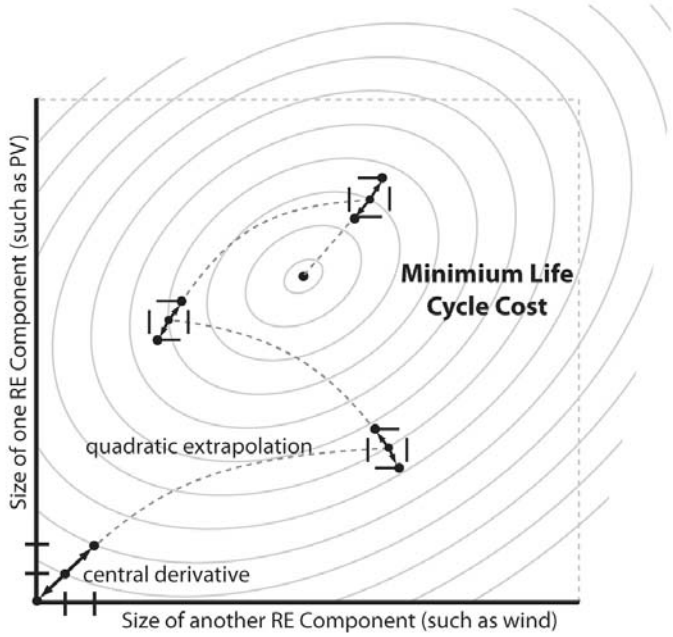

Figure A-20: Illustration of the solver routine

To further illustrate the cost effectiveness of each RE solution, simple payback period (initial cost divided by first full year of savings) was calculated and reported. Other results reported for decision makers include the percentage contribution of cost-effective RE solutions to energy use. This percentage is reported for each LPOE site and is aggregated across regions. These same cost analyses were run for the Base Case where no RE solutions are applied and for the RE Solutions Case where optimal RE technologies are used. The Base Case analyses are compared with the RE Solutions Case in several results tables.

Appendix B. Results of Life-Cycle Cost Optimization (No Tax Incentives)

The key result of the analysis is the size of each renewable-energy measure that minimizes life-cycle cost at each LPOE. Results indicate that daylighting has application at LPOE sites without excessive heat loss through skylights and solar ventilation air preheating is cost-effective at every cold-weather location that can use the heat. Other measures such as solar water heating depend on the solar resource and utility rates at a site. PV depends on local incentives to be cost effective. It is difficult to compare the sizes because they are in different units (kW, sf, Mbtu/hr, etc.) so in order to compare equal units, the annual energy delivery of each technology (Mbtu/year) is illustrated in Figure B-2.

Note that each technology is recommended as part of the optimized solution for a site, and these sizes minimize life-cycle costs. In other words, it is possible for an LPOE site to cost effectively generate more RE than the optimized solution indicates, but the life cycle costs would be higher.

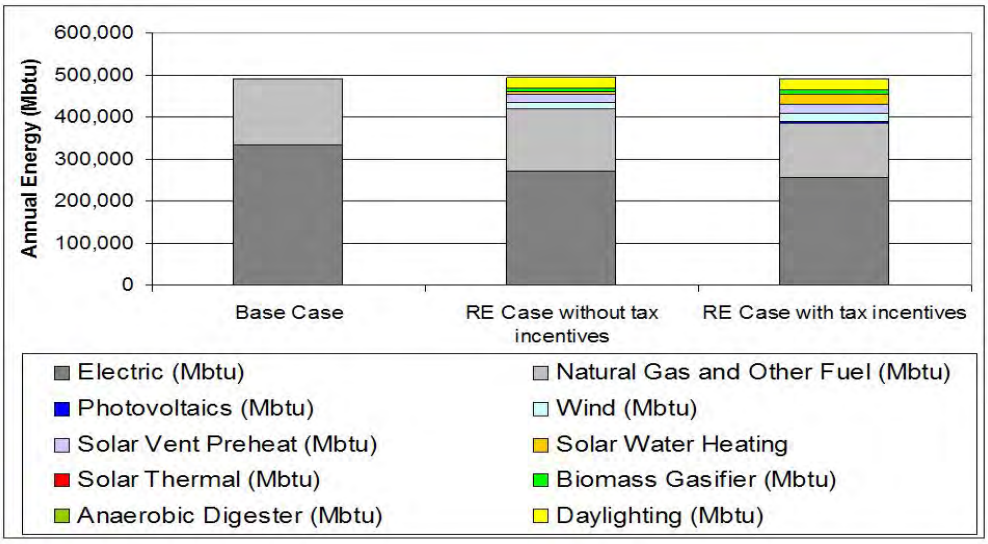

Figure B-1: Annual energy delivery of each cost-effectvie RE technology summed over all GSA LPOE

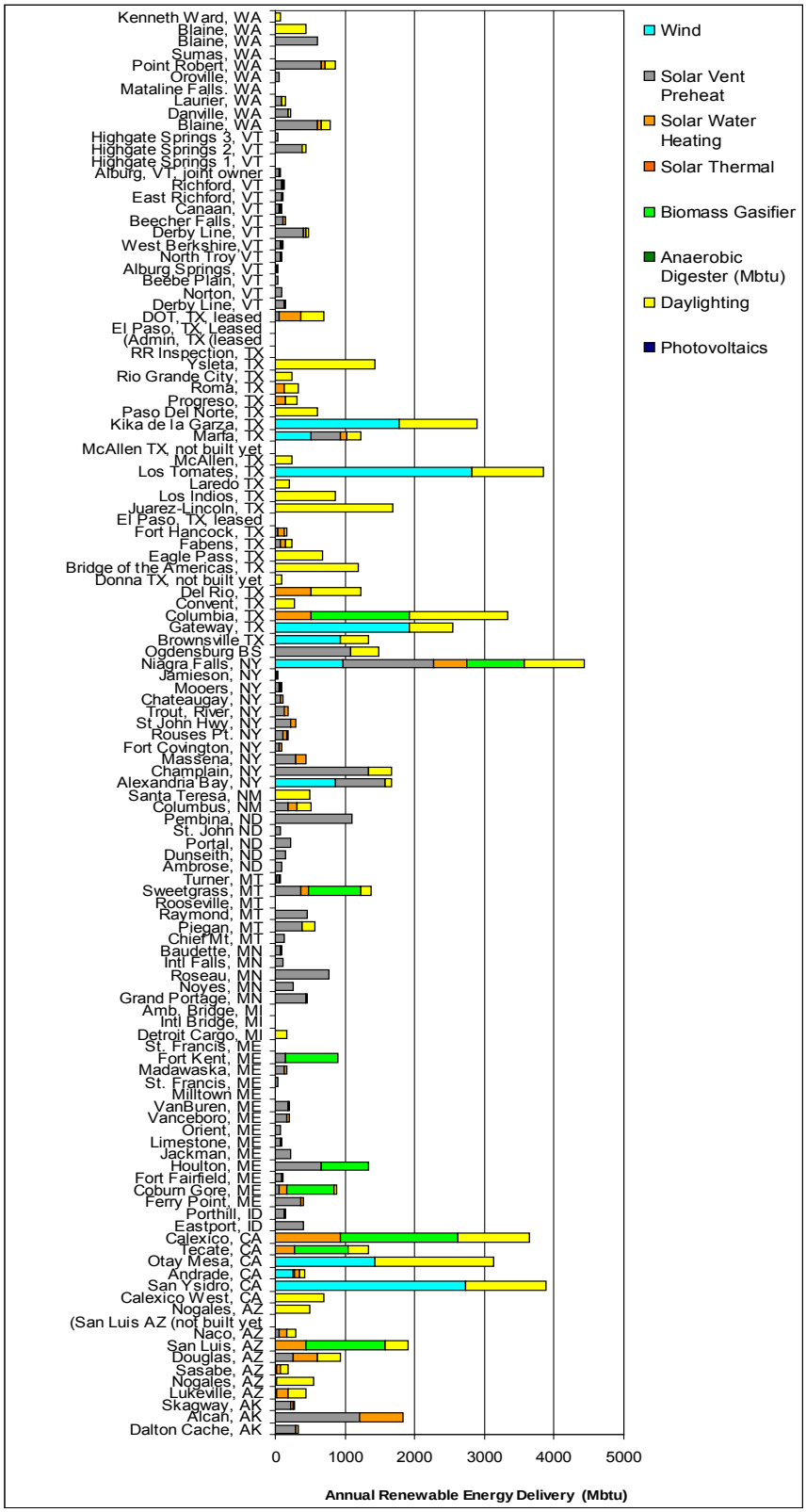

Figure B-2: Annual energy from cost-effective RE technologies at each LPOE (without tax incentives)

B.1 Renewable Energy Use v. Total Energy Use

While some LPOEs may get a large fraction of their power from cost-effective renewable energy projects on-site, and some even generate more than they use (selling excess to the utility at avoided cost), the total percentage of renewable energy use for all of the LPOEs combined would be more than 15 percent without financial incentives and 22 percent with financial incentives. Table B-2 shows results for each site without financial incentives.

Table B-1: RE Use as Percentage of Total Energy Use by GSA Region (without incentives)

	GSA Region							
Data	**1**	**2**	**5**	**7**	**8**	**9**	**10**	**Grand Total**
Sum of Base Case Energy Use (Mbtu/year)	32,101	59,543	37,033	162,773	39,936	115,340	49,782	**496,508**
Sum of RE Case Energy Use (Mbtu/year)	26,117	49,027	33,118	130,308	35,467	95,059	43,607	**412,703**
Percent Renewable Energy Use (%)	18.6%	17.6%	10.6%	19.9%	11.2%	17.6%	12.4%	**16.8%**

Table B-2: RE Use as Percentage of Total Energy Use by LPOE Site (without incentives)

LPOE Site Name	Base Case Energy Use (Mbtu/yr)	RE Solutions Case Energy Use (Mbtu/yr)	Renewable Energy Use (%)
Turner, MT	53	-21	140.8%
Niagra Falls, NY	6,647	2,093	68.5%
Laurier, WA	243	98	59.8%
Marfa, TX	2,098	845	59.7%
Coburn Gore, ME	1,531	620	59.5%
Sweetgrass, MT	2,488	1,081	56.6%
Fort Kent, ME	1,609	712	55.7%
Alburg, VT (Joint ownership)	142	71	50.2%
Orient, ME	159	83	47.6%
Columbia, TX	7,275	3,811	47.6%
Los Tomates, TX	8,674	4,820	44.4%
Brownsville/Matamoros TX	3,377	2,042	39.5%
Gateway, TX	6,538	3,998	38.9%
Houlton, ME	3,515	2,171	38.2%

Table B-2: RE Use as Percentage of Total Energy Use by LPOE Site (without incentives)

LPOE Site Name	Base Case Energy Use (Mbtu/yr)	RE Solutions Case Energy Use (Mbtu/yr)	Renewable Energy Use (%)
Derby Line, VT	1,296	804	38.0%
Andrade, CA	1,163	726	37.6%
Point Robert, WA	2,385	1,518	36.4%
RR Inspection, TX	28	18	35.8%
Tecate, CA	3,929	2,525	35.7%
Alexandria Bay, NY	4,703	3,044	35.3%
San Luis, AZ	6,091	4,072	33.1%
Baudette, MN	265	177	33.0%
Kika de la Garza, TX	9,197	6,309	31.4%
Jamieson, NY	94	65	31.2%
Porthill, ID	487	338	30.6%
Danville, WA	710	493	30.6%
Calexico, CA	12,926	9,052	30.0%
St. Francis, ME	125	88	30.0%
Columbus, NM	1,845	1,305	29.3%
North Troy VT	353	257	27.1%
Ogdensburg NY	5,477	3,998	27.0%
Ferry Point, ME	1,574	1,153	26.7%
Blaine, WA	3,113	2,309	25.8%
Trout, River, NY	782	583	25.5%
Fabens, TX	1,000	751	25.0%
Sasabe, AZ	775	584	24.7%
West Berkshire,VT	437	329	24.6%
Blaine, WA	2,486	1,882	24.3%
VanBuren, ME	892	684	23.3%
Roseau, MN	3,397	2,626	22.7%
Massena, NY	2,046	1,580	22.7%
Beecher Falls, VT	717	555	22.6%
St John Hwy, NY	1,360	1,056	22.3%
Jackman, ME	977	760	22.2%
Vanceboro, ME	985	772	21.6%
Eastport, ID	1,896	1,492	21.3%
East Richford, VT	520	409	21.3%
Douglas, AZ	4,835	3,821	21.0%
Richford, VT	656	520	20.7%
Limestone, ME	446	355	20.4%
Lukeville, AZ	2,521	2,028	19.5%
Naco, AZ	1,627	1,309	19.5%

Table B-2: RE Use as Percentage of Total Energy Use by LPOE Site (without incentives)

LPOE Site Name	Base Case Energy Use (Mbtu/yr)	RE Solutions Case Energy Use (Mbtu/yr)	Renewable Energy Use (%)
Rouses Pt. NY	1,000	808	19.3%
Grand Portage, MN	2,365	1,916	19.0%
Mooers, NY	497	402	19.0%
Noyes, MN	1,396	1,138	18.5%
Fort Covington, NY	582	476	18.2%
Otay Mesa, CA	17,593	14,455	17.8%
DOT, TX (leased)	4,326	3,557	17.8%
Fort Fairfield, ME	644	530	17.7%
Dunseith, ND	866	714	17.6%
Canaan, VT	509	419	17.6%
Chateaugay, NY	702	580	17.5%
Dalton Cache, AK	2,004	1,668	16.8%
Skagway, AK	1,651	1,373	16.8%
Del Rio, TX	8,114	6,766	16.6%
Ambrose, ND	528	442	16.3%
Alburg Springs, VT	300	251	16.3%
Progreso, TX	2,103	1,761	16.2%
Madawaska, ME	1,049	884	15.7%
St. John ND	528	450	14.7%
Alcan, AK	13,613	11,626	14.6%
Fort Hancock, TX	1,264	1,081	14.4%
Beebe Plain, VT	308	266	13.6%
San Ysidro, CA	29,704	25,820	13.1%
Portal, ND	1,725	1,511	12.4%
Eagle Pass, TX	5,495	4,811	12.4%
St. Francis, ME	143	127	11.4%
Ysleta, TX	12,438	11,017	11.4%
Los Indios, TX	7,665	6,798	11.3%
Donna TX (not built yet)	765	679	11.2%
Juarez-Lincoln, TX	15,520	13,830	10.9%
Piegan, MT	5,321	4,751	10.7%
Intl Falls, MN	1,144	1,029	10.0%
Roma, TX	3,739	3,368	9.9%
Norton, VT	976	879	9.9%
Highgate Springs 3, VT	448	406	9.5%
Milltown ME	295	268	9.1%
Paso Del Norte, TX	6,595	5,995	9.1%
Santa Teresa, NM	5,621	5,130	8.7%

Table B-2: RE Use as Percentage of Total Energy Use by LPOE Site (without incentives)

LPOE Site Name	Base Case Energy Use (Mbtu/yr)	RE Solutions Case Energy Use (Mbtu/yr)	Renewable Energy Use (%)
Pembina, ND	12,723	11,627	8.6%
Laredo TX	2,469	2,264	8.3%
McAllen, TX	2,810	2,576	8.3%
Rio Grande City, TX	3,346	3,108	7.1%
Nogales, AZ	8,039	7,485	6.9%
Derby Line, VT	2,241	2,091	6.7%
Bridge of the Americas, TX	19,742	18,554	6.0%
Raymond, MT	7,866	7,401	5.9%
Calexico West, CA	13,567	12,868	5.2%
Convent, TX	5,731	5,454	4.8%
Champlain, NY	35,654	33,994	4.7%
Highgate Springs 2, VT	9,244	8,808	4.7%
Nogales, AZ	11,804	11,310	4.2%
Blaine, WA	10,592	10,151	4.2%
Kenneth Ward, WA	1,830	1,756	4.0%
Chief Mt, MT	5,885	5,750	2.3%
Oroville, WA	4,818	4,759	1.2%
Detroit Cargo, MI	14,848	14,688	1.1%
TOTAL FOR ALL SITES (including ones with no RE Solutions)	**496,508**	**420,694**	**15.3%**

The following LPOE sites had no cost-effective RE solutions:

- San Luis AZ (not built);
- Amb. Bridge, MI;
- Intl Bridge, MI;
- Rooseville, MT;
- Admin, TX (leased);
- El Paso, TX (Leased);
- McAllen TX (not built);
- Highgate Springs 1, VT;
- Mataline Falls. WA;
- Sumas, WA.

B.2 CO_2 Emissions Avoided

For each LPOE site, electricity saved from daylighting, wind power, solar ventilation preheat, and biomass in kWh was totaled. This total was multiplied by the appropriate CO_2 offset factor for the zip code of the LPOE site. The multipliers were taken from the US EPA on-line application http://www.epa.gov/cleanenergy/energy-and-you/how-clean.html.

For each LPOE site, therms saved/produced for daylighting (negative), solar ventilation preheating, biomass, and solar water heating were multiplied by the CO_2 offset factor for natural gas of 11.64 lb/therm.

CO_2 emissions avoided from electricity saved and natural gas saved at each site were totaled and reported by region (Table B-3) and by individual sites (Table B-4).

Table B-3: CO_2 Avoided by GSA Region (without incentives)

	GSA Region							
	1	2	5	7	8	9	10	Overall
CO_2 Emissions Avoided: electricity (million lbs/yr)	0.53	1.61	0.24	9.73	0.50	7.11	1.31	21.03
CO_2 Emissions Avoided: natural gas (million lbs/yr)	0.58	0.63	0.17	0.44	0.38	0.57	0.58	**3.35**
Total CO_2 Emissions Avoided (million lbs/yr)	1.11	2.24	0.41	10.17	0.88	7.68	1.89	**24.38**

Table B-4: CO_2 Avoided by Site (without incentives)

LPOE Site Name	CO_2 prevented from natural gas savings (lbs/yr)	CO_2 prevented from electricity saved (lbs)	Total CO_2 prevented (lbs/yr)
Dalton Cache, AK	32,618	8,185	40,803
Alcan, AK	231,311	1	231,312
Skagway, AK	29,321	3,750	33,071
Lukeville, AZ	26,576	421,003	447,579
Nogales, AZ	-5,834	232,278	226,444
Sasabe, AZ	9,164	141,536	150,700
Douglas, AZ	73,202	148,080	221,282
San Luis, AZ	141,619	1,080,617	1,222,237
Naco, AZ	21,177	52,044	73,221
San Luis AZ (not built)	0	1	1
Nogales, AZ	-6,764	212,093	205,329
Calexico West, CA	-6,679	290,802	284,124
San Ysidro, CA	-14,227	850,222	835,994
Andrade, CA	12,614	274,056	286,670
Otay Mesa, CA	-21,011	704,265	683,254
Tecate, CA	91,322	406,479	497,800
Calexico, CA	252,662	2,293,549	2,546,211
Eastport, ID	47,021	165,428	212,449
Porthill, ID	17,331	42,480	59,810
Ferry Point, ME	49,004	1	49,005
Coburn Gore, ME	63,591	99,351	162,941
Fort Fairfield, ME	9,608	8,561	18,169
Houlton, ME	124,147	75,525	199,672
Jackman, ME	25,217	0	25,217
Limestone, ME	7,816	6,524	14,340
Orient, ME	5,836	6,937	12,773
Vanceboro, ME	20,294	10,544	30,838
VanBuren, ME	24,227	0	24,227
Milltown ME	2,430	1,596	4,026
St. Francis, ME	4,380	11,244	15,624
Madawaska, ME	13,694	12,872	26,566
Fort Kent, ME	63,199	96,113	159,312
St. Francis, ME	1,909	12,874	14,783
Detroit Cargo, MI	-20,031	152,131	132,099
Intl Bridge, MI	0	0	0
Amb. Bridge, MI	0	0	0
Grand Portage, MN	43,379	41,034	84,413
Noyes, MN	30,033	0	30,033

Table B-4: CO_2 Avoided by Site (without incentives)

LPOE Site Name	CO_2 prevented from natural gas savings (lbs/yr)	CO_2 prevented from electricity saved (lbs)	Total CO_2 prevented (lbs/yr)
Roseau, MN	89,728	0	89,728
Intl Falls, MN	13,370	0	13,370
Baudette, MN	10,163	46,641	56,804
Chief Mt, MT	15,677	0	15,677
Piegan, MT	19,211	107,123	126,334
Raymond, MT	54,089	1	54,091
Rooseville, MT	0	1	1
Sweetgrass, MT	95,489	372,218	467,707
Turner, MT	2,025	19,564	21,589
Ambrose, ND	10,023	1	10,024
Dunseith, ND	17,689	1	17,690
Portal, ND	24,880	1	24,882
St. John ND	9,001	1	9,001
Pembina, ND	127,622	4	127,626
Columbus, NM	40,240	308,621	348,861
Santa Teresa, NM	-1,598	194,134	192,536
Alexandria Bay, NY	61,614	238,686	300,300
Champlain, NY	101,838	165,866	267,704
Massena, NY	54,160	0	54,160
Fort Covington, NY	8,772	6,406	15,178
Rouses Pt. NY	16,320	11,088	27,408
St John Hwy, NY	35,322	1	35,322
Trout, River, NY	16,564	12,055	28,618
Chateaugay, NY	14,295	0	14,295
Mooers, NY	7,764	5,861	13,626
Jamieson, NY	2,506	1,636	4,142
Niagra Falls, NY	232,113	1,004,548	1,236,660
Ogdensburg, NY	79,618	168,138	247,756
Brownsville/ Matamoros, TX	-14	517,782	517,768
Gateway, TX	-681	987,929	987,248
Columbia, TX	171,344	1,704,380	1,875,724
Convent, TX	-2,259	114,955	112,696
Del Rio, TX	72,297	281,769	354,066
Donna TX (not built)	0	33,332	33,332
Bridge of the Americas, TX	-6,509	477,901	471,392
Eagle Pass, TX	-1,258	269,402	268,144
Fabens, TX	18,777	160,892	179,669

Table B-4: CO_2 Avoided by Site (without incentives)

LPOE Site Name	CO_2 prevented from natural gas savings (lbs/yr)	CO_2 prevented from electricity saved (lbs)	Total CO_2 prevented (lbs/yr)
Fort Hancock, TX	16,630	15,183	31,814
El Paso, TX (out leased)	0	-1,435,344	-1,435,344
Juarez-Lincoln, TX	-1,933	662,509	660,576
Los Indios, TX	-613	338,517	337,904
Laredo TX	-507	81,365	80,858
Los Tomates, TX	-671	1,497,772	1,497,101
McAllen, TX	-272	91,443	91,170
McAllen TX (not built)	0	1	1
Marfa, TX	61,581	280,919	342,501
Kika de la Garza, TX	-590	1,122,805	1,122,215
Paso Del Norte, TX	-5,589	249,095	243,506
Progreso, TX	21,084	331,540	352,624
Roma, TX	18,971	80,705	99,675
Rio Grande City, TX	-1,184	96,411	95,228
Ysleta, TX	-4,405	560,715	556,311
RR Inspection, TX	-107	7,773	7,666
Admin, TX (leased)	0	1	1
El Paso, TX (leased)	0	0	0
DOT, TX (leased)	47,154	695,143	742,297
Derby Line, VT	10,859	15,485	26,345
Norton, VT	6,288	11,592	17,880
Beebe Plain, VT	2,800	4,801	7,601
Alburg Springs, VT	3,431	5,280	8,710
North Troy VT	7,671	8,067	15,738
West Berkshire,VT	8,006	10,568	18,574
Derby Line, VT	45,016	28,720	73,736
Beecher Falls, VT	13,295	13,020	26,315
Canaan, VT	7,499	6,888	14,387
East Richford, VT	7,898	11,686	19,585
Richford, VT	11,091	10,985	22,076
Alburg, VT (Joint ownership)	5,415	19,426	24,841
Highgate Springs 1, VT	0	1,110	1,110
Highgate Springs 2, VT	34,401	38,153	72,555
Highgate Springs 3, VT	2,298	6,165	8,463
Blaine, WA	69,782	325,436	395,219
Danville, WA	18,730	14,902	33,632
Laurier, WA	9,250	38,620	47,871
Mataline Falls. WA	0	25,480	25,480

Table B-4: CO_2 Avoided by Site (without incentives)

LPOE Site Name	CO_2 prevented from natural gas savings (lbs/yr)	CO_2 prevented from electricity saved (lbs)	Total CO_2 prevented (lbs/yr)
Oroville, WA	6,886	3	6,889
Point Robert, WA	75,940	264,748	340,688
Sumas, WA	0	1	1
Blaine, WA	70,372	216,898	287,270
Blaine, WA	-24,453	172,095	147,642
Kenneth Ward, WA	-3,910	28,322	24,412
Totals (millions)	**3.35**	**21.03**	**24.38**

B.3 Initial Cost

Initial cost of $0 means the RE technology could not be sized to yield a return on investment greater than the discount rate of the life-cycle analysis (4.6 percent). PV and solar process heat were not found to be cost effective at any LPOE site without incentives.

Note that each technology is recommended as part of the optimized solution for a site, and these sizes minimize life-cycle costs. In other words, it is possible for an LPOE site to cost effectively generate more RE than the optimized solution indicates, but the life cycle costs would be higher.

Table B-5: Initial Cost of RE Technologies by GSA Region (without incentives)

	$236,602	$719,494	$96,240	$2,739,282	$158,736	$1,602,373	$336,348	**$5,889,073**
	$4,350	$1,007,008	$0	$3,040,547	$14,562	$1,501,536	$0	**$5,568,005**
	$623,082	$1,070,017	$222,167	$157,312	$373,540	$85,603	$712,677	**$3,244,397**
	$185,083	$341,784	$4,312	$580,114	$40,669	$572,870	$332,260	**$2,057,091**
	$221,424	$100,237	$81	$137,234	$83,082	$408,204	$0	**$950,262**
	$1,270,542.00	$3,238,542.00	$322,805.00	$6,654,496.00	$670,597.00	$4,170,595.00	$1,381,295.00	**$17,708,828.00**

Table B-6: Initial Costs for RE Technologies by Site (without incentives)

	Wind Initial Cost ($)	Solar Vent Preheat Cost ($)	Solar Water Heating Cost ($)	Biomass Gasifier Cost ($)	Daylighting Cost ($)	Total Initial Cost ($)
Juarez-Lincoln, TX	$1,253,512	$0	$0	$0	$316,588	$1,570,100
Niagra Falls, NY	$527,588	$512,553	$119,938	$98,311	$262,393	$1,520,782
Otay Mesa, CA	$595,107	$0	$214,833	$0	$405,135	$1,215,074
Los Tomates, TX	$933,797	$0	$0	$0	$197,511	$1,131,309
Columbia, TX	$567,630	$0	$117,830	$164,393	$252,593	$1,102,447
Kika de la Garza, TX	$848,325	$0	$0	$0	$206,342	$1,054,667
San Ysidro, CA	$768,846	$0	$0	$0	$270,670	$1,039,517
Bridge of the Americas, TX	$737,064	$0	$0	$0	$219,433	$956,498
Gateway, TX	$690,677	$0	$0	$0	$121,059	$811,736
Champlain, NY	$402,486	$229,362	$0	$0	$173,289	$805,137
Alexandria Bay, NY	$479,418	$56,770	$0	$0	$64,198	$600,386
Calexico, CA	$0	$0	$179,648	$177,412	$206,908	$563,968
Brownsville/ Matamoros, TX	$394,213	$0	$0	$0	$72,198	$466,410
Ogdensburg, NY	$0	$226,561	$0	$0	$175,361	$401,922
Alcan, AK	$0	$148,625	$219,513	$0	$1	$368,140
Sweetgrass, MT	$0	$98,160	$39,911	$91,169	$58,033	$287,272
San Luis, AZ	$0	$0	$83,316	$130,831	$69,113	$283,260
Nogales, AZ	$0	$0	$163,909	$0	$108,131	$272,040
Del Rio, TX	$0	$0	$132,905	$0	$136,352	$269,257
Ysleta, TX	$0	$0	$0	$0	$259,146	$259,146
Tecate, CA	$0	$46,845	$47,974	$87,268	$69,177	$251,264
Marfa, TX	$173,533	$0	$29,958	$0	$34,951	$238,443
Nogales, AZ	$0	$0	$110,359	$0	$120,850	$231,210
Douglas, AZ	$0	$70,483	$67,951	$0	$77,813	$216,247
DOT, TX (leased)	$0	$70,007	$71,366	$0	$72,904	$214,277
Piegan, MT	$0	$27,744	$85,509	$0	$90,607	$203,861
Houlton, ME	$0	$44,147	$61,189	$83,149	$1	$188,485
Blaine, WA	$0	$79,049	$48,829	$0	$50,389	$178,267
Andrade, CA	$137,582	$0	$16,185	$0	$12,947	$166,715
Los Indios, TX	$0	$0	$0	$0	$163,432	$163,432
Calexico West, CA	$0	$0	$0	$0	$162,694	$162,695
Blaine, WA	$0	$0	$0	$0	$162,654	$162,654
Raymond, MT	$0	$33,957	$128,247	$0	$1	$162,206
Point Robert, WA	$0	$75,821	$36,522	$0	$43,680	$156,023

Table B-6: Initial Costs for RE Technologies by Site (without incentives)

	Wind Initial Cost ($)	Solar Vent Preheat Cost ($)	Solar Water Heating Cost ($)	Biomass Gasifier Cost ($)	Daylighting Cost ($)	Total Initial Cost ($)
Coburn Gore, ME	$0	$5,655	$27,996	$79,804	$19,673	$133,128
Eagle Pass, TX	$0	$0	$0	$0	$127,361	$127,361
Paso Del Norte, TX	$0	$0	$0	$0	$117,745	$117,746
Fort Kent, ME	$0	$9,426	$0	$90,978	$12,691	$113,095
Columbus, NM	$0	$48,451	$25,652	$0	$31,569	$105,673
Roma, TX	$0	$0	$59,677	$0	$44,628	$104,305
Santa Teresa, NM	$0	$0	$0	$0	$88,329	$88,330
Lukeville, AZ	$0	$0	$34,520	$0	$48,486	$83,007
Derby Line, VT	$0	$34,070	$24,735	$0	$24,057	$82,862
Admin, TX (leased)	$0	$0	$0	$0	$79,230	$79,230
Blaine, WA	$0	$79,049	$0	$0	$1	$79,050
Pembina, ND	$0	$78,326	$0	$0	$1	$78,327
Detroit Cargo, MI	$0	$0	$0	$0	$77,868	$77,868
Progreso, TX	$0	$0	$35,031	$0	$35,880	$70,912
Dalton Cache, AK	$0	$20,588	$29,864	$0	$19,267	$69,718
Derby Line, VT	$0	$11,295	$42,775	$0	$13,963	$68,033
Kenneth Ward, WA	$0	$40,436	$0	$0	$26,495	$66,931
Highgate Springs 2, VT	$1	$32,391	$0	$0	$32,210	$64,603
Convent, TX	$0	$0	$0	$0	$62,573	$62,574
Massena, NY	$0	$23,290	$37,942	$0	$0	$61,232
Eastport, ID	$0	$31,757	$28,686	$0	$0	$60,444
Roseau, MN	$0	$60,384	$0	$0	$1	$60,384
Limestone, ME	$38,060	$4,471	$8,291	$0	$6,331	$57,152
Ferry Point, ME	$0	$24,711	$28,549	$0	$0	$53,260
Rio Grande City, TX	$0	$0	$0	$0	$52,686	$52,686
Naco, AZ	$0	$0	$22,329	$0	$29,422	$51,751
Fabens, TX	$0	$20,344	$14,545	$0	$15,729	$50,618
Skagway, AK	$0	$15,290	$24,591	$0	$8,757	$48,638
Grand Portage, MN	$0	$27,760	$0	$0	$18,372	$46,132
McAllen, TX	$0	$0	$0	$0	$44,664	$44,664
St John Hwy, NY	$0	$18,171	$25,006	$0	$0	$43,177
Rouses Pt. NY	$0	$10,138	$18,396	$0	$13,318	$41,852
Laredo TX	$0	$0	$0	$0	$40,968	$40,968
Madawaska, ME	$0	$8,871	$19,608	$0	$12,352	$40,831
Trout, River, NY	$0	$10,958	$14,638	$0	$14,368	$39,965
Vanceboro, ME	$0	$11,445	$18,061	$0	$9,855	$39,361

Table B-6: Initial Costs for RE Technologies by Site (without incentives)

	Wind Initial Cost ($)	Solar Vent Preheat Cost ($)	Solar Water Heating Cost ($)	Biomass Gasifier Cost ($)	Daylighting Cost ($)	Total Initial Cost ($)
Beecher Falls, VT	$0	$9,331	$13,754	$0	$11,985	$35,071
Fort Hancock, TX	$0	$8,913	$17,957	$0	$7,170	$34,040
Turner, MT	$14,561	$8,396	$839	$0	$10,091	$33,887
Richford, VT	$0	$7,814	$12,515	$0	$10,231	$30,561
Danville, WA	$0	$17,465	$0	$0	$11,590	$29,056
East Richford, VT	$0	$8,392	$9,928	$0	$10,725	$29,045
Laurier, WA	$0	$11,501	$3,986	$0	$13,512	$28,998
VanBuren, ME	$0	$12,167	$16,045	$0	$0	$28,212
Sasabe, AZ	$0	$0	$6,371	$0	$21,024	$27,395
Fort Fairfield, ME	$0	$5,882	$12,065	$0	$8,266	$26,212
West Berkshire,VT	$0	$7,364	$8,148	$0	$10,148	$25,660
Fort Covington, NY	$0	$5,733	$10,881	$0	$7,812	$24,426
Mooers, NY	$0	$5,278	$9,108	$0	$7,202	$21,589
Canaan, VT	$0	$4,800	$9,575	$0	$6,615	$20,990
Norton, VT	$0	$7,702	$0	$0	$12,198	$19,900
North Troy VT	$0	$5,884	$6,695	$0	$7,274	$19,854
Jackman, ME	$0	$19,242	$0	$0	$0	$19,242
Chateaugay, NY	$1	$6,080	$12,925	$0	$0	$19,006
Alburg, VT (Joint ownership)	$2,435	$8,550	$2,588	$0	$4,730	$18,302
Highgate Springs 3, VT	$0	$4,381	$8,153	$0	$5,751	$18,285
Porthill, ID	$0	$9,956	$7,680	$0	$0	$17,636
Noyes, MN	$0	$16,334	$0	$0	$0	$16,334
Portal, ND	$0	$15,518	$0	$0	$0	$15,519
Donna TX (not built)	$0	$0	$0	$0	$14,708	$14,708
El Paso, TX (out leased)	$0	$0	$0	$0	$14,295	$14,296
Orient, ME	$0	$4,318	$2,824	$0	$6,542	$13,685
Alburg Springs, VT	$0	$3,166	$5,480	$0	$4,898	$13,545
Baudette, MN	$0	$8,399	$4,572	$0	$0	$12,971
Chief Mt, MT	$0	$12,461	$0	$0	$0	$12,461
Intl Falls, MN	$0	$11,464	$0	$0	$0	$11,464
El Paso, TX (Leased)	$0	$0	$0	$0	$11,351	$11,351
Dunseith, ND	$0	$11,130	$0	$0	$0	$11,131
Milltown, ME	$0	$1,089	$5,342	$0	$1,560	$7,992
Beebe Plain, VT	$0	$3,378	$0	$0	$4,545	$7,923
Ambrose, ND	$0	$6,430	$0	$0	$0	$6,430

Table B-6: Initial Costs for RE Technologies by Site (without incentives)

	Wind Initial Cost ($)	Solar Vent Preheat Cost ($)	Solar Water Heating Cost ($)	Biomass Gasifier Cost ($)	Daylighting Cost ($)	Total Initial Cost ($)
St. John ND	$0	$5,563	$0	$0	$0	$5,563
Jamieson, NY	$0	$1,823	$1,721	$0	$1,552	$5,097
St. Francis, ME	$0	$2,012	$2,184	$0	$0	$4,196
St. Francis, ME	$0	$901	$2,641	$0	$0	$3,542
RR Inspection, TX	$0	$0	$450	$0	$2,760	$3,210
Highgate Springs 1, VT	$1,911	$0	$0	$0	$0	$1,911
Amb. Bridge, MI	$0	$0	$0	$0	$0	$0
Intl Bridge, MI	$0	$0	$0	$0	$0	$0
Oroville, WA	$0	$0	$0	$0	$0	$0
Rooseville, MT	$0	$0	$0	$0	$0	$0
Sumas, WA	$0	$0	$0	$0	$0	$0
San Luis AZ (not built)	$0	$0	$0	$0	$0	$0
McAllen TX (not built)	$0	$0	$0	$0	$0	$0
Mataline Falls. WA	$0	$0	$0	$0	$0	$0

PV and solar industrial process heat technology were not cost effective at any LPOE site without incentives. Zero initial cost indicates that the technology was not cost effective at the site.

Note that each technology is recommended as part of the optimized solution for a site, and these sizes minimize life-cycle costs. In other words, it is possible for an LPOE site to cost effectively generate more RE than the optimized solution indicates, but the life cycle costs would be higher.

B.4 Life-Cycle Cost

Life-cycle cost is calculated by adding initial cost to any annual costs discounted to their present value. Annual costs include maintenance, fuel (as in the case of biomass), standby charges from the utility, payments to the utility associated with the difference between retail and delivered power, any production incentives or other cash flows.

$$LCC = C_{initial} + (S_{energy} - C_{O\&M} - C_{biomass\ fuel})\ pwf_{25} + (S_{prod\ incentive})\ pwf_{prod\ incentive}$$

where

- LCC= life-cycle cost
- $C_{initial}$ = initial cost of renewable energy system
- S_{energy} = annual savings in electricity and natural gas purchased from utility
- $C_{O\&M}$ = annual cost of operating and maintaining renewable energy systems
- $C_{biomass\ fuel}$ = annual cost of delivering biomass fuel to the site
- pwf_{25} = present worth factor for future savings stream for 25 year lifetime and 3 percent real discount rate (specified by NIST for 2008) [ref. 2].
- $S_{prod\ incentive}$ =annual revenue from production incentive
- $pwf_{prod\ incentive}$ = present worth factor associated with the term of the production incentive

Simple payback period is not a good criterion because it does not include the analysis period or term of production incentives, but it is a useful indicator and is given by the equation
SPB = C / S

General O&M costs are escalated at the general inflation rate and annual costs for fuels and electricity are inflated according to census region and fuel type. All annual costs are discounted according to discount rate. The factors are provided in Table B-7 [ref. 2].

Table B-7: Economic Parameters Used in Life-Cycle Cost Calculations

Discount Rate	4.6%
General Inflation Rate	1.8%
Corporate Tax Rate (for case with incentives)	35%

Depreciation Schedule (for case with incentives)						
Year	1	2	3	4	5	6
Fraction	0.200	0.320	0.192	0.115	0.115	0.058

Table B-8: Fuel Escalation Rates Used in Life-Cycle Cost Calculations

State	AK	AZ	CA	ID	ME	MI	MN	MT	ND	NM	NY	TX	VT	WA
Fuel Escalation Rate	1.66%	1.66%	1.66%	1.66%	1.72%	1.48%	1.48%	1.65%	1.48%	1.65%	1.72%	1.73%	1.72%	1.66%
Electric Escalation Rate	1.25%	1.25%	1.25%	1.25%	1.42%	1.79%	1.79%	1.25%	1.79%	1.25%	1.42%	1.75%	1.42%	1.25%

Table B-9: Technology Sizes That Minimize Life-Cycle Cost by GSA Region*

	GSA Region							
Technology Size	1	2	5	7	8	9	10	Grand Total
Average Daylighting non-Office Skylight/Floor Area	3.4%	3.6%	1.6%	5%	1.1%	4.2%	2.5%	**3.5%**
Average Daylighting Office Skylight/Floor Area	3.1%	3.1%	1.4%	3.9%	1.1%	3.6%	2.3%	**3.0%**
Wind Capacity (kW)	13	384	N/A	1,763	2	1,284	N/A	**3,445 kW**
Solar Vent Preheat Area (ft^2)	11,053	40,413	13,544	5,391	11,884	4,282	19,326	**105,893 ft^2**
Solar Water Heating Area (ft^2)	4,783	3,432	63	6,923	3,486	13,967	5,475	**38,129 ft^2**
Biomass Gasifier (M Btu/h)	0.32	0.12	N/A	0.21	0.11	0.50	N/A	**1.27 Mbtu/h**
Biomass Gasifier Cogen Size (kW)	34	13	N/A	23	12	55	N/A	**137.0 kW**

* N/A means the RE technology could not be sized to yield a return on investment greater than the discount rate of the life-cycle analysis (4.6 percent). PV and solar industrial process heat were not cost effective at any LPOE site without incentives.

Note that each technology is recommended as part of the optimized solution for a site, and these sizes minimize life-cycle costs. In other words, it is possible for an LPOE site to cost effectively generate more RE than the optimized solution indicates, but the life cycle costs would be higher.

Table B-10 presents the life-cycle cost for the base case and RE solutions case at each LPOE. The base case of continuing to purchase electricity, gas, and coal has zero initial cost but high annual cost, while the RE solutions case has high initial cost but lower annual cost. Over a 25 year analysis period, the life-cycle cost of the RE case is slightly less in all LPOE sites.

Table B-11 lists the size of each RE technology that minimizes life-cycle costs as part of the optimal RE solutions case. Table B-12 and B-13 show the detailed calculations of the optimal sizes for daylighting and wind energy. Table B-14 shows the calculations for biomass gasification of dry waste. Table B-15 is a shortened version of Table B-14, showing only the LPOE sites with a simple payback period of 17 years or less. Table B-16 and B-17 show the detailed calculations of the optimal sizes for solar ventilation air preheating and solar water heating.

Table B-18 presents the ROI for the RE solutions case by LPOE site, and Table B-19 aggregates the ROI by GSA Region.

Table B-10: Life-Cycle Costs for RE Solutions Case, Base Case, and ROI (without incentives)

Name	Renewable Energy Initial Cost ($)	RE Life-Cycle O&M Cost ($)	RE Life-Cycle Biomass Fuel Cost ($)	RE Life-Cycle Gas Cost ($)	RE Life-Cycle Electric Cost ($)	RE Case Life-Cycle Cost ($)	Base Case Life-Cycle Cost ($)	Return on investment (%)
Oroville, WA	$10,415	$0	$0	$0	$1,202,343	$1,201,469	$1,254,894	44.8%
Fabens, TX	$46,957	$1,450	$0	$140,046	$482,523	$640,297	$777,609	27.4%
Sasabe, AZ	$32,691	$1,103	$0	$111,157	$255,330	$377,290	$456,025	23.3%
Columbus, NM	$95,087	$2,610	$0	$148,653	$588,539	$799,531	$976,752	19.9%
Tecate, CA	$224,279	$166,489	$39,496	$329,205	$1,294,555	$1,963,062	$2,367,343	19.7%
Santa Teresa, NM	$88,330	$0	$0	$130,137	$2,251,019	$2,422,683	$2,593,983	19.4%
Donna TX, not built	$14,708	$0	$0	$28,669	$244,750	$280,294	$307,574	18.9%
Paso Del Norte, TX	$117,746	$0	$0	$266,206	$2,183,995	$2,496,897	$2,712,162	18.7%
Baudette, MN	$16,701	$465	$39	$18	$105,303	$120,794	$147,275	18.5%
Ysleta, TX	$259,146	$0	$0	$774,624	$2,779,835	$3,642,882	$4,089,669	18.0%
Calexico, CA	$627,943	$363,280	$103,995	$1,221,774	$4,057,221	$6,069,151	$7,063,869	18.0%
Bridge of the Americas, TX	$219,433	$0	$0	$1,613,870	$3,569,154	$5,081,708	$5,452,568	17.8%
Calexico West, CA	$162,695	$0	$0	$318,844	$6,377,768	$6,739,396	$7,013,550	17.7%
Dalton Cache, AK	$78,957	$1,131	$245	$489,290	$925,961	$1,399,128	$1,521,347	17.5%
McAllen TX, not built	$0	$0	$0	$28,669	$286,424	$307,574	$307,574	n/a
Nogales, AZ	$124,450	$0	$0	$348,569	$3,011,976	$3,391,983	$3,578,824	16.5%
McAllen, TX	$44,664	$0	$0	$30,418	$1,166,614	$1,223,880	$1,290,185	16.4%
Lukeville, AZ	$95,330	$3,546	$0	$295,053	$696,666	$1,029,003	$1,154,779	15.7%
Juarez-Lincoln, TX	$316,588	$0	$0	$409,333	$5,117,021	$5,711,558	$6,146,785	15.6%
Eagle Pass, TX	$127,361	$0	$0	$470,817	$1,160,808	$1,661,380	$1,835,503	15.6%
Raymond, MT	$56,749	$1,260	$440	$1,457,616	$675,156	$1,930,963	$1,997,355	15.2%
Laredo TX	$40,968	$0	$0	$29,362	$945,194	$1,000,052	$1,053,164	15.1%
Los Indios, TX	$163,432	$0	$0	$123,356	$2,600,711	$2,835,216	$3,046,057	15.1%
Alburg, VT, joint owner	$19,095	$235	$0	$170	$46,084	$64,251	$87,027	15.0%
Rio Grande City, TX	$52,686	$0	$0	$39,986	$1,425,134	$1,495,642	$1,562,354	14.9%
Jamieson, NY	$6,298	$144	$0	$16,620	$19,167	$38,897	$46,171	14.6%
St. Francis, ME	$6,517	$192	$0	$1,592	$36,031	$43,431	$50,393	14.4%
Columbia, TX	$543,397	$314,541	$119,654	$452,093	$1,446,565	$2,728,986	$3,318,599	14.1%
Fort Hancock, TX	$34,852	$1,797	$0	$99,217	$467,675	$580,607	$617,218	14.0%
Nogales, AZ	$108,132	$0	$0	$402,577	$4,011,091	$4,411,255	$4,534,344	14.0%
Ambrose, ND	$10,210	$0	$0	$68,023	$77,461	$142,785	$153,144	13.9%
Noyes, MN	$32,457	$0	$0	$145,099	$250,047	$398,807	$431,149	13.8%
Skagway, AK	$59,255	$1,742	$245	$366,140	$534,367	$890,982	$950,179	13.7%
Convent, TX	$62,574	$0	$0	$116,108	$2,064,851	$2,202,026	$2,265,586	13.1%

Table B-10: Life-Cycle Costs for RE Solutions Case, Base Case, and ROI (without incentives)

Name	Renewable Energy Initial Cost ($)	RE Life-Cycle O&M Cost ($)	RE Life-Cycle Biomass Fuel Cost ($)	RE Life-Cycle Gas Cost ($)	RE Life-Cycle Electric Cost ($)	RE Case Life-Cycle Cost ($)	Base Case Life-Cycle Cost ($)	Return on investment (%)
Laurier, WA	$31,892	$310	$0	$359	$54,226	$84,751	$115,171	13.1%
Sweetgrass, MT	$225,652	$164,473	$39,981	$362	$524,075	$926,893	$1,131,193	13.0%
Otay Mesa, CA	$1,000,242	$60,560	$0	$1,206,212	$5,609,206	$7,571,426	$8,525,158	12.7%
Fort Kent, ME	$112,520	$161,396	$39,771	$175,759	$112,459	$553,009	$649,941	12.6%
Orient, ME	$19,355	$232	$0	$6,344	$53,666	$77,119	$94,455	12.6%
San Ysidro, CA	$1,039,517	$102,378	$0	$2,520,953	$7,293,202	$10,407,761	$11,365,375	12.4%
Beebe Plain, VT	$10,345	$0	$0	$49,698	$78,016	$128,300	$137,465	12.4%
Ogdensburg NY	$377,470	$0	$0	$423,030	$1,538,422	$2,234,485	$2,569,924	12.3%
Eastport, ID	$57,326	$0	$0	$67,158	$384,676	$491,441	$538,000	12.3%
St. John ND	$9,675	$0	$0	$50,667	$98,880	$149,141	$156,946	12.2%
Derby Line, VT	$102,253	$1,290	$0	$160,242	$224,594	$453,948	$535,282	11.9%
Fort Fairfield, ME	$30,203	$685	$0	$120,981	$182,341	$310,294	$334,467	11.8%
Limestone, ME	$24,553	$650	$0	$89,362	$118,874	$215,812	$235,286	11.8%
East Richford, VT	$27,681	$0	$0	$60,209	$160,275	$235,045	$257,160	11.8%
Ferry Point, ME	$73,078	$1,336	$0	$34,826	$703,513	$797,020	$850,481	11.6%
Jackman, ME	$32,959	$0	$0	$17,056	$270,810	$313,910	$337,700	11.5%
Roma, TX	$85,057	$3,315	$0	$3,903	$1,447,274	$1,521,923	$1,587,054	11.5%
Pembina, ND	$137,934	$0	$0	$1,532,384	$1,838,664	$3,221,645	$3,320,512	11.5%
Porthill, ID	$24,445	$531	$0	$3,916	$108,281	$134,387	$151,440	11.3%
San Luis, AZ	$289,853	$248,428	$70,273	$340,985	$1,409,058	$2,253,582	$2,452,837	11.2%
DOT, TX, leased	$189,091	$7,576	$0	$473,885	$1,174,698	$1,744,160	$1,878,746	11.2%
Madawaska, ME	$42,018	$816	$0	$156,770	$341,295	$508,829	$538,666	11.1%
Norton, VT	$26,317	$0	$0	$159,794	$270,974	$425,853	$444,738	11.1%
Alcan, AK	$403,956	$20,667	$245	$3,925,689	$1,390,247	$5,032,271	$5,302,416	11.1%
Derby Line, VT	$34,673	$0	$0	$413,343	$481,346	$852,106	$876,501	11.1%
Del Rio, TX	$288,329	$12,463	$0	$604,546	$2,221,514	$2,989,214	$3,192,497	11.0%
VanBuren, ME	$36,550	$700	$0	$105,008	$208,585	$329,151	$352,943	10.9%
Vanceboro, ME	$48,446	$1,000	$0	$161,326	$234,147	$412,727	$445,136	10.9%
Beecher Falls, VT	$41,812	$1,019	$0	$74,064	$250,919	$350,836	$378,661	10.8%
Highgate Springs 3, VT	$12,905	$0	$0	$86,643	$95,113	$178,256	$186,327	10.3%
Coburn Gore, ME	$140,181	$146,654	$33,649	$227,588	$54,958	$546,031	$627,043	10.3%
Grand Portage, MN	$73,841	$0	$0	$271,835	$392,215	$684,020	$726,801	10.2%
Houlton, ME	$174,282	$147,476	$35,297	$171,395	$824,960	$1,297,218	$1,392,579	10.2%
Progreso, TX	$81,634	$3,752	$0	$215,112	$523,709	$778,603	$826,572	10.2%
St. Francis, ME	$3,825	$217	$0	$13,575	$42,174	$56,893	$58,984	10.1%
Richford, VT	$36,618	$870	$0	$82,211	$206,162	$308,121	$329,003	10.0%

Table B-10: Life-Cycle Costs for RE Solutions Case, Base Case, and ROI (without incentives)

Name	Renewable Energy Initial Cost ($)	RE Life-Cycle O&M Cost ($)	RE Life-Cycle Biomass Fuel Cost ($)	RE Life-Cycle Gas Cost ($)	RE Life-Cycle Electric Cost ($)	RE Case Life-Cycle Cost ($)	Base Case Life-Cycle Cost ($)	Return on investment (%)
Naco, AZ	$70,556	$2,317	$0	$36,533	$561,820	$656,596	$697,006	10.0%
Chateaugay, NY	$28,841	$1,215	$0	$95,287	$186,674	$292,562	$307,451	9.8%
Canaan, VT	$24,276	$717	$0	$59,702	$176,414	$248,095	$261,045	9.7%
Trout, River, NY	$55,944	$1,255	$0	$78,526	$254,170	$371,460	$400,914	9.7%
Niagra Falls, NY	$1,383,426	$209,751	$42,494	$119,939	$1,378,087	$3,023,102	$3,746,085	9.6%
Los Tomates, TX	$1,131,309	$39,812	$0	$50,900	$2,041,062	$3,183,399	$3,791,946	9.5%
St John Hwy, NY	$70,551	$2,329	$0	$166,705	$142,933	$349,193	$383,476	9.5%
Dunseith, ND	$19,012	$0	$0	$33,922	$178,014	$222,609	$231,773	9.5%
Douglas, AZ	$220,785	$6,932	$0	$77,745	$1,655,824	$1,922,732	$2,033,183	9.4%
RR Inspection, TX	$2,760	$0	$0	$5,585	$5,762	$12,963	$14,416	9.4%
Alburg Springs, VT	$15,417	$434	$0	$54,162	$75,890	$135,159	$142,793	9.4%
Fort Covington, NY	$31,915	$990	$0	$67,929	$214,552	$300,255	$315,542	9.3%
Andrade, CA	$174,114	$5,086	$0	$176,370	$299,457	$613,811	$697,785	9.2%
Gateway, TX	$811,736	$27,069	$0	$59,433	$1,756,133	$2,590,613	$2,984,200	9.1%
Massena, NY	$109,903	$4,209	$0	$27,521	$439,608	$567,438	$615,736	9.1%
Detroit Cargo, MI	$77,868	$0	$0	$1,422,562	$2,572,481	$3,800,734	$3,839,007	9.1%
Champlain, NY	$415,889	$0	$0	$4,149,002	$9,021,117	$12,769,725	$12,963,556	9.1%
West Berkshire,VT	$32,551	$622	$0	$43,333	$136,805	$203,090	$217,239	8.9%
Piegan, MT	$137,642	$0	$0	$1,001,213	$542,764	$1,497,580	$1,557,310	8.8%
Mooers, NY	$28,052	$825	$0	$56,037	$152,735	$225,304	$236,566	8.6%
Rouses Pt. NY	$55,590	$1,544	$0	$165,992	$229,484	$419,324	$441,563	8.6%
Kenneth Ward, WA	$26,495	$0	$0	$131,221	$387,562	$517,919	$529,039	8.6%
Highgate Springs 2, VT	$107,349	$0	$0	$1,844,877	$1,479,443	$3,095,076	$3,137,323	8.5%
Blaine, WA	$188,460	$1,533	$0	$152,579	$671,314	$972,738	$1,040,623	8.3%
Turner, MT	$31,218	$256	$0	$0	$19,439	$49,283	$59,614	8.0%
Blaine, WA	$162,654	$0	$0	$180,098	$3,427,536	$3,700,823	$3,755,228	7.9%
Point Robert, WA	$176,860	$1,334	$0	$40,194	$413,220	$612,709	$667,543	7.9%
Danville, WA	$41,203	$0	$0	$15,813	$152,322	$203,316	$216,147	7.8%
Blaine, WA	$119,368	$0	$0	$64,493	$497,621	$660,308	$695,963	7.8%
Brownsville TX	$466,410	$13,212	$0	$62,723	$779,817	$1,282,641	$1,428,943	7.7%
Alexandria Bay, NY	$674,659	$16,969	$0	$56,798	$2,055,652	$2,744,416	$2,953,875	7.7%
Roseau, MN	$104,341	$0	$0	$195,362	$534,963	$791,280	$817,759	7.4%
Kika de la Garza, TX	$1,054,667	$35,212	$0	$173,590	$2,841,094	$4,000,071	$4,290,611	7.4%
North Troy VT	$24,896	$483	$0	$92,283	$3,894	$104,441	$110,418	7.2%
Milltown ME	$7,955	$378	$0	$15,014	$153,039	$172,052	$173,937	7.2%
Marfa, TX	$315,565	$6,640	$0	$111,241	$205,051	$602,769	$670,371	6.9%

Table B-10: Life-Cycle Costs for RE Solutions Case, Base Case, and ROI (without incentives)

Name	Renewable Energy Initial Cost ($)	RE Life-Cycle O&M Cost ($)	RE Life-Cycle Biomass Fuel Cost ($)	RE Life-Cycle Gas Cost ($)	RE Life-Cycle Electric Cost ($)	RE Case Life-Cycle Cost ($)	Base Case Life-Cycle Cost ($)	Return on invest ment (%)
Portal, ND	$25,714	$0	$0	$73,680	$335,561	$418,026	$421,940	6.4%
Intl Falls, MN	$17,592	$0	$0	$87,388	$216,376	$303,514	$305,496	6.0%
Chief Mt, MT	$16,780	$0	$0	$469,955	$742,171	$1,140,375	$1,140,633	5.1%
Highgate Springs 1, VT	$1,911	$23	$0	$2,181	$3,871	$7,486	$6,193	-4.2%

The following ten LPOE sites did not have cost-effective applications of RE technologies:

- San Luis AZ (not built);
- Amb. Bridge, MI;
- Intl Bridge, MI;
- Rooseville, MT;
- Admin, TX (leased);
- El Paso, TX (out leased);
- McAllen TX (not built);
- Highgate Springs 1, VT;
- Mataline Falls. WA;
- Sumas, WA.

Table B-11: RE Solutions that Minimize Life-Cycle Cost (without incentives)

	Wind Capacity (kW)	Solar Vent Preheat Area (ft^2)	Solar Water Heating Area (ft^2)	Biomass Gasifier Size (M Btu/h)	Biomass Gasifier Cogen Size (kW)	Daylighting non-Office Skylight/Floor Area Ratio	Daylighting Office Skylight/Floor Area Ratio
Dalton Cache, AK	0	1,275	189	0.00	0	4.2%	4.5%
Alcan, AK	0	4,220	3,452	0.00	0	0.0%	0.0%
Skagway, AK	0	813	291	0.00	0	4.3%	4.4%
Lukeville, AZ	0	2,380	592	0.00	0	4.6%	4.2%
Nogales, AZ	0	0	0	0.00	0	4.5%	3.5%
Sasabe, AZ	0	1,035	184	0.00	0	4.5%	4.3%
Douglas, AZ	0	1,623	1,158	0.00	0	4.5%	3.6%
San Luis, AZ	0	0	1,445	0.17	17	4.7%	3.8%
Naco, AZ	0	358	387	0.00	0	4.5%	4.1%
San Luis AZ (not built yet)	0	0	0	0.00	0	0.0%	0.0%
Nogales, AZ	0	0	0	0.00	0	4.5%	3.3%
Calexico West, CA	0	0	0	0.00	0	4.5%	3.7%
San Ysidro, CA	790	0	0	0.00	0	4.5%	3.8%
Andrade, CA	27	97	275	0.00	0	4.6%	4.4%
Otay Mesa, CA	467	0	0	0.00	0	4.7%	3.9%
Tecate, CA	0	0	1,028	0.12	12	4.6%	4.1%
Calexico, CA	0	0	3,062	0.25	24	4.6%	2.9%
Eastport, ID	0	1,592	0	0.00	0	0.0%	0.0%
Porthill, ID	0	499	89	0.00	0	0.0%	0.0%
Ferry Point, ME	0	1,577	223	0.00	0	0.0%	0.0%
Coburn Gore, ME	0	269	556	0.10	11	4.6%	4.3%
Fort Fairfield, ME	0	377	114	0.00	0	4.5%	4.4%
Houlton, ME	0	2,832	0	0.11	11	0.0%	0.0%
Jackman, ME	0	916	0	0.00	0	0.0%	0.0%
Limestone, ME	0	286	109	0.00	0	4.5%	4.4%
Orient, ME	0	277	39	0.00	0	4.5%	4.4%
Vanceboro, ME	0	733	167	0.00	0	4.5%	4.3%
VanBuren, ME	0	778	117	0.00	0	0.0%	0.0%
Milltown ME	0	50	63	0.00	0	4.5%	4.5%
St. Francis, ME	0	116	32	0.00	0	0.0%	0.0%
Madawaska, ME	0	548	136	0.00	0	4.5%	4.3%
Fort Kent, ME	0	582	0	0.11	12	4.5%	4.2%
St. Francis, ME	0	33	36	0.00	0	0.0%	0.0%
Detroit Cargo, MI	0	0	0	0.00	0	4.5%	3.0%

Table B-11: RE Solutions that Minimize Life-Cycle Cost (without incentives)

	Wind Capacity (kW)	Solar Vent Preheat Area (ft^2)	Solar Water Heating Area (ft^2)	Biomass Gasifier Size (M Btu/h)	Biomass Gasifier Cogen Size (kW)	Daylighting non-Office Skylight/Floor Area Ratio	Daylighting Office Skylight/Floor Area Ratio
Intl Bridge, MI	0	0	0	0.00	0	0.0%	0.0%
Amb. Bridge, MI	0	0	0	0.00	0	0.0%	0.0%
Grand Portage, MN	0	1,541	0	0.00	0	4.5%	3.5%
Noyes, MN	0	902	0	0.00	0	0.0%	0.0%
Roseau, MN	0	2,898	0	0.00	0	0.0%	0.0%
Intl Falls, MN	0	489	0	0.00	0	0.0%	0.0%
Baudette, MN	0	342	59	0.00	0	0.0%	0.0%
Chief Mt, MT	0	466	0	0.00	0	0.0%	0.0%
Piegan, MT	0	1,307	0	0.00	0	2.7%	3.0%
Raymond, MT	0	1,555	0	0.00	0	0.0%	0.0%
Rooseville, MT	0	0	0	0.00	0	0.0%	0.0%
Sweetgrass, MT	0	1,261	547	0.11	12	4.5%	4.5%
Turner, MT	2	161	10	0.00	0	4.4%	4.2%
Ambrose, ND	0	284	0	0.00	0	0.0%	0.0%
Dunseith, ND	0	528	0	0.00	0	0.0%	0.0%
Portal, ND	0	714	0	0.00	0	0.0%	0.0%
St. John ND	0	269	0	0.00	0	0.0%	0.0%
Pembina, ND	0	3,831	0	0.00	0	0.0%	0.0%
Columbus, NM	0	880	436	0.00	0	4.9%	4.5%
Santa Teresa, NM	0	0	0	0.00	0	5.4%	4.2%
Alexandria Bay, NY	131	3,640	0	0.00	0	4.7%	3.6%
Champlain, NY	0	6,739	0	0.00	0	5.4%	3.2%
Massena, NY	0	1,627	703	0.00	0	0.0%	0.0%
Fort Covington, NY	0	334	165	0.00	0	4.5%	4.2%
Rouses Pt. NY	0	651	258	0.00	0	4.5%	4.0%
St John Hwy, NY	0	1,171	389	0.00	0	0.0%	0.0%
Trout, River, NY	0	730	210	0.00	0	4.5%	4.0%
Chateaugay, NY	0	389	203	0.00	0	0.0%	0.0%
Mooers, NY	0	300	138	0.00	0	4.5%	4.2%
Jamieson, NY	0	111	24	0.00	0	4.9%	5.2%
Niagra Falls, NY	148	8,444	2,592	0.13	13	3.8%	4.5%
Ogdensburg NY	0	5,614	0	0.00	0	6.2%	4.5%
Brownsville/Matamoros TX	102	0	0	0.00	0	5.5%	4.5%
Gateway, TX	209	0	0	0.00	0	5.6%	4.0%
Columbia, TX	0	0	2,104	0.21	23	5.2%	4.4%

Table B-11: RE Solutions that Minimize Life-Cycle Cost (without incentives)

	Wind Capacity (kW)	Solar Vent Preheat Area (ft^2)	Solar Water Heating Area (ft^2)	Biomass Gasifier Size (M Btu/h)	Biomass Gasifier Cogen Size (kW)	Daylighting non-Office Skylight/Floor Area Ratio	Daylighting Office Skylight/Floor Area Ratio
Convent, TX	0	0	0	0.00	0	4.5%	3.2%
Del Rio, TX	0	0	2,082	0.00	0	5.5%	3.6%
Donna TX (not built)	0	0	0	0.00	0	4.9%	4.5%
Bridge of the Americas, TX	0	0	0	0.00	0	5.6%	3.2%
Eagle Pass, TX	0	0	0	0.00	0	5.3%	3.9%
Fabens, TX	0	376	242	0.00	0	5.0%	4.4%
Fort Hancock, TX	0	160	300	0.00	0	4.6%	4.4%
El Paso, TX (out leased)	0	0	0	0.00	0	0.0%	0.0%
Juarez-Lincoln, TX	0	0	0	0.00	0	5.4%	3.3%
Los Indios, TX	0	0	0	0.00	0	5.5%	3.9%
Laredo TX	0	0	0	0.00	0	5.1%	4.4%
Los Tomates, TX	307	0	0	0.00	0	5.7%	4.0%
McAllen, TX	0	0	0	0.00	0	5.2%	4.2%
McAllen TX (not built)	0	0	0	0.00	0	0.0%	0.0%
Marfa, TX	36	2,292	337	0.00	0	4.3%	4.0%
Kika de la Garza, TX	272	0	0	0.00	0	5.5%	4.0%
Paso Del Norte, TX	0	0	0	0.00	0	5.6%	3.4%
Progreso, TX	0	0	627	0.00	0	4.5%	3.6%
Roma, TX	0	0	554	0.00	0	4.5%	3.3%
Rio Grande City, TX	0	0	0	0.00	0	4.5%	3.2%
Ysleta, TX	0	0	0	0.00	0	5.8%	3.4%
RR Inspection, TX	0	0	0	0.00	0	4.5%	4.5%
Admin, TX (leased)	0	0	0	0.00	0	0.0%	0.0%
El Paso, TX (Leased)	0	0	0	0.00	0	0.0%	0.0%
DOT, TX (leased)	0	661	1,266	0.00	0	4.5%	3.0%
Derby Line, VT	0	575	0	0.00	0	4.5%	3.7%
Norton, VT	0	392	0	0.00	0	4.5%	5.1%
Beebe Plain, VT	0	161	0	0.00	0	4.5%	4.2%
Alburg Springs, VT	0	145	72	0.00	0	4.6%	4.3%
North Troy VT	0	326	81	0.00	0	4.5%	3.7%
West Berkshire,VT	0	412	104	0.00	0	4.5%	4.3%
Derby Line, VT	0	1,735	216	0.00	0	4.7%	3.3%
Beecher Falls, VT	0	483	170	0.00	0	4.5%	3.9%
Canaan, VT	0	248	120	0.00	0	4.5%	4.3%
East Richford, VT	0	471	0	0.00	0	4.5%	3.9%

Table B-11: RE Solutions that Minimize Life-Cycle Cost (without incentives)

	Wind Capacity (kW)	Solar Vent Preheat Area (ft^2)	Solar Water Heating Area (ft^2)	Biomass Gasifier Size (M Btu/h)	Biomass Gasifier Cogen Size (kW)	Daylighting non-Office Skylight/Floor Area Ratio	Daylighting Office Skylight/Floor Area Ratio
Richford, VT	0	438	145	0.00	0	4.5%	4.0%
Alburg, VT (Joint ownership)	0	261	34	0.00	0	4.2%	4.5%
Highgate Springs 1, VT	0	0	0	0.00	0	0.0%	0.0%
Highgate Springs 2, VT	0	2,087	0	0.00	0	4.4%	2.8%
Highgate Springs 3, VT	0	199	0	0.00	0	4.4%	4.0%
Blaine, WA	0	3,316	256	0.00	0	4.9%	4.2%
Danville, WA	0	823	0	0.00	0	4.7%	4.1%
Laurier, WA	0	406	52	0.00	0	4.6%	4.2%
Mataline Falls. WA	0	0	0	0.00	0	0.0%	0.0%
Oroville, WA	0	289	0	0.00	0	0.0%	0.0%
Point Robert, WA	0	3,248	223	0.00	0	4.4%	4.1%
Sumas, WA	0	0	0	0.00	0	0.0%	0.0%
Blaine, WA	0	3,316	0	0.00	0	0.0%	0.0%
Blaine, WA	0	0	0	0.00	0	5.7%	4.4%
Kenneth Ward, WA	0	0	0	0.00	0	5.1%	4.8%

*Size 0 means the RE technology could not be sized to yield a return on investment greater than the discount rate of the life-cycle analysis (4.6 percent). PV, Solar Thermal, and Solar Thermal Electric were not cost effective at any LPOE site without incentives.

Note that each technology is recommended as part of the optimized solution for a site, and these sizes minimize life-cycle costs. In other words, it is possible for an LPOE site to cost effectively generate more RE than the optimized solution indicates, but the life cycle costs would be higher.

Table B-12: Daylighting Calculations by Site

LPOE Site Name	Total Skylight Area (ft^2)	Daylighting Initial Cost ($)	Electricity Saved (kWh/yr)	Natural Gas Saved (therms/yr)	Utility Savings ($/yr)	Daylighting Payback Period (yrs)
Dalton Cache, AK	621	$19,267	16403	(481.1)	$4,976	4
Alcan, AK	0	$1	2	(0.1)	$0	32
Skagway, AK	285	$8,757	7515	(220.4)	$910	10
Lukeville, AZ	1,582	$48,486	77340	(81.2)	$7,624	6
Nogales, AZ	3,761	$120,850	177176	(647.9)	$18,514	7
Sasabe, AZ	686	$21,024	33010	(37.9)	$4,168	5
Douglas, AZ	2,439	$77,813	112952	(683.8)	$9,757	8
San Luis, AZ	2,217	$69,113	105134	(163.7)	$8,970	8
Naco, AZ	945	$29,422	39698	(161.4)	$3,589	8
San Luis AZ (not built yet)	0	$0	1	0.0	$0	4
Nogales, AZ	3,326	$108,131	161780	(581.1)	$13,798	8
Calexico West, CA	5,126	$162,694	221817	(573.8)	$26,314	6
San Ysidro, CA	8,588	$270,670	371949	(1,222.3)	$46,464	6
Andrade, CA	424	$12,947	20207	(23.0)	$2,601	5
Otay Mesa, CA	12,936	$405,135	552036	(1,805.0)	$73,406	6
Tecate, CA	2,230	$69,177	94695	(285.7)	$11,548	6
Calexico, CA	6,184	$206,908	322052	(663.8)	$36,714	6
Eastport, ID	0	$0	1	(0.0)	$0	18
Porthill, ID	0	$0	0	(0.0)	$0	16
Ferry Point, ME	0	$0	1	(0.0)	$0	7
Coburn Gore, ME	644	$19,673	27005	(435.4)	$2,359	8
Fort Fairfield, ME	269	$8,266	9225	(304.9)	$1,093	8
Houlton, ME	0	$1	1	(0.0)	$0	11
Jackman, ME	0	$0	1	(0.0)	$0	11
Limestone, ME	207	$6,331	7030	(233.9)	$722	9
Orient, ME	213	$6,542	7476	(235.8)	$715	9
Vanceboro, ME	321	$9,855	11362	(352.9)	$952	10
VanBuren, ME	0	$0	0	(0.0)	$0	9
Milltown ME	51	$1,560	1720	(57.8)	$125	12
St. Francis, ME	0	$0	0	(0.0)	$0	27
Madawaska, ME	402	$12,352	13870	(454.7)	$1,227	10
Fort Kent, ME	409	$12,691	14569	(463.5)	$1,425	9
St. Francis, ME	0	$0	0	(0.0)	$0	26
Detroit Cargo, MI	2,328	$77,868	97333	(1,720.9)	$6,631	12
Intl Bridge, MI	0	$0	0	(0.0)	$0	42

Table B-12: Daylighting Calculations by Site

LPOE Site Name	Total Skylight Area (ft^2)	Daylighting Initial Cost ($)	Electricity Saved (kWh/yr)	Natural Gas Saved (therms/yr)	Utility Savings ($/yr)	Daylighting Payback Period (yrs)
Amb. Bridge, MI	0	$0	0	(0.0)	$0	6
Grand Portage, MN	576	$18,372	22521	(658.3)	$1,211	15
Noyes, MN	0	$0	0	(0.0)	$0	21
Roseau, MN	0	$0	0	(0.0)	$0	14
Intl Falls, MN	0	$0	0	(0.0)	$0	14
Baudette, MN	0	$0	0	(0.0)	$0	10
Chief Mt, MT	0	$0	0	(0.0)	$0	13
Piegan, MT	2,668	$90,607	118761	(2,124.9)	$5,252	17
Raymond, MT	0	$1	2	(0.0)	$0	83
Rooseville, MT	0	$1	1	(0.0)	$0	12
Sweetgrass, MT	1,900	$58,033	82780	(1,397.8)	$4,220	14
Turner, MT	327	$10,091	11854	(317.9)	$639	16
Ambrose, ND	0	$0	0	(0.0)	$0	13
Dunseith, ND	0	$0	1	(0.0)	$0	16
Portal, ND	0	$0	1	(0.0)	$0	13
St. John ND	0	$0	0	(0.0)	$0	14
Pembina, ND	0	$1	2	(0.0)	$0	19
Columbus, NM	1,049	$31,569	56981	(12.3)	$6,655	5
Santa Teresa, NM	2,959	$88,329	148080	(137.3)	$15,696	6
Alexandria Bay, NY	2,020	$64,198	79158	(1,906.5)	$9,134	7
Champlain, NY	5,530	$173,289	230050	(4,580.0)	$18,682	9
Massena, NY	0	$0	0	(0.0)	$0	23
Fort Covington, NY	253	$7,812	8885	(243.9)	$636	12
Rouses Pt. NY	427	$13,318	15378	(381.8)	$943	14
St John Hwy, NY	0	$0	1	(0.0)	0	(126)
Trout, River, NY	460	$14,368	16719	(444.5)	$1,225	12
Chateaugay, NY	0	$0	0	(0.0)	$0	11
Mooers, NY	233	$7,202	8130	(208.4)	$426	17
Jamieson, NY	52	$1,552	2269	(21.8)	$326	5
Niagra Falls, NY	8,295	$262,393	370412	(4,083.1)	$31,373	8
Ogdensburg BS	6,042	$175,361	233201	(4,019.4)	$29,248	6
Brownsville TX	2,444	$72,198	116515	(1.2)	$11,050	7
Gateway, TX	4,051	$121,059	183631	(58.5)	$18,054	7
Columbia, TX	8,465	$252,593	415211	(9.3)	$42,024	6
Convent, TX	1,907	$62,573	86824	(194.1)	$7,546	8
Del Rio, TX	4,535	$136,352	212817	(169.0)	$20,363	7

Table B-12: Daylighting Calculations by Site

LPOE Site Name	Total Skylight Area (ft^2)	Daylighting Initial Cost ($)	Electricity Saved (kWh/yr)	Natural Gas Saved (therms/yr)	Utility Savings ($/yr)	Daylighting Payback Period (yrs)
Donna TX, not built yet	488	$14,708	25175	0.0	$2,541	6
Bridge of the Americas, TX	7,224	$219,433	364532	(559.2)	$35,605	6
Eagle Pass, TX	4,253	$127,361	203476	(108.1)	$18,159	7
Fabens, TX	520	$15,729	25962	(45.7)	$4,249	4
Fort Hancock, TX	235	$7,170	11582	(29.3)	$1,255	6
El Paso, TX, leased	0	$0	1	0.0	$0	4
Juarez-Lincoln, TX	10,514	$316,588	500384	(166.0)	$45,314	7
Los Indios, TX	5,476	$163,432	255677	(52.6)	$22,548	7
Laredo TX	1,359	$40,968	61454	(43.6)	$5,662	7
Los Tomates, TX	6,663	$197,511	303904	(57.6)	$28,330	7
McAllen, TX	1,484	$44,664	69065	(23.4)	$6,691	7
McAllen TX, not built yet	0	$0	1	0.0	$0	4
Marfa, TX	1,131	$34,951	61123	(103.1)	$5,425	6
Kika de la Garza, TX	6,933	$206,342	325365	(50.7)	$34,153	6
Paso Del Norte, TX	3,828	$117,745	190004	(480.2)	$20,078	6
Progreso, TX	1,122	$35,880	47022	(70.8)	$3,922	9
Roma, TX	1,373	$44,628	60955	(86.6)	$5,225	9
Rio Grande City, TX	1,611	$52,686	72818	(101.7)	$7,169	7
Ysleta, TX	8,706	$259,146	427700	(378.4)	$42,632	6
RR Inspection, TX	90	$2,760	3184	(9.2)	$336	8
Admin, TX (leased)	0	$0	0	(0.0)	$0	5
El Paso, TX, Leased	0	$0	0	(0.0)	$0	4
DOT, TX, leased	2,186	$72,904	106635	(379.1)	$9,210	8
Derby Line, VT	441	$13,963	16687	(394.1)	$1,126	12
Norton, VT	408	$12,198	12491	(364.5)	$1,081	11
Beebe Plain, VT	147	$4,545	5173	(131.1)	$540	8
Alburg Springs, VT	159	$4,898	5689	(136.3)	$523	9
North Troy VT	230	$7,274	8693	(205.3)	$1,471	5
West Berkshire,VT	329	$10,148	11388	(294.3)	$887	11
Derby Line, VT	751	$24,057	30948	(623.4)	$2,809	9
Beecher Falls, VT	382	$11,985	14030	(341.7)	$1,268	9
Canaan, VT	215	$6,615	7423	(191.9)	$635	10
East Richford, VT	341	$10,725	12593	(305.4)	$1,190	9
Richford, VT	328	$10,231	11838	(293.1)	$1,099	9
Alburg, VT, joint owner	152	$4,730	6838	(90.6)	$570	8

Table B-12: Daylighting Calculations by Site

LPOE Site Name	Total Skylight Area (ft^2)	Daylighting Initial Cost ($)	Electricity Saved (kWh/yr)	Natural Gas Saved (therms/yr)	Utility Savings ($/yr)	Daylighting Payback Period (yrs)
Highgate Springs 1, VT	0	$0	0	(0.0)	$0	9
Highgate Springs 2, VT	951	$32,210	41113	(850.1)	$2,211	15
Highgate Springs 3, VT	184	$5,751	6644	(164.9)	$592	10
Blaine, WA	1,676	$50,389	59755	(635.4)	$3,053	17
Danville, WA	382	$11,590	16521	(190.7)	$945	12
Laurier, WA	443	$13,512	19317	(221.5)	$1,350	10
Mataline Falls. WA	0	$0	0	(0.0)	$0	24
Oroville, WA	0	$2	3	(0.0)	0	(16)
Point Robert, WA	1,422	$43,680	62869	(710.4)	$2,613	17
Sumas, WA	0	$1	1	(0.0)	$0	13
Blaine, WA	0	$1	1	(0.0)	$0	16
Blaine, WA	5,542	$162,654	190793	(2,100.8)	$12,501	13
Kenneth Ward, WA	886	$26,495	31399	(335.9)	$2,180	12
Total					$846,453.00	

Therms/yr in red and in paratheses (xx.x) indicate additional natural gas will need to be purchased/consumed at some locations to compensate for heat loss through skylights. This extra cost was included in the Utility Savings and Daylighting Payback Period calculations.

Note that each technology is recommended as part of the optimized solution for a site, and these sizes minimize life-cycle costs. In other words, it is possible for an LPOE site to cost effectively generate more RE than the optimized solution indicates, but the life cycle costs would be higher.

Table B-13: Wind Energy Calculations by Site

LPOE Site Name	Wind Capacity (kW)	Wind Initial Cost ($)	Wind Rebate ($)	Wind Net Metering up to (kW)	Wind Annual Energy Delivery (kWh/yr)	Wind Annual Cost Savings ($)	Wind Annual O&M Cost ($/yr)	Wind Payback Period (yrs)
Dalton Cache, AK	0	$0	0	$0	$0	0	0	$0
Alcan, AK	0	$0	$0	0	0	$0	$0	182
Skagway, AK	0	$0	$0	0	0	$0	$0	143
Lukeville, AZ	0	$0	$0	100	0	$0	$0	166
Nogales, AZ	0	$0	$0	100	0	$0	$0	98
Sasabe, AZ	0	$0	$0	0	0	$0	$0	88
Douglas, AZ	0	$0	$0	100	0	$0	$0	104
San Luis, AZ	0	$0	$0	100	0	$0	$0	177
Naco, AZ	0	$0	$0	100	0	$0	$0	109
San Luis AZ (not built yet)	0	$0	$0	100	0	$0	$0	154
Nogales, AZ	0	$0	$0	0	0	$0	$0	178
Calexico West, CA	0	0	$0	$0	0	0	$0	$0
San Ysidro, CA	790	$1,954,078	$1,185,232	1,000	802,390	$103,006	$6,242	8
Andrade, CA	27	$137,582	$0	0	76,326	$10,051	$210	14
Otay Mesa, CA	467	$1,296,214	$701,107	1,000	420,706	$57,579	$3,692	11
Tecate, CA	0	$0	$0	1,000	0	$0	$0	84
Calexico, CA	0	$0	$0	0	0	$0	$0	92
Eastport, ID	0	$0	$0	0	0	$0	$0	1,545
Porthill, ID	0	$0	$0	0	0	$0	$0	287
Ferry Point, ME	0	$0	$0	0	0	$0	$0	78
Coburn Gore, ME	0	$0	$0	0	0	$0	$0	87
Fort Fairfield, ME	0	$0	$0	0	0	$0	$0	31
Houlton, ME	0	$0	$0	0	0	$0	$0	64
Jackman, ME	0	$0	$0	0	0	$0	$0	109
Limestone, ME	0	$0	$0	0	0	$0	$0	28
Orient, ME	0	$0	$0	0	0	$0	$0	54
Vanceboro, ME	0	$0	$0	0	0	$0	$0	56
VanBuren, ME	0	$0	$0	0	0	$0	$0	137
Milltown ME	0	$0	$0	0	0	$0	$0	76
St. Francis, ME	0	$0	$0	0	0	$0	$0	62
Madawaska, ME	0	$0	$0	0	0	$0	$0	96
Fort Kent, ME	0	$0	$0	0	0	$0	$0	97
St. Francis, ME	0	$0	$0	0	0	$0	$0	176
Detroit Cargo, MI	0	$0	$0	0	0	$0	$0	92
Intl Bridge, MI	0	$0	$0	0	0	$0	$0	0
Amb. Bridge, MI	0	$0	0	$0	$0	0	0	$0
Grand Portage, MN	0	$0	$0	0	0	$0	$0	43

Table B-13: Wind Energy Calculations by Site

LPOE Site Name	Wind Capacity (kW)	Wind Initial Cost ($)	Wind Rebate ($)	Wind Net Metering up to (kW)	Wind Annual Energy Delivery (kWh/yr)	Wind Annual Cost Savings ($)	Wind Annual O&M Cost ($/yr)	Wind Payback Period (yrs)
Noyes, MN	0	$0	$0	0	0	$0	$0	41
Roseau, MN	0	$0	$0	0	0	$0	$0	63
Intl Falls, MN	0	$0	$0	0	0	$0	$0	79
Baudette, MN	0	$0	$0	0	0	$0	$0	48
Chief Mt, MT	0	$0	$0	0	0	$0	$0	65
Piegan, MT	0	$0	$0	0	0	$0	$0	62
Raymond, MT	0	$0	$0	0	0	$0	$0	86
Rooseville, MT	0	$0	$0	0	0	$0	$0	77
Sweetgrass, MT	0	$0	$0	0	0	$0	$0	33
Turner, MT	2	$14,561	$0	0	4,754	$940	$12	16
Ambrose, ND	0	$0	$0	0	0	$0	$0	39
Dunseith, ND	0	$0	$0	0	0	$0	$0	80
Portal, ND	0	$0	$0	0	0	$0	$0	53
St. John ND	0	$0	$0	0	0	$0	$0	35
Pembina, ND	0	$0	$0	0	0	$0	$0	70
Columbus, NM	0	$0	$0	0	0	$0	$0	59
Santa Teresa, NM	0	$0	$0	0	0	$0	$0	74
Alexandria Bay, NY	131	$479,418	$0	0	251,889	$37,724	$1,035	13
Champlain, NY	0	$0	$0	0	0	$0	$0	54
Massena, NY	0	$0	$0	0	0	$0	$0	102
Fort Covington, NY	0	$0	$0	0	0	$0	$0	41
Rouses Pt. NY	0	$0	$0	0	0	$0	$0	128
St John Hwy, NY	0	$0	$0	0	0	$0	$0	406
Trout, River, NY	0	$0	$0	0	0	$0	$0	43
Chateaugay, NY	0	$1	$0	0	0	$0	$0	na
Mooers, NY	0	$0	$0	0	0	$0	$0	133
Jamieson, NY	0	$0	$0	10	0	$0	$0	35
Niagra Falls, NY	148	$527,588	$0	0	284,705	$35,623	$1,169	15
Ogdensburg, NY	0	$0	$0	0	0	$0	$0	na
Brownsville/ Matamoros, TX	102	$394,213	$0	0	274,559	$26,042	$806	16
Gateway, TX	209	$690,677	$0	0	562,539	$55,523	$1,650	13
Columbia, TX	0	$0	$0	0	0	$0	$0	59
Convent, TX	0	$0	$0	0	0	$0	$0	67
Del Rio, TX	0	$0	$0	0	0	$0	$0	61
Donna TX (not built yet)	0	$0	$0	0	0	$0	$0	59
Bridge of the Americas, TX	0	$0	$0	0	0	$0	$0	60

Table B-13: Wind Energy Calculations by Site

LPOE Site Name	Wind Capacity (kW)	Wind Initial Cost ($)	Wind Rebate ($)	Wind Net Metering up to (kW)	Wind Annual Energy Delivery (kWh/yr)	Wind Annual Cost Savings ($)	Wind Annual O&M Cost ($/yr)	Wind Payback Period (yrs)
Eagle Pass, TX	0	$0	$0	0	0	$0	$0	67
Fabens, TX	0	$0	$0	0	0	$0	$0	88
Fort Hancock, TX	0	$0	$0	0	0	$0	$0	137
El Paso, TX (out leased)	0	$0	$0	0	0	$0	$0	62
Juarez-Lincoln, TX	0	$0	$0	0	0	$0	$0	66
Los Indios, TX	0	$0	$0	0	0	$0	$0	68
Laredo TX	0	$0	$0	0	0	$0	$0	64
Los Tomates, TX	307	$933,797	$0	0	827,344	$77,571	$2,427	12
McAllen, TX	0	$0	$0	0	0	$0	$0	61
McAllen TX (not built yet)	0	$0	$0	0	0	$0	$0	59
Marfa, TX	36	$173,533	$0	0	151,052	$13,771	$282	13
Kika de la Garza, TX	272	$848,325	$0	0	522,675	$54,958	$2,147	16
Paso Del Norte, TX	0	$0	$0	0	0	$0	$0	55
Progreso, TX	0	$0	$0	0	0	$0	$0	69
Roma, TX	0	$0	$0	0	0	$0	$0	67
Rio Grande City, TX	0	$0	$0	0	0	$0	$0	59
Ysleta, TX	0	$0	$0	0	0	$0	$0	159
RR Inspection, TX	0	$0	$0	0	0	$0	$0	51
Admin, TX (leased)	0	$0	$0	0	0	$0	$0	64
El Paso, TX (Leased)	0	$0	$0	0	0	$0	$0	59
DOT, TX (leased)	0	$0	$0	0	0	$0	$0	62
Derby Line, VT	0	$0	$0	0	0	$0	$0	98
Norton, VT	0	$0	$0	0	0	$0	$0	43
Beebe Plain, VT	0	$0	$0	0	0	$0	$0	81
Alburg Springs, VT	0	$0	$0	0	0	$0	$0	45
North Troy VT	0	$0	$0	0	0	$0	$0	44
West Berkshire,VT	0	$0	$0	0	0	$0	$0	55
Derby Line, VT	0	$0	$0	0	0	$0	$0	84
Beecher Falls, VT	0	$0	$0	0	0	$0	$0	188
Canaan, VT	0	$0	$0	0	0	$0	$0	127
East Richford, VT	0	$0	$0	0	0	$0	$0	56
Richford, VT	0	$0	$0	0	0	$0	$0	55
Alburg, VT (Joint ownership)	0	$2,435	$0	0	383	$52	$2	48
Highgate Springs 1, VT	0	$1,911	$0	0	243	$34	$1	59
Highgate Springs 2, VT	0	$1	$0	0	0	$0	$0	87
Highgate Springs 3, VT	0	$0	$0	0	0	$0	$0	59
Blaine, WA	0	$0	$0	100	0	$0	$0	136

Table B-13: Wind Energy Calculations by Site

LPOE Site Name	Wind Capacity (kW)	Wind Initial Cost ($)	Wind Rebate ($)	Wind Net Metering up to (kW)	Wind Annual Energy Delivery (kWh/yr)	Wind Annual Cost Savings ($)	Wind Annual O&M Cost ($/yr)	Wind Payback Period (yrs)
Danville, WA	0	$0	$0	0	0	$0	$0	1,006
Laurier, WA	0	$0	$0	0	0	$0	$0	671
Mataline Falls. WA	0	$0	$0	0	0	$0	$0	(110,018)
Oroville, WA	0	$0	$0	0	0	$0	$0	1,558
Point Robert, WA	0	$0	$0	0	0	$0	$0	1,124
Sumas, WA	0	$0	$0	100	0	$0	$0	149
Blaine, WA	0	$0	$0	100	0	$0	$0	165
Blaine, WA	0	$0	$0	100	0	$0	$0	129
Kenneth Ward, WA	0	$0	$0	100	0	$0	$0	124
Totals						**$472,874.00**		

Note that each technology is recommended as part of the optimized solution for a site, and these sizes minimize life-cycle costs. In other words, it is possible for an LPOE site to cost effectively generate more RE than the optimized solution indicates, but the life cycle costs would be higher.

Table B-14: Calculations for Biomass Gasification of Dry Waste for Heat and Electric Power

LPOE Site Name	Biomass Gasifier Size (MBtu/h)	Biomass Gasifier Cogen Size (kW)	Biomass Initial Cost ($)	Biomass Natural Gas Savings (therms/yr)	Biomass Gasifier Electric Delivery (kWh/yr)	Biomass Gasifier Annual Utility Cost Savings ($/yr)	Tons of Fuel Used	Fuel Cost ($)	Biomass Gasifier O&M Cost($/yr)	Biomass Gasifier Payback Period (yrs)
Dalton Cache, AK	0	0	$0	0	0	$0	0	$0	$0	n/a
Alcan, AK	0	0	$0	0	0	$0	0	$0	$0	n/a
Skagway, AK	0	0	$0	0	0	$0	0	$0	$0	n/a
Lukeville, AZ	0	0	$0	0	0	$0	0	$0	$0	n/a
Nogales, AZ	0	0	$0	0	0	$0	0	$0	$0	n/a
Sasabe, AZ	0	0	$0	0	0	$0	0	$0	$0	n/a
Douglas, AZ	0	0	$0	0	0	$0	0	$0	$0	n/a
San Luis, AZ	0.172	17	$115,233	6,878	129,993	$29,643	171	$4,285	$14,620	11
Naco, AZ	0	0	$0	0	0	$0	0	$0	$0	n/a
San Luis AZ (not built yet)	0	0	$0	0	0	$0	0	$0	$0	n/a
Nogales, AZ	0	0	$0	0	0	$0	0	$0	$0	n/a
Calexico West, CA	0	0	$0	0	0	$0	0	$0	$0	n/a
San Ysidro, CA	0	0	$0	0	0	$0	0	$0	$0	n/a
Andrade, CA	0	0	$0	0	0	$0	0	$0	$0	n/a
Otay Mesa, CA	0	0	$0	0	0	$0	0	$0	$0	n/a
Tecate, CA	0.115	12	$95,485	4,615	86,759	$29,700	114	$2,408	$9,776	5
Calexico, CA	0.254	24	$197,485	10,800	177,241	$59,910	252	$6,341	$21,032	6
Eastport, ID	0	0	$0	0	0	$0	0	$0	$0	n/a
Porthill, ID	0	0	$0	0	0	$0	0	$0	$0	n/a
Ferry Point, ME	0	0	$0	0	0	$0	0	$0	$0	n/a
Coburn Gore, ME	0.101	11	$70,229	3,893	80,054	$19,782	101	$2,052	$8,739	8
Fort Fairfield, ME	0	0	$0	0	0	$0	0	$0	$0	n/a
Houlton, ME	0.105	11	$72,315	4,098	81,383	$16,804	104	$2,152	$8,992	13
Jackman, ME	0	0	$0	0	0	$0	0	$0	$0	n/a
Limestone, ME	0	0	$0	0	0	$0	0	$0	$0	n/a
Orient, ME	0	0	$0	0	0	$0	0	$0	$0	n/a
Vanceboro, ME	0	0	$0	0	0	$0	0	$0	$0	n/a
VanBuren, ME	0	0	$0	0	0	$0	0	$0	$0	n/a
Milltown ME	0	0	$0	0	0	$0	0	$0	$0	n/a
St. Francis, ME	0	0	$0	0	0	$0	0	$0	$0	n/a
Madawaska, ME	0	0	$0	0	0	$0	0	$0	$0	n/a
Fort Kent, ME	0.115	12	$78,880	4,491	89,001	$22,350	114	$2,425	$9,841	8
St. Francis, ME	0	0	$0	0	0	$0	0	$0	$0	n/a
Detroit Cargo, MI	0	0	$0	0	0	$0	0	$0	$0	n/a

Table B-14: Calculations for Biomass Gasification of Dry Waste for Heat and Electric Power

LPOE Site Name	Biomass Gasifier Size (MBtu/h)	Biomass Gasifier Cogen Size (kW)	Biomass Initial Cost ($)	Biomass Natural Gas Savings (therms/yr)	Biomass Gasifier Electric Delivery (kWh/yr)	Biomass Gasifier Annual Utility Cost Savings ($/yr)	Tons of Fuel Used	Fuel Cost ($)	Biomass Gasifier O&M Cost($/yr)	Biomass Gasifier Payback Period (yrs)
Intl Bridge, MI	0	0	$0	0	0	$0	0	$0	$0	n/a
Amb. Bridge, MI	0	0	$0	0	0	$0	0	$0	$0	n/a
Grand Portage, MN	0	0	$0	0	0	$0	0	$0	$0	n/a
Noyes, MN	0	0	$0	0	0	$0	0	$0	$0	n/a
Roseau, MN	0	0	$0	0	0	$0	0	$0	$0	n/a
Intl Falls, MN	0	0	$0	0	0	$0	0	$0	$0	n/a
Baudette, MN	0	0	$81	9	0	$32	0	$2	$7	n/a
Chief Mt, MT	0	0	$0	0	0	$0	0	$0	$0	n/a
Piegan, MT	0	0	$0	0	0	$0	0	$0	$0	n/a
Raymond, MT	0.001	0	$784	99	0	$193	1	$27	$77	9
Rooseville, MT	0	0	$0	0	0	$0	0	$0	$0	n/a
Sweetgrass, MT	0.115	12	$82,297	4,454	89,228	$22,182	114	$2,438	$9,829	8
Turner, MT	0	0	$0	0	0	$0	0	$0	$0	n/a
Ambrose, ND	0	0	$0	0	0	$0	0	$0	$0	n/a
Dunseith, ND	0	0	$0	0	0	$0	0	$0	$0	n/a
Portal, ND	0	0	$0	0	0	$0	0	$0	$0	n/a
St. John ND	0	0	$0	0	0	$0	0	$0	$0	n/a
Pembina, ND	0	0	$0	0	0	$0	0	$0	$0	n/a
Columbus, NM	0	0	$0	0	0	$0	0	$0	$0	n/a
Santa Teresa, NM	0	0	$0	0	0	$0	0	$0	$0	n/a
Alexandria Bay, NY	0	0	$0	0	0	$0	0	$0	$0	n/a
Champlain, NY	0	0	$0	0	0	$0	0	$0	$0	n/a
Massena, NY	0	0	$0	0	0	$0	0	$0	$0	n/a
Fort Covington, NY	0	0	$0	0	0	$0	0	$0	$0	n/a
Rouses Pt. NY	0	0	$0	0	0	$0	0	$0	$0	n/a
St John Hwy, NY	0	0	$0	0	0	$0	0	$0	$0	n/a
Trout, River, NY	0	0	$0	0	0	$0	0	$0	$0	n/a
Chateaugay, NY	0	0	$0	0	0	$0	0	$0	$0	n/a
Mooers, NY	0	0	$0	0	0	$0	0	$0	$0	n/a
Jamieson, NY	0	0	$0	0	0	$0	0	$0	$0	n/a
Niagra Falls, NY	0.126	13	$100,237	4,988	95,270	$30,211	125	$2,591	$10,673	6
Ogdensburg, NY	0	0	$0	0	0	$0	0	$0	$0	n/a
Brownsville/ Matamoros, TX	0	0	$0	0	0	$0	0	$0	$0	n/a
Gateway, TX	0	0	$0	0	0	$0	0	$0	$0	n/a

Table B-14: Calculations for Biomass Gasification of Dry Waste for Heat and Electric Power

LPOE Site Name	Biomass Gasifier Size (MBtu/h)	Biomass Gasifier Cogen Size (kW)	Biomass Initial Cost ($)	Biomass Natural Gas Savings (therms/yr)	Biomass Gasifier Electric Delivery (kWh/yr)	Biomass Gasifier Annual Utility Cost Savings ($/yr)	Tons of Fuel Used	Fuel Cost ($)	Biomass Gasifier O&M Cost($/yr)	Biomass Gasifier Payback Period (yrs)
Columbia, TX	0.214	23	$137,234	8,218	168,483	$41,457	212	$7,296	$18,411	9
Convent, TX	0	0	$0	0	0	$0	0	$0	$0	n/a
Del Rio, TX	0	0	$0	0	0	$0	0	$0	$0	n/a
Donna TX (not built yet)	0	0	$0	0	0	$0	0	$0	$0	n/a
Bridge of the Americas, TX	0	0	$0	0	0	$0	0	$0	$0	n/a
Eagle Pass, TX	0	0	$0	0	0	$0	0	$0	$0	n/a
Fabens, TX	0	0	$0	0	0	$0	0	$0	$0	n/a
Fort Hancock, TX	0	0	$0	0	0	$0	0	$0	$0	n/a
El Paso, TX (out leased)	0	0	$0	0	0	$0	0	$0	$0	n/a
Juarez-Lincoln, TX	0	0	$0	0	0	$0	0	$0	$0	n/a
Los Indios, TX	0	0	$0	0	0	$0	0	$0	$0	n/a
Laredo TX	0	0	$0	0	0	$0	0	$0	$0	n/a
Los Tomates, TX	0	0	$0	0	0	$0	0	$0	$0	n/a
McAllen, TX	0	0	$0	0	0	$0	0	$0	$0	n/a
McAllen TX (not built yet)	0	0	$0	0	0	$0	0	$0	$0	n/a
Marfa, TX	0	0	$0	0	0	$0	0	$0	$0	n/a
Kika de la Garza, TX	0	0	$0	0	0	$0	0	$0	$0	n/a
Paso Del Norte, TX	0	0	$0	0	0	$0	0	$0	$0	n/a
Progreso, TX	0	0	$0	0	0	$0	0	$0	$0	n/a
Roma, TX	0	0	$0	0	0	$0	0	$0	$0	n/a
Rio Grande City, TX	0	0	$0	0	0	$0	0	$0	$0	n/a
Ysleta, TX	0	0	$0	0	0	$0	0	$0	$0	n/a
RR Inspection, TX	0	0	$0	0	0	$0	0	$0	$0	n/a
Admin, TX (leased)	0	0	$0	0	0	$0	0	$0	$0	n/a
El Paso, TX (Leased)	0	0	$0	0	0	$0	0	$0	$0	n/a
DOT, TX (leased)	0	0	$0	0	0	$0	0	$0	$0	n/a
Derby Line, VT	0	0	$0	0	0	$0	0	$0	$0	n/a
Norton, VT	0	0	$0	0	0	$0	0	$0	$0	n/a
Beebe Plain, VT	0	0	$0	0	0	$0	0	$0	$0	n/a
Alburg Springs, VT	0	0	$0	0	0	$0	0	$0	$0	n/a
North Troy VT	0	0	$0	0	0	$0	0	$0	$0	n/a

Table B-14: Calculations for Biomass Gasification of Dry Waste for Heat and Electric Power

LPOE Site Name	Biomass Gasifier Size (MBtu/h)	Biomass Gasifier Cogen Size (kW)	Biomass Initial Cost ($)	Biomass Natural Gas Savings (therms/yr)	Biomass Gasifier Electric Delivery (kWh/yr)	Biomass Gasifier Annual Utility Cost Savings ($/yr)	Tons of Fuel Used	Fuel Cost ($)	Biomass Gasifier O&M Cost($/yr)	Biomass Gasifier Payback Period (yrs)
West Berkshire,VT	0	0	$0	0	0	$0	0	$0	$0	n/a
Derby Line, VT	0	0	$0	0	0	$0	0	$0	$0	n/a
Beecher Falls, VT	0	0	$0	0	0	$0	0	$0	$0	n/a
Canaan, VT	0	0	$0	0	0	$0	0	$0	$0	n/a
East Richford, VT	0	0	$0	0	0	$0	0	$0	$0	n/a
Richford, VT	0	0	$0	0	0	$0	0	$0	$0	n/a
Alburg, VT (Joint ownership)	0	0	$0	0	0	$0	0	$0	$0	n/a
Highgate Springs 1, VT	0	0	$0	0	0	$0	0	$0	$0	n/a
Highgate Springs 2, VT	0	0	$0	0	0	$0	0	$0	$0	n/a
Highgate Springs 3, VT	0	0	$0	0	0	$0	0	$0	$0	n/a
Blaine, WA	0	0	$0	0	0	$0	0	$0	$0	n/a
Danville, WA	0	0	$0	0	0	$0	0	$0	$0	n/a
Laurier, WA	0	0	$0	0	0	$0	0	$0	$0	n/a
Mataline Falls. WA	0	0	$0	0	0	$0	0	$0	$0	n/a
Oroville, WA	0	0	$0	0	0	$0	0	$0	$0	n/a
Point Robert, WA	0	0	$0	0	0	$0	0	$0	$0	n/a
Sumas, WA	0	0	$0	0	0	$0	0	$0	$0	n/a
Blaine, WA	0	0	$0	0	0	$0	0	$0	$0	n/a
Blaine, WA	0	0	$0	0	0	$0	0	$0	$0	n/a
Kenneth Ward, WA	0	0	$0	0	0	$0	0	$0	$0	n/a
Totals						**$272,264**				

Note that each technology is recommended as part of the optimized solution for a site, and these sizes minimize life-cycle costs. In other words, it is possible for an LPOE site to cost effectively generate more RE than the optimized solution indicates, but the life cycle costs would be higher.

Table B-15: Calculations for Biomass Gasification of Dry Waste for Heat and Electric Power (Only Sites with Payback Periods Fewer than 17 Years)

LPOE Site Name	Biomass Gasifier Size (MBtu/h)	Biomass Gasifier Cogen Size (kW)	Biomass Gasifier Initial Cost ($)	Biomass Fuel Cost ($)	Biomass Gasifier O&M ($/yr)	Natural Gas Saved (therms/yr)	Biomass Gasifier Electric Delivery (kWh/yr)	Utility Savings ($/yr)	Biomass Gasifier Payback Period (yrs)
Tecate, CA	0.115	12	$95,485	$2,408	$9,776	4,615	86,759	$29,700	5
Calexico, CA	0.254	24	$197,485	$6,341	$21,032	10,800	177,241	$59,910	6
Niagra Falls, NY	0.126	13	$100,237	$2,591	$10,673	4,988	95,270	$30,211	6
Coburn Gore, ME	0.101	11	$70,229	$2,052	$8,739	3,893	80,054	$19,782	8
Fort Kent, ME	0.115	12	$78,880	$2,425	$9,841	4,491	89,001	$22,350	8
Sweetgrass, MT	0.115	12	$82,297	$2,438	$9,829	4,454	89,228	$22,182	8
Raymond, MT	0.001	0	$784	$27	$77	99	0	$193	9
Columbia, TX	0.214	23	$137,234	$7,296	$18,411	8,218	168,483	$41,457	9
San Luis, AZ	0.172	17	$115,233	$4,285	$14,620	6,878	129,993	$29,643	11
Houlton, ME	0.105	11	$72,315	$2,152	$8,992	4,098	81,383	$16,804	13
Totals	**1.318**	**135**	**$950,179.00**	**$32,015.00**	**$111,990.00**	**52,534**	**997,412**	**$272,232**	

Note that each technology is recommended as part of the optimized solution for a site, and these sizes minimize life-cycle costs. In other words, it is possible for an LPOE site to cost effectively generate more RE than the optimized solution indicates, but the life cycle costs would be higher.

Table B-16: Details of Solar Ventilation Air Preheating Calculations

LPOE Site Name	SVP Ventilation Rate (CFM)	Solar Vent Preheat Area (ft^2)	Annual Gas Savings (therms/yr)	Initial Cost ($)	Annual Utility Cost Savings ($/yr)	Solar Vent Preheat Payback Period (yrs)
Dalton Cache, AK	3,005	1275	2,906	$45,903	$7,476	6
Alcan, AK	21,697	4,220	12,178	$151,931	$30,537	5
Skagway, AK	2,232	813	2,158	$29,256	$5,877	5
Lukeville, AZ	9,520	100	108	$3,600	$323	11
Nogales, AZ	15,552	100	147	$3,600	$180	20
Sasabe, AZ	4,140	100	132	$3,600	$504	7
Douglas, AZ	10,290	1,623	2,645	$58,443	$4,642	13
San Luis, AZ	10,934	0	0	$0	$0	21
Naco, AZ	3,341	358	525	$12,884	$993	13
San Luis AZ (not built yet)	3,400	0	0	$0	$0	55
Nogales, AZ	13,994	0	0	$0	$0	21
Calexico West, CA	19,888	0	0	$0	$0	48
San Ysidro, CA	31,339	0	0	$0	$0	60
Andrade, CA	646	97	65	$3,477	$256	14
Otay Mesa, CA	48,105	0	0	$0	$0	53
Tecate, CA	6,839	0	0	$0	$0	16
Calexico, CA	34,637	0	0	$0	$0	14
Eastport, ID	4,636	1,592	4,040	$57,326	$7,458	8
Porthill, ID	1,453	499	1,266	$17,973	$2,563	7
Ferry Point, ME	3,607	1,577	3,676	$56,783	$8,009	7
Coburn Gore, ME	826	269	636	$9,682	$1,570	6
Fort Fairfield, ME	859	377	875	$13,585	$1,944	7
Houlton, ME	6,445	2,832	6,568	$101,965	$13,455	8
Jackman, ME	2,809	916	2,166	$32,958	$4,068	8
Limestone, ME	653	286	665	$10,292	$1,638	6
Orient, ME	630	277	642	$9,979	$1,474	7
Vanceboro, ME	1,671	733	1,703	$26,390	$3,715	7
VanBuren, ME	1,776	778	1,810	$28,008	$3,803	7
Milltown ME	159	50	115	$1,783	$239	7
St. Francis, ME	29	116	299	$4,181	$782	5
Madawaska, ME	1,295	548	1,320	$19,714	$2,869	7
Fort Kent, ME	1,376	582	1,402	$20,949	$2,613	8
St. Francis, ME	132	33	79	$1,184	$212	6
Detroit Cargo, MI	11,013	0	0	$0	$0	21
Intl Bridge, MI	25,009	0	0	$0	$0	18

Table B-16: Details of Solar Ventilation Air Preheating Calculations

LPOE Site Name	SVP Ventilation Rate (CFM)	Solar Vent Preheat Area (ft^2)	Annual Gas Savings (therms/yr)	Initial Cost ($)	Annual Utility Cost Savings ($/yr)	Solar Vent Preheat Payback Period (yrs)
Amb. Bridge, MI	131,810	0	0	$0	$0	17
Grand Portage, MN	4,053	1,541	4,385	$55,469	$6,690	8
Noyes, MN	2,384	902	2,580	$32,457	$4,663	7
Roseau, MN	8,815	2,898	7,709	$104,341	$9,280	11
Intl Falls, MN	1,674	489	1,149	$17,592	$1,382	13
Baudette, MN	1,226	342	713	$12,308	$2,581	5
Chief Mt, MT	1,819	466	1,347	$16,780	$1,198	14
Piegan, MT	4,050	1,307	3,775	$47,035	$7,001	7
Raymond, MT	4,957	1,555	4,547	$55,964	$8,806	6
Rooseville, MT	4,076	0	0	$0	$0	21
Sweetgrass, MT	14,330	1,261	3,645	$45,411	$10,782	4
Turner, MT	1,226	161	464	$5,809	$3,423	2
Ambrose, ND	939	284	861	$10,210	$1,480	7
Dunseith, ND	1,625	528	1,520	$19,012	$2,011	9
Portal, ND	2,265	714	2,138	$25,713	$2,095	12
St. John ND	812	269	773	$9,675	$1,255	8
Pembina, ND	11,434	3,831	10,964	$137,933	$16,974	8
Columbus, NM	7,073	880	1,818	$31,694	$6,263	5
Santa Teresa, NM	16,819	0	0	$0	$0	17
Alexandria Bay, NY	8,288	3,640	7,200	$131,044	$10,275	13
Champlain, NY	33,484	6,739	13,329	$242,600	$19,778	12
Massena, NY	3,400	1,627	2,954	$58,573	$7,358	8
Fort Covington, NY	837	334	607	$12,029	$1,554	8
Rouses Pt. NY	1,480	651	1,188	$23,449	$2,893	8
St John Hwy, NY	2,653	1,171	2,135	$42,152	$5,385	8
Trout, River, NY	1,600	730	1,371	$26,273	$3,314	8
Chateaugay, NY	888	389	753	$14,021	$1,971	7
Mooers, NY	771	300	547	$10,793	$1,402	8
Jamieson, NY	355	111	177	$3,980	$438	7
Niagra Falls, NY	74,825	8,444	13,087	$303,989	$47,991	6
Ogdensburg, NY	33,075	5,614	10,859	$202,109	$15,098	13
Brownsville/ Matamoros, TX	14,995	0	0	$0	$0	269
Gateway, TX	21,815	0	0	$0	$0	259
Columbia, TX	54,548	0	0	$0	$0	32
Convent, TX	8,344	0	0	$0	$0	87

Table B-16: Details of Solar Ventilation Air Preheating Calculations

LPOE Site Name	SVP Ventilation Rate (CFM)	Solar Vent Preheat Area (ft^2)	Annual Gas Savings (therms/yr)	Initial Cost ($)	Annual Utility Cost Savings ($/yr)	Solar Vent Preheat Payback Period (yrs)
Del Rio, TX	25,464	0	0	$0	$0	21
Donna TX (not built yet)	3,400	0	0	$0	$0	267
Bridge of the Americas, TX	40,439	0	0	$0	$0	20
Eagle Pass, TX	25,438	0	0	$0	$0	32
Fabens, TX	2,970	376	763	$13,542	$3,861	4
Fort Hancock, TX	1,301	160	327	$5,765	$843	7
El Paso, TX (out leased)	3,400	0	0	$0	$0	18
Juarez-Lincoln, TX	63,132	0	0	$0	$0	81
Los Indios, TX	31,515	0	0	$0	$0	241
Laredo TX	19,621	0	0	$0	$0	80
Los Tomates, TX	35,259	0	0	$0	$0	256
McAllen, TX	22,730	0	0	$0	$0	91
McAllen TX (not built yet)	3,400	0	0	$0	$0	189
Marfa, TX	16,532	2,292	4,152	$82,515	$5,944	14
Kika de la Garza, TX	40,431	0	0	$0	$0	165
Paso Del Norte, TX	19,968	0	0	$0	$0	20
Progreso, TX	4,381	0	0	$0	$0	104
Roma, TX	5,776	0	0	$0	$0	45
Rio Grande City, TX	6,952	0	0	$0	$0	82
Ysleta, TX	44,995	0	0	$0	$0	20
RR Inspection, TX	282	0	0	$0	$0	28
Admin, TX (leased)	10,416	0	0	$0	$0	159
El Paso, TX (Leased)	1,218	0	0	$0	$0	17
DOT, TX (leased)	10,220	661	558	$23,797	$1,577	15
Derby Line, VT	1,649	575	1,327	$20,710	$2,725	8
Norton, VT	1,124	392	905	$14,119	$1,802	8
Beebe Plain, VT	493	161	372	$5,799	$706	8
Alburg Springs, VT	462	145	265	$5,231	$608	9
North Troy VT	859	326	681	$11,731	$1,408	8
West Berkshire,VT	1,075	412	741	$14,817	$1,646	9
Derby Line, VT	4,974	1,735	4,003	$62,463	$8,594	7
Beecher Falls, VT	1,362	483	1,094	$17,397	$2,498	7
Canaan, VT	701	248	561	$8,922	$1,253	7
East Richford, VT	1,225	471	984	$16,957	$2,024	8
Richford, VT	1,141	438	916	$15,779	$2,008	8

Table B-16: Details of Solar Ventilation Air Preheating Calculations

LPOE Site Name	SVP Ventilation Rate (CFM)	Solar Vent Preheat Area (ft^2)	Annual Gas Savings (therms/yr)	Initial Cost ($)	Annual Utility Cost Savings ($/yr)	Solar Vent Preheat Payback Period (yrs)
Alburg, VT (Joint ownership)	1,24	261	477	$9,414	$1,904	5
Highgate Springs 1, VT	323	0	0	$0	$0	5
Highgate Springs 2, VT	4,729	2,087	3,806	$75,137	$7,667	10
Highgate Springs 3, VT	640	199	362	$7,153	$727	10
Blaine, WA	11,540	3,316	6,046	$119,379	$13,153	9
Danville, WA	2,550	823	1,800	$29,612	$2,653	11
Laurier, WA	1,679	406	888	$14,603	$2,737	5
Mataline Falls. WA	1,547	0	0	$0	$0	17
Oroville, WA	24,285	289	592	$10,413	$4,668	2
Point Robert, WA	11,069	3,248	6,642	$116,913	$12,099	10
Sumas, WA	4,060	0	0	$0	$0	19
Blaine, WA	11,540	3,316	6,046	$119,367	$11,012	11
Blaine, WA	32,791	0	0	$0	$0	18
Kenneth Ward, WA	5,903	0	0	$0	$0	19
Totals					**$404,658.00**	

Note that each technology is recommended as part of the optimized solution for a site, and these sizes minimize life-cycle costs. In other words, it is possible for an LPOE site to cost effectively generate more RE than the optimized solution indicates, but the life cycle costs would be higher.

Table B-17: Details of Solar Water Heating Calculations

Name	Hot Water Use (gallon/day)	Solar Water Heating Area (ft^2)	Solar Water Heating Initial Cost ($)	SWH Utility Rebate ($)	Solar Water Heating Gas Savings (therms/yr)	Solar Water Heating Annual Utility Cost Savings ($/yr)	Solar Water Heating O&M Cost ($/yr)	Solar Water Heating Payback Period (yrs)
Dalton Cache, AK	652	189	$13,788	$0	377	$970	$69	15
Alcan, AK	4,430	3,452	$252,024	$0	7,694	$19,293	$1,260	14
Skagway, AK	537	291	$21,242	$0	581	$1,583	$106	14
Lukeville, AZ	820	592	$43,243	$0	2,256	$6,725	$216	7
Nogales, AZ	2,616	0	$0	$0	0	$0	$0	17
Sasabe, AZ	252	184	$13,445	$5,378	694	$2,656	$67	3
Douglas, AZ	1,574	1,158	$84,530	$0	4,328	$7,597	$423	12
San Luis, AZ	1,982	1,445	$105,506	$0	5,452	$14,285	$528	8
Naco, AZ	529	387	$28,250	$0	1,456	$2,754	$141	11
San Luis AZ (not built yet)	249	0	$0	$0	0	$0	$0	21
Nogales, AZ	3,841	0	$0	$0	0	$0	$0	17
Calexico West, CA	4,415	0	$0	$0	0	$0	$0	21
San Ysidro, CA	9,666	0	$0	$0	0	$0	$0	18
Andrade, CA	379	275	$20,108	$0	1,041	$4,064	$101	5
Otay Mesa, CA	5,725	0	$0	$0	0	$0	$0	16
Tecate, CA	1,279	1,028	$75,034	$15,418	3,516	$13,788	$375	4
Calexico, CA	4,206	3,062	$223,550	$0	11,570	$41,140	$1,118	6
Eastport, ID	617	0	$0	$0	0	$0	$0	17
Porthill, ID	158	89	$6,472	$0	222	$450	$32	15
Ferry Point, ME	512	223	$16,294	$0	534	$1,163	$81	15
Coburn Gore, ME	498	556	$40,598	$0	1,369	$3,376	$203	13
Fort Fairfield, ME	210	114	$8,353	$0	255	$567	$42	16
Houlton, ME	1,144	0	$0	$0	0	$0	$0	16
Jackman, ME	318	0	$0	$0	0	$0	$0	18
Limestone, ME	145	109	$7,931	$0	240	$592	$40	14
Orient, ME	52	39	$2,834	$0	95	$217	$14	14
Vanceboro, ME	321	167	$12,200	$0	394	$859	$61	15
VanBuren, ME	290	117	$8,541	$0	271	$570	$43	16
Milltown ME	96	63	$4,612	$0	151	$313	$23	16
St. Francis, ME	41	32	$2,336	$0	78	$203	$12	12
Madawaska, ME	341	136	$9,951	$0	311	$677	$50	16
Fort Kent, ME	523	0	$0	$0	0	$0	$0	18
St. Francis, ME	47	36	$2,641	$0	85	$227	$13	12
Detroit Cargo, MI	4,832	0	$0	$0	0	$0	$0	35
Intl Bridge, MI	3,581	0	$0	$0	0	$0	$0	37

Table B-17: Details of Solar Water Heating Calculations

Name	Hot Water Use (gallon/day)	Solar Water Heating Area (ft^2)	Solar Water Heating Initial Cost ($)	SWH Utility Rebate ($)	Solar Water Heating Gas Savings (therms/yr)	Solar Water Heating Annual Utility Cost Savings ($/yr)	Solar Water Heating O&M Cost ($/yr)	Solar Water Heating Payback Period (yrs)
Amb. Bridge, MI			851	0	$0	$0	0	$0
Grand Portage, MN	770	0	$0	$0	0	$0	$0	21
Noyes, MN	454	0	$0	$0	0	$0	$0	18
Roseau, MN	1,106	0	$0	$0	0	$0	$0	28
Intl Falls, MN	372	0	$0	$0	0	$0	$0	31
Baudette, MN	86	59	$4,312	$0	151	$548	$22	8
Chief Mt, MT	1,915	0	$0	$0	0	$0	$0	36
Piegan, MT	1,732	0	$0	$0	0	$0	$0	16
Raymond, MT	2,560	0	$0	$0	0	$0	$0	16
Rooseville, MT	636	0	$0	$0	0	$0	$0	61
Sweetgrass, MT	810	547	$39,911	$0	1,502	$4,444	$200	9
Turner, MT	17	10	$757	$0	28	$208	$4	4
Ambrose, ND	172	0	$0	$0	0	$0	$0	18
Dunseith, ND	282	0	$0	$0	0	$0	$0	24
Portal, ND	561	0	$0	$0	0	$0	$0	34
St. John ND	172	0	$0	$0	0	$0	$0	19
Pembina, ND	4,140	0	$0	$0	0	$0	$0	22
Columbus, NM	600	436	$31,824	$0	1,651	$5,689	$159	6
Santa Teresa, NM	1,829	0	$0	$0	0	$0	$0	20
Alexandria Bay, NY	1,530	0	$0	$0	0	$0	$0	24
Champlain, NY	11,603	0	$0	$0	0	$0	$0	23
Massena, NY	666	703	$51,329	$0	1,699	$4,233	$257	13
Fort Covington, NY	189	165	$12,074	$0	391	$1,002	$60	13
Rouses Pt. NY	325	258	$18,823	$0	596	$1,452	$94	14
St John Hwy, NY	442	389	$28,398	$0	900	$2,269	$142	13
Trout, River, NY	254	210	$15,303	$0	496	$1,199	$77	14
Chateaugay, NY	229	203	$14,820	$0	475	$1,242	$74	13
Mooers, NY	162	138	$10,057	$0	329	$843	$50	13
Jamieson, NY	31	24	$1,760	$0	61	$150	$9	12
Niagra Falls, NY	2,163	2,592	$189,220	$0	5,949	$21,817	$946	9
Ogdensburg, NY	1,782	0	$0	$0	0	$0	$0	25
Brownsville/ Matamoros, TX	1,099	0	$0	$0	0	$0	$0	24
Gateway, TX	2,128	0	$0	$0	0	$0	$0	23
Columbia, TX	2,367	2,104	$153,570	$0	6,511	$19,328	$768	8
Convent, TX	1,865	0	$0	$0	0	$0	$0	24

Table B-17: Details of Solar Water Heating Calculations

Name	Hot Water Use (gallon/day)	Solar Water Heating Area (ft^2)	Solar Water Heating Initial Cost ($)	SWH Utility Rebate ($)	Solar Water Heating Gas Savings (therms/yr)	Solar Water Heating Annual Utility Cost Savings ($/yr)	Solar Water Heating O&M Cost ($/yr)	Solar Water Heating Payback Period (yrs)
Del Rio, TX	2,640	2,082	$151,977	$0	6,380	$11,708	$760	14
Donna TX (not built yet)	249	0	$0	$0	0	$0	$0	28
Bridge of the Americas, TX	6,425	0	$0	$0	0	$0	$0	24
Eagle Pass, TX	1,788	0	$0	$0	0	$0	$0	20
Fabens, TX	326	242	$17,686	$0	895	$4,529	$88	4
Fort Hancock, TX	411	300	$21,918	$0	1,131	$2,918	$110	8
El Paso, TX (out leased)	1,465	0	$0	$0	0	$0	$0	21
Juarez-Lincoln, TX	5,051	0	$0	$0	0	$0	$0	22
Los Indios, TX	2,494	0	$0	$0	0	$0	$0	25
Laredo TX	804	0	$0	$0	0	$0	$0	22
Los Tomates, TX	2,823	0	$0	$0	0	$0	$0	23
McAllen, TX	914	0	$0	$0	0	$0	$0	12
McAllen TX (not built yet)	249	0	$0	$0	0	$0	$0	27
Marfa, TX	683	337	$24,566	$0	1,242	$1,778	$123	15
Kika de la Garza, TX	2,993	0	$0	$0	0	$0	$0	23
Paso Del Norte, TX	2,146	0	$0	$0	0	$0	$0	24
Progreso, TX	684	627	$45,753	$0	1,882	$4,814	$229	10
Roma, TX	1,217	554	$40,429	$0	1,716	$4,715	$202	9
Rio Grande City, TX	1,089	0	$0	$0	0	$0	$0	17
Ysleta, TX	4,048	0	$0	$0	0	$0	$0	24
RR Inspection, TX	9	0	$0	$0	0	$0	$0	7
Admin, TX (leased)	2,635	0	$0	$0	0	$0	$0	22
El Paso, TX (Leased)	532	0	$0	$0	0	$0	$0	21
DOT, TX (leased)	1,408	1,266	$92,390	$0	3,872	$10,942	$462	9
Derby Line, VT	729	0	$0	$0	0	$0	$0	17
Norton, VT	317	0	$0	$0	0	$0	$0	18
Beebe Plain, VT	100	0	$0	$0	0	$0	$0	19
Alburg Springs, VT	98	72	$5,288	$0	166	$381	$26	15
North Troy VT	115	81	$5,891	$0	184	$380	$29	17
West Berkshire,VT	142	104	$7,587	$0	241	$537	$38	15
Derby Line, VT	422	216	$15,733	$0	488	$1,048	$79	16
Beecher Falls, VT	233	170	$12,430	$0	390	$891	$62	15
Canaan, VT	166	120	$8,739	$0	275	$614	$44	15

Table B-17: Details of Solar Water Heating Calculations

Name	Hot Water Use (gallon/day)	Solar Water Heating Area (ft^2)	Solar Water Heating Initial Cost ($)	SWH Utility Rebate ($)	Solar Water Heating Gas Savings (therms/yr)	Solar Water Heating Annual Utility Cost Savings ($/yr)	Solar Water Heating O&M Cost ($/yr)	Solar Water Heating Payback Period (yrs)
East Richford, VT	169	0	$0	$0	0	$0	$0	17
Richford, VT	213	145	$10,607	$0	330	$724	$53	16
Alburg, VT (Joint ownership)	46	34	$2,517	$0	79	$316	$13	8
Highgate Springs 1, VT	3	0	$0	$0	0	$0	$0	8
Highgate Springs 2, VT	3,008	0	$0	$0	0	$0	$0	17
Highgate Springs 3, VT	146	0	$0	$0	0	$0	$0	17
Blaine, WA	1,013	256	$18,691	$0	584	$1,271	$93	16
Danville, WA	231	0	$0	$0	0	$0	$0	21
Laurier, WA	79	52	$3,777	$0	129	$397	$19	10
Mataline Falls. WA	95	0	$0	$0	0	$0	$0	35
Oroville, WA	1,568	0	$0	$0	0	$0	$0	4
Point Robert, WA	776	223	$16,267	$0	592	$1,079	$81	16
Sumas, WA	1,192	0	$0	$0	0	$0	$0	36
Blaine, WA	809	0	$0	$0	0	$0	$0	19
Blaine, WA	3,447	0	$0	$0	0	$0	$0	34
Kenneth Ward, WA	595	0	$0	$0	0	$0	$0	36
Totals						**$237,535.00**		

Note that each technology is recommended as part of the optimized solution for a site, and these sizes minimize life-cycle costs. In other words, it is possible for an LPOE site to cost effectively generate more RE than the optimized solution indicates, but the life cycle costs would be higher.

Table B-18: Return on Investment of RE Solutions (without incentives)

LPOE Site Name	Renewable Energy Initial Cost	RE Case Life-Cycle Cost	Base Case Life-Cycle Cost	RE Solution Case Return on investment
Oroville, WA	$10,415	$1,201,469	$1,254,894	44.8%
Fabens, TX	$46,957	$640,297	$777,609	27.4%
Sasabe, AZ	$32,691	$377,290	$456,025	23.3%
Columbus, NM	$95,087	$799,531	$976,752	19.9%
Tecate, CA	$224,279	$1,963,062	$2,367,343	19.7%
Santa Teresa, NM	$88,330	$2,422,683	$2,593,983	19.4%
Donna TX (not built)	$14,708	$280,294	$307,574	18.9%
Paso Del Norte, TX	$117,746	$2,496,897	$2,712,162	18.7%
Baudette, MN	$16,701	$120,794	$147,275	18.5%
Calexico, CA	$627,943	$6,069,151	$7,063,869	18.0%
Ysleta, TX	$259,146	$3,642,882	$4,089,669	18.0%
Bridge of the Americas, TX	$219,433	$5,081,708	$5,452,568	17.8%
Calexico West, CA	$162,695	$6,739,396	$7,013,550	17.7%
Dalton Cache, AK	$78,957	$1,399,128	$1,521,347	17.5%
Nogales, AZ	$124,450	$3,391,983	$3,578,824	16.5%
McAllen, TX	$44,664	$1,223,880	$1,290,185	16.4%
Lukeville, AZ	$95,330	$1,029,003	$1,154,779	15.7%
Juarez-Lincoln, TX	$316,588	$5,711,558	$6,146,785	15.6%
Eagle Pass, TX	$127,361	$1,661,380	$1,835,503	15.6%
Raymond, MT	$56,749	$1,930,963	$1,997,355	15.2%
Los Indios, TX	$163,432	$2,835,216	$3,046,057	15.1%
Laredo TX	$40,968	$1,000,052	$1,053,164	15.1%
Alburg, VT (Joint ownership)	$19,095	$64,251	$87,027	15.0%
Rio Grande City, TX	$52,686	$1,495,642	$1,562,354	14.9%
Jamieson, NY	$6,298	$38,897	$46,171	14.6%
St. Francis, ME	$6,517	$43,431	$50,393	14.4%
Columbia, TX	$543,397	$2,728,986	$3,318,599	14.1%
Nogales, AZ	$108,132	$4,411,255	$4,534,344	14.0%
Fort Hancock, TX	$34,852	$580,607	$617,218	14.0%
Ambrose, ND	$10,210	$142,785	$153,144	13.9%
Noyes, MN	$32,457	$398,807	$431,149	13.8%
Skagway, AK	$59,255	$890,982	$950,179	13.7%
Convent, TX	$62,574	$2,202,026	$2,265,586	13.1%
Laurier, WA	$31,892	$84,751	$115,171	13.1%
Sweetgrass, MT	$225,652	$926,893	$1,131,193	13.0%

Table B-18: Return on Investment of RE Solutions (without incentives)

LPOE Site Name	Renewable Energy Initial Cost	RE Case Life-Cycle Cost	Base Case Life-Cycle Cost	RE Solution Case Return on investment
Otay Mesa, CA	$1,000,242	$7,571,426	$8,525,158	12.7%
Fort Kent, ME	$112,520	$553,009	$649,941	12.6%
Orient, ME	$19,355	$77,119	$94,455	12.6%
San Ysidro, CA	$1,039,517	$10,407,761	$11,365,375	12.4%
Beebe Plain, VT	$10,345	$128,300	$137,465	12.4%
Ogdensburg NY	$377,470	$2,234,485	$2,569,924	12.3%
Eastport, ID	$57,326	$491,441	$538,000	12.3%
St. John ND	$9,675	$149,141	$156,946	12.2%
Derby Line, VT	$102,253	$453,948	$535,282	11.9%
Fort Fairfield, ME	$30,203	$310,294	$334,467	11.8%
East Richford, VT	$27,681	$235,045	$257,160	11.8%
Limestone, ME	$24,553	$215,812	$235,286	11.8%
Ferry Point, ME	$73,078	$797,020	$850,481	11.6%
Pembina, ND	$137,934	$3,221,645	$3,320,512	11.5%
Roma, TX	$85,057	$1,521,923	$1,587,054	11.5%
Jackman, ME	$32,959	$313,910	$337,700	11.5%
Porthill, ID	$24,445	$134,387	$151,440	11.3%
San Luis, AZ	$289,853	$2,253,582	$2,452,837	11.2%
DOT, TX (leased)	$189,091	$1,744,160	$1,878,746	11.2%
Alcan, AK	$403,956	$5,032,271	$5,302,416	11.1%
Madawaska, ME	$42,018	$508,829	$538,666	11.1%
Derby Line, VT	$34,673	99852,106	$876,501	11.1%
Norton, VT	$26,317	$425,853	$444,738	11.1%
Del Rio, TX	$288,329	$2,989,214	$3,192,497	11.0%
Vanceboro, ME	$48,446	$412,727	$445,136	10.9%
VanBuren, ME	$36,550	$329,151	$352,943	10.9%
Beecher Falls, VT	$41,812	$350,836	$378,661	10.8%
Coburn Gore, ME	$140,181	$546,031	$627,043	10.3%
Highgate Springs 3, VT	$12,905	$178,256	$186,327	10.3%
Houlton, ME	$174,282	$1,297,218	$1,392,579	10.2%
Progreso, TX	$81,634	$778,603	$826,572	10.2%
Grand Portage, MN	$73,841	$684,020	$726,801	10.2%
St. Francis, ME	$3,825	$56,893	$58,984	10.1%
Naco, AZ	$70,556	$656,596	$697,006	10.0%
Richford, VT	$36,618	$308,121	$329,003	10.0%
Chateaugay, NY	$28,841	$292,562	$307,451	9.8%
Trout, River, NY	$55,944	$371,460	$400,914	9.7%

Table B-18: Return on Investment of RE Solutions (without incentives)

LPOE Site Name	Renewable Energy Initial Cost	RE Case Life-Cycle Cost	Base Case Life-Cycle Cost	RE Solution Case Return on investment
Canaan, VT	$24,276	$248,095	$261,045	9.7%
Niagra Falls, NY	$1,383,426	$3,023,102	$3,746,085	9.6%
Los Tomates, TX	$1,131,309	$3,183,399	$3,791,946	9.5%
St John Hwy, NY	$70,551	$349,193	$383,476	9.5%
Dunseith, ND	$19,012	$222,609	$231,773	9.5%
Douglas, AZ	$220,785	$1,922,732	$2,033,183	9.4%
Alburg Springs, VT	$15,417	$135,159	$142,793	9.4%
RR Inspection, TX	$2,760	$12,963	$14,416	9.4%
Fort Covington, NY	$31,915	$300,255	$315,542	9.3%
Andrade, CA	$174,114	$613,811	$697,785	9.2%
Gateway, TX	$811,736	$2,590,613	$2,984,200	9.1%
Champlain, NY	$415,889	$12,769,725	$12,963,556	9.1%
Massena, NY	$109,903	$567,438	$615,736	9.1%
Detroit Cargo, MI	$77,868	$3,800,734	$3,839,007	9.1%
West Berkshire,VT	$32,551	$203,090	$217,239	8.9%
Piegan, MT	$137,642	$1,497,580	$1,557,310	8.8%
Rouses Pt. NY	$55,590	$419,324	$441,563	8.6%
Mooers, NY	$28,052	$225,304	$236,566	8.6%
Kenneth Ward, WA	$26,495	$517,919	$529,039	8.6%
Highgate Springs 2, VT	$107,349	$3,095,076	$3,137,323	8.5%
Blaine, WA	$188,460	$972,738	$1,040,623	8.3%
Turner, MT	$31,218	$49,283	$59,614	8.0%
Point Robert, WA	$176,860	$612,709	$667,543	7.9%
Blaine, WA	$162,654	$3,700,823	$3,755,228	7.9%
Blaine, WA	$119,368	$660,308	$695,963	7.8%
Danville, WA	$41,203	$203,316	$216,147	7.8%
Alexandria Bay, NY	$674,659	$2,744,416	$2,953,875	7.7%
Brownsville/ Matamoros, TX	$466,410	$1,282,641	$1,428,943	7.7%
Kika de la Garza, TX	$1,054,667	$4,000,071	$4,290,611	7.4%
Roseau, MN	$104,341	$791,280	$817,759	7.4%
North Troy, VT	$24,896	$104,441	$110,418	7.2%
Milltown, ME	$7,955	$172,052	$173,937	7.2%
Marfa, TX	$315,565	$602,769	$670,371	6.9%
Portal, ND	$25,714	$418,026	$421,940	6.4%
Intl Falls, MN	$17,592	$303,514	$305,496	6.0%
Chief Mt, MT	$16,780	$1,140,375	$1,140,633	5.1%

The following LPOE Sites did not have cost-effective applications of RE technologies.

- Rooseville, MT,
- Sumas, WA,
- San Luis AZ (not built),
- Intl Bridge, MI,
- Amb. Bridge, MI,
- El Paso, TX (out leased),
- McAllen TX (not built),
- Admin, TX (leased),
- El Paso, TX (leased),
- Mataline Falls. WA,
- Highgate Springs 1, VT.

Table B-19: ROI of RE Solutions by GSA Region (without incentives)

	GSA Region							
	1	2	5	7	8	9	10	Grand Total
RE Solutions Case Life-cycle Cost	$13,989,463	$23,524,359	$8,871,273	$57,994,499	$10,212,440	$47,714,623	$17,025,517	$179,332,174
Base Case Life-Cycle Cost	$14,941,605	$25,004,919	$9,039,609	$63,225,183	$10,683,561	$52,247,654	$17,869,336	$193,011,868
Average Return on investment (%)	10.4%	10.4%	8.2%	13.9%	10.0%	15.0%	11.6%	11.8%

Table B-20 offers a snapshot of the number of technologies included in the optimized RE solutions by region and by technology. It is important to understand that for each LPOE site, a technology is only counted here if it is part of the optimized combination of RE solutions for that site.

In other words, it is possible for an LPOE site to have the potential to generate biomass energy cost effectively. However, if it is more cost-effective to generate wind energy and use solar water heating at that LPOE site, then biomass energy will not be counted as an optimized technology for that site.

Further more, the number of technologies counted in this table does not reflect the total amount of energy that each region has the potential to generate.

Table B-20: Number of Technologies Included in Optimized RE Solutions (without incentives)

	Number of Sites by GSA Region							
RE Technology	1	2	5	7	8	9	10	Grand Total
Daylighting	3	4	0	8	1	3	0	**19**
Wind Energy	28	12	5	4	10	2	11	**72**
Biomass Energy	22	9	2	26	3	12	8	**82**
Solar Ventilation Air Preheat	23	9	1	10	4	10	8	**65**
Solar Water Heating	3	1	0	1	1	2	0	**8**
Solar Electric Photovoltaics	0	0	0	0	0	0	0	**0**
Solar Industrial Process Heat	0	0	0	0	0	0	0	**0**

Appendix C. Results of Life-Cycle Cost Optimization (with Financial Incentives)

Results are presented both with and without financial incentives. GSA does not benefit directly from tax credits when paying for projects with appropriations. However, by partnering with an entity that does have a tax liability through an alternative financing mechanism such as an ESPC, the tax credits could improve the cost-effectiveness of the project. Tables in the body of the report and Appendix A and B are without incentives, and tables in Appendix C are with-incentives.

There are 4 types of incentives that are considered for each technology and at each site:

1. Federal Business Investment Tax Credit (% of cost);
2. State tax credit (% of cost);
3. Rebate ($/watt or % of cost); and
4. Production incentives ($/kWh produced).

The 30% business investment tax credit is assumed for PV in the with-incentives case.

Renewable Energy Credits (RECs) could be sold for the power generated from renewable sources, but these would be used to offset another organization's goals, and thus it would be double-counting to say that GSA is using the renewable energy if the REC's are sold.

Incentives offered by federal and state governments, local utilities, and private organizations have a huge effect on solar project economics, and need to be taken into account even at this early planning stage. For this analysis, descriptions of incentives available at each LPOE site are taken from the Database for State Incentives for Renewable Energy [ref. 6]. These descriptions, however complicated, are approximated as a % reduction in initial cost, a $/watt or $/m^2 reduction in initial cost, a $/kWh production incentive, or a combination of the three. Incentives represented in this way modify the initial cost estimate or the annual cost savings estimate to calculate the life-cycle cost and payback period.

Federal incentives are applied at all sites in the with-incentives case. State incentives considered include:

- California Solar Initiative (San Diego tier)
  - <50kW: EPBB $2.30/W
  - >50kW: $0.32/kWh for 5 years

- California Emerging Renewables Program
    - Wind: $2.5/W for first 7.5kW, then $1.50/W for additional kW up to 30kW

- NYSERDA Anaerobic Digester Rebate and PBI
    - $500/W and $0.10/kWh up to $1M

- NYSERDA On-Site Small Wind
    - Max of $150,000 per site, for projects up to 250kW

- NYSERDA PV Incentive Program
    - $4/W up to 25kW, building integrated PV are eligible for an additional $500/kW
    - Max incentive: $225,000

- Vermont Solar and Small Wind Rebate Program
    - PV: $1.75/W up to $8,750
    - Wind: $4.50/w up to $20,000
    - SWH: up to $8,750

- Vermont Green Mountain Power- Solar GMP for PV
    - $0.06/kWh for 20 years, up to 250kW

It is important to note that most incentive and rebate programs have requirements, such as minimum or maximum size limitations or specific technology specifications, which a system must meet in order to qualify.

Other forms of incentives include tax rebates and loan options. Sales and property tax rebates or exemptions exist, as do low and no interest loans. These loans can be applied towards the purchase and installation costs of a renewable-energy system.

Net metering is another form of an incentive. It is an arrangement in which a utility provider credits a customer for generating electricity with a renewable technology and either using that electricity or feeding it into the local utility grid.

- One method is when two meters are installed: one meter records electricity drawn from the grid while the other records excess electricity that's generated by the customer and then fed to the grid. Generally in this type of arrangement the utility customer pays retail rates for the electricity they use, and they are paid wholesale rates for the electricity they generate and feed back into the grid.
- Another net metering arrangement occurs when a single bi-directional meter is used to record electricity drawn from the grid (the meter would spin forward) as well as excess electricity from the renewable technology that is fed back into the grid (the meter would spin backward). For this

type of arrangement the customer pays the retail price for any electricity used in excess of what they produce, and for any excess electricity produced by the customer, the utility provider pays for the electricity at its avoided cost, which is essentially the retail price.

Table C-1 presents the initial costs for the optimized mix of RE technologies for each LPOE site. Table C-2 shows the size of each technology in the optimized mix for every LPOE site. Table C-3 compares the difference in size of the optimal solutions with and without financial incentives. Table C-4 shows the calculations for the return on investment for the optimized mix of RE solutions for each site.

Table C-1: Initial Cost of RE Technology (with incentives)

LPOE Site Name	PV Initial Cost w/incentives	Wind Initial Cost w/ incentives	Solar Vent Preheat Cost w/incentives	Solar Water Heating Cost w/incentives	Biomass Gasifier Cost w/incentives	Daylighting Cost w/incentives	Total Initial Cost
Dalton Cache, AK	$537,950	$1	$27,544	$30,397	$55	$19,267	$615,214
Alcan, AK	$1	$1	$91,166	$239,475	$55	$1	$330,700
Skagway, AK	$1	$1	$17,554	$25,018	$55	$8,757	$51,387
Lukeville, AZ	$1	$0	$1,944	$23,351	$40	$48,486	$73,822
Nogales, AZ	$1	$0	$1,944	$75,398	$40	$120,850	$198,233
Sasabe, AZ	$1	$0	$1,944	$4,045	$40	$21,024	$27,054
Douglas, AZ	$1	$0	$31,553	$45,646	$40	$77,813	$155,053
San Luis, AZ	$1	$0	$32,503	$56,974	$101,852	$69,113	$260,443
Naco, AZ	$1	$0	$6,964	$15,255	$40	$29,422	$51,682
San Luis AZ (not built yet)	$1	$0	$0	$0	$40	$0	$41
Nogales, AZ	$1	$0	$0	$111,512	$40	$108,131	$219,684
Calexico West, CA	$1	$0	$0	$141,182	$49	$162,694	$303,926
San Ysidro, CA	$2,028,297	$849,150	$0	$270,450	$49	$270,670	$3,418,616
Andrade, CA	$1	$131,347	$3,008	$12,065	$49	$12,947	$159,417
Otay Mesa, CA	$983,563	$849,150	$0	$160,171	$49	$405,135	$2,398,067
Tecate, CA	$255,478	$0	$32,905	$35,773	$82,546	$69,177	$475,879
Calexico, CA	$1	$0	$107,977	$134,132	$167,814	$206,908	$616,833
Eastport, ID	$1	$0	$34,418	$25,400	$45	$0	$59,864
Porthill, ID	$1	$0	$10,786	$5,398	$45	$0	$16,230
Ferry Point, ME	$0	$0	$34,077	$25,053	$40	$0	$59,171
Coburn Gore, ME	$0	$0	$6,039	$23,643	$62,127	$19,673	$111,482
Fort Fairfield, ME	$0	$25,260	$6,493	$8,266	$40	$8,266	$48,326
Houlton, ME	$0	$0	$61,185	$55,743	$64,731	$1	$181,660
Jackman, ME	$0	$0	$19,421	$10,024	$40	$0	$29,486
Limestone, ME	$0	$19,030	$4,773	$5,396	$40	$6,331	$35,570
Orient, ME	$0	$0	$4,452	$1,431	$40	$6,542	$12,466
Vanceboro, ME	$0	$24,276	$15,846	$14,655	$40	$9,855	$64,673
VanBuren, ME	$0	$0	$16,806	$11,796	$40	$0	$28,643
Milltown ME	$0	$0	$917	$2,803	$40	$1,560	$5,320
St. Francis, ME	$0	$0	$1,901	$1,104	$40	$0	$3,046
Madawaska, ME	$0	$0	$11,322	$15,744	$40	$12,352	$39,458
Fort Kent, ME	$0	$0	$11,310	$22,572	$70,826	$12,691	$117,400
St. Francis, ME	$0	$0	$711	$1,188	$40	$0	$1,939
Detroit Cargo, MI	$1	$0	$62,081	$0	$45	$77,868	$139,996

Table C-1: Initial Cost of RE Technology (with incentives)

LPOE Site Name	PV Initial Cost w/incentives	Wind Initial Cost w/ incentives	Solar Vent Preheat Cost w/incentives	Solar Water Heating Cost w/incentives	Biomass Gasifier Cost w/incentives	Daylighting Cost w/incentives	Total Initial Cost
Intl Bridge, MI	$1	$0	$105,404	$0	$45	$2	$105,452
Amb. Bridge, MI	$1	$0	$0	$0	$45	$471,075	$471,122
Grand Portage, MN	$1	$0	$34,594	$22,969	$49	$18,372	$75,985
Noyes, MN	$1	$0	$19,478	$14,879	$49	$0	$34,407
Roseau, MN	$1	$0	$62,625	$21,923	$49	$1	$84,599
Intl Falls, MN	$1	$0	$10,245	$9,557	$49	$0	$19,852
Baudette, MN	$1	$0	$7,327	$2,739	$49	$0	$10,116
Chief Mt, MT	$1	$219,431	$7,549	$0	$42	$0	$227,023
Piegan, MT	$1	$172,445	$18,350	$74,880	$42	$90,607	$356,324
Raymond, MT	$1	$0	$21,894	$118,174	$42	$1	$140,112
Rooseville, MT	$1	$0	$10,258	$390	$42	$1	$10,692
Sweetgrass, MT	$1	$0	$17,748	$23,820	$74,175	$58,033	$173,777
Turner, MT	$0	$9,464	$3,936	$490	$42	$10,091	$24,024
Ambrose, ND	$1	$0	$6,126	$5,453	$40	$0	$11,620
Dunseith, ND	$1	$0	$10,835	$7,666	$40	$0	$18,542
Portal, ND	$1	$0	$14,638	$0	$40	$0	$14,680
St. John ND	$1	$0	$5,103	$4,994	$40	$0	$10,138
Pembina, ND	$1	$0	$82,768	$118,768	$5	$1	$201,543
Columbus, NM	$1	$0	$19,048	$19,095	$41	$31,569	$69,754
Santa Teresa, NM	$1	$0	$36,269	$44,942	$41	$88,329	$169,583
Alexandria Bay, NY	$1	$379,418	$74,250	$36,671	$47	$64,198	$554,584
Champlain, NY	$1	$302,486	$145,492	$11,596	$47	$173,289	$632,911
Massena, NY	$1	$0	$30,330	$30,171	$47	$0	$60,548
Fort Covington, NY	$1	$50,194	$5,277	$6,283	$47	$7,812	$69,614
Rouses Pt. NY	$1	$0	$10,196	$11,728	$47	$13,318	$35,290
St John Hwy, NY	$1	$0	$21,804	$18,532	$47	$0	$40,385
Trout, River, NY	$1	$53,452	$11,306	$8,829	$47	$14,368	$88,003
Chateaugay, NY	$1	$0	$5,760	$7,810	$47	$0	$13,618
Mooers, NY	$1	$0	$4,809	$5,090	$47	$7,202	$17,149
Jamieson, NY	$1	$0	$1,530	$811	$47	$1,552	$3,941
Niagra Falls, NY	$1	$427,588	$182,394	$110,538	$89,807	$262,393	$1,072,721
Ogdensburg BS	$1	$0	$121,213	$33,628	$47	$175,361	$330,250
Brownsville/Matamoros TX	$1	$394,213	$0	$29,191	$39	$72,198	$495,641
Gateway, TX	$1	$690,677	$0	$0	$39	$121,059	$811,775

Table C-1: Initial Cost of RE Technology (with incentives)

LPOE Site Name	PV Initial Cost w/incentives	Wind Initial Cost w/ incentives	Solar Vent Preheat Cost w/incentives	Solar Water Heating Cost w/incentives	Biomass Gasifier Cost w/incentives	Daylighting Cost w/incentives	Total Initial Cost
Columbia, TX	$1	$567,630	$0	$92,148	$123,245	$252,593	$1,035,618
Convent, TX	$1	$0	$0	$41,299	$5	$62,573	$103,878
Del Rio, TX	$1	$0	$50,414	$103,795	$5	$136,352	$290,567
Donna TX (not built yet)	$1	$0	$0	$7,014	$5	$14,708	$21,727
Bridge of the Americas, TX	$1	$0	$0	$24,046	$5	$219,433	$243,484
Eagle Pass, TX	$1	$0	$0	$69,672	$5	$127,361	$197,039
Fabens, TX	$1	$0	$10,950	$10,614	$5	$15,729	$37,298
Fort Hancock, TX	$1	$0	$6,050	$13,151	$5	$7,170	$26,376
El Paso, TX (out leased)	$1	$0	$11,692	$4,107	$5	$14,295	$30,100
Juarez-Lincoln, TX	$1	$0	$0	$122,934	$5	$316,588	$439,528
Los Indios, TX	$1	$0	$0	$40,339	$5	$163,432	$203,777
Laredo TX	$1	$0	$0	$19,413	$5	$40,968	$60,387
Los Tomates, TX	$1	$933,797	$0	$0	$5	$197,511	$1,131,314
McAllen, TX	$1	$0	$0	$0	$5	$44,664	$44,669
McAllen TX (not built yet)	$1	$0	$0	$7,006	$5	$14,603	$21,615
Marfa, TX	$1	$173,533	$50,596	$22,289	$5	$34,951	$281,375
Kika de la Garza, TX	$1	$848,325	$0	$62,317	$5	$206,342	$1,116,990
Paso Del Norte, TX	$1	$0	$0	$43,018	$5	$117,745	$160,769
Progreso, TX	$1	$0	$0	$27,452	$5	$35,880	$63,338
Roma, TX	$1	$0	$0	$24,258	$5	$44,628	$68,892
Rio Grande City, TX	$1	$0	$0	$20,312	$5	$52,686	$73,003
Ysleta, TX	$1	$0	$0	$52,683	$5	$259,146	$311,834
RR Inspection, TX	$1	$0	$1,481	$277	$5	$2,760	$4,524
Admin, TX (leased)	$1	$0	$0	$69,799	$5	$79,230	$149,034
El Paso, TX (Leased)	$1	$0	$5,720	$14,339	$5	$11,351	$31,416
DOT, TX (leased)	$1	$0	$40,796	$55,435	$90,598	$72,904	$259,734
Derby Line, VT	$1	$0	$11,927	$34,048	$91,019	$13,963	$150,959
Norton, VT	$1	$0	$7,413	$12,617	$5	$12,198	$32,234
Beebe Plain, VT	$1	$0	$2,902	$3,730	$5	$4,545	$11,183
Alburg Springs, VT	$2,498	$0	$2,692	$3,517	$5	$4,898	$13,610
North Troy VT	$1	$0	$5,350	$4,235	$5	$7,274	$16,865
West Berkshire,VT	$1	$0	$6,787	$5,362	$5	$10,148	$22,302

Table C-1: Initial Cost of RE Technology (with incentives)

LPOE Site Name	PV Initial Cost w/incentives	Wind Initial Cost w/ incentives	Solar Vent Preheat Cost w/incentives	Solar Water Heating Cost w/incentives	Biomass Gasifier Cost w/incentives	Daylighting Cost w/incentives	Total Initial Cost
Derby Line, VT	$1	$0	$37,486	$18,289	$5	$24,057	$79,838
Beecher Falls, VT	$1	$0	$9,706	$9,667	$5	$11,985	$31,364
Canaan, VT	$1	$0	$4,385	$6,384	$5	$6,615	$17,390
East Richford, VT	$1	$0	$8,049	$6,421	$5	$10,725	$25,201
Richford, VT	$1	$0	$7,534	$8,487	$5	$10,231	$26,258
Alburg, VT (Joint ownership)	$1,184	$0	$5,841	$1,429	$5	$4,730	$13,189
Highgate Springs 1, VT	$1	$0	$1,683	$107	$5	$0	$1,796
Highgate Springs 2, VT	$1	$0	$41,920	$157,308	$131,374	$32,210	$362,813
Highgate Springs 3, VT	$1	$0	$3,751	$5,187	$5	$5,751	$14,695
Blaine, WA	$1	$0	$71,647	$43,913	$6	$50,389	$165,957
Danville, WA	$1	$0	$17,493	$6,794	$6	$11,590	$35,884
Laurier, WA	$1	$0	$8,754	$2,392	$6	$13,512	$24,665
Mataline Falls. WA	$1	$0	$7,896	$2,731	$6	$0	$10,634
Oroville, WA	$1	$0	$0	$9,739	$6	$2	$9,747
Point Robert, WA	$1	$0	$70,150	$29,280	$6	$43,680	$143,116
Sumas, WA	$1	$0	$23,711	$12,886	$6	$1	$36,604
Blaine, WA	$1	$0	$71,585	$26,643	$6	$1	$98,235
Blaine, WA	$1	$0	$55,052	$0	$6	$162,654	$217,713
Kenneth Ward, WA	$1	$0	$35,706	$0	$6	$26,495	$62,208
							$24,799,302.00

*Anaerobic digestor and solar thermal are not cost effective with incentives.

Note that each technology is recommended as part of the optimized solution for a site, and these sizes minimize life-cycle costs. In other words, it is possible for an LPOE site to cost effectively generate more RE than the optimized solution indicates, but the life cycle costs would be higher.

Table C-2: Size of RE Technology that Minimizes Life-Cycle Cost by State (with incentives)

LPOE Site Name	PV Size (kW)	Wind Capacity (kW)	Solar Vent Preheat Area (ft^2)	Solar Water Heating Area (ft^2)	Biomass Gasifier Size (M Btu/h)	Biomass Gasifier Cogen Size (kW)	Daylighting non-Office Skylight/ Floor Area Ratio	Daylighting Office Skylight/ Floor Area Ratio
Dalton Cache, AK	0	0	1,275	694	0	0	4.2%	4.5%
Alcan, AK	0	0	4,221	5,467	0	0	0.0%	0.0%
Skagway, AK	0	0	813	571	0	0	4.3%	4.4%
Lukeville, AZ	0	0	2,380	592	0	0	4.6%	4.2%
Nogales, AZ	0	0	0	1,913	0	0	4.5%	3.5%
Sasabe, AZ	0	0	1,035	185	0	0	4.5%	4.3%
Douglas, AZ	0	0	1,623	1,158	0	0	4.5%	3.6%
San Luis, AZ	0	0	1,672	1,445	0.17	18	4.7%	3.8%
Naco, AZ	0	0	358	387	0	0	4.5%	4.1%
San Luis AZ (not built yet)	0	0	0	0	0	0	0.0%	0.0%
Nogales, AZ	0	0	0	2,829	0	0	4.5%	3.3%
Calexico West, CA	0	0	0	3,223	0	0	4.5%	3.7%
San Ysidro, CA	467	1,000	0	7,772	0	0	4.5%	3.8%
Andrade, CA	0	25	139	275	0	0	4.6%	4.4%
Otay Mesa, CA	217	1,000	0	4,603	0	0	4.7%	3.9%
Tecate, CA	52	0	1,523	1,028	0.11	12	4.6%	4.1%
Calexico, CA	0	0	4,999	3,062	0.23	25	4.6%	2.9%
Eastport, ID	0	0	1,593	580	0	0	0.0%	0.0%
Porthill, ID	0	0	499	123	0	0	0.0%	0.0%
Ferry Point, ME	0	0	1,578	589	0	0	0.0%	0.0%
Coburn Gore, ME	0	0	280	557	0.1	11	4.6%	4.3%
Fort Fairfield, ME	0	7	301	206	0	0	4.5%	4.4%
Houlton, ME	0	0	2,833	1,290	0.1	11	0.0%	0.0%
Jackman, ME	0	0	899	246	0	0	0.0%	0.0%
Limestone, ME	0	5	221	140	0	0	4.5%	4.4%
Orient, ME	0	0	206	44	0	0	4.5%	4.4%
Vanceboro, ME	0	7	734	352	0	0	4.5%	4.3%
VanBuren, ME	0	0	778	286	0	0	0.0%	0.0%
Milltown ME	0	0	42	81	0	0	4.5%	4.5%
St. Francis, ME	0	0	88	34	0	0	0.0%	0.0%
Madawaska, ME	0	0	524	377	0	0	4.5%	4.3%
Fort Kent, ME	0	0	524	532	0.11	12	4.5%	4.2%
St. Francis, ME	0	0	33	36	0	0	0.0%	0.0%
Detroit Cargo, MI	0	0	2,874	0	0	0	4.5%	3.0%
Intl Bridge, MI	0	0	4,880	0	0	0	0.0%	0.0%

Table C-2: Size of RE Technology that Minimizes Life-Cycle Cost by State (with incentives)

LPOE Site Name	PV Size (kW)	Wind Capacity (kW)	Solar Vent Preheat Area (ft^2)	Solar Water Heating Area (ft^2)	Biomass Gasifier Size (M Btu/h)	Biomass Gasifier Cogen Size (kW)	Daylighting non-Office Skylight/ Floor Area Ratio	Daylighting Office Skylight/ Floor Area Ratio
Amb. Bridge, MI	0	0	0	0	0	0	3.9%	4.5%
Grand Portage, MN	0	0	1,602	524	0	0	4.5%	3.5%
Noyes, MN	0	0	902	340	0	0	0.0%	0.0%
Roseau, MN	0	0	2,899	501	0	0	0.0%	0.0%
Intl Falls, MN	0	0	474	218	0	0	0.0%	0.0%
Baudette, MN	0	0	339	63	0	0	0.0%	0.0%
Chief Mt, MT	0	84	538	0	0	0	0.0%	0.0%
Piegan, MT	0	61	1,307	1,710	0	0	2.7%	3.0%
Raymond, MT	0	0	1,559	2,698	0	0	0.0%	0.0%
Rooseville, MT	0	0	731	9	0	0	0.0%	0.0%
Sweetgrass, MT	0	0	1,264	544	0.11	12	4.5%	4.5%
Turner, MT	0	2	280	11	0	0	4.4%	4.2%
Ambrose, ND	0	0	284	124	0	0	0.0%	0.0%
Dunseith, ND	0	0	502	175	0	0	0.0%	0.0%
Portal, ND	0	0	678	0	0	0	0.0%	0.0%
St. John ND	0	0	236	114	0	0	0.0%	0.0%
Pembina, ND	0	0	3,832	2,712	0	0	0.0%	0.0%
Columbus, NM	0	0	882	436	0	0	4.9%	4.5%
Santa Teresa, NM	0	0	1,679	1,026	0	0	5.4%	4.2%
Alexandria Bay, NY	0	131	3,437	906	0	0	4.7%	3.6%
Champlain, NY	0	105	6,736	333	0	0	5.4%	3.2%
Massena, NY	0	0	1,404	757	0	0	0.0%	0.0%
Fort Covington, NY	0	13	244	191	0	0	4.5%	4.2%
Rouses Pt. NY	0	0	472	336	0	0	4.5%	4.0%
St John Hwy, NY	0	0	1,009	492	0	0	0.0%	0.0%
Trout, River, NY	0	14	523	269	0	0	4.5%	4.0%
Chateaugay, NY	0	0	267	238	0	0	0.0%	0.0%
Mooers, NY	0	0	223	155	0	0	4.5%	4.2%
Jamieson, NY	0	0	94	25	0	0	4.9%	5.2%
Niagra Falls, NY	0	148	8,444	2,592	0.12	13	3.8%	4.5%
Ogdensburg, NY	0	0	5,612	836	0	0	6.2%	4.5%
Brownsville/ Matamoros, TX	0	102	0	666	0	0	5.5%	4.5%
Gateway, TX	0	209	0	0	0	0	5.6%	4.0%
Columbia, TX	0	163	0	2,104	0.21	23	5.2%	4.4%
Convent, TX	0	0	0	943	0	0	4.5%	3.2%
Del Rio, TX	0	0	2,334	2,370	0	0	5.5%	3.6%

Table C-2: Size of RE Technology that Minimizes Life-Cycle Cost by State (with incentives)

LPOE Site Name	PV Size (kW)	Wind Capacity (kW)	Solar Vent Preheat Area (ft^2)	Solar Water Heating Area (ft^2)	Biomass Gasifier Size (M Btu/h)	Biomass Gasifier Cogen Size (kW)	Daylighting non-Office Skylight/ Floor Area Ratio	Daylighting Office Skylight/ Floor Area Ratio
Donna TX (not built yet)	0	0	0	160	0	0	4.9%	4.5%
Bridge of the Americas, TX	0	0	0	549	0	0	5.6%	3.2%
Eagle Pass, TX	0	0	0	1,591	0	0	5.3%	3.9%
Fabens, TX	0	0	507	242	0	0	5.0%	4.4%
Fort Hancock, TX	0	0	280	300	0	0	4.6%	4.4%
El Paso, TX (out leased)	0	0	541	94	0	0	4.7%	4.5%
Juarez-Lincoln, TX	0	0	0	2,807	0	0	5.4%	3.3%
Los Indios, TX	0	0	0	921	0	0	5.5%	3.9%
Laredo TX	0	0	0	443	0	0	5.1%	4.4%
Los Tomates, TX	0	307	0	0	0	0	5.7%	4.0%
McAllen, TX	0	0	0	0	0	0	5.2%	4.2%
McAllen TX (not built yet)	0	0	0	160	0	0	4.8%	4.7%
Marfa, TX	0	36	2,342	509	0	0	4.3%	4.0%
Kika de la Garza, TX	0	272	0	1,423	0	0	5.5%	4.0%
Paso Del Norte, TX	0	0	0	982	0	0	5.6%	3.4%
Progreso, TX	0	0	0	627	0	0	4.5%	3.6%
Roma, TX	0	0	0	554	0	0	4.5%	3.3%
Rio Grande City, TX	0	0	0	464	0	0	4.5%	3.2%
Ysleta, TX	0	0	0	1,203	0	0	5.8%	3.4%
RR Inspection, TX	0	0	69	6	0	0	4.5%	4.5%
Admin, TX (leased)	0	0	0	1,594	0	0	4.5%	3.3%
El Paso, TX (Leased)	0	0	265	327	0	0	4.5%	4.2%
DOT, TX (leased)	0	0	1,889	1,266	0.15	16	4.5%	3.0%
Derby Line, VT	0	0	552	777	0.15	16	4.5%	3.7%
Norton, VT	0	0	343	288	0	0	4.5%	5.1%
Beebe Plain, VT	0	0	134	85	0	0	4.5%	4.2%
Alburg Springs, VT	0	0	125	80	0	0	4.6%	4.3%
North Troy VT	0	0	248	97	0	0	4.5%	3.7%
West Berkshire,VT	0	0	314	122	0	0	4.5%	4.3%
Derby Line, VT	0	0	1,735	418	0	0	4.7%	3.3%
Beecher Falls, VT	0	0	449	221	0	0	4.5%	3.9%
Canaan, VT	0	0	203	146	0	0	4.5%	4.3%
East Richford, VT	0	0	373	147	0	0	4.5%	3.9%

Table C-2: Size of RE Technology that Minimizes Life-Cycle Cost by State (with incentives)

LPOE Site Name	PV Size (kW)	Wind Capacity (kW)	Solar Vent Preheat Area (ft^2)	Solar Water Heating Area (ft^2)	Biomass Gasifier Size (M Btu/h)	Biomass Gasifier Cogen Size (kW)	Daylighting non-Office Skylight/ Floor Area Ratio	Daylighting Office Skylight/ Floor Area Ratio
Richford, VT	0	0	349	194	0	0	4.5%	4.0%
Alburg, VT (Joint ownership)	0	0	270	33	0	0	4.2%	4.5%
Highgate Springs 1, VT	0	0	78	2	0	0	0.0%	0.0%
Highgate Springs 2, VT	0	0	1,941	3,591	0.22	24	4.4%	2.8%
Highgate Springs 3, VT	0	0	174	118	0	0	4.4%	4.0%
Blaine, WA	0	0	3,317	1,003	0	0	4.9%	4.2%
Danville, WA	0	0	810	155	0	0	4.7%	4.1%
Laurier, WA	0	0	405	55	0	0	4.6%	4.2%
Mataline Falls. WA	0	0	366	62	0	0	0.0%	0.0%
Oroville, WA	0	0	0	222	0	0	0.0%	0.0%
Sumas, WA	0	0	1,098	294	0	0	0.0%	0.0%
Blaine, WA	0	0	3,314	608	0	0	0.0%	0.0%
Blaine, WA	0	0	2,549	0	0	0	5.7%	4.4%
Kenneth Ward, WA	0	0	1,653	0	0	0	5.1%	4.8%

*Solar thermal and solar thermal electric were not cost effective at any LPOE sites with incentives.

Note that each technology is recommended as part of the optimized solution for a site, and these sizes minimize life-cycle costs. In other words, it is possible for an LPOE site to cost effectively generate more RE than the optimized solution indicates, but the life cycle costs would be higher.

Table C-3: Size of RE Solutions (with and without incentives)

	Without Tax Incentives	With Tax Incentives
Skylight Area (sf)	190,951	209,666
Wind Energy (kW)	2,491	3,689
Solar Ventilation Air Preheat (sf)	93,265	119,652
Solar Water Heating (sf)	28,464	90,703
Biomass Gasification Boiler (MBH)	1.3	1.8
Biomass Gasification Cogen (kW)	134	193
PV (kW)	0	737

Biomass Anaerobic Digester (ft^3), Biomass Anaerobic Digester Cogen (kW), Solar Thermal Electric, and Solar Thermal Parabolic Trough technologies were not found to be cost-effective at any LPOE sites even with incentives. PV was cost effective at 3 sites when incentives were considered:

- San Ysidro, CA (467 kW),
- Otay Mesa, CA (217 kW), and
- Tecate, CA (52 kW).

The resultant table is not included here as the preponderance of entries show PV as not cost effective given the evaluation criteria.

Note that each technology is recommended as part of the optimized solution for a site, and these sizes minimize life-cycle costs. In other words, it is possible for an LPOE site to cost effectively generate more RE than the optimized solution indicates, but the life cycle costs would be higher.

Table C-4: Return on Investment for RE Solutions (with incentives)

Name	Renewable Energy Initial Cost ($)	RE Life Cycle O&M Cost ($)	Life Cycle Biomass Fuel Cost ($)	RE Life Cycle Gas Cost ($)	RE Life Cycle Electric Cost ($)	Post-Tax RE Case Life-Cycle Cost ($)	Post-Tax Basecase Life-Cycle Cost ($)	Return on investment (%)
Oroville, WA	$9,747	$1,341	$3	$0	$1,202,343	$781,821	$815,681	36.40%
Fabens, TX	$37,298	$1,460	$3	$139,984	$482,523	$411,716	$505,446	27.60%
Baudette, MN	$10,115	$449	$26	$0	$105,301	$74,823	$95,729	25.00%
Columbus, NM	$69,754	$2,685	$26	$148,322	$588,537	$506,752	$634,889	22.30%
St. Francis, ME	$3,046	$276	$26	$4,279	$36,030	$27,718	$32,755	21.50%
Jamieson, NY	$3,941	$223	$26	$17,371	$19,165	$24,452	$30,011	18.70%
Alburg, VT (joint ownership)	$12,944	$228	$3	$0	$46,530	$38,677	$56,568	18.60%
St. Francis, ME	$1,939	$291	$26	$13,319	$42,173	$35,816	$38,339	18.40%
Chateaugay, NY	$13,618	$1,498	$184	$101,741	$186,673	$185,048	$199,843	16.50%
Fort Hancock, TX	$26,375	$1,807	$3	$98,866	$467,675	$373,046	$401,192	16.00%
St John Hwy, NY	$40,385	$3,018	$26	$168,826	$142,932	$211,550	$249,259	15.10%
Sweetgrass, MT	$173,777	$164,696	$40,046	$2	$523,869	$575,022	$735,276	14.80%
Laurier, WA	$24,664	$336	$3	$0	$54,226	$51,450	$74,861	14.80%
Orient, ME	$12,466	$336	$26	$11,875	$53,664	$49,426	$61,396	14.70%
VanBuren, ME	$28,643	$1,790	$26	$91,275	$208,584	$203,566	$229,413	14.70%
Noyes, MN	$34,406	$2,108	$26	$120,682	$250,045	$250,108	$280,247	14.50%
Massena, NY	$60,548	$4,608	$26	$38,463	$439,607	$346,904	$400,228	14.50%
Derby Line, VT	$79,838	$2,509	$3	$144,095	$224,594	$276,576	$347,934	14.40%
Bridge of the Americas, TX	$243,484	$3,296	$3	$1,583,662	$3,569,154	$3,313,941	$3,544,169	14.30%
Jackman, ME	$29,486	$1,547	$26	$2	$270,809	$194,956	$219,505	14.10%
Ambrose, ND	$11,620	$820	$26	$59,013	$77,460	$89,866	$99,544	14.10%
McAllen, TX	$44,669	$9	$3	$30,393	$1,166,614	$797,357	$838,620	14.10%
Ysleta, TX	$311,834	$7,210	$6	$707,932	$2,779,835	$2,382,202	$2,658,285	13.80%
Paso Del Norte, TX	$160,769	$5,889	$3	$211,041	$2,183,994	$1,630,441	$1,762,905	13.30%
Beecher Falls, VT	$31,363	$1,331	$3	$72,582	$250,919	$222,267	$246,130	13.00%
Ogdensburg NY	$330,249	$5,081	$184	$378,412	$1,538,420	$1,416,168	$1,670,450	12.90%
Madawaska, ME	$39,458	$2,329	$26	$139,003	$341,293	$322,223	$350,133	12.60%
Raymond, MT	$140,112	$16,226	$26	$1,236,980	$675,155	$1,203,447	$1,298,281	12.60%
St. John ND	$10,138	$757	$26	$45,119	$98,879	$95,171	$102,015	12.60%
Donna TX (not built)	$21,726	$968	$3	$20,749	$244,750	$183,810	$199,923	12.60%
McAllen TX (not built)	$21,614	$967	$3	$20,707	$244,919	$183,822	$199,923	12.60%
Roma, TX	$68,891	$3,325	$3	$3,870	$1,447,273	$982,057	$1,031,585	12.60%
Santa Teresa, NM	$169,583	$6,217	$26	$3,675	$2,251,018	$1,568,132	$1,686,089	12.30%
Fort Kent, ME	$117,400	$164,322	$39,590	$143,564	$111,858	$349,093	$422,461	12.00%
Mooers, NY	$17,148	$1,003	$26	$59,985	$152,734	$142,650	$153,768	12.00%

Table C-4: Return on Investment for RE Solutions (with incentives)

Name	Renewable Energy Initial Cost ($)	RE Life Cycle O&M Cost ($)	Life Cycle Biomass Fuel Cost ($)	RE Life Cycle Gas Cost ($)	RE Life Cycle Electric Cost ($)	Post-Tax RE Case Life-Cycle Cost ($)	Post-Tax Basecase Life-Cycle Cost ($)	Return on investment (%)
East Richford, VT	$25,201	$887	$3	$55,872	$160,275	$150,528	$167,154	12.00%
Richford, VT	$26,257	$1,169	$3	$84,947	$206,161	$196,608	$213,852	12.00%
Canaan, VT	$17,390	$882	$3	$61,198	$176,414	$158,625	$169,679	11.90%
Rouses Pt., NY	$35,290	$2,088	$26	$171,575	$229,483	$264,806	$287,016	11.80%
Progreso, TX	$63,338	$3,761	$3	$215,081	$523,709	$497,352	$537,272	11.80%
Houlton, ME	$181,660	$154,597	$34,965	$69,211	$824,074	$802,043	$905,176	11.60%
DOT, TX (leased)	$259,733	$224,255	$85,105	$144,925	$986,301	$1,068,667	$1,221,185	11.60%
Los Indios, TX	$203,776	$5,523	$3	$73,867	$2,600,711	$1,853,271	$1,979,937	11.50%
Rio Grande City, TX	$73,003	$2,786	$3	$4,451	$1,425,134	$970,472	$1,015,530	11.50%
Beebe Plain, VT	$11,183	$519	$3	$45,770	$78,015	$82,603	$89,352	11.50%
Milltown ME	$5,320	$561	$26	$13,918	$153,038	$109,963	$113,059	11.40%
Juarez-Lincoln, TX	$439,528	$16,811	$3	$241,944	$5,117,020	$3,727,748	$3,995,410	11.40%
Niagra Falls, NY	$1,072,720	$209,376	$42,019	$130,237	$1,376,446	$1,818,025	$2,434,955	11.30%
El Paso, TX (out leased)	$30,100	$571	$3	$8,528	$1,962,810	$1,289,215	$1,306,938	11.30%
Limestone, ME	$35,570	$1,579	$26	$92,393	$89,865	$132,134	$152,936	11.20%
Del Rio, TX	$290,567	$14,196	$3	$511,703	$2,221,514	$1,907,529	$2,075,123	11.20%
Portal, ND	$14,679	$75	$26	$75,344	$335,560	$266,441	$274,261	11.10%
Eagle Pass, TX	$197,038	$9,532	$3	$363,756	$1,160,808	$1,079,835	$1,193,077	11.10%
Blaine, WA	$98,235	$3,651	$3	$23,106	$497,621	$400,278	$452,376	11.10%
Grand Portage, MN	$75,984	$3,214	$26	$238,514	$392,214	$433,262	$472,420	10.80%
Dunseith, ND	$18,542	$1,123	$26	$25,503	$178,013	$141,387	$150,652	10.80%
Laredo TX	$60,386	$2,663	$3	$2,360	$945,194	$651,772	$684,557	10.80%
West Berkshire,VT	$22,302	$742	$3	$48,128	$136,805	$129,234	$141,205	10.80%
Blaine, WA	$165,956	$6,011	$3	$91,783	$671,314	$595,397	$676,405	10.50%
Pembina, ND	$201,543	$16,242	$3	$1,367,604	$1,838,664	$2,063,780	$2,158,333	10.40%
Point Robert, WA	$143,116	$4,011	$3	$4,787	$413,220	$365,950	$433,903	10.40%
Vanceboro, ME	$64,673	$3,087	$26	$145,558	$210,862	$258,888	$289,338	10.30%
Norton, VT	$32,233	$1,734	$3	$142,305	$270,974	$273,526	$289,080	10.30%
Highgate Springs 3, VT	$14,695	$718	$3	$79,142	$95,113	$114,017	$121,113	10.30%
Roseau, MN	$84,598	$3,071	$26	$170,639	$534,961	$494,305	$531,543	10.10%
Alburg Springs, VT	$13,186	$542	$3	$54,876	$74,914	$86,841	$92,815	10.00%
Turner, MT	$24,024	$336	$26	$0	$19,438	$28,630	$38,749	9.70%
Derby Line, VT	$150,958	$215,705	$49,690	$166,701	$254,749	$512,621	$569,725	9.60%
Danville, WA	$35,884	$938	$3	$6,817	$152,322	$126,113	$140,495	9.60%
Alexandria Bay, NY	$554,584	$22,466	$26	$15,544	$2,055,651	$1,713,705	$1,920,019	9.10%
Admin, TX (leased)	$149,034	$9,549	$3	$65,276	$3,126,952	$2,154,097	$2,207,059	9.00%
Convent, TX	$103,878	$5,654	$3	$63,705	$2,064,851	$1,436,701	$1,472,631	8.90%

Table C-4: Return on Investment for RE Solutions (with incentives)

Name	Renewable Energy Initial Cost ($)	RE Life Cycle O&M Cost ($)	Life Cycle Biomass Fuel Cost ($)	RE Life Cycle Gas Cost ($)	RE Life Cycle Electric Cost ($)	Post-Tax RE Case Life-Cycle Cost ($)	Post-Tax Basecase Life-Cycle Cost ($)	Return on investment (%)
North Troy VT	$16,865	$588	$3	$96,563	$3,894	$65,976	$71,772	8.90%
Champlain, NY	$632,910	$15,637	$26	$4,129,693	$8,655,304	$8,225,057	$8,426,312	8.50%
Columbia, TX	$1,035,618	$335,529	$118,212	$464,794	$1,004,516	$1,851,926	$2,157,089	8.40%
Los Tomates, TX	$1,131,314	$39,821	$3	$50,885	$2,041,062	$2,115,756	$2,464,765	8.40%
Trout, River, NY	$88,003	$3,463	$26	$88,116	$201,043	$237,329	$260,594	8.00%
Gateway, TX	$811,775	$27,144	$26	$59,317	$1,756,132	$1,717,320	$1,939,730	8.00%
Marfa, TX	$281,374	$7,681	$3	$94,151	$205,050	$373,681	$435,741	7.50%
RR Inspection, TX	$4,523	$47	$3	$3,032	$5,761	$8,364	$9,370	7.50%
El Paso, TX (Leased)	$31,415	$1,969	$3	$14,615	$652,472	$450,207	$457,041	7.50%
Highgate Springs 2, VT	$362,812	$333,870	$77,549	$1,309,396	$1,206,884	$1,968,643	$2,039,260	7.40%
Intl Bridge, MI	$105,452	$75	$184	$605,855	$958,217	$1,012,939	$1,031,382	7.10%
Blaine, WA	$217,712	$9	$3	$95,114	$3,427,535	$2,402,906	$2,440,898	7.00%
Kenneth Ward, WA	$62,207	$9	$3	$78,985	$387,562	$333,247	$343,875	7.00%
Detroit Cargo, MI	$139,995	$75	$26	$1,343,348	$2,572,480	$2,472,189	$2,495,355	6.90%
Intl Falls, MN	$19,851	$1,381	$26	$78,214	$216,375	$195,483	$198,572	6.90%
Fort Covington, NY	$69,613	$2,862	$26	$71,967	$166,732	$193,996	$205,102	6.80%
Brownsville/ Matamoros, TX	$495,641	$17,276	$184	$25,343	$779,816	$854,874	$928,813	6.70%
Piegan, MT	$356,324	$18,270	$26	$863,360	$396,055	$966,914	$1,012,252	6.50%
Kika de la Garza, TX	$1,116,990	$43,738	$3	$92,511	$2,841,093	$2,646,591	$2,788,897	6.40%
Mataline Falls. WA	$10,634	$383	$3	$133	$31,790	$27,828	$28,899	6.20%
Chief Mt, MT	$227,022	$10,910	$26	$466,854	$498,577	$729,432	$741,412	5.60%
Amb. Bridge, MI	$471,121	$75	$184	$258,745	$472,024	$754,683	$770,497	5.30%
Highgate Springs 1, VT	$1,796	$24	$3	$0	$4,428	$4,056	$4,026	4.70%
Sumas, WA	$36,604	$1,771	$3	$226,577	$680,946	$585,852	$585,364	4.70%

The following LPOE sites were not suitable for cost-effective RE solutions with incentives:

- San Luis, AZ (not built);
- Rooseville, MT;
- Highgate Springs 1,
- VT; Sumas, WA.

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