

Near-Zero Energy Restaurants With Integrated Waste to Energy System

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Introduction

Buildings consume significant energy throughout their lifecycle, with restaurants among the highest consumers in the commercial sector. The global rise in restaurant numbers highlights the urgency for energy-efficient solutions, such as converting them into near-zero energy buildings (NZEBS) powered by renewable sources. Restaurants also produce large amounts of organic waste, which, when incinerated or landfilled, harms the environment through methane emissions and pollution. Integrating waste-to-energy (WTE) systems in restaurants can reduce environmental impact and support their transition to NZEBs.

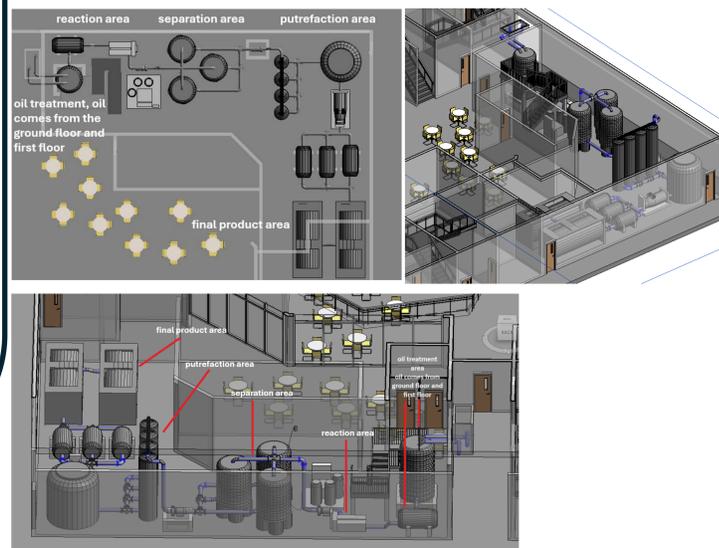
Objectives

- Assess energy consumption patterns in restaurants and optimize it.
- Integrate an efficient WTE system that converts cooking oil/organic waste generated by restaurants into usable energy.

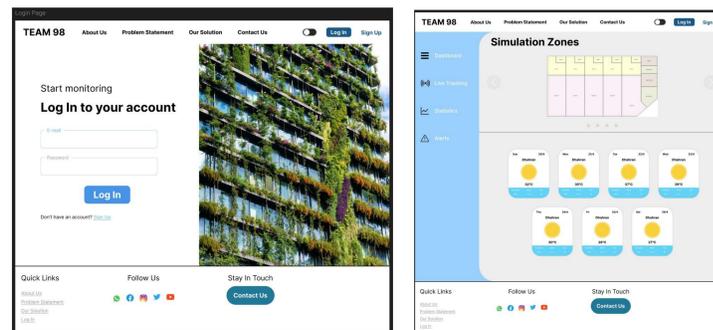
Prototype (3D Render)



WTE System 3D Model



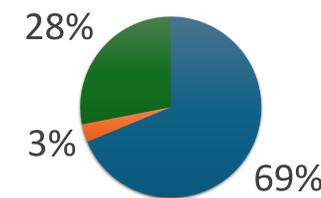
Interface of Project Website



Testing/Validation

- Used Design-Builder software to run energy analysis. The following is the energy consumption of various systems:

Energy Consumption %



■ HVAC ■ Lighting ■ Equipment

- Building energy utilization index (EUI) = 422.96 kWh/m²/yr.
- After some assumptions on the amount of cooking oil produced and its density it was concluded after thorough calculation The Waste to Energy system will provide 8505-8978 MJ/day of energy.
- Waste Allocation optimization model:

x_i : Organic waste from restaurant i (kg)
 y_i : Used cooking oil from restaurant i (L)

$0 \leq x_i \leq 150, \sum x_i \leq 2100$
 $0 \leq y_i \leq 4.97, \sum y_i \leq 70$

Decision Variables:
Objective Function: Maximize $Z = \sum (x_i \times 0.78 + y_i \times 10.5)$ (Total energy output)
Constraints:
Optimal Result: Full allocation from all 14 restaurants
 Total Energy: 2,367.8 kWh/day

Results

Results from the energy analysis simulation and calculations concluded that the WTE system contributes between 55.82% and 58.94% of the building's energy demand, establishing a baseline for near-zero energy buildings. However, the percentage of renewable energy can be increased by integrating solar panels. Based on our research and calculations, a solar panel system generating 1.55 kWh/m²/year can enable 80% renewable energy coverage with approximately 58 to 64 panels.

Conclusion

- Near-Zero Energy achieved with 80% renewable energy generation from WTE system and solar panels.
- Established a website to showcase and predict the energy each zones produce based on the weather.
- Encourage stakeholders in the restaurant industry to adopt these sustainable practices to meet global energy efficiency and waste reduction goals.