BOARD #138: Strategies for Optimization: Enhancing Operational Processes Through Energy Efficiency

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Strategies for Optimization: Energy and Environmental Assessment for a Business in El Paso, Texas

Abstract

The food processing sector in the US has consistently been the fourth largest energy-consuming industry since the early 2000s, demanding nearly 1.25 exajoules (EJ) of final energy annually (Brueske, 2012). Identifying strategies to effectively optimize energy-efficient practices in the food processing industry is essential for long-term reductions in greenhouse gas emissions (GHG) and direct realization of operational cost savings.

A Case Study of a food processing business in El Paso, Texas is presented as an example of strategies that can be scaled across similar businesses in size and scope. The assessment process comprised a walk-through inspection of the receiving and shipping processes, and a comprehensive assessment of equipment usage, lighting, water consumption, electrical consumption, heating, ventilation, air conditioning (HVAC) systems, and the physical building envelope. The assessment revealed numerous opportunities for operational improvements.

This Case Study provides insight into the on-site assessment process, including expectations for management involvement and buy-in in the process. Key findings from this Case Study will be shared including subsequent recommendations to guide process improvements for reductions in energy, CO_2 emissions, water consumption, and ultimately opportunities for cost savings. Additional strategies for integrating renewable energy, tracking solid waste, enhancing recycling processes, conserving water, and lowering energy consumption are also shared. As evidence of effective strategies for optimizing operational practices, this Case Study will convey recommendations that, if fully implemented, could result in reductions in energy use, reductions in CO_2 emissions, reductions in consumed water, and the potential to realize meaningful annual cost savings for the respective food processing business.

This Case Study will also share best practices on the engagement of undergraduate and graduate students in the assessment process as an embedded strategy for fostering an aligned future workforce. Strategies for engagement include direct participation in the assessment process and mentored guidance for effective data collection and analysis, report preparation with relevant recommendations for operational efficiency, and direct participation on a team-based project, each of which is valuable workplace skills. Student experiences in the program will be shared, including how engagement influenced their future career pathways.

Introduction

The U.S. food processing industry is characterized by high energy demands required for production stages including raw material processing, refrigeration, heating, cooling, and distribution. Despite the sector’s critical role in the economy, inefficiencies in energy utilization persist, contributing to elevated operational costs and environmental degradation. Furthermore, these inefficiencies result in significant carbon emissions, compounding the environmental challenges posed by the industry.

As the industry faces increasing pressure to adopt sustainable practices, there is a growing need for structured assessments that identify inefficiencies and recommend actionable solutions. This study investigates a food processing business in El Paso, Texas, as a case study to evaluate strategies for optimizing resource use. By conducting detailed assessments of utility expenses, equipment efficiency, and operational practices, this research identifies actionable recommendations tailored to the facility's unique needs. Moreover, the inclusion of students in these assessments underscores the dual benefits of fostering educational development and advancing sustainability initiatives.

Student Involvement

Undergraduate and graduate students played a vital role in the assessment process. Undergraduate students are hired as hourly employees and primarily work in the office rather than in the field due to scheduling constraints. They learn the process from graduate students and assist with data organization and analysis. Graduate students, on the other hand, are employed as Research Assistants (RAs) and funded through various grants from different agencies. They collaborate with staff and faculty to collect and analyze data, contributing significantly to the assessment.

Their participation spans multiple stages of the assessment, including:

- **On-Site Inspections**: Students joined the evaluation team to observe and document facility operations, gaining hands-on experience with industrial processes and sustainability assessments. This immersive experience allowed students to identify inefficiencies in real-time and understand the practical implications of energy optimization.
- **Data Collection**: Utility bills, equipment logs, and operational metrics were analyzed to establish baseline performance levels. Students were instrumental in gathering and organizing this data, applying classroom knowledge to a real-world context.
- **Report Preparation**: Under faculty mentorship, students prepared detailed recommendations, learning to balance technical analysis with practical solutions. This process enhanced their critical thinking, communication, and teamwork skills, fostering a deeper understanding of the challenges and opportunities in sustainability.

By involving students in every stage of the process, this initiative not only enriched their academic experiences but also prepared them for careers in sustainability, energy management, and environmental engineering. Their involvement highlighted the importance of interdisciplinary collaboration and real-world problem-solving in education, providing a foundation for lifelong learning and professional growth

E3 and P2 Assessments

The E3 (Economy, Energy, and Environment) and P2 (Pollution Prevention) frameworks were pivotal in guiding the evaluation process. These programs emphasize the integration of economic and environmental goals, fostering business practices that reduce waste, optimize resource use, and enhance profitability. Key elements included:

- **Source Reduction**: Identifying opportunities to prevent waste and pollution at the source, thereby minimizing environmental impacts. This approach focuses on proactive measures rather than reactive solutions, ensuring long-term sustainability.

- **Energy Optimization**: Conducting energy audits to identify inefficiencies and recommend improvements, such as equipment upgrades and operational adjustments. This component aims to align energy use with operational demands while minimizing waste.
- **Government Support**: Leveraging federal grants from agencies like the EPA, USDA, and DOE to subsidize assessments and encourage businesses to adopt sustainable practices. These grants reduce financial barriers and incentivize businesses to invest in sustainable solutions.

Embracing a comprehensive approach, the College of Engineering at New Mexico State University (NMSU) conducts energy audits benefiting the environment and businesses together. The case study has assisted over 80 businesses and plans to continue improving the sustainability of New Mexico, Texas, and surrounding areas. These assessments provide a holistic review of operational practices, pinpointing areas for improvement and offering clear, actionable recommendations that align with industry best practices.

Implementation of Recommendations

There are three types of recommendations provided to businesses:

A - No-Cost: These involve simple behavioral and operational changes that reduce energy consumption and costs. Examples include setting thermostats to the appropriate temperature, turning off lights and electronics when not in use, utilizing natural light, encouraging employees to unplug personal devices, and regularly cleaning air filters.

B - Low-Cost: These require minimal investment, such as sealing air leaks around doors and windows or switching to LED lighting.

C - High-Cost: These involve significant expenses, such as replacing outdated equipment with Energy Star-rated alternatives or integrating renewable energy. The primary challenge for businesses in implementing these recommendations is the upfront cost. However, various incentives and resources are available, though many businesses are unaware of them.

The team works closely with businesses to explore funding options and connect them with service providers. Many utility companies offer energy efficiency programs, providing LED lighting and equipment upgrades. Additionally, programs such as the USDA’s Rural Energy for America Program (REAP) offer grants and loans to support these improvements.

Literature Review

Energy efficiency in the food processing sector has been extensively studied, with prior research emphasizing the adoption of advanced technologies, renewable energy sources, and waste management practices. For instance, Brueske (2012) highlighted the potential for energy reductions through process optimization and equipment upgrades. However, existing studies often lack specific guidance for mid-sized facilities in unique geographic or climatic conditions, such as those found in El Paso, Texas. This research addresses these gaps by providing targeted recommendations tailored to the facility’s operational and environmental context.

Additionally, studies on student involvement in sustainability projects underscore the dual benefits of academic engagement and professional development. This research builds on these findings by documenting the tangible contributions of student participants to the assessment process, emphasizing how hands-on experience bridges the gap between theoretical knowledge and practical application.

Methodology and Data Presentation

Process

The methodology employed in this study involved a systematic, multi-phase approach designed to capture detailed and replicable data. The steps included:

1. **Data Collection**: Utility bills, equipment specifications, and operational data were analyzed to establish baseline metrics for energy, water, and resource usage. This step ensured that the assessment was grounded in accurate, comprehensive data.
2. **On-Site Assessment**: A comprehensive walkthrough of the facility was conducted, focusing on key areas such as:
    - Equipment efficiency and maintenance.
    - Lighting systems and HVAC performance.
    - Water usage patterns and waste management practices. This stage involved detailed documentation and photography to capture operational inefficiencies.
3. **Stakeholder Engagement**: Facility managers and staff were interviewed to gather insights into operational challenges and opportunities for improvement. Their input was critical for tailoring recommendations to the facility's specific needs.
4. **Analysis and Recommendations**: The collected data was analyzed to identify inefficiencies and propose actionable solutions. These recommendations were prioritized based on cost-effectiveness, feasibility, and environmental impact, ensuring their practical relevance to the business.

Table 1: Electric use in 2020 and 2021

Electricity Use:		
Month	**Consumed (kWh)**	**Electric Charge ($)**
January	877,614	50,506
February	860,582	49,443
March	767,249	49,452
April	921,191	51,723
May	895,527	57,225
June	944,155	75,171
July	1,122,482	96,978
August	1,143,150	97,935
September	-	-
October	-	-
November	-	-
December	-	-
Total	7,531,950	528,434
Monthly Average	941,494	66,054
Daily Average	30,869	2,166

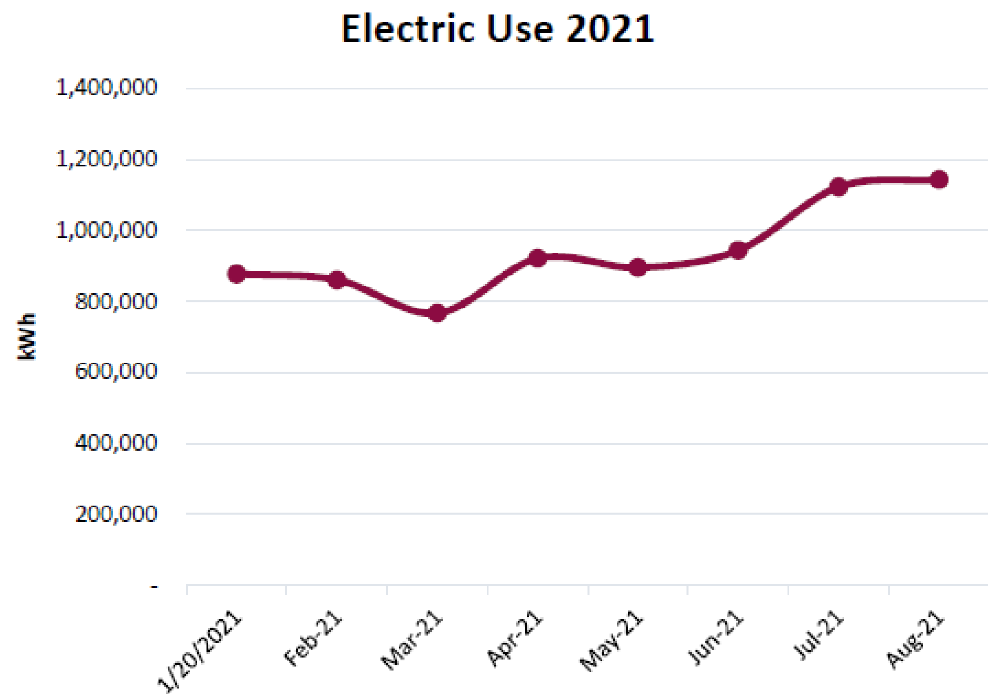

Figure 1. Electricity charges monthly in 2021

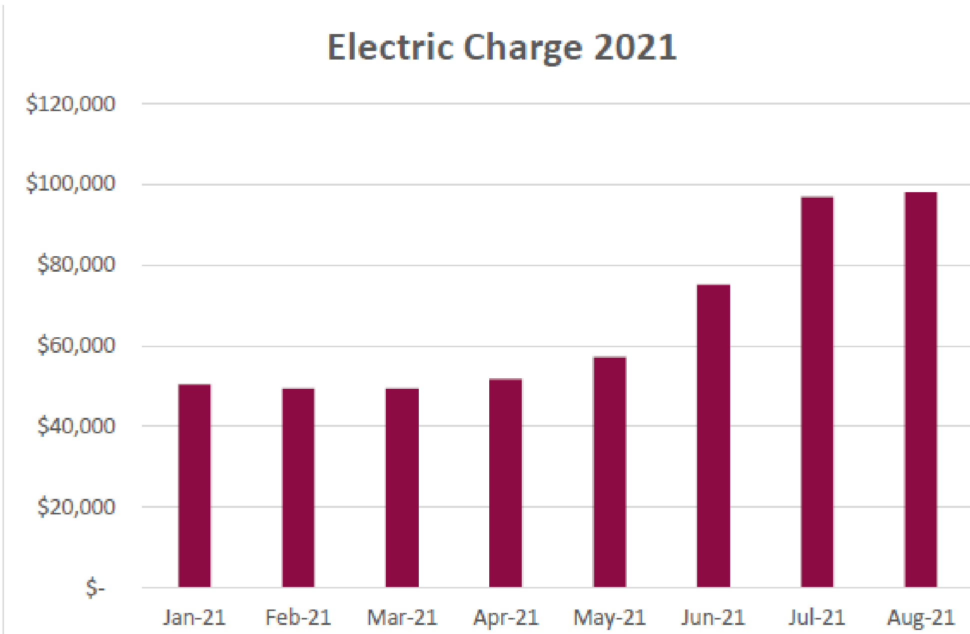

Figure 2. Electricity charges monthly in 2021

Table 2. Electricity Water Use 2021

Electricity Use:		
Month	Consumed (Gal)	Water Charge ($)
January	1,777,248	33,765
February	2,193,136	49,651
March	1,174,360	22,792
April	381,480	10,321
May	89,760	7,497
June	110,704	8,079
July	549,032	11.486
August	598,400	12,254
September	-	-
October	-	-
November	-	-
December	-	-
Total	6,871,120	155,845
Monthly Average	869,265	12,987
Daily Average	28,173	426

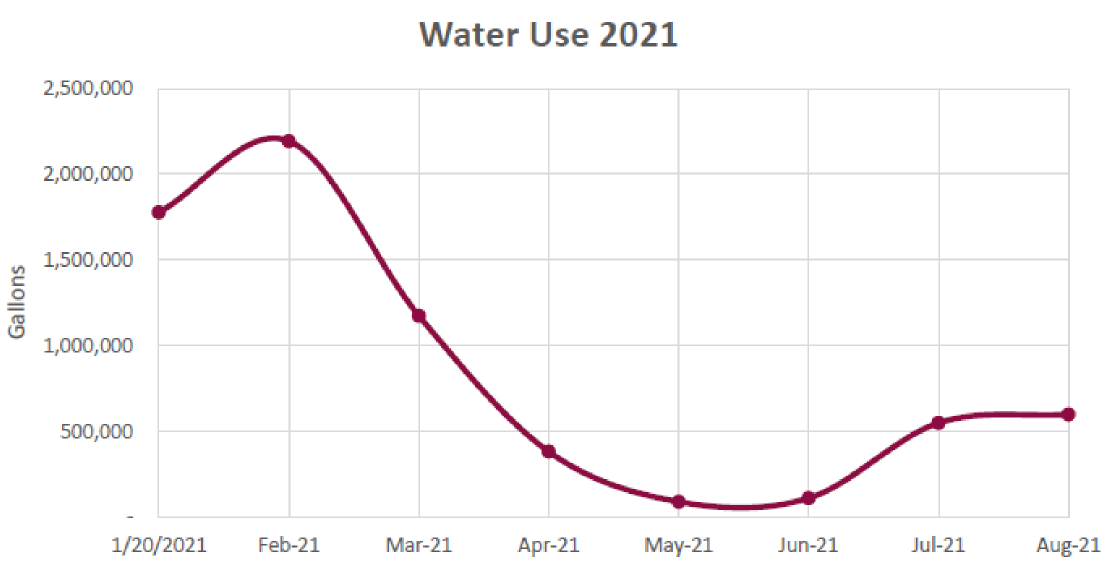

Figure 3. Water use 2021

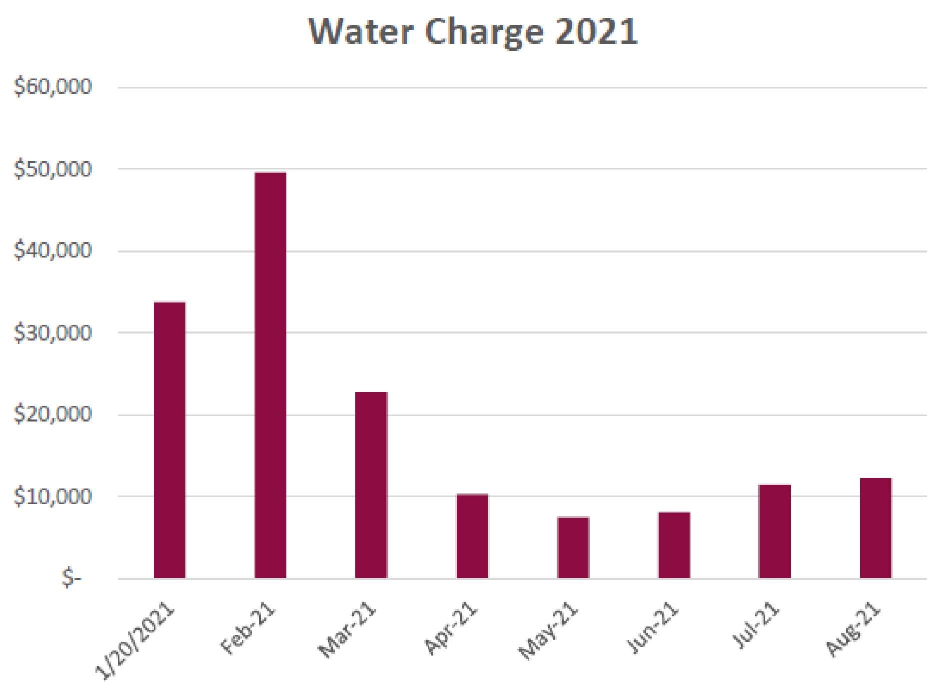

Figure 4. Water charge 2021

Assessment

The assessment revealed significant opportunities for improvement across multiple areas:

- **Energy Use**: Inefficient lighting and outdated equipment were identified as major contributors to high energy consumption. Recommendations focused on transitioning to energy-efficient technologies and optimizing equipment use.
- **Water Management**: Excessive water waste in the milk processing operation highlighted the need for conservation measures. A detailed plan for water reuse and recycling was proposed to address this issue.
- **Waste Reduction**: Existing recycling programs were underutilized, presenting opportunities for enhancement. The assessment recommended strategies for optimizing waste segregation and expanding recycling initiatives.

Discussion and Opportunity for Improvement

Boilers

The business had two boilers for their heating system. One of them is more than twenty years old, with damage on one side from corrosion. The recommendation for this boiler is to replace it with a modern model that is more efficient in operation and consumption. The other boiler that was not damaged should have proper maintenance and inspections to verify the conditions of the boiler are intact with no defects or leaks. The pipes are recommended to be insulated on the boilers ensuring energy, cost savings, safety, and efficiency. According to the Firwin Corporation, "Insulated boiler pipes can raise hot water temperatures by 2° F to 4° F higher than uninsulated pipes. In the long term, this can lead to 3% to 4% energy savings every year." [2].

Energy Savings

The replacement of incandescent bulbs with LED lighting resulted in measurable energy savings of 129,823.2 kWh annually. This change not only reduced energy costs by $17,000 but also lowered CO2 emissions by 162.3 tons per year. These results demonstrate the efficacy of simple, low-cost interventions in achieving substantial environmental and financial benefits.

Table 3. Incandescent and LED bulb comparison

Incandescent vs. LED		
	Incandescent	LED
Number of Bulbs	57	57
Bulb Wattage	300	40
Hours on per Day	24	24
kWh per Day	410.40	54.72
kWh per Year	149,796.00	19,972.80
Annual Energy Difference (kWh)		129,823.20

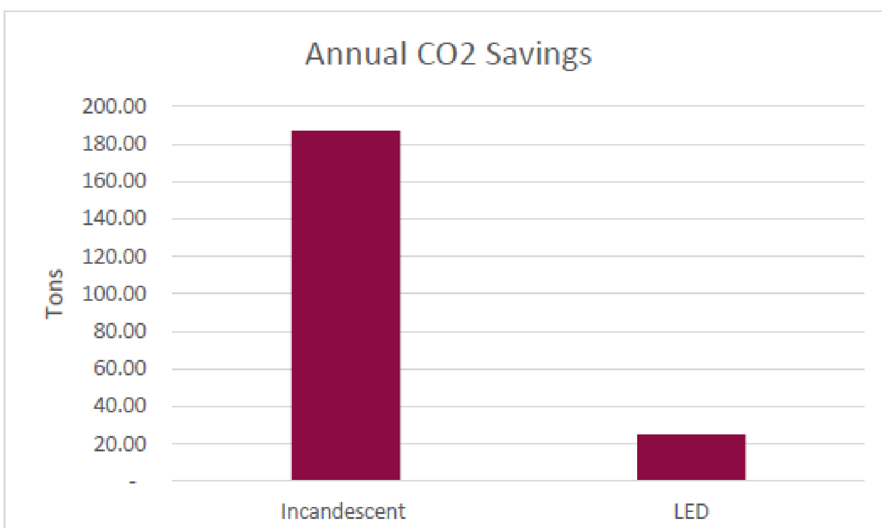

Figure 5. Annual CO_2 savings

Water Treatment and Conservation

The business processes approximately one million gallons of milk each day. Of this total, 60% consists of water, with the company using only about 30% for cooling purposes; the remainder is sent to the drain. By calculating the total volume of water recovered from the processed milk compared to the amount that is wasted. This excess water presents an opportunity for reuse for irrigation around the property to minimize waste. The NMSU team outlines a comprehensive plan, detailing the appropriate amount of water needed, the size of the irrigation system, optimal watering times, and the implementation of smart technology. The company has a total irrigation area of approximately 60,000 square feet, which would require around 37,200 gallons of water. This approach provides a practical solution for utilizing water that would otherwise go to waste.

Table 4. Water recovered from processed milk

Total water recovered from milk	
Amount of milk received (gal)	1,000,000
Amount of water (%)	60
Amount of water (gal)	600,000
Amount of water used for cooling (%)	30
Amount of water used for cooling (gal)	180,000
Amount of water going to the drain(gal)	420,000
Annual gallons saved by reusing water for irrigation	1,785,589.92
Price per 748 gallons	$3.00
Annual Dollar Savings	$7,161.46

Figure 6. Irrigation areas outlined

Table 5. Water required for irrigation

Water required for irrigation per week (.62 gal/sq ft)		
Area	Sq. ft.	Amount (gal)
1	36,440.47	22,593.10
2	3,774.58	2,340.24
3	457.04	283.36
4	18,221.57	11,297.37
5	1,106	685.72
Total	58,893.66	37,199.79

Solar Energy

Installing solar energy is a strategic long-term investment for businesses and can be an effective way to reduce energy costs. Several factors influence the overall cost and energy production of solar panels, including location, system size, type, and whether the system is off-grid or on-grid with energy storage.

Currently, the food processing business consumes 7,531,950 kWh per year, which necessitates a system size of approximately 4,094.34 kW to meet this demand. However, it's essential to account for potential energy losses due to factors such as low sunlight, temperature variations, and equipment efficiency. To ensure adequate coverage, an additional 10% is recommended, bringing the desired system size to around 4,400 kW. Depending on the company's needs, it can install a system of this estimated size to cover 100% of its electricity consumption or just a portion of it. In either case, both the size requirement and the cost will be reduced.

The estimated cost for a system to cover 50% of the energy needs is $10,314,084 if purchased by the food processing business. However, the business can take advantage of various incentives to help fund the solar panels. With the Federal ITC applied, the net system price (including battery and inverter) drops to $7,632,422 (see Table 8). While this represents a significant investment, the payback period is projected to be 19 years, resulting in annual savings of approximately $396,325 on the electric bill. Additionally, the system would contribute to an annual reduction of 7,061.20 tons of CO_2 emissions. Tables 10 and 11 outline the system costs and savings if 70% of the energy needs are covered by solar panels.

While a solar array represents a significant investment, the cost of installing solar systems has been decreasing over the years. Additionally, various state incentives can assist in financing solar panel installations. This information was highlighted in the report for the client to emphasize that solar energy can be a cost-effective solution with the right support.

Table 6. System cost covering 50% of energy

Solar System Annual Consumption (kWh)	11,297,925
kWh Required	5,648,963
Electricity Bill covered	50%
Solar Hours per Day	6.72
Average Lifetime of System	20
Solar Array Size Required (kW)	3,842.83
Solar Array Size Desired (kW)	4,227
System Cost	$7,933,911
Battery Estimated Cost	$2,380,173
Estimated Total System Cost	$10,314,084
Investment Tax Credit	26%
Net Cost	$7,632,422

Table 7. Savings with solar panels

Annual Energy, MTCO2e and Cost Savings with Installing Solar System	
Annual Charge	**$792,650.70**
Current Annual Energy Consumption (kWh)	7,908,548
Current Annual Electricity Charges ($)	554,855
Annual Solar System Energy Produced (kW)	5,918
Annual Cost Savings ($)	554,855
System Cost	$ 10,685,391
Payback Period	19
CO2 Emissions per kWh (tons)	2.5
Annual MTCO2e Savings (Tons)	9,885.68

Table 8. System cost covering 70% of energy

Solar System	
Annual Consumption	**11,297,925**
kWh Required	7,908,548
Electricity Bill covered	70%
Solar Hours per Day	6.72
Average Lifetime of System	20
Solar Array Size Required (kW)	5,379.96
Solar Array Size Desired (10% more energy)	5,917.96
System Cost	$11,107,475
Battery Estimated Cost	$3,332,242
Estimated Total System Cost	$14,439,717
Investment Tax Credit	26%
Net Cost	$10,685,391

Table 9. Savings with solar panels

Annual Energy, MTCO2e and Cost Savings with Installing Solar System	
Annual Charge	**$792,650.70**
Current Annual Energy Consumption (kWh)	7,908,548
Current Annual Electricity Charges ($)	554,855
Annual Solar System Energy Produced (kW)	5,918
Annual Cost Savings ($)	554,855
System Cost	$ 10,685,391
Payback Period	19
CO2 Emissions per kWh (tons)	2.5
Annual MTCO2e Savings (Tons)	9,885.68

Recycling

A company operating 24/7 produces a substantial amount of waste, which can significantly harm the environment. The business collects about 30 cubic yards of aluminum cans and 20 cubic yards of mixed solid waste (such as cardboard, plastic, and paper) each week. This waste management strategy effectively reduces the quantity of materials directed to landfills and incinerators, thereby lowering greenhouse gas emissions. For instance, every ton of aluminum can be disposed of in a landfill, resulting in approximately 11.09 tons of CO_2 emissions. A positive aspect of this business is its existing recycling process. The NMSU team explores opportunities to enhance and optimize these already established practices.

Table 10. CO_2 savings from solid waste recycling

CO2 Savings from solid wastes recycling	
Annual Amount of Solid waste (yd^3)	1040
Cu. Yd/Ton	4.44
Total Weight (tons)	234.23
Tons of CO2 Saved per Tons of solid waste	2.94
Annual CO2 Saved (tons)	**688.65**

Table 11. CO_2 savings from aluminum recycling

CO2 Savings from aluminum cans recycling	
Annual Amount of Solid waste (yd^3)	1560
Cu. Yd/Ton	4.44
Total Weight (tons)	49.13
Tons of CO2 Saved per Tons of solid waste	2.94
Annual CO2 Saved (tons)	**544.89**

Lean Manufacturing

The food processing business incorporates lean manufacturing, a systematic approach aimed at identifying and eliminating waste through continuous improvement. This method focuses on streamlining product flow based on customer demand, all while striving for perfection. Recommendations for the business are through their motion and transport. In terms of motion, tasks that involve excessive movement should be redesigned to optimize personnel workflows and enhance health and safety. This can include better plant layouts and the creation of sub-stations adjacent to main operations to reduce transportation needs. Regarding transport, minimizing the excessive movement of materials is essential, as it can lead to product damage and defects. Additionally, unnecessary movement of people and equipment can result in wasted effort, increased wear and tear, and employee exhaustion.

Conclusion

These assessments are crucial for environmental sustainability and the future of humanity, as small victories contribute to achieving larger sustainability goals. Investing in these initiatives will support significant long-term benefits for the business. Doing these assessments helps spread environmental awareness. The NMSU has helped over 80 businesses throughout the years and is getting more inquiries for future assessments.

The food processing business harms the environment through pollution of air, soil, and water, they received recommendations to enhance these processes for both environmental and business benefits. Key suggestions include awareness of energy consumption, enhanced water conservation measures, solar energy systems, and improved tracking of solid waste and recyclables.

The result of the assessment indicates that the business could save 129,823.2 kWh of energy, decrease 1,395.82 tons of CO_2 emissions, reduce water consumption by 1,785,589.92 gallons, and have $60,878.48 in cost savings per year.

Table 12. Annual savings from recommendations without solar

Annual Savings			
Energy Savings (kWh)	MTCO2e emissions (tons)	Water Savings (gal)	Annual Savings from P2 ($)
129,823.20	1,395.82	1,785,589.92	60,878.48

Table 13. Annual savings from recommendations with solar

Annual Savings			
Energy Savings (kWh)	MTCO2e emissions (tons)	Water Savings (gal)	Annual Savings from P2 ($)
5,665,806.8	11,281.5	1,785,589.92	615,733.48

This study demonstrates the feasibility and benefits of comprehensive energy and environmental assessments for mid-sized food processing businesses. By implementing the recommended strategies, the facility in El Paso can achieve significant cost savings, reduce environmental impacts, and serve as a model for similar enterprises. Additionally, student engagement in the assessment process fosters a pipeline of skilled professionals equipped to address future sustainability challenges.

Future research should explore long-term outcomes of these interventions and investigate sector-wide applications of the findings. Policy frameworks and funding mechanisms should also be examined to support broader adoption of sustainable practices in the industry. Integrating interdisciplinary approaches and advanced technologies will further enhance the effectiveness of such assessments.

References

Material Type	Works Cited
Brueske, 2012	[1] US manufacturing energy use and greenhouse gas emissions analysis. No. ORNL/TM-2012/504. Oak Ridge National Lab (ORNL), Building Technologies Research and Integration Center (BTRIC). Oak Ridge, TN (United States): Oak Ridge National Lab (ORNL).
eJournal (from internet)	[2] O. US EPA, “E3: Economy - Energy - Environment,” www.epa.gov, Aug. 28, 2013. Available: https://www.epa.gov/e3
eJournal (from internet)	[3] Firwin, “What to Know About Boiler Insulation,” *Firwin Corporation*, Dec. 10, 2019. Available: https://www.firwin.com/blog/what-to-know-about-boiler-insulation/#:~:text=According%20to%20the%20guidelines%20set. [Accessed: Sep. 23, 2024]