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Energy Efficiency and Renewable Energy Benefits Agua Caliente Band of Cahuilla Indians via Implementation at Their Indian Canyons Trading Post

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ABSTRACT

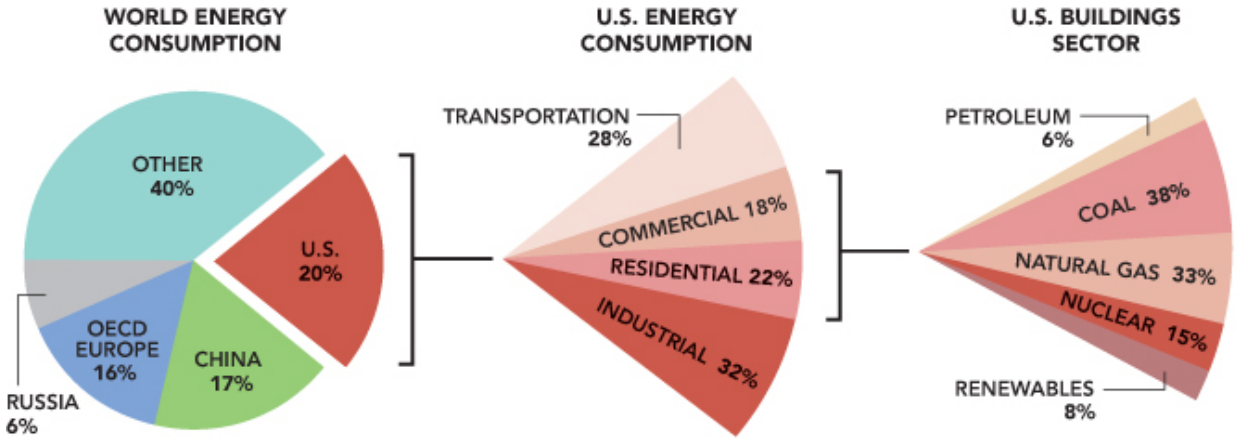
Modern society has experienced numerous climatic catastrophic events (tsunamis, hurricanes, tornadoes, droughts, and earthquakes) in the recent past; communities and governments throughout the world are feeling the effects of global warming through the changing climate. Additionally, the amount of historically used energy resources (coal, oil, and natural gas) is being depleted as energy demand (consumption) is increasing. Even more so, infrastructure to extend energy to many people and businesses is extremely costly.

Energy efficiency and renewable energy installations can be solutions to these challenges by reducing energy demand, generating energy on-site regardless of infrastructure, emitting little or no greenhouse gases, and can cost less over time. Thinking about the global community in terms of climate catastrophes, energy consumption, and costs can be daunting but addressing these challenges in increments is implementable, "think globally, act locally."

Through a site visit, interviews, and research, one tribe in Southern California, the Agua Caliente Band of Cahuilla Indians, demonstrates the benefits of energy efficiency and renewable energy implementation. The Indian Canyons Trading Post, owned and operated by the tribe, is an approximately 700 square feet visitor's center and retail shop located within tribal boundaries and approximately 2 miles from the electric grid. Being an off-grid site, propane was used for several years to run a generator, refrigerator, and freezer until costs became too high. With a Federal grant, an 8.25 kW photovoltaic array was mounted onto the roof of the Trading Post in 2009 to serve as the new energy source, along with energy efficiency implementation. This resulted in an energy demand savings and a tremendous savings in operations and maintenance costs and carbon dioxide emissions per month. Installing a photovoltaic array was more cost effective than running business as usual (diesel generator and propane) or extending the grid. Not only did the tribe save money on diesel fuel, it is taking part in slowing down and reducing the effects of climate change at a local and global level.

INTRODUCTION

The United States, as a single country, continues to lead the world in energy consumption, where U.S. buildings consume more energy than transportation or industrial sectors. 92% of that energy is sourced from non-renewable energy (coal, petroleum, natural gas, and nuclear).[2] The proceeding picture depicts a graphical representation of the statements above:



Source: http://buildingsdatabook.eren.doe.gov/ChapterIntro1.aspx

Non-renewable energy cannot be replenished in a short amount of time, therefore is limited in the amount available to generate energy. For example: coal, petroleum, and natural gas took millions of years to form[3], limiting the amount available for energy generation. With an increasing energy demand, non-renewable energy is not replenishing itself as fast as we demand energy. There is a need to seek other sources of energy production for our increasing demand for energy and the limited amount of non-renewable resources available. Non-renewable energy,

[2] U.S. Department of Energy: Energy Efficiency & Renewable Energy. (March 2011). *Buildings Energy Data Book*. Retrieved from http://buildingsdatabook.eren.doe.gov/

[3] U.S. Energy Information Administration. (July 2011). *Nonrenewable Energy Explained'*. Retrieved from http://www.eia.gov/energyexplained/index.cfm?page=nonrenewable_home

particularly fossil based fuels (coal, petroleum, and natural gas), emit large amounts of carbon dioxide into the atmosphere, about 5,839.3 million metric tons in 2008.[4] Carbon dioxide is a greenhouse gas that contributes to global warming and results in climate change.

Most U.S. buildings are not sustainable; they consume large amounts of energy while dependent on depleting and limited non-renewable energy sources. Fortunately, energy efficiency can decrease energy consumption and renewable energy sources are replenishable and created from abundant sources. Energy efficiency can be implemented in lighting, appliances, electronics, heating, cooling, and weatherization.[5] Renewable energy can be created from solar, wind, water, biomass, geothermal, and hydrogen and fuel cells.[6] Renewable energy can generate power either for an electrical grid (on-grid) or independent from the electrical grid (off-grid) and can vary in scale.

Off-grid renewable energy systems can be implemented for "economic sense and… environmental values." [7] Off-grid systems are cost effective if extending the electrical grid to locations far from the grid is too expensive. Renewable systems "are also used by people who live near the grid and wish to obtain independence from the power provider or demonstrate a commitment to non-polluting energy sources." [8] Off-grid systems are dependent on the amount

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[4] U.S. Energy Information Administration. (December 2009). *Emissions of Greenhouse Gases Report*. Retrieved from http://www.eia.gov/oiaf/1605/ggrpt/carbon.html

[5] United States Department of Energy. (February 2011). *Energy Savers*. Retrieved from http://www.energysavers.gov/your_home/appliances/index.cfm/mytopic=10070

[6] United States Department of Energy. (December 2011). *Renewable Energy*. Retrieved from http://www.eere.energy.gov/topics/renewable_energy.html

[7] United States Department of Energy Efficiency & Renewable Energy. (February 2011). *Energy Savers – Operating Your System Off*-Grid. Retrieved from http://www.energysavers.gov/your_home/electricity/index.cfm/mytopic=10610

[8] United States Department of Energy Efficiency & Renewable Energy. (February 2011). *Energy Savers – Operating Your System Off*-Grid. Retrieved from http://www.energysavers.gov/your_home/electricity/index.cfm/mytopic=10610

of power needed and designed for that particular energy need. If a large amount of energy is demanded, then a system is designed to meet that demand, and it is a similar case with smaller demands. Thus, energy conservation and efficiency should be the first step prior to selecting a renewable energy system because the smaller your load or demand, the less cost incurred to design and build an energy system.

The Agua Caliente Band of Cahuilla Indians recognized the opportunity of implementing energy efficiency and renewable energy measures on their Indian Canyons Trading Post due to the cost of their original energy generation and its location away from the Southern California Edison power grid.[9]

AGUA CALIENTE BAND OF CAHUILLA INDIANS

Agua Caliente Band currently stewards about 31,500 acres of ancestral lands in Southern California along the Coachella Valley. Historically, the Agua Caliente Band lived on approximately 2,000 square miles; however, after the introduction of the railroad the land base was reduced. Under the terms of the Pacific Railway Act of 1862, the Southern Pacific railroad was given the odd-numbered sections in Townships within 10 miles on both sides of the railroad.[10] Therefore, when the Agua Caliente Indian Reservation was established in 1876 by President Grant and later expanded by President Hayes in 1876, the tribe was given the remaining even-numbered sections in Townships 4 South – Range 4 East, 4 South – Range 5 East, and 5 South – Range 4 East of the San Bernardino Base and Meridian, creating a

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[9] Dansby, M. E. & J. Jussila. (October 2008). *Agua Caliente Band of Cahuilla Indians: Mineral Assessment Program Phase II*.

[10] The Pacific Railway Act: July 1, 1862. (2011). *Archives of the West*. Retrieved from http://www.pbs.org/weta/thewest/resources/archives/five/railact.htm

checkerboard of tribal lands.[11] Individual tribal members were given sections as part of the 1891 Allotment Act, in which most leased out their land in the developing communities of Palm Springs, Rancho Mirage, Cathedral City, and Riverside County. Today, the tribal government has primary control over land use and development for tribal land.[12]

Indian Canyons, a 1,748 acre site, is south of Palm Springs and falls within tribal control. The mouths of three canyons identified under the National Register of Historical Places (Palm Canyon, Andreas Canyon, and Murray Canyon) feed into Indian Canyons. Indian Canyons' beautiful oases and canyon walls are open to the public, where hiking, horseback riding, scenic views, cultural sites, flora, and fauna can be enjoyed. Also included are "the most numerous and second most numerous naturally occurring 'Washintonia filifera' palm in the Americas" (4).[13] Remarkably, the historical Indian Canyons has a Trading Post that serves as a visitor's center and retail store; owned and operated by Agua Caliente Band and located in Palm Canyon about 2 miles from the City of Palm Springs.[14] It is open October through June from 8 AM to 5 PM, daily and July through September from 8 AM to 5 PM, Friday, Saturday, and Sunday.[15]

INDIAN CANYONS TRADING POST

In 2005, Agua Caliente applied and was awarded two federal grants: Bureau of Indian Affairs 638 Mineral Assessment grant and Department of Energy Tribal Energy Program First

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[11] Agua Caliente Band of Cahuilla Indians. (2011). *History & Culture*. Retrieved from http://www.aguacaliente.org/content/History%20&%20Culture/

[12] Tribal Planning & Development. (2008). *Indian Canyons Master Plan: 2007 Update*. Retrieved from: http://www.aguacaliente.org/downloads/ICMP.pdf

[13] Tribal Planning & Development. (2008). *Indian Canyons Master Plan: 2007 Update*. Retrieved from: http://www.aguacaliente.org/downloads/ICMP.pdf

[14] Agua Caliente Band of Cahuilla Indians. (2007). *Indian Canyons*. Retrieved from http://www.indian-canyons.com

[15] Agua Caliente Band of Cahuilla Indians. (2007). *Indian Canyons: Hours*. Retrieved from http://www.indian-canyons.com/hours.html

Steps grant. The Mineral Assessment grant allowed the tribe to identify (Phase I) and develop (Phase II) the tribe's energy resource. Additionally, the First Steps grant was aimed at creating a strategic plan for the tribe's energy resource. Together, renewable energy resources and projects to be developed were identified, of which Indian Canyons Trading Post was listed.

Indian Canyons Trading Post is an off-grid ~700 square foot building. Although the Southern California Edison power grid is about two miles away and extending the grid to the Trading Post would be beneficial, the National Register of Historical Places identification of Indian Canyons prohibits this extension; making grid extension to the Trading Post not an option. Thus, power must be generated on-site to provide electricity that the business needed for lighting, refrigeration, sales, water pumping, heating, and cooling. Propane was the major energy source used to power a 34 kilowatt hour (kWh)/day peak energy demand via generator and additional energy needed for a propane refrigerator and freezer (see Appendix A for breakdown of energy use). Propane was used for about 10 years, averaging $1,348.12 per month for operations and maintenance until it became too costly to continue. This included: two major repairs costing $6,299.05 (in 2007) and $6,162.65 (in 2008) and continuously increasing fuel costs, about $1,194.27 per month for about 329.4 gallons of propane used per month (see Appendix B for actual fuel costs). Initial costs for this system were not available so it was not included in the total cost for this analysis. The table below shows an overall view of only the operations and maintenance costs for the propane system:

Table 1: Operation & Maintenance Costs for Propane System

	Costs Per Month
Operations	$1,194.27
Maintenance	$153.85
TOTAL	**$1,348.12**

Also, the constant humming of the generator interrupted the serenity of the canyons' allure to visitors.

A renewable energy installation at the Indian Canyons Trading Post was ideal with a strategic energy plan supporting renewable energy development, a grant available to implement a project, and a location with a reasonable energy load, off the grid, inconsistent propane costs, amount of fuel used, and noise pollution.[16] Most importantly, the tribe was in support of the project. As a result, an 8.25 kilowatt (kW) photovoltaic (PV) system installation, based on the existing energy load, was completed on Indian Canyons Trading Post on February 13, 2010 and is the tribe's first renewable energy project.[17]

This project cost a total of $135,000 which included an $18,000 roof repair on the Trading Post (a cost that had to occur regardless of the PV installation) and an $117,000 PV system. The PV system is complete with thirty 275 watt (w) ETSOLAR Solar Panels, three Outback Flexmax 60 Charge Controllers, sixteen Rolls Deep Cycle Battery, and two 4.5 kW Xantrex XW Series Hybrid Inverter/Chargers. It was designed to provide energy for a 34 KWh/day energy load.

The PV installation required several changes to occur: a roof replacement and appliance change outs. In addition, the propane refrigerator and freezer were no longer needed and needed to be replaced since propane was no longer going to be purchased. This provided an opportunity to reduce the existing energy load by replacing appliances and lighting with energy efficient equipment. An Electric Frigidaire Refrigerator/Freezer P/N 241851242 replaced the propane upright model refrigerator/freezer and an Electric Arctic Air Commercial Freezer Model Cf136

[16] Dansby, M. E. & J. Jussila. (October 2008). *Agua Caliente Band of Cahuilla Indians: Mineral Assessment Program Phase II*.

[17] Interview with Dan Malcolm, Senior Planner with Agua Caliente Band of Cahuilla Indians

replaced the propane floor model freezer. Ten 16w florescent rack lights replaced twenty-five 19w spot and task lighting with the roof replacement. To continue with the energy efficient goal, a 1000w Euro Pro Toaster replaced a 1500w toaster, two ceiling fans were installed, and an unnecessary extra electric freezer was removed.[18] The change out resulted in a 26% energy demand savings of 9 kWh/day when comparing the old peak demand of 34 kWh/day to the new peak demand of 25 kWh/day.

Again, the PV system was designed based on the old energy demand (before energy efficiency measures) and with the new energy demand (after energy efficiency measures) the PV system is able to provide enough energy to cover the peak energy demand of the summer. In the winter, PV energy generation is generally lower because of the short daylight hours. Moreover, the Trading Post is located in a narrow canyon, where the short daylight hours are limited by the canyon walls. Even though this location has limited daylight in the winter, the PV system generates just enough power for the winter demand because it was designed for a bigger demand (the old energy demand). The PV system is a reliable energy source because it provides enough energy for the Trading Post demand all year around.

[18] Interview with Dan Malcolm, Senior Planner with Agua Caliente Band of Cahuilla Indians

Photo showing Trading Post prior to PV installation, taken from Eastern view.
Source: *Mineral Assessment Program Phase II*

Photo showing Trading Post after PV installation, taken from Southwestern view.
Source: Sandra Begay-Campbell

This system requires about four hours a month of Indian Canyons' staff time to complete daily, weekly, monthly, quarterly, and yearly maintenance procedures, costing about $1,200 per year (based on a company proposal since Indian Canyons' staff pay was not available). The

batteries also have a ten-year warranty, after which batteries cost a total of $1,200 per battery to replace. A 7.5 kW Kubota Generator Lowboy II diesel generator serves as a back up to the PV system and is usually not needed but it is operated 30 minutes per month to keep the generator maintained, costing less than $4.00 a month for diesel fuel for 0.83 gallons of diesel used per month (see Appendix C for full operations and maintenance costs).[19] Again, initial costs for this system are not included in total cost because initial costs for propane system were not available for analysis and comparisons. The table below shows an overall view of the costs and total for the PV and diesel generator system:

Table 2: Operation & Maintenance Costs for Photovoltaic (PV) Array & Back-up Diesel Generator System

	PV System	Diesel Generator	Total Per Month
Operations	$160.00	$4.00	$164.00
Maintenance	$100.00	$5.83	$105.83
TOTAL	$260.00	$9.83	**$269.83**

Financial costs to the Trading Post for operations and maintenance is only part of the costs incurred. Environmental costs are difficult to calculate, therefore are not correctly valued and rarely used. One way to account for environmental costs, when using non-renewable energy sources, is to quantify the amount of carbon dioxide (CO_2) that is emitted. According to the data, the propane system used 329.39 gallons of propane per month; resulting in 4,280.8 pounds of carbon emitted a month (see Appendix D for calculations).[20] On the other hand, the PV system has no carbon emissions; however, the back-up diesel generator only uses an estimated 0.83 gallons of diesel a month; resulting in 18 pounds of carbon emitted a month (see Appendix D for

[19] Interview with Dan Malcolm, Senior Planner with Agua Caliente Band of Cahuilla Indians

[20] earth lab.(ND). *Carbon Calculations*. Retrieved from http://www.earthlab.com/carbon-calculator.html

calculations).[21] Agua Caliente saved 4,262.8 pounds of carbon from being released into the atmosphere, a 99.6% savings (see Appendix D for calculations) with their energy efficiency and renewable energy implementations.

Table 3: Comparison of CO_2 Emissions for Propane System versus Photovoltaic (PV) Array with Back-up Diesel Generator System

	Propane	PV	Diesel	Difference	Savings
Fuel Amount (per month)	329.39 gal	-	0.83 gal	**328.56 gal**	**99.7%**
CO_2 Emissions (per month)	4,280.8 lbs	-	18 lbs	**4,262.8 lbs**	**99.6%**

The table below shows an overall view of the load, costs, and carbon emissions before and after energy efficiency and renewable energy implementation (see Appendix F for calculations).

Table 4: Comparison of Off-Grid Costs for Propane Fuel versus Photovoltaic (PV) Array with Back-up Diesel Generator

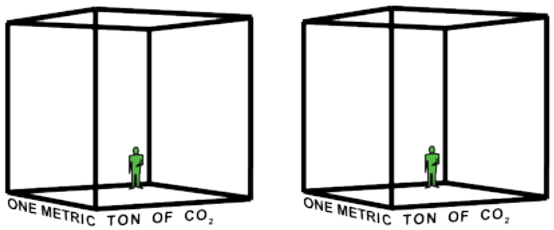
	Propane	PV & Diesel	Difference	Savings
O&M Costs (per month)	$1,348.12	$269.83	**$1,078.29**	**80.0%**
CO_2 Emissions (per month)	4,280.8 lbs	18 lbs	**4,262.8 lbs**	**99.6 %**

CONCLUSION

[21] United States Environmental Protection Agency. (April 2011). *Overview: Pollutants and Programs*. Retrieved from http://www.epa.gov/oms/climate/420f05001.htm

The Indian Canyons Trading Post demonstrated the benefits of energy efficiency and renewable energy through the size of the cost and carbon emission savings. An incredible 80% of costs, about $12,939.48 a year and $129,394.80 in a ten year span, are saved. This savings results in a return on investment in a little more than nine years, with $12,394.80 left to go toward operation and maintenance costs for three years and ten months. Additionally, since off-grid PV systems are designed to be "size appropriate" the total cost could have been lower if energy efficiency was implemented first to get a better understanding of energy load then putting renewable energy into place. Even more costs would have been saved; regardless though the savings incurred are astonishing.

Even more incredible is the 99.6% savings on carbon emissions: 4,262.8 pounds of carbon emission a month, about 51,154 pounds a year and 511,540 pounds in a ten year span. Since one pound equals 0.00045359237 metric tons[22], 1.9336 metric tons of carbon emissions were saved per month. The picture below illustrates what almost 2 metric tons would look like:



Source: Versus Carbon Neutral

[22] metric-conversions.org. (2011). *Pounds to Metric Tons (or Tonnes) Conversion*. Retrieved from http://www.metric-conversions.org/weight/pounds-to-metric-tons.htm

So in a year, 23.203 metric tons of carbon dioxide was saved from being emitted into the atmosphere, that's twenty-three of the boxes shown above.[23] Energy efficiency and renewable energy proved to be more cost effective and environmentally sound than running business as usual.

Indian Canyons Trading Post could market their business as a sustainable business with their green power to attract a certain market of visitors/customers through their business publications (advertisements, website, brochures, etc). Highlighting the amount of carbon dioxide emissions saved would be beneficial. Publicizing emission savings in real time at the Trading Post would also be valuable. This marketing strategy could lead to have visitors/customers feeling like they are contributing to reducing greenhouse gas emissions by visiting the Trading Post; they are thinking globally, by acting locally.

The Agua Caliente Band of Cahuilla Indians is extending their leadership with this energy efficiency and renewable energy installation, their first renewable energy project. They are generating their own power while being environmentally conscientious, as per tribal values. Not only did the tribe save money on fuel, it is taking part in slowing down and reducing the effects of climate change at a local and global level. The Agua Caliente Band is an example for others to follow so more costs and carbon emissions can be saved.

[23] Versus Carbon Neutral. (March 2011). *What Does a Metric Ton of CO2 Look Like?* Retrieved from http://www.verus-co2.com/blog/?p=1964

APPENDIX

APPENDIX A: ELECTRICITY DEMAND AT INDIAN CANYONS TRADING POST [24]

Estimated Electricity Load Demand at Indian Canyons Trading Post					
Description	#	Watts/unit	Total Watts	Hours per day	kWh/day
Swamp cooler	4	560	2,238	8	17.90
Computer	1	700	700	8	5.60
Microwave	2	1,500	3,000	1	3.00
"spot" lighting	13	20	260	10	2.60
"task" lighting	12	18	216	10	2.16
Fluorescent strips	4	32	128	10	1.28
Display lighting	3	15	45	10	0.45
Water pump for storage tank	1	207	207	2	0.41
TV/VCR	1	100	100	2	0.20
Radio/CD player	1	20	20	8	0.16
DVD player	1	25	25	2	0.05
Air conditioner	1	1,010	1,010	0	-
Total			**7,949**		**34**

[24] Dansby, M. E. & J. Jussila. (October 2008). *Agua Caliente Band of Cahuilla Indians: Mineral Assessment Program Phase II*.

APPENDIX B: PROPANE OPERATION & MAINTENANCE COSTS [25]

FERRELL GAS HISTORY: 10/7/05 to 11/8/07

Date	Qty	Price	Total
10/7/2005	186.00	$ 3.24	$ 602.45
10/24/2005	194.20	$ 3.24	$ 629.01
11/7/2005	190.10	$ 3.27	$ 621.44
11/17/2005	141.80	$ 3.27	$ 463.54
11/23/2005	84.30	$ 3.27	$ 275.58
11/30/2005	99.50	$ 3.35	$ 333.23
12/7/2005	94.30	$ 3.35	$ 315.81
12/13/2005	82.30	$ 3.34	$ 279.74
12/21/2005	88.30	$ 3.44	$ 303.66
12/27/2005	77.90	$ 3.44	$ 267.90
12/31/2006	53.00	$ 3.44	$ 182.27
1/6/2006	72.70	$ 3.44	$ 250.02
1/10/2006	69.00	$ 3.44	$ 237.29
1/24/2006	100.80	$ 3.44	$ 346.65
1/26/2008	75.69	$ 3.44	$ 260.33
2/1/2006	108.40	$ 3.44	$ 372.79
2/8/2006	95.30	$ 3.44	$ 327.74
2/15/2006	100.40	$ 3.44	$ 345.28
3/1/2006	191.60	$ 3.44	$ 658.91
3/9/2006	115.90	$ 3.44	$ 401.52
3/22/2006	175.50	$ 3.44	$ 606.48
3/29/2006	107.60	$ 3.44	$ 372.98
4/10/2006	163.40	$ 3.48	$ 571.41
4/20/2006	142.40	$ 3.51	$ 502.62
4/28/2006	118.80	$ 3.53	$ 422.19
5/8/2006	145.20	$ 3.50	$ 510.99
5/18/2006	142.30	$ 3.47	$ 496.58
5/31/2006	177.70	$ 3.46	$ 617.60
6/14/2006	175.20	$ 3.42	$ 601.95
6/21/2006	101.00	$ 3.50	$ 356.34
7/19/2006	90.60	$ 3.41	$ 311.80
8/10/2006	156.40	$ 3.41	$ 536.11
8/30/2006	155.20	$ 3.41	$ 532.02
9/15/2006	157.00	$ 3.40	$ 538.15
9/29/2006	171.40	$ 3.41	$ 587.24
10/9/2006	111.40	$ 3.50	$ 392.73
10/16/2006	107.10	$ 3.50	$ 377.68
10/23/2007	106.70	$ 3.57	$ 383.75
10/30/2006	109.80	$ 3.59	$ 397.01
11/6/2006	103.40	$ 3.59	$ 374.04
11/13/2006	109.50	$ 3.59	$ 395.94
11/22/2006	118.20	$ 3.59	$ 428.85
11/27/2006	105.20	$ 3.60	$ 383.24
12/6/2006	116.50	$ 3.66	$ 431.07
12/16/2006	141.50	$ 3.72	$ 531.04
12/27/2006	185.40	$ 3.72	$ 694.30
1/4/2007	109.20	$ 3.73	$ 412.17

[25] Interview with Dan Malcolm, Senior Planner with Agua Caliente Band of Cahuilla Indians

APPENDIX B – Continued

1/24/2007	146.84	$ 3.74	$ 549.02
1/31/2007	154.50	$ 3.74	$ 582.64
1/11/2007	103.20	$ 3.73	$ 389.79
2/8/2007	123.00	$ 3.74	$ 464.53
2/19/2007	66.90	$ 3.74	$ 254.77
2/15/2007	120.30	$ 3.74	$ 452.74
2/27/2007	118.90	$ 3.74	$ 449.20
3/8/2007	57.80	$ 3.74	$ 220.91
3/30/2007	153.40	$ 3.72	$ 575.29
4/5/2007	86.60	$ 3.72	$ 326.87
4/12/2007	104.90	$ 3.72	$ 394.92
5/10/2007	45.00	$ 3.77	$ 174.57
6/21/2007	154.60	$ 3.74	$ 586.01
7/3/2007	168.70	$ 3.74	$ 636.71
7/20/2007	160.00	$ 3.62	$ 586.94
8/2/2007	111.60	$ 3.84	$ 436.39
8/24/2007	159.30	$ 3.84	$ 619.68
9/14/2007	148.20	$ 3.90	$ 585.79
10/4/2007	173.50	$ 4.02	$ 705.18
10/11/2007	98.30	$ 4.34	$ 434.65
10/18/2007	95.80	$ 4.42	$ 431.47
10/22/2007	59.70	$ 4.46	$ 274.33
11/1/2007	134.40	$ 4.55	$ 619.57
11/8/2007	75.90	$ 4.58	$ 356.06
TOTAL	8646.43	$ 256.58	$ 31,349.47
AVERAGE		$ 3.67	
Divide "Total" by 105 weeks of data **PER WEEK**	82.35		$ 298.57
Multiply "Per Week" by 4 **PER MONTH**	329.39		$ 1,194.27

PROPANE MAINTENANCE

Regular maintenance

- $600 per year ÷ 12 months per year= $50 per month

Major repairs throughout 10 year lifetime

- May 2007: $6,299.05
- June 2008: $6,162.65
- Sub-total = $12,461.70 per 10 years ÷ 10 years = $1,246.17 per year ÷ 12 months per year = $103.85 per month

TOTAL = $50 + $103.85 = $153.85 per month

APPENDIX B – Continued

Table 1: Operation & Maintenance Costs for Propane System	
	Costs Per Month
Operations	$1,194.27
Maintenance	$153.85
TOTAL	**$1,348.12**

APPENDIX C: PV & BACK-UP DIESEL SYSTEM OPERATION & MAINTENANCE COSTS [26]

PV OPERATIONS

Batteries replaced at ten years

- $1,200 per battery × 16 batteries = $19,200 per 10 years ÷ 10 years = $1,920 per year ÷ 12 months per year= $160 per month

BACK-UP DIESEL OPERATIONS

Fuel

- 10 gallons per year ÷ 12 months per year = 0.83 per month
- $48.00 per year ÷ 12 months per year = $4.00 per month

PV MAINTENANCE

Regular maintenance quoted by Renova for tribe for two year maintenance = $2,400

- $2,400 ÷ 2 years = $1,200 per year ÷ 12 months per year = $100 per month*

*Cost may differ due to Indian Canyon staff doing maintenance and information for staff pay was not available for this calculation

BACK-UP DIESEL MAINTENANCE

Regular Maintenance

- $50 per year ÷ 12 months per year = $4.16 per month

Repair over projected 10 year lifetime

- Auto shut off switch = $200 ÷ 10 years = $20 per year ÷ 12 months per year = $1.67 per month

TOTAL = $4.16 + $1.67 = $5.83 per month

Table 2: Operation & Maintenance Costs for Photovoltaic (PV) Array & Back-up Diesel Generator System

	PV System	Diesel Generator	Total Per Month
Operations	$160.00	$4.00	$164.00
Maintenance	$100.00	$5.83	$105.83
TOTAL	$260.00	$9.83	**$269.83**

[26] Interview with Dan Malcolm, Senior Planner with Agua Caliente Band of Cahuilla Indians

APPENDIX D: CARBON DIOXIDE EMISSIONS

PROPANE EMISSIONS

Conversion from *earth lab carbon calculations* [27]

- [gallons of propane used] × [12.996 pounds of CO_2 emitted per gallon of propane] = pounds of CO_2 emitted

  329.39 gallons of propane/month × 12.996 pounds of CO_2 emitted/gallon of propane = 4280.8 pounds of CO_2 emitted per month

PV EMISSIONS & DIESEL EMISSIONS

PV Emissions

- No CO_2 emitted per month

Diesel Emission

- Conversion from *U.S. Environmental Protection Agency Carbon Dioxide Emission* [28]
  [gallons of diesel used] × [22.2 pounds of CO_2 emitted per gallon of diesel] = pounds of CO_2 emitted

  0.83 gallons of diesel/month × 22.2 pounds of CO_2 emitted/gallon of diesel
  = 18 pounds of CO_2 emitted per month

Total = 0 + 18 = 18 pounds of CO_2 emitted per month

FUEL AMOUNT SAVINGS

Propane fuel amount used – Diesel fuel amount used = Fuel amount saved

- 329.39 gal per month – 0.83 gal per month = 328.56 gal saved per month

[Fuel amount saved ÷ Propane fuel amount used] × 100% = Percent fuel amount saved

- [328.56 gal saved per month ÷ 329.39 gal per month] × 100% = 99.7% saved per month

EMISSIONS SAVINGS

Pre-PV system emissions – Post-PV system emissions = Propane emission – [PV emissions + Diesel emissions] = Emissions saved

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[27] earth lab.(ND). *Carbon Calculations*. Retrieved from http://www.earthlab.com/carbon-calculator.html

[28] United States Environmental Protection Agency. (April 2011). *Overview: Pollutants and Programs*. Retrieved from http://www.epa.gov/oms/climate/420f05001.htm

APPENDIX D - Continued

- 4280.8 pounds of CO_2 emitted per month – [0 pounds of CO_2 emitted per month + 18 pounds of CO_2 emitted per month] = 4,262.8 pounds of CO_2 saved per month

[Emissions saved ÷ Pre-PV systems emissions] × 100% = Percent emissions saved

- 4,262.8 pounds of CO_2 saved per month ÷ 4280.8 pounds of CO_2 emitted per month] × 100% = 99.6% CO_2 emissions saved per month

Table 3: Comparison of CO_2 Emissions for Propane System versus Photovoltaic (PV) Array with Back-up Diesel Generator System

	Propane	PV	Diesel	Difference	Savings
Fuel Amount (per month)	329.39 gal	-	0.83 gal	**328.56 gal**	**99.7%**
CO_2 Emissions (per month)	4,280.8 lbs	-	18 lbs	**4,262.8 lbs**	**99.6%**

APPENDIX F: OVERALL COMPARISONS

COST SAVINGS

Propane O&M system costs – PV & Diesel O&M system costs = Costs saved

- $1,348.12 – $269.83 = $1,078.29

[Costs saved ÷ Propane O&M costs] × 100% = Percent of costs saved

- [$1,078.29 ÷ $1,349.12] × 100% = 80.0% cost savings per month

Table 4: Comparison of Off-Grid Costs for Propane Fuel versus Photovoltaic (PV) Array with Back-up Diesel Generator

	Propane	PV & Diesel	Difference	Savings
O&M Costs (per month)	$1,348.12	$269.83	**$1,078.29**	**80.0%**
CO_2 Emissions (per month)	4,280.8 lbs	18 lbs	**4,262.8 lbs**	**99.6 %**