Project 1:
Case Study
Santa Rita Jail MicroGrid

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ABSTRACT

The Santa Rita Jail in Alameda County, California, relies on consistent electricity to safely run day to day activities. The jail had installed a large array of PV & a fuel cell with the aim of reducing operation costs and increasing reliability. This condition established the jail as an exceptional candidate for the installation of a microgrid. A team of expert implementors and analytics was assembled by Chevron Energy Solutions to study the outcomes of implementing a CERTS microgrid concept in the Jail. The project was a success and is currently one of the most studied and documented microgrid cases.

1.0 LOCATION & CLIMATE

Twenty miles west of Oakland California lies Santa Rita Jail. A “one-half mile long by one quarter mile wide site” in the County of Alameda (Lott). Here, both prisoners and the jail operators enjoy a “relatively rare Mediterranean type climate” that consist of dry-warm summers and moist-mild winters (Golden Gate Weather).

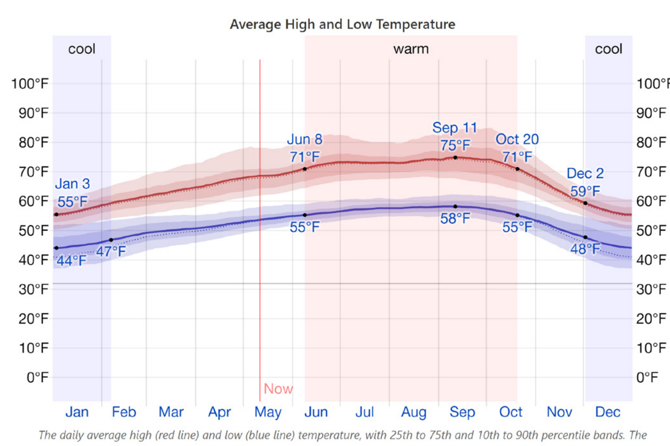

Figure 1. *Average Temperatures in Oakland, California (weatherspark.com)*

1.1 DEMOGRAPHICS

This detention facility is the fifth largest in the United States and “consumes more energy than any other county government building” (Alameda County Government). Housing 4,000 inmates, this high-tech prison is possibly the most dangerous place in the county. About half of the inmates in the jail are affiliated with gangs (Kazami). Those who inhabit the prison run a constant risk of conflict with opposing gangs.

1.3 FUNCTIONAL REQUIREMENTS

Officers are put in harm’s way to prevent and stop any form of conflict. The high-tech aspect of this prison is intended to alleviate the difficult operations that maintain the facility safe for both prisoners and imprisoners. This of course has a downside. Given that the system’s meant to provide safety depend on the proper functioning of the prison’s technology, “it is easy to understand that any interruption in the electricity potentially puts […] deputies in harm’s way. . . When the lights go out because of a power outage, those few seconds it takes for our emergency generators to bring the lights back on seems like an eternity to a deputy who is in the process of moving inmates within the jail” (Algeria, Ma and Idrees). The element of safety and particularly of constant safety, is a partial motivator for developing a microgrid that is capable of seamlessly islanding from the main grid in the event of a power outage. During islanding, the facility must continue to run on “3 megawatts (MW) of reliable and secure electricity 24 hours a day, seven days a week to power the million-square-foot facility”

Figure 2. *(Imagery, Google), aerial view of the facility, showing the PV roof array*

(Chevron Energy Soultions). However, the Santa Rita Jail microgrid project originally took off as a response to the California energy crisis of 2001 (Chevron Energy Soultions). It was during this period that the county "installed a 1.2 MW solar photovoltaic system on the jail's roof (fig. 1), one of the largest installations of its kind at the time" (Chevron Energy Soultions). This marked a starting point for the transformation of the Santa Rita Jail into a Green Prison.

Another motivator has shaped the prison into what it is today. The rapid growth of the county and of the state of California is pushing the capacity of the current energy infrastructure to the limit (Algeria, Ma and Idrees). This condition further accelerated the implementation of additional distributed energy sources (DER) and opened the possibility of a microgrid that integrates the facility's sources. The successful implementation of a CERTS microgrid concept is the result of an in-depth analysis of the prison's energy consumption patterns and energy generation potentials performed by multiple teams with different backgrounds. The project was sponsored by the US. Department of Energy and led by Chevron Energy Solutions Company (Algeria, Ma and Idrees). The exceptional results of the project have popularized Santa Rita Jail as an exemplary project for analysis that, given it is so well documented, make it a perfect microgrid case study.

2.0 PLANNING PROCESS

Before the microgrid was installed, analysts from different backgrounds and with different specializations, examined the conditions of the jail and the existing DERs to make better and more informed decisions in the design and implementation of the CERTS microgrid. A long process of gathering data sets from different agencies and organizations preceded a stage of simulating distinct scenarios. Throughout the planning and analysis process incomplete data sets were often used to roughly estimate despite the lack of data. Still, most of the simulations performed turned out to be fairly in line with the results of the installed microgrid. Given the size of the investment, the analysis process was highly polished and tried. This was done to ensure that the completed microgrid would function optimally, achieving the project's goals and demonstrating the feasibility of the CERTS microgrid concept.

2.1 METHODS

Before the project was set in motion, a team of analysts simulated different implementation scenarios to ensure that the end-product met specific objectives. Early in the project, HOMER software was used to simulate how a microgrid would operate over a year-long period. The tool helped "estimate the best equipment sizes for optimizing the economics," this includes the estimation of energy storage sizes (Kramer, Martin and Martin). Weather and load data were used to estimate potential savings.

2.2 PROCESS & OBJECTIVES

There were 7 initial ambitions that guided the analysis, design, and implementation processes. Each of the following objectives was more or less met, "(1) reduce facility peak load by 50% or more, (2) reduce peak load of utility distribution feeder by at least 10% to 15%, (3) demonstrate the commercial implementation of CERTS microgrid, (4) improve grid reliability, (5) demonstrate the potential to provide grid ancillary services, (6) increase grid efficiency and security, and (7) meet critical customer reliability requirements" (Algeria, Ma and Idrees).

The peak load happens in the afternoon and the max demand was measured at 2MW each month (Algeria, Ma and Idrees). Prior to the implementation of the microgrid, the facility had a 1MW fuel cell running continuously (Algeria, Ma and Idrees). This slices the maximum load in half. Additionally, a 2MW, 4-MWh advanced energy storage (AES) battery system discharges from 12 P.M. to 6 P.M. and, with the photovoltaics, the peak power load is reduced from 1750 kW to 85 kW (Algeria, Ma and Idrees). Peak time energy consumption is thus reduced by 98%, from 10,221 kWh to 228 kWh (Algeria, Ma and Idrees). These measured results mark a clear achievement of the first objective. The DERs and the AES are integrated with a "control system termed Distributed Energy Resources Management System (DERMS)" this algorithm reduces the facility and utility feeder peak loading by 15.1% (Algeria, Ma and Idrees). This achieves the second objective. The third objective, demonstrating "the commercial implementation of CERTS microgrid" measures the reduction of energy costs resulting from the installation of the AES and the intelligent use of

Figure 3. *Fuel Cell (microgrid-symposiums.org)*

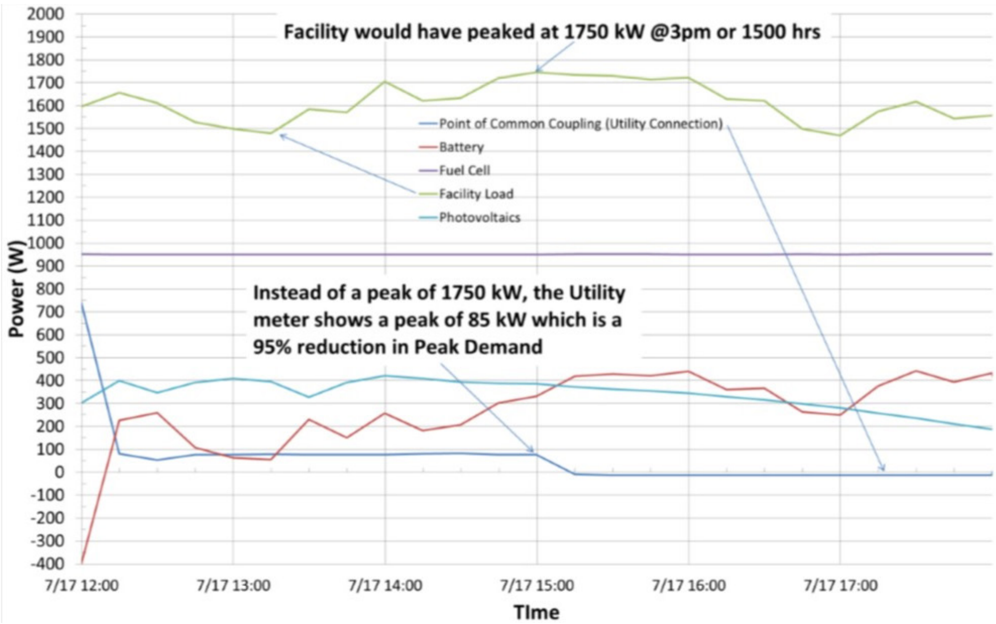

Figure 4. *DER power generation during battery discharge hours. (Algeria, Ma and Idrees)*

the DERs as decided by the DERMS algorithm (Algeria, Ma and Idrees).. The DERMS optimizes its strategic use of the DERs with information input related to Data Monitoring and Metering, Power Flow at the point of Common Coupling (PCC), Solar Photovoltaic Power Output, Fuel cell constant output, wind power output, battery state of charge (SOC), and DERMS human machine interface (HMI) (Algeria, Ma and Idrees).. The algorithm uses the battery to shift the loads from peak periods to off-peak periods and the annual resulting energy cost savings are estimated to be $110M (Algeria, Ma and Idrees). The capital cost of the entire project, from the design to the installation was of $12MM, predicting a payback period of 109 years (Algeria, Ma and Idrees). This is clearly a long payback period, but regardless, the annual savings are significant and, coupled with the islanding capability of the microgrid, demonstrate "the potential for large commercialization of CERTS Microgrids to future target customers with demand for reliable power" (Algeria, Ma and Idrees). The fourth objective aimed at improving the overall grid reliability. It is connected to a mixture of Residential, Commercial, and Industrial Agricultural loads (Algeria, Ma and Idrees). During the hottest days of the year, the peak loads on the grid heat the transformers and reduce reliability by overheating and decreasing their life-span (Algeria, Ma and Idrees). The DERMS algorithm reduces the load during these times and reduces damage to the affected transformers and protects reliability of the grid. The fifth objective is met because the installed microgrid enables the Jail's DERs to transfer excess energy into the grid as opposed to the prior protocol that required tripping of the DERs during excess generation periods. The sixth objective was met by measuring and attempting to reduce the total current running through the electrical equipment (Algeria, Ma and Idrees). The greater the current flowing, the greater the resistance, and therefore the greater the inefficient system losses. The flow is reduced as a consequence of achieving the second objective: reduction of demand on the utility's feeder. The seventh and last objective was to ensure reliability in the event of an outage. In order to measure this, utility disturbances were simulated to test the microgrid's islanding capabilities (Algeria, Ma and Idrees). Successful disconnections and reconnections from the grid without the slightest interruption of sensitive electronic equipment will maintain prisoners and operators safe by eliminating "those risky blackout events that had occurred prior to the installation" (Algeria, Ma and Idrees). This last objective was one of the major motivators that led to the installation of the microgrid.

3.0 PERFORMANCE & LIFECYCLE GOALS

Urban nuclei need energy to survive, grow, and evolve. Government leaders in Alameda county have recognized this in the context of the current climate change crisis and have decided to use the county government's budget, power, and influence on the market to promote the development of environmentally friendly behavior (Kerr). The aim is not only to transform the energy footprint of government agencies, but to reduce the price of environmental products by directing the government's $20 million total buying power in a sustainable direction (Kerr). Santa Rita Jail was a clear focal point for the county's climate action plan given that the facility is the "fastest growing jurisdiction in Alameda County" and consumes more energy than any other county government building (Algeria, Ma and Idrees). As a result, the Microgrid project became essential in the county's Climate action plan.

Alameda county seems determined to become a forerunner in the global race to reduce greenhouse gas emissions. The county's short-term target is to reduce emissions by 15 to 30% by 2020 (Alameda County Government). For the long-term, the county has an ambitious goal of reducing emissions by 80% before 2050 (Alameda County Government). The plan to achieve these is composed of fundamental policy strategies that will serve as structure for the long-term goal (Alameda County Government). Applying reduction measures in the transportation, building, and waste generation and disposal sectors is an essential part of the plan (Alameda County Government). The plans go beyond reductions, taking "steps to remove

Alameda County Solar Project	Predicted Energy	Offset Emissions 25 Years		Equivalent to Saving	
	Energy Production in kWh	Global Warming CO_2 (lbs)	Smog NOx (lbs)	Not Driving Miles	Removing Autos from Roadways
Santa Rita Jail	1,460,000	3,024,813	965	5,047,657	404
Total over 25 year life:	36,500,000	75,620,325	24,125	126,191,417	10,095

Figure 5. *Solar DER 25 year lifecycle performance. (PowerLight Corp.)*

GHGs from the atmosphere after they have been released and to prepare for the impacts of climate change" (Alameda County Government). These commitments, particularly those acting as a blueprint for the built environment, initiated the installment of DERs and eventually possibilities a true microgrid installation in the largest of the county government's facilities. The success of the transformation of the jail into a "green prison" (Marnay, DeForest and Lai). The demonstration of a CERTS microgrid in Santa Rita Jail has proven several significant benefits that serve as encouragement to different government and non-government organizations both in Alameda County and beyond. Some of the benefits for customers with an installed CERTS microgrid include "bill savings, price certainty, reliability (including power quality), [and] energy independence" (Lasseter). There are also benefits to the grid, and both grid operators and grid costumers benefit from these (Lasseter). From a more distant perspective, however, societal benefits are perhaps the most impactful as they provoke developments of similar microgrid systems in areas with DERs as it makes for not only "more resilient local energy infrastructure," but also increased environmental benefits that are currently so sought after and well viewed by the general public (Lasseter).

The Jails transition to DERs and implementation of a microgrid already had a sort of contagious impact as factories adjacent to the facility have also began installing rooftop PVs. The new installations of wind turbines around the facility also function as symbols of clean energy that have an effect on the day to day lives of passerbys and establish the region's identity as environmentally friendly. Ultimately, the Santa Rita Jail acts as a symbol that influences surrounding urban form and represents the possibility of transformation for the built and to-be built environment in accordance with and exceedance of the county's climate action plan blueprint.

4.0 APPLICATION AND CONCLUSIONS

The Santa Rita Jail in Alameda County, California, has become an environmental symbol over the course of several decades. The facility first installed a 1.2 MW solar PV rooftop system and a 1.0 MW fuel cell to reduce operation cost and increase reliability. These paved the way for future development of a CERTS microgrid protocol that integrated existing DERs as well as new ones (12KW Small Wind Turbines and 2.0 MW Advanced Energy Storage). The integration uses the DERMS algorithm to alternate between energy resources, optimizing and aligning peak load and generation patterns to provide economic benefits. The microgrid also provides reliability with its ability to island from the main grid seamlessly and at any given moment in the case of an outage. The installation functions as a proof of concept and the extensive documentation of the process is an exemplary form of communicating and enabling the development and advancement of similar microgrid projects elsewhere.

The CERTS microgrid concept has a proven to be a great tool for integrating DERs. But in this project, the existence of the DERs as well as the installation of new ones was the critical condition that paved the way for such

Santa Rita Jail Microgrid

a successful microgrid. The exact type of DER does not seem to be of great importance with the exception for the energy storage system. A powerful battery is crucial in permitting the manipulation of the facility's peak load hours to reduce the cost of purchased energy from the grid. It is also crucial in enabling the possibility of total islanding from the grid. Even though the CERTS concept is applauded for its simplicity, the complex operation of it is better suited for the DERMS algorithm, establishing it as another essential element in the proper realization of the microgrid.

The analysis process was invaluable in determining the goals for the project. The team that worked on the research and design of the microgrid, after determining the goals, set the project in motion by simulating and estimating the numerous benefits of the installation. Given the ROI period of 109 years, perhaps the most important piece in the project was the 12-million-dollar funding (in this case from the DOE). For this reason, the analysis that preceded the implementation of the microgrid was of even greater importance as it promised that the funding would be fruitful, if not in capital, at least in lessons learned and in proof of concept.

For a microgrid to properly work in a place like Houston, similar conditions must be met. Primarily, funding. Installing DERs, even in an energy abundant state, is expensive. In Texas, the project must make economic sense or policies must change.

It makes the most sense to adhere to the scale of the Santa Rita Jail Microgrid scale, deploying multiple microgrids throughout Houston. The large open spaces around the city open the possibility of a variety of DERs. A fuel cell and PVs could be installed in Houston but diesel generators, small hydro, biomass, or geothermal are also possibilities. An advanced energy storage battery system and a DERMS smart interface integration algorithm are essential. These will allow for intelligent charge and discharge of energy that will create a more efficient system that also benefits the main grid by reducing demand during peak load hours. Recently, weather has negatively impacted the reliability of the main grid and power outages have lasted week-long periods. A microgrid might prove to be very beneficial in this respect and might even be a strong enough motivator for some critical facilities in the city to develop their own microgrid. Houston as an energy capital can also strengthen its identity with the installation of multiple microgrids and reducing the city's energy consumption could increase fuel exports and further activate the economy. Alameda County's government published several reports and websites that draw out a storyline that both justifies and promotes the city's environmental behavior. This may be the most important piece in the installation of DERs and the development of the microgrid.

Case Study

Santa Rita Jail Microgrid

I. Project

a. Name: Santa Rita Jail Smart Grid
b. Client: Alameda COunty
c. City: Oakland
d. State: California
e. Country: USA
f. Lat/Long/Elev: 37.71782845/ -121.88798940004307/ 116 m

II. Team

a. Lead & General Contractor: Chevron Energy Solutions
b. Owner: Alameda County
c. Interconnection & Communication: Pacific Gas & Electric
d. System Operator: California Independent System Operator
e. Technical Oversight: University of Wisconsin, The Wisconsin Alumni Research Foundation
f. Measurement and Verification: National Renewable Energy Laboratory
g. Storage Scheduling & Optimization: Lawrence Berkley National Lab

III. General

a. Timeline: 2001-2011
b. Coverage Area: one-half mile long by one quarter mile wide site
c. Occupancy: 4,000 inmates

IV. Site

a. Site Description:FIfth largest detention facility in the United States
b. Climate: Dry-warm Summers and moist mild Winters

V. DER

a. PV: 1.20MW rooftop System
b. Fuel Cell: 1 MW with heat recovery for facility hot water and space heating
c. Wind: Five 2.3 kW turbines
d. Storage: 2 MW advanced energy storage system (AES)

VI. Control

a. Disconnect: 12kV sub-cycle static disconnect switch
b. Islanding Capability
c. Electric Power export and Import Capability.
d. CERTS smart grid control logic

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