PROVIDING ENERGY AND ENVIRONMENTAL ASSESSMENT SERVICES TO NEW MEXICO'S BUSINESSES TO COMBAT CLIMATE CHANGE

PATRICIA A. SULLIVAN, JALAL RASTERGARY & PAUL AMEND
Office of Outreach and Recruitment, College of Engineering, New Mexico State University, USA

ABSTRACT

Most solutions for dealing with environmental issues and climate change are focused on a few major causes of the problem and often do not have a holistic approach. The Office of Outreach and Recruitment in the College of Engineering at New Mexico State University has been studying and providing a holistic approach to this problem by providing onsite energy and environmental assessments to businesses since 1999 under a federally funded pollution prevention grant program. The program, funded through a grant from the U.S. Environmental Protection Agency, focuses on providing technical assistance, training, and educational outreach on a variety of pollution prevention (P2) and economy, environment and energy (E3) strategies to businesses, industries, and communities across the state of New Mexico and the west Texas region. The overarching goal of the program is to mitigate climate change by improving resource efficiency and reducing greenhouse gas (GHG) emissions; reduce the generation of toxic and hazardous materials; conserve water and energy resources by reducing their use in manufacturing processes; and reduce organic waste disposal through organic composting projects with food manufacturing businesses. Recipients of such services have included a variety of businesses in the healthcare, agriculture, hospitality, food and beverage production and processing, and manufacturing sectors. In this paper, the P2 and E3 assessment process is described. The amount of reduction in energy, water, and waste and cost savings from one business will be presented as a case study. The methodology for the case study assessment will be presented along with industry and site-specific recommendations for realizing source reductions and cost savings.
Keywords: pollution prevention, energy efficiency, sustainability, environment, economic.

1 INTRODUCTION

As the world debate on climate change continues, communities and businesses across the globe are beginning to recognize the economic and societal benefits of sustainability realized through energy efficient and waste minimization strategies. Based on data from the World Bank, while small and medium enterprises, i.e., organizations with fewer than 500 employees, make up roughly 90% of the world's business and provide many jobs, most global emissions can be tracked to a small number of the world's largest companies. However, given that big corporations with large value chains use smaller firms for things like raw materials, packaging, production, and marketing, all of which contribute to the carbon footprint, an opportunity exists to foster sustainability across the broader supply chain [1].

Over the past 20 years, the College of Engineering (COE) at New Mexico State University (NMSU) has been a leader in advancing environmentally sustainable practices by working directly with businesses to identify opportunities for adoption. The Office of Outreach and Recruitment (OOR) within the COE has specifically developed strategies to assist small to mid-size businesses (500 or fewer employees) by providing no-cost on-site pollution prevention and energy-efficiency technical assessment services.

Working directly with business management, assessments help businesses to become more energy and water efficient, minimize waste, reduce pollution, promote energy efficiency (resulting in lower greenhouse gas emissions), and encourage the use of less toxic cleaning products. By adopting sustainable operational best practices focused on pollution

WIT Transactions on Ecology and the Environment, Vol 261, © 2023 WIT Press
www.witpress.com, ISSN 1743-3541 (on-line)
doi:10.2495/ESUS230181

prevention (P2) and economy, environment and energy (E3), businesses can increase their profitability while helping the environment.

P2, a program administered by the U.S. EPA, is defined as any practice that reduces, eliminates, or prevents pollution at its source before it is created. Also known as 'source reduction', P2 is fundamentally different and, where feasible, more desirable than recycling, treatment, or disposal. It is often more cost-effective to prevent pollution from being created at its source than to pay for the control, treatment, and disposal of waste products. When less pollution is created, there are fewer impacts on human health and the environment [2]. E3 is another U.S. federal program that started in 2009 as a technical assistance initiative for communities, manufacturers, and manufacturing supply chains to thrive in the emerging green economy [3]. The E3 program is comprised of six federal government agencies, including the Environmental Protection Agency (EPA), with a collective goal to reduce energy consumption, minimize carbon footprint, reduce pollution, increase productivity, and drive innovation. E3 connects agencies and organizations in local communities and small and medium-sized manufacturers with experts from federal agencies, states, and regions. To ensure relevant assistance for businesses at the community level, E3 federal agencies created partnerships with academic institutions across the country through a competitive grant outreach assistance program. The funding for these academic partnerships were grounded on the passage of the Pollution Prevention (P2) Act in 1990 [4]. As an academic institution, NMSU is among a group of institutions across the country selected to provide P2/E3 technical assistance services, educational awareness, and outreach to the business community. In this paper, the P2 and E3 assessment process is described. A literature review and methodology for on-site assessments will be presented along with business and site-specific recommendations for realizing source reductions and cost savings conveyed as a case study.

2 LITERATURE REVIEW

Since the dawn of the industrial age, manufacturers have been evolving and adapting in response to technological innovations and changing market demands. Today, the industry is moving through another evolution, with sustainability at its centre [5]. According to the U.S. Environmental Protection Agency, sustainable manufacturing is defined as 'the creation of manufactured products through economically sound processes that minimize negative environmental impacts while conserving energy and natural resource' [6]. This increased focus on sustainability across the manufacturing sector has been driven by global supply chain disruptions exasperated by the COVID-19 pandemic, increasingly prevalent extreme weather impacts on manufacturing productivity, regulatory mandates, and a genuine concern for the environment [5], [7], [8]. The end results of sustainable manufacturing are well documented to include, but not limited to, a reduction in operational costs and improvements in product quality, product safety, and improved health and safety profile of employees [9]–[11].

Manufacturing companies of all sizes are seeking opportunities to improve operational performance and reduce their resource footprint [6]. Factors affecting sustainable manufacturing practices can be divided into three main dimensions; management, internal and external factors, with management's attitude towards adoption and integration of sustainable manufacturing practices as one of the key drivers [9]. It is important for manufacturing to put in place sustainable practices that lead to better approaches for creating goods, by reducing and/or reusing materials throughout the process [12]. Furthermore, the easiest and most cost-effective ways to reduce energy costs in the manufacturing process is to implement the use of more energy efficient machines than those currently in use during the manufacturing process. By reducing energy consumption and minimizing waste, the

manufacturer can save money on costs that can be passed on to the consumer or re-invested into the manufacturing company to further benefit a goal of increased productivity and to help mitigate manufacturing waste [13].

As the positive correlation between energy efficiency and productivity becomes more widely understood, businesses will be more motivated to invest in energy-efficient technologies that have productivity benefits, and productivity technologies that have energy efficiency benefits. This is particularly relevant to the leather goods manufacturing industry, an industrial sector requiring large amounts of water and energy. As a result, many leather manufacturers are now implementing energy-efficient technologies and water conservation measures and integrating renewable energy into their operations [14].

A survey of the literature for manufacturing-based businesses conveys emerging best practices for improving sustainable processes and operational cost savings. Key practices include the use of sustainable materials, water conservation, renewable energy production, waste reduction, ethical labour practices, and end-of-life management [4], [15].

3 METHODOLOGY

The methodology for conducting onsite assessments for small- and mid-sized manufacturing-based businesses (defined as 500 employees or less) is presented to identify opportunities to improve productivity, reduce waste, and save energy. Experienced professionals at OOR have developed a five-stage best management practice (BMP), to gauge businesses that are most likely to benefit from sustainable practices. Through this framework, businesses that either pose the most risk to their local environments, consume extensive resources, or create large volumes of waste are selected for onsite assessment services. A business that is considered and participates in the program must undergo and adhere to the following criteria:

1. Need: The business must display operating procedures and business models that need improvement. The staff looks for industrial sectors that usually have little to no environmental standards, high rate of waste generation plus power and water consumption or fall within the U.S. EPA National Emphasis Areas (NEAs). Staff will consider businesses that can and should reduce hazardous material use and waste creation, consume large amounts of electrical energy, consume extensive amounts of water, or generate large volumes of wastewater.
2. Recruitment: If a business has any needs that match the above criteria, the staff will contact the business management to inform them of the benefits of the program. Opportunities for cost-savings and operational performance improvement are highlighted along with implementation and adoption of no-cost and low-cost sustainable strategies.
3. Commitment: The business must agree to have upper management involved throughout the entire process and allow other employees to accommodate and accompany the assessment team as needed. Management is encouraged to implement changes given by the assessment team and allow future assessments to track the effects of the implemented changes and offer further improvements.
4. Implementation: A dedicated room must be provided by the business for training purposes, and management must provide access to all areas of the business during a walkthrough and allow pictures and videos to be taken for use in the final report and presentation. All machinery and equipment will be evaluated during the data collection process; therefore, employees that can access hazardous or secure areas should be available to conduct a thorough inspection.

5. Recommendations and evaluation: The final report and final presentation will be presented to management and employees who participated in the assessment. The report will detail all findings, proposed recommendations, and the potential savings (e.g., cost, energy and water use, waste reduction).

While onsite assessments may vary from business to business, all participating businesses follow these criteria. By using this five-stage method, staff members can efficiently recruit and inform businesses of areas in need of improvement while leaving management in control of what procedures should be adopted and the timeline for adoption.

The process begins with an initial survey of the business facility to assure the business qualifies as a small-or mid-sized business and that management is committed to supporting the assessment process and implementation of recommendations when possible. An onsite visit is then scheduled, which may vary from one to two days depending on the size of the facility. This is followed by the actual onsite assessment, which includes an initial training for senior management and key personnel involved in day-to-day operation of the facility outlining the assessment process, an overview of data to be collected, and an in-depth overview of direct P2/E3 strategies and techniques with examples of waste elimination, energy reductions, water reductions, building efficiencies, and indirect benefits such as operational cost savings and achieving environmental performance goals. Following the initial training, a facility walk-through of the production line is conducted, along with extensive data collection (cycle time, machine uptime, production batch sizes, defect and scrap rate, waste disposal costs, utility costs, non-product outputs, materials usage, energy usage on machinery, lighting, HVAC system, use of compressed air and other gases in the manufacturing process, other energy waste, and water usage, and chemical usage and disposal). The onsite assessment concludes with an exit interview with senior management and key personnel reviewing visual observations resulting from the walk-through and a summary of any additional data required for the assessment analysis. Following the actual onsite assessment, OOR staff focus on finalizing data collection and data analysis using the U.S. EPA Simplified Greenhouse Gas (GHG) Emissions Calculator, a calculation tool designed to estimate and inventory annual GHG emissions and determine direct and indirect emissions from all sources based on business-specific data collected during the assessment process. The Simplified GHG Emissions Calculator methodologies and default values provided are based on the most current Center for Corporate Climate Leadership Greenhouse *Gas Inventory Guidance Documents* and the *Emission Factors Hub* [16]. Upon completion of the data analysis, a final report is prepared for the business. The final report includes an overview of the assessment process, documentation of management and key personnel involved in the walk-through and data collection, data analysis summary, and proposed recommendation for operational improvements, facility enhancements, machinery upgrades, lighting and HAVC enhancements, and waste disposal processes. The final report recommendations also include estimated reductions in GHG, water, energy, chemicals and hazardous waste, and proposed cost savings. A post-assessment follow-up is conducted at 6 months to track progress towards adoption and implementation of assessment recommendations.

3.1 P2 and E3 program

The P2 program focuses on reducing carbon emissions, water waste, and solid waste from industrial sites. The program works to convert existing machinery and operating procedures to be more efficient and cleaner; by focusing on the source of waste creation this program reduces waste created, hence pollution generated, and has been shown to reduce costs

concerning waste disposal. Reducing the amount of waste generated also reduces the cost of disposing of the waste allowing the company to save on overhead. The program works alongside E3 program to create a synergetic relationship where waste can be reduced by implementing more efficient machinery and enacting energy-efficient practices [17].

The E3 program focuses on reducing the power consumption of a business entity by recommending replacing current machinery with more energy-efficient models or by suggesting new working procedures that can reduce consumption. Changing appliances that are not Energy Star (products must achieve high levels of energy efficiency set by the U.S EPA to earn the ENERGY STAR label [18] is usually the best method for certain businesses to increase their sustainability but most businesses wish to enact sustainable measures quickly without having to wait several years for the new appliances to repay themselves. The E3 program's focus on work procedures plays a vital role; by enacting employee work procedures, power could be saved that does not increase operating costs and increases the employee's effect on the sustainability of the business. OOR has found that employee contributions can have large impacts on businesses, with many businesses being more willing to purchase newer appliances after seeing the amount saved from the procedures enacted. This is a major benefit of the E3 program.

The team performing the onsite assessments is composed of the following positions:

- Project leader and advisor: A senior staff member with significant experience that oversees the assessment and communicates with the client directly; train students to collect data and responsible for examining machinery that would be unsafe for students to inspect; presents the final report to upper management and decides which recommendations should be included in the report.
- Assessors: Responsible for inspecting all machinery, within safety guidelines, and conducting a search for more efficient equipment along with calculating the effect recommendations have on the business; in charge of writing the final report, with the leader making edits as necessary; usually, a student with an engineering background or entry-level staff member.

The OOR is focused on guiding the adoption and transition of small-business operating procedures to a more economical and environmentally friendly model; the P2 and E3 programs help businesses reach a more sustainable operation through the implementation of greener practices that can also decrease operating costs. These programs work to achieve the AWARE goals: Assist small-scale operations in adopting or improving pollution and energy efficiency Best Practices within their ongoing operations.

1. Work with like-minded organizations to increase environmental awareness and educate business owners on the benefits of greener practices.
2. Assess and evaluate current operating procedures and regulations to determine areas that need improvement along with recommendations to increase sustainability.
3. Report all findings and advisable programs to the company and all results of implemented recommendations for their final approval and assure that assessments are non-regulatory.
4. Educating current industry and the future industry, i.e., students, on energy efficiency and pollution prevention practices by incorporating them in all steps in assisting a small businesses conversion to environmentally friendly practices.

4 CASE STUDY

An onsite assessment was conducted at a local leather footwear manufacturing facility to identify opportunities for improving sustainability practices and to determine if more efficient operational processes could be enacted. The OOR team conducted a P2 and E3 assessment in collaboration with the Texas Manufacturing Assistance Center (TMAC), and the New Mexico Manufacturing Extension Partnership (NMMEP). The manufacturing facility specializes in hand-stitched leather footwear with sales that span the U.S. and global markets. Leather is purchased through a global supply chain of tanneries of exotic skins, custom steel-rule dies, and leather tooling. The facility specializes in artisan techniques for stonewashing and burnishing leather, techniques that are both water and energy intensive. The hand-stitched nature of their footwear requires a uniquely trained workforce, and the management was particularly focused on improvements that ensured a commitment to a healthy work environment.

An onsite assessment was conducted utilizing the BPM five-stage process previously outlined. The business considered for this case study is used as an example facility to demonstrate the effectiveness of the assessment process and potential environmental and cost savings realized through adoption of site-specific recommendations.

4.1 Assessment results

During the facility walk through, the team visually observed several areas for improvement that could result in immediate cost savings, reduce the environmental impact of the business, and possibly foster increased sales of their footwear. An example of these visual observations included an opportunity to convert electric lighting to LED throughout the facility, providing both cost savings and enhanced lighting for craftsmen within the facility. Other visual observations noted 13 air compressor leakages, which increases the amount of energy required to operate these machines and reduces the amount of air that can be stored, further increasing electric costs. Further analysis estimated that fixing the leaks could save the business about $42,000 per year and reduce their electric consumption by nearly 600,000 kWh. Fixing the leaks was not the only aspect that could be changed regarding the operation of the air compressors; reducing the operating pressure of the compressors by 4 psi could reduce the costs of operating the air compressors by about 5%, an annual savings of about $4,000 per year. These suggestions not only were easily implemented, and in the case of leakage should be implemented, they had the potential to save the business $46,000 per year; the costs of fixing the leaks would easily be paid back by the electric power savings.

Waste generation was examined and noted; the team found that 5,518 cubic feet bins of waste were generated per day. The team advised management to reduce their waste production by 25%; this would save the business nearly $19,000 per year in waste collection costs. To reduce waste, it was advised to separate reusable materials and unusable materials efficiently through employee participation; this allows employees to be accountable for the business's sustainability efforts and have all employees be aware of their impact on the environment.

Workplace operations and procedures proved to show the need for the most improvement, with the layout of workstations being a primary focus. During the inspection work areas were spread out and required minutes to travel from one station to another resulting in a loss of work time. It was advised that workstations should be moved closer together to create a smooth sequence during operation with subsequent operations being right next to each other. This would reduce lost work time and can increase production while also reducing mistakes being made; if the stations are closer together, employees can more easily determine if any

of the workstations requires attention especially if it is impacting the entire production line. Recording ticket information for the product seemed to have the greatest area for improvement, based on the team's calculations, the amount of time lost using a slow system where each employee must stop and record items at nearly a minute for every rack and 20 seconds for every six pairs of boots. If this lost time is eliminated or reduced the business could save nearly $720,000 per year in lost production time. Therefore, the saving would be greater since more items could be created and hence sold for an increased profit.

Employee safety and work methods were also examined and analysed to find more efficient practices. Standard methods had increased liability for the company due to the hazards employees would face. Moving heavy equipment daily and checking for nails in the boot by hand could lead to lost employee time due to work injuries. Enacting safer measures for checking for nails, and teaching employees more efficient methods of moving heavy equipment could reduce liability costs for the company by nearly $20,000. The company also seemed to have many employees waiting for work, it was advised that employees should be rotated so they can learn all workstations and increase productivity, so that wasted time can be decreased significantly. This would also increase sales due to increased production leaving almost no reason for the company to not enact these procedures.

Based on the team's walkthrough and the recommendations given to management, the business could save nearly $1,000,000 per year due to more efficient practices and fixed equipment, reduce electrical consumption by nearly 600,000 kWh, reduce the amount of solid waste generated by almost 1,300 tons, and 323,000 $MTCO_2e$ of GHG reduction. Most of the recommendations required no money to enact and could save the company substantial amounts for the fiscal year. The employee procedures implemented alone could save the company nearly $800,000, showing the importance of a company considering more sustainable operating procedures. The company was very grateful for the help and was willing to enact all the recommendations given; this not only helps the company but can also help the OOR by showing a specific example of a business that could save money through the advice given by the skilled staff participating in the P2 and E3 programs.

4.2 Post-assessment follow-up

A case study has been presented for a local leather footwear manufacturing business who participated in a P2/E3 onsite assessment of their facility. As part of the assessment process, business management was presented with a final report that outlined the assessment process, key personnel involved in the assessment, data collected, and recommendations for operational and process improvement based on the subsequent data analysis. Many of the proposed recommendations were either no cost or low-cost practices, resulting in the potential cost savings of nearly $1,000,000 per year. Recommendations prevalent in the case study resulted in savings realized by reducing lost work time, lost production time, and other savings stemming from fixing leaks in the current air compressor system. These savings did not require new things to be added nor did they require the business to purchase new equipment. The company appreciated the assessment and expressed a commitment to enacting the recommendations. A post-assessment follow-up, which included an in-person site visit to the facility and conversations with management indicated that they had adopted most of the recommendations provided through the assessment process with plans to implement the remaining recommendations in the immediate future.

4.3 Lessons learned

The onsite assessment provided management with an opportunity to strategically focus on sustainability strategies specific to their industry sector and their specific physical facility. The engagement of key personnel provided additional insight on employee behaviours that could support adoption of new processes and maintenance of equipment. Management commitment to the assessment process was key to successful adoption of the proposed recommendations, as many of the recommendations required some level of management approval. Management commitment also led to a move towards enhancing sustainability as a goal across their business.

5 CONCLUSIONS

Through an established and formalized technical assistance program, OOR at NMSU has contributed to the adoption of sustainability practices to businesses across New Mexico and west Texas. These contributions are a direct result of onsite P2 and E3 assessment services provided through federal grant programs, allowing businesses to participate at no-cost. The presented case study of a leather footwear manufacturing business demonstrates the criteria for business participation in the program, implementation of the assessment process, and potential impact on the participating business by adopting recommendations for operational efficiencies, environmental sustainability, and cost savings. This onsite nature of the assessment ensures recommendations are relevant to the respective business and increases the likelihood for future adoption.

In addition to the case study presented, OOR staff have worked with over 54 businesses in the past seven years to advance environmental sustainability practices across 11 business sectors (agriculture, hospitality, food packaging and processing, breweries, metal manufacturing, footwear manufacturing, grocery stores, health care providers, restaurants, and service providers) in 17 U.S. counties. Proposed recommendations to these 54 businesses, if fully adopted, could lead to reduced CO_2 emissions by 105,931 metric tons, hazardous waste reductions of 18,996 tons, energy use reductions by 64,434,340 kWh, water conservation of 102,137,645 gallons, and potential cost savings of $23,758,338. As conveyed in the case study, the assessment process is highly effective in helping businesses identify opportunities for adopting best practices with direct and indirect benefits to the environment and cost savings to the businesses. The successful outcomes of the assessment process have also resulted in increased public awareness of the program, as evidenced by a 200% increase is requests for assessment services on 2022 alone.

ACKNOWLEDGEMENT

The funding for this study was provided by the U.S. EPA Pollution Prevention Grant program with additional matching funds from the State of New Mexico.

REFERENCES

[1] TIME, How small businesses can have a big impact in the climate fight, October 13, 2022. https://time.com/6213434/climate-change-action-companies-businesses/.

[2] EPA, Pollution Prevention Grant: Environmental justice through safer and more sustainable products, 2023. https://www.epa.gov/p2/pollution-prevention-grant-environmental-justice-through-safer-and-more-sustainable-products#:~:text=The%20purpose%20of%20the%20Pollution%20Prevention%20Grant%3A%20Environmental,Specifications%2C%20Standards%20and%20Ecolabels%20for%.

[3] EPA, E3: Economy–Energy-Environment, 2023. https://www.epa.gov/e3#:~:text=Accelerating%20the%20Resurgence%20of%20Manufacturing&text=E3%3A%20Economy%2C%20Energy%20and%20Environment,thrive%20in%20today's%20green%20economy.
[4] EPA, Pollution Prevention (P2), 2023. https://www.epa.gov/p2/pollution-prevention-grant-environmental-justice-through-safer-and-more-sustainable-products#:~:text=The%20purpose%20of%20the%20Pollution%20Prevention%20Grant%3A%20Environmental,Specifications%2C%20Standards%20and%20Ecolabels%20for%.
[5] Deloitte, 2021 Sustainable manufacturing: from vision to action, 2021. https://www2.deloitte.com/content/dam/Deloitte/tw/Documents/energy-resources/gx-eri-sustainable-manufacturing-2021.pdf.
[6] EPA, Sustainable manufacturing, 2023. https://www.epa.gov/sustainability/sustainable-manufacturing.
[7] Forbes, Sustainability in the manufacturing industry is a work in process, 20 May, 2022.
[8] Nordin, N.H., Case study of sustainable manufacturing practices. *Journal of Advanced Management Science*, **2**(1), pp. 12–16, 2014.
[9] Roberts, S.P., Developing a library of sustainable manufacturing practices. *Procedia CIRP*, **15**, pp. 159–164, 2014.
[10] Gupta, S.S., Closed loop value chain to achieve sustainable solutions for tannery effluent. *Journal of Cleaner Production*, **213**, pp. 845–846, 2019.
[11] Smith, L. & Ball, P., Steps towards sustainable manufacturing through modelling material, energy and waste flows. *International Journal of Production Economics*, **140**(1), pp. 227–238, 2012.
[12] Samani, N., A comprehensive guide on leather manufacturing, 2023. https://www.deskera.com/blog/leather-manufacturing/.
[13] Md Abdul Moktadir, T.R., Drivers to sustainable manufacturing practices and circular economy: A perspective of leather industries in Bangladesh. *Journal of Cleaner Production*, **18**, pp. 1366–1380, 2018.
[14] U.S. Department of Energy. https://www.energy.gov/mesc/industrial-assessment-centers-iacs.
[15] Villena, V.H. & Gioia, D.A., A more sustainable supply chain. *Harvard Business Review*, March–April 2020. https://hbr.org/2020/03/a-more-sustainable-supply-chain.
[16] EPA, EPA Simplified GHG Emissions Calculator, 2023. https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fwww.epa.gov%2Fsystem%2Ffiles%2Fother-files%2F2022-09%2Fcalculator_tool.xlsm&wdOrigin=BROWSELINK.
[17] New Mexico State University, College of Engineering, 2023. https://engrnm.nmsu.edu/eba/index.html.
[18] EPA, Energy Star, 2023. https://www.energystar.gov.