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Fales Hot Springs: A case study in renewable augmented net zero energy

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ABSTRACT

The renewable augmented zero energy (RAZE) structure in Fales Hot Springs, Calif., is near abundant geothermal hot spring, solar, biomass, wind, and run-of-river hydrokinetic natural resources that can be harvested to create a net zero energy facility. This provided an excellent platform from which to systemically assess the technical feasibility, economic efficiency, environmental sustainability, and social benefit as functions of weighted customer requirements.

1. Introduction

Renewable energy options have significant potential but also various drawbacks that require a detailed analysis from all three pillars of the sustainability triad. The objective of this case study is to propose a combination of renewable energy technologies that utilize the local indigenous resources in the Sierra Nevada region to transform the Renewable Augmented Zero Energy (RAZE) structure in Fales Hot Springs, Calif., into a net zero energy building. The RAZE structure in Fales Hot Springs was once a fully operational hotel with natural hot spring baths that was popular among travelers heading to the gold strikes in Bodie, Calif., in the late 1800s. The hotel, hot spring baths, cabins, restaurant, lounge, and pool went through various life-cycle stages and ultimately were purchased by Sweetwater Project, LLC, in 2003 in an effort to renovate the restaurant and lounge into livable space and eventually open to share the rich history with the public (Fales Hot Springs, 2011).

1.1. Technical facility details

The facility technical details in Table 1 are a reference to support the analysis of evaluating various renewable energy opportunities to incorporate into the net zero energy approach outlined in the following sections (Sweetwater-Project-LLC, 2015).

Assumptions. The following list of assumptions incorporate the net zero energy approach analysis:

1. This approach assumes there is a grid connection to Southern California Edison utility company, which will allow for flexibility in terms of when the resources are generating electricity versus using electricity.
2. This approach assumes that the system advisory model (SAM) data from Reno, Nev., is accurate for Fales Hot Springs because it is the nearest site to the location with similar latitude at 39.5°N for Reno versus 38.2°N for Fales Hot Springs and longitude at −119.8°W for Reno versus −119.2°W for Fales Hot Springs.

1.2. Power and energy use

The RAZE building's annual electricity consumption is 17,000 kWh, space heating energy use is 35,000 kWh, and domestic water heating energy use is 7,000 kWh or approximately 60,000 kWh in total. Power and energy data were obtained from the owners of the proposed RAZE building and are summarized in Table 2 (Sweetwater-Project-LLC, 2015).

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Table 1
Summary of RAZE Technical Facility Details.

Category	Details
Size	• The main floor is approximately 2,650 square feet with 450 square feet of second floor and 400 square feet of a walk-in partial basement.
Heating	• A propane-fueled condensing boiler feeds radiant floor heating on the main floor and also provides domestic hot water needs. • Two large back-to-back fireplaces provide auxiliary space heating. • The second floor and basement are not directly heated but are heated convectively via the radiant flooring system.
Cooling	• There is no space cooling unit because the structure is naturally cooled by winds from the Sierra Nevada range.
Energy Efficiency	• The walls, floors, and ceilings are insulated and new double pane replacement windows have been installed. • The corrugated steel roof was installed in 2012.
Local resource (s)	• The main hot spring, located about 100 feet from the structure, maintains a temperature of 60 °C year round.

Table 2
RAZE Building Current Energy Demand and Use.

	Electrical	Space Heating	Domestic Hot Water	Total Load
Peak Hourly Power (kW)	6.4	24.7	1.8	32.9
Average Hourly Power (kW)	1.9	4.0	0.8	6.8
Annual Energy Use (kWh)	16,989	34,921	7,330	59,240
Percent of Total Annual Energy Use	**28.7%**	**58.9%**	**12.4%**	**100%**

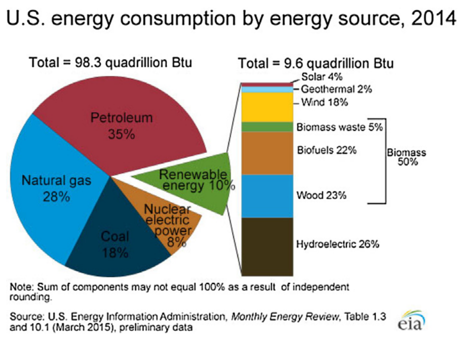
2. Indigenous resource evaluation

With growing energy needs and an increasing need to reduce greenhouse gas emissions to fight climate change, the use of renewable energy resources has increased globally. In the United States, renewable energy now makes up 10% of total national energy consumption (Fig. 1) (Monthly Energy Review, 2015).

This case study's goal is to present an efficient design for the RAZE building energy resource utilization to zero net emissions including being: self-sustainable, reliable, and low cost, with minimal impact to the local environment. The energy sources considered to meet the energy use are clean renewable resources to ensure long-lasting sustainability is achieved for the constructed system.

2.1. Sierra Nevada region

The California Sierra Nevada region where the RAZE building is located is abundant in natural, renewable energy resources to transform the building into a net zero energy site (Sierra Nevada Conservancy, 2015). California is a U.S. leader in net electricity generation from renewable energy resources. The state utilizes the diverse range of natural resources in the region generating power from geothermal, solar, conventional hydroelectric power, wind, and biomass (California Profile Analysis, 2015).


U.S. energy consumption by energy source, 2014

Note: Sum of components may not equal 100% as a result of independent rounding.
Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 1.3 and 10.1 (March 2015), preliminary data

Fig. 1. U.S. Power Generation by Energy Source 2014.

3. Methodology to achieve net zero energy

The stepwise methodology to a net zero energy facility started with an assessment of the natural energy resources within the vicinity of the Fales Hot Springs property. The primary resources identified as having strong and useful potential include geothermal, solar, and biomass. High-level utilization feasibility to meet the net zero goal narrowed the renewable energy technologies to a geothermal mechanical heat pump, a solar PV array, and a biomass wood pellet stove. The subsequent process step includes determining comparative levelized cost of energy (LCOE) for converting the primary energy resource into useful facility energy and power. High-level LCOE determination results in the following LCOE value for each primary energy resource: geothermal = $54/MWh, solar = $119/MWh, and biomass = $130/MWh. LCOE values for each conversion technology are assessed for economic competitiveness versus the 2015 average utility cost for supplied propane at $73/MWh and electricity at $171/MWh. The initial LCOE assessment provides for a semi-prioritized resource conversion technology order based on economic competitiveness. Practical technical consideration favors geothermal for direct energy resource use to offset onsite propane fueled boiler space and domestic hot water heating. Practical technical consideration also favors solar energy conversion for all electrical loads. Finally, although space heating via biomass does have some value, the negative impact of a high LCOE versus propane eliminates it from the facility energy generation pool after final evaluation. These practical technical assessments based on team energy conversion expertise were combined with previous guidance to deliver the optimized energy conversion load mix to feasibly and effectively meet the net zero energy goal with geothermal meeting 71.3% of energy use and solar meeting 28.7%.

3.1. Levelized cost of energy analysis

In an attempt to determine the economic perspective of the chosen technologies, the LCOE was analyzed for each renewable energy technology over a 25-year life cycle meeting 100% of the annual energy use of the RAZE building, which totals to 60,000 kWh. All of the technologies were fairly competitive in