# Cogeneration with Energy Sustainability Project for Bacardi Distillery

*Luis F. Saavedra Hernandez*
*Advisor: Prof. Héctor J. Cruzado, PhD, PE*
*Graduated Program in Engineering Management*

## Abstract

At the Bacardi Distillery facilities in Puerto Rico, power outages are a problem that have affected rum production operations and costs. It has been identified that the cause of this problem is that the facilities do not have an energy cogeneration system that can provide them with reliable and low-cost energy to operate their facilities. Additionally, senior management wants the facilities to be self-sustaining, using by-products of alcohol production as a fuel source and eco-friendly to the environment to reduce the carbon footprint. To meet the needs of the plant, a process was designed to obtain information from the operations, to create an analytical model of self-sustainability and develop a project that meets these expectations. An analysis of the processes was able to identify the necessary information to produce an analytical model with low-cost alternatives that could be implemented to achieve self-sustainability. After the changes, the facilities are self-sustaining and have a cogeneration system that produces reliable, low-cost energy and has the capacity to operate for long periods of time.

## Introduction

The Bacardi Distillery Rum, located at Cataño, PR, went through energy and sustainability challenges that affected its operations. This caused an increase in operational costs in addition to the business interruptions. The rum production equipment has seen affected by the energy service quality.

## Background

Sustainable design seeks to reduce negative impacts on the environment, and the health and comfort of building occupants, thereby improving building performance. The basic objectives of sustainability are to reduce the consumption of non-renewable resources, minimize waste, and create healthy, productive environments [1]

Utilizing a sustainable design philosophy encourages decisions at each phase of the design process that will reduce negative impacts on the environment and the health of the occupants, without compromising the bottom line. It is an integrated, holistic approach that encourages compromise and tradeoffs. Such an integrated approach positively impacts all phases of a building's life cycle, including design, construction, operation, and decommissioning [1].

For projecting a model, the data acquisition process is based on three "pillars" of sustainability. These pillars are characterized as follows environmental, social, and economic. Each category can be further divided into subcategories; for example, social sustainability indicators for industrial health and safety are distinguished from those for community well-being. Sometimes classifying an indicator depends on the scale and type of system being considered. For example, water use can be a one-dimensional or a two-dimensional indicator depending on the scope of analysis. As discussed in the previous section, some indicators such as "energy intensity" may capture the intersection of multiple pillars or dimensions of sustainability [2].

Combined heat and power (CHP), also known as cogeneration as well as several other names, is the simultaneous production of heat and the generation of power (typically electric power) from a single fuel source and which, as will been seen, also builds on the convergence and integration of most state-of-the-art engineering disciplines [3].

## Background (Cont.)

The most common cogeneration systems used for rum distillery facilities in the United States are identified in the five technology categories listed in Table 1. They make up 97% of the Combined Heat Power (CHP) projects in place today and 99% of the total installed CHP electric capacity. Table 1 shows the breakdown by each prime mover technology [4].

**Table 1**
**US Installed CHP Capacity by Prime Mover**

| Prime Mover | Sites | Share of Sites | Capacity (MW) | Share of Capacity |
|---|---|---|---|---|
| Reciprocating Engine | 2,194 | 51.9% | 2,288 | 2.7% |
| Gas Turbine* | 667 | 15.8% | 53,320 | 64.0% |
| Boiler/Steam Turbine | 734 | 17.4% | 26,741 | 32.1% |
| Microturbine | 355 | 8.4% | 78 | 0.1% |
| Fuel Cell | 155 | 3.7% | 84 | 0.1% |
| Other | 121 | 2.9% | 806 | 1.0% |
| Total | 4,226 | 100% | 83,317 | 100% |

* Includes gas turbine/steam turbine combined cycle

For CHP types of fuels, the most common fuel is natural gas. Hydrogen, natural gas, propane, methanol Steam turbines for CHP are used primarily where a solid fuel (e.g., coal or biomass) is used in a boiler [5].

The CHP specifiers have many variables to consider in calculating sizing. It is critical to understand both the unique requirements of the site, along the motivations of the project, including the cost and carbon requirements [6].

## Problem

- Power interruptions
- Equipment's failures
- Operational Cost Increase
- Plant operational procedures inefficient
- No backup power

## Methodology

To develop the design process of a sustainability and cogeneration system in an industrial facility, the following methodology presented in Figure 1 was established. This methodology allowed to organize the information in a simple form that can be shown off deliverable reports to Bacardi's facility staff and senior management so that decisions can be taken to reform the process in a simple form and based on empiric data over the actual operation and the goals that they want to be based into sustainability and cogeneration. Following is a list of steps performed following the methodology established.

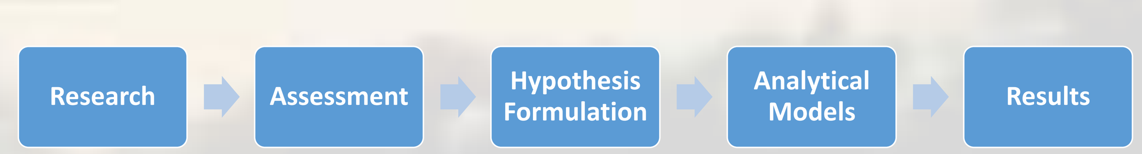


Figure 1
Methodology

## Methodology (Cont.)

**Research**

- Procedures in departments were observed.
- Gathered information of by-products that was been used as fuel

**Assessment**

- Identified the common failures in the system.

**Hypothesis Formulation**

- The evaluation of the best scenario with the fuel's alternatives or the use of by-products was completed.

**Analytical Model**

- Design of an energy model simulation

## Results

- The variance between the new and old processes plant sustainability was confirmed.
- The energy reliability validation was done.
- Was confirmed the reduction of hibernating effect gasses.
- Established the final model from implementation.
- Showed the results and the hypothesis validation to senior management and plant staff.

## Conclusions

The strategies that were established in the methodology produced the information for the redesign of self-sustaining strategies in the departments. Among the new processes that were implemented is the increase in the frequency of equipment maintenance and the adjustment of operating controls such as temperature control thermostats. The equipment that was replaced by more modern equipment is air conditioning systems, motors, pumps, and lighting. In addition, an automation system was installed for the utilities.

In Figure 2, the results of energy savings by the department. The total energy savings for all the apartments is approximately 110,290 KW-H, or 30% less consumption before starting the project.

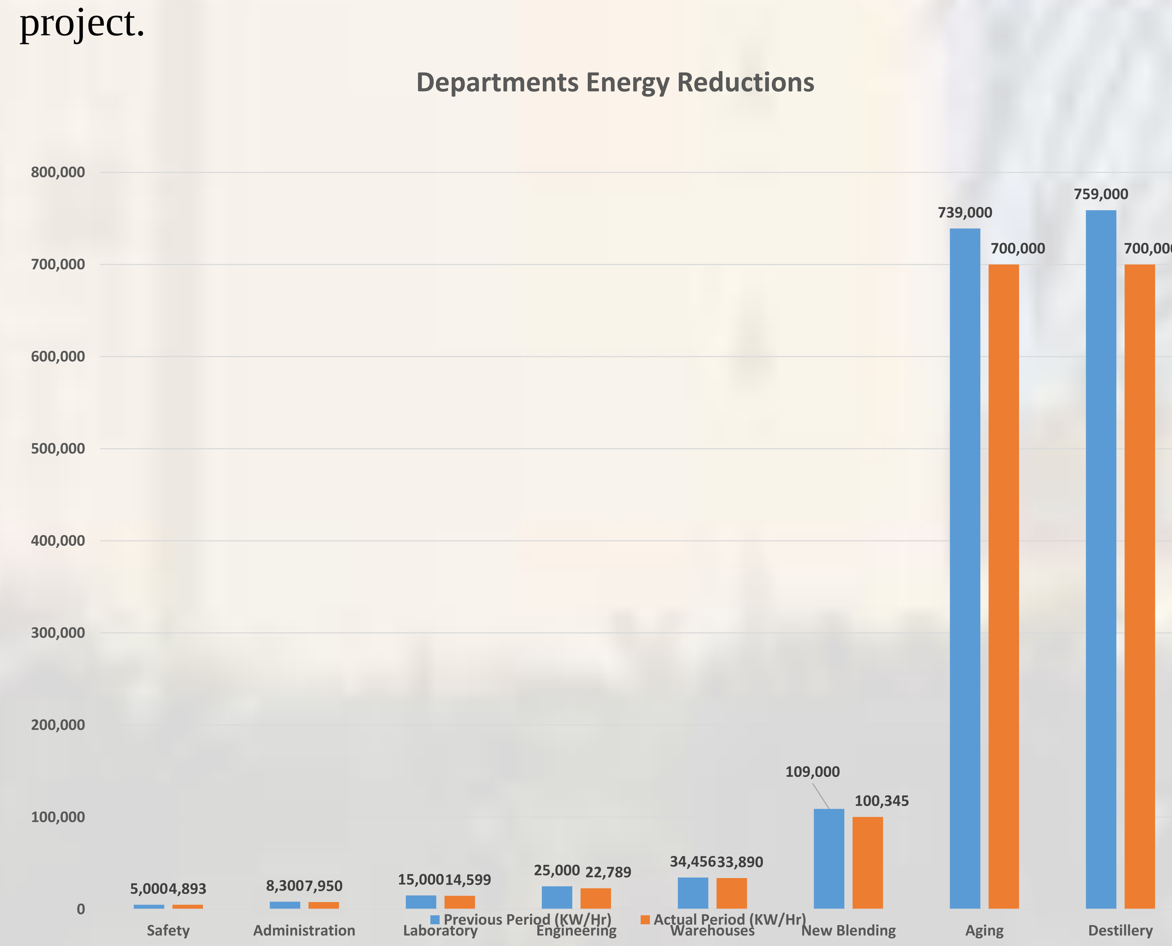


Figure 2
Departments Energy Reductions

## Conclusions (Cont.)

Due to this reduction in energy consumption per department, the plant approved another measure that was identified as part of the project, which was the repair of the bio-digester tanks. These tanks are fed with waste from rum production. Methane is produced in the tanks, which is fuel for the boilers and the new cogeneration system. This cogeneration system turned out to be smaller than the one previously considered in the hypothesis, since, by obtaining the excellent results by department, the system was built on a smaller scale of generation.

Once the construction of the cogeneration system and the sustainability measures by the department were completed, the reliability of the new electrical system of the facilities could be validated according to the projections that had been established. From this moment on, power interruptions in the plant's production systems were a thing of the past.

## Future Work

Research on what other alternatives we can carry out to improve production processes and equipment replacement continues. The operation of the cogeneration equipment is also being monitored to identify areas of opportunity to improve its efficiency.

## Acknowledgements

- Prof. Hector J. Cruzado, PhD, PE (Advisor)
- Bacardi Senior Management & Department Staff

## References

[1] U.S. General Service Administration, Sustainable Design, Last Reviewed: 2021-03-17, [On-line Source] https://www.gsa.gov/real-estate/design-construction/design-excellence/sustainability/sustainable-design

[2] U.S. Environmental Protection Agency, A-Frame for Sustainability at EPA, October 2012, [On-line Source] https://www.epa.gov/sites/default/files/2014-10/documents/framework-for-sustainability-indicators-at-epa.pdf

[3] Milton Meckler, P.E. and Lucas B. Hyman, P.E. (2010) Sustainable On-Site CHP Systems: United States of America: Mc Graw Hill

[4] U.S. Environmental Protection Agency, Catalog of CHP Technologies, Full Report, September 2017, [On-line Source] https://www.epa.gov/chp/catalog-chp-technologies

[5] U.S. Department of Energy, Better Buildings, [On-line Source] https://betterbuildingssolutioncenter.energy.gov/

[6] la Edina, CHP Sizing and Key Considerations to Optimize Plants Performance, Mar 4, 2020 [On-line Source] https://www.edina.eu/news/chp-sizing-to-optimise-performance