Pollution Prevention and Energy Efficiency: A Case Study for Engineering Extension Services in the Desert Southwest

Jalal Rastegary, New Mexico State University
Dr. Patricia A. Sullivan, New Mexico State University

Patricia A. Sullivan serves as Associate Dean for Outreach and Recruitment in the College of Engineering at New Mexico State University. She received her PhD in industrial engineering and has over 34 years' experience directing statewide engineering outreach services that include technical engineering business assistance, professional development, and educational outreach programs. She is co-PI for a National Science Foundation (NSF) INCLUDES pilot grant, co-PI for a NSF grant to broaden participation in STEM, and was a co-PI for an i6 Challenge grant through the U.S. Economic Development Administration (EDA). She is institutional integrator for the Partnership for the Advancement of Engineering Education (PACE) at NMSU, is University Affiliate Director for the NM Project Lead the Way program, and was co-lead for a NSF funded Pathways to Innovation cohort at NMSU. Currently, Patricia serves as a commissioner with the Western Interstate Commission for Higher Education (WICHE), and a member of the board of directors for Enchantment Land Certified Development Company (a program that certifies SBA 504 loans that foster economic development.) She has extensive experience in economic development particularly efforts that build on collaborative partnerships with business and industry, government agencies, and other stake-holders to enhance employment opportunities for engineering students.

Mr. Christopher Campbell, New Mexico State University, Engineering New Mexico Resource Network

Mr. Campbell currently serves as Senior Program Manager at New Mexico State University's Engineering New Mexico Resource Network in Albuquerque, NM where he manages statewide pollution prevention, energy efficiency and recycling outreach programs. The Network provides information on pollution prevention and energy efficiency for New Mexico businesses, communities and Tribes.

Chris has authored and managed seventeen EPA Pollution Prevention grants since 1999 (totaling over $2.9 million) providing outreach and training on rural and Borderland P2 issues. Chris implements on-site presentations and training for a variety of industrial sectors on pollution prevention, energy efficiency and Lean & Green manufacturing; he collaborates with State agencies and non-profits in promoting pollution prevention efforts throughout New Mexico and the region.

He co-instructs an on-line course on pollution prevention at NMSU and has contributed to waste minimization and environmental education efforts in India through US-AEP and the Council of State Governments. Chris received his BA degree at Columbia University and a Master's at the University of Michigan. He served as a Senior Environmental Planner with the Rhode Island Department of Environmental Management for 16 years before joining the U.S. Peace Corps in Hungary where he served as an environmental volunteer. Before joining the staff at NMSU, Chris initiated the Source Water Protection Program for the New Mexico Rural Water Association from 1997-1999.

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Jalal Rastegary, Patricia A. Sullivan, PhD, Chris Campbell, Amirreza Barin, Edward Rojas

Engineering New Mexico Resource Network, College of Engineering, New Mexico State University

rastegar@nmsu.edu

Abstract

As a land-grant institution, New Mexico State University (NMSU) has leveraged services offered through their engineering extension program under the Engineering New Mexico Resource Network (ENMRN) in the College of Engineering to foster environmentally sustainable Best Practices among businesses statewide. With services spanning northern New Mexico to west Texas, ENMRN has become a recognized leader in providing on-site technical services to businesses in the desert southwest that are seeking effective ways to implement Pollution Prevention (P2) and Economy, Energy and Environment (E3) Best Practices. Over the past year, business sectors such as healthcare, hospitality and manufacturing, have benefited from ENMRN's on-site P2 and E3 assessments that guide businesses on strategies for reducing energy consumption and minimizing water use and waste. Conducted by a team of faculty and staff alongside graduate and undergraduate students from NMSU, these engineering extension outreach services not only increase the operational and financial efficiency of local industry, but also educates businesses on the impact they have on the environment. Through the assessment process, the NMSU team collects data, calculates energy savings, provides recommendations for energy efficient equipment, and prepares a final report for the business management team. The final report details recommendations for adopted Best Practices to decrease costs and environmental impact (waste), with detailed analyses on cost savings over the course of five to ten years. This paper will present a Case Study on a recent assessment that was completed at a medical center's admissions department and food and nutrition services department where the following suggestions were offered: centralizing recycling bins for easier and daily pick-up, implementation of a food waste composting program, and installing energy efficient appliances and a solar energy source. Calculations showed that installing a solar system to power the food and nutrition department would save enough money to pay itself back within five years and would additionally save the medical center over $250,000 within ten years, assuming only the nutrition department ran on solar energy and their energy consumption constituted about 6% of the center's total energy consumption. Analyses also considered having the entire hospital run on solar energy, finding that this system would pay itself back within five years and save the hospital an additional $5,000,000 within ten years.

Introduction

The ENMRN at NMSU has been working with local businesses and organizations to reduce pollution and increase energy efficiency in an effort to decrease operating costs and decrease environmental impact of commercial industry [1]. The Pollution Prevention (P2) and Economy,

Energy and Environment Best Practices (E3) programs were created in 1999 through funding from the U.S. Environmental Protection Agency (EPA) Pollution Prevention Grants (PPG) program [2–4]. In 2016, the programs merged with ENMRN, which now serves as NMSU's formalized engineering extension unit within the College of Engineering.

As anchor programs for ENMRN's engineering extension services, the P2 and E3 programs focus on providing small and medium-size businesses with green, environmentally friendly processes for reducing energy consumption and minimizing current waste streams. These programs encourage businesses to go beyond baseline efficiency requirements and educates them on the advantages of adopting P2 and E3 Best Practices within their current operations. Many of the processes proposed by the ENMRN staff require minimal or no cost to implement, allowing management the ease and flexibility to incorporate new systems and operating practices.

Studies have shown the positive influence P2 programs have had in decreasing overall waste streams among businesses that have adopted Best Practices within their operations. Businesses that voluntarily focus on reducing their pollution usually realize cost savings, outcomes supported by both environmentalists and business owners [5]. As such, engineering extension-type services are a known way for organizations and academic institutions to directly partner with the business community to improve the environment. Funding through a grant from EPA, ENMRN's engineering extension services are an example of how NMSU fosters environmental educational awareness to industry and commercial entities, a service similar to other university institutions across the country. Collectively, these programs have contributed to positive results, saving hundreds of thousands of gallons of water, eliminating tens of thousands of pounds of waste and saving millions of dollars for businesses. A list of previous pollution reduction results can be found at the EPA website by year [3].

Preparing a future workforce with an understanding and working knowledge of P2 and E3 practices is important for long-term adoption within the workplace. As such, ENMRN has integrated an experiential learning opportunity for graduate and undergraduate students to participate in conducting on-site P2 and E3 assessments. Participating students not only learn the benefits of implementing green practices within a business, but they also strengthen their presentation skills, learn problem solving, and gain first-hand knowledge of cost-benefit analysis. While little is known about the integration of students among energy consulting firms across the U.S., ENMRN's integration of students within the delivery of engineering extension services has proven effective in training future members of the workforce in green methods. Other institutions with similar student-integrated engagement include, Penn State University and Montana State University. A complete list of participating institutions can be found online at the EPA pollution prevention website [6].

The delivery of P2 and E3 engineering extension services has made adoption of many operational aspects of the program achievable for businesses of varied size. These programs help increase awareness of the local environment and help businesses understand how running a more environmentally sustainable business can save them money. Through the programs offered by ENMRN, businesses have become more open to adopting other Best Practices (e.g. Lean), and

also serve as strong referral to their peers, reflecting the grassroots impact these programs can have on the environment.

P2 and E3 program

ENMRN is focused on assisting small and medium-sized businesses to adopt operational processes that are both economical and environmentally sustainable. Specifically, the P2 and E3 programs have proven effective in helping businesses reach a more sustainable operation through the implementation of greener practices that can also decrease operating costs. These programs work to achieve the following:

1) Assist small-scale operations in adopting or improving pollution and energy efficiency Best Practices within their ongoing operations.
2) Work with like-minded organizations to increase environmental awareness and educate business owners on the benefits of greener practices.
3) Educating the future of industry, *i.e.* students, on energy efficient and pollution prevention practices by incorporating them in all steps in assisting a small businesses conversion to environmentally friendly practices.
4) Assure the company that the assessments are non-regulatory and that all results and recommendations will be kept confidential by the team

Over the course of many assessments, staff members at ENMRN have developed a scalable process, the five-stage Best Management Practice (BMP), to gauge which businesses are most likely to benefit from greener practices [7]. 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 consideration of assessment. A business that participates in the programs 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 areas of industry that usually have little to no environmental standards, high rate of waste generation plus power and water consumption. 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 management to inform them of the benefits of the programs along with previous successes. Improvements in cost-savings and performance are highlighted along with implementation and utilization of no-cost services.
3. *Commitment:* The business must agree to have upper management be involved throughout the entire process and allow other employees to accommodate the assessment staff. Management is encouraged to implement changes given by the assessment team and to allow future assessments to track the effects of the implemented changes and offer further improvements.
4. *Implementation:* A training room must be provided by the business during inspections 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 appliances will be investigated; therefore, employees that can access hazardous 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 inspection. The report will detail all changes and their beneficial impact. Any results and recommendations that are implemented by the business should be reported to the U.S. EPA where applicable.

All participating businesses follow and perform these steps; the on-site inspections and assessments vary from business to business but follow a simple procedure detailed in the next section. By using this five-step method, staff members can efficiently recruit and inform businesses about areas in need of improvement while leaving management in control of what changes to implement.

Assessments and methodology

Clients that request services under ENMRN's P2 and E3 programs are typically large industrial sites with large workspace areas or small businesses. To accommodate varied business operations, ENMRN has developed and implemented a general assessment procedure that can be utilized for any client. The assessment is conducted by a team of two senior staff members, who oversee all aspects of the inspection, review of business operations, development of recommendations, and preparation and presentation of a final report to business management.

Engineering students from NMSU are involved when possible through a train-the-trainer type role. They assist in data collection, analysis and calculations to identify cost savings, and research recommendations for energy efficient equipment. The assessment provides hands-on experience to students and helps them to better understand the business operations and opportunities for P2 and E3 implementation as well as expand working knowledge of environmental health and safety issues. This experiential experience offers a glimpse at real world applications for environmental sustainability and helps expand career opportunities upon graduation.

The adopted on-site assessment is conducted as follows:

1. A walkthrough of the entire area, both inside and outside.
2. Work area layouts are recorded and safety regulations are analyzed and inspected.
    a. Work flow is examined to determine efficiency in current layout.
    b. Safety aspects are checked to determine workstation compliance.
3. Appliances are examined, photographed, and recorded.
    a. Any electrical machinery, and its power consumption if available, is documented.
    b. All machinery maintenance materials are recorded.
    c. Any machinery needing maintenance is recorded.
4. Buildings are visually inspected to determine if maintenance is necessary.
    a. Any areas where energy loss can occur due to poor building conditions are noted, *e.g.* missing gaskets on a bay door where heat can enter or escape.
5. Lighting is inspected

    a. Current lighting method recorded
    b. Current lighting disposal is recorded.
    c. Age of lighting system recorded along with any updates or recent changes in fixtures.
6. HVAC systems are inspected, analyzed and recorded.
    a. Type of system and any chemicals required for operation are recorded.
7. Current source of electricity recorded, *i.e.* if the location has any solar power sources.
8. Amount of water, electricity and hazardous chemicals used within a year is recorded
    a. Hazardous chemicals can include cleaning supplies, oil, any solid or wet trash, etc.
9. Waste handling and sources of waste generation are examined
    a. Determine if any recycling programs are in place.
    b. Determine how wastewater is handled.
    c. Determine how waste chemicals are disposed.
10. Obtain operating costs over the course of a year especially concerning water, electrical and disposal costs.
    a. Other costs, such as amount spent of maintenance of machinery, are obtained.

Once the inspection is completed, the team members then investigate if any appliances should be changed or replaced, if any work areas should be relocated, and if any waste reduction programs should be initiated. A final report is written that compares recommended changes to the current setup through cost or usage figures and a projection of savings over the course of the next ten years. The report details all changes that can be enacted, including changes to employee operating procedures. Using this procedure, staff at ENMRN have found many easy and low-cost changes that can be implemented to reduce operating costs significantly.

Previous assessment and results

ENMRN team identified a local medical center's Admissions Department and the Food, and Nutrition Services Department as candidates for a P2/E3 assessment based on the owner's desire to improve and implement practices that are more efficient and to determine current energy performance. The assessment was divided into two sections. The first section focused on the Admissions Department and the second focused on the Food and Nutrition Services Department. The two sections highlighted different inspection environments, one an office-based work area, and the second a commercial kitchen with several large appliances and refrigeration. At the beginning of the on-site visit, the ENMRN team recorded current operational practices, both positive and negative, to benchmark how environmentally conscience the centers were prior to the on-site assessment.

The admissions department was responsible for registering all patients and served as the main hub between patients and doctors. This department was considered an office space with no major appliances needing inspection. Management was interested in increasing sustainability, a sign that they would be more willing to implement more impactful recommendations. Cardboard boxes were recycled and used as recyclable paper bins for each individual workstation like computer desks. Shredded paper was collected daily by a recycling company, medical record

boxes were collected monthly, voluntary light reduction procedures were established, and the facility showed an increased use of natural lighting. The Admissions Department was already functioning at a high level of efficiency, however suggestions were offered to further increase efficiency. Centralized recycling bins would allow management to easily see how much paper was being used and would ease daily collection. Converting to a paperless office would reduce costs on paper, ink, toner, and printer maintenance, reducing paper use by about 90% and saving about $6,400 per year. Further savings come from reduced printer usage. Though the Admissions Department already had green operations including reducing electrical consumption and recycling used paper, in place improvements were advised to maximize cost savings.

The Food and Nutritional Services Department was the larger operation, due to the number of appliances in use and high volume of work in serving over 1000 meals a day. Some efficient practices were already in place. Cardboard was recycled by the local city waste utility. Some unused consumable food was collected by a local soup kitchen and used fry oil was collected and recycled by a larger company. The ENMRN team observed a recent installation of an energy efficient dishwasher and an energy efficient HVAC system, and accounted for a previous installation of LED lighting throughout the facility. Although this center had several green operational practices in place, there was room for improvement. Of note was the recommendation to integrate a food waste composting program as an opportunity to reduce the amount of food waste currently being diverted to landfills. A recommendation was made to look into the amount of wastewater currently being discharged to determine how much water was being used and disposed of. Further, ENMRN staff recommended installing motion detection lighting or occupancy sensors to reduce power consumption in areas with minimal foot traffic.

The Food and Nutritional Services Department also had several energy efficient appliances currently in operation, i.e. the oven and griddle were both Energy Star compliant. ENMRN staff advised management to prioritize Energy Star rated models when buying new appliances to increase long-term environmental sustainability. Staff recommended replacement of existing spray washers with new low-flow models, noting a realized two-month return on this investment through cost savings from reduced water use alone. The only major appliances that were suggested to be replaced, regardless of their current condition, were the boilers. It was recommended that a condensing boiler with heat recovery be installed. Though expensive, the appliances would realize a return on investment from reduced water and gas savings within five years making the conversion a worthwhile investment. The age of the boilers was also a consideration when making the recommendation for replacement, as the current boilers were not as energy efficient as newer models and did not appear to meet the growing demands of the center.

The major recommendation that the team offered was converting the Food and Nutrition Services Department to operate on solar power. Nationwide, medical centers are one of the most intensive users of electrical energy [8] and therefore, management should begin transitioning to solar power in an effort to reduce energy consumption and cost. Electric utility companies usually have programs that credit commercial customers the cost of installing solar panels whilst also offering a tax credit on the cost of electricity, reducing their electric bill by 30%. Figure 1

shows cost savings from converting the Food and Nutrition Services Department to solar power assuming it uses about 6% of the total center's energy over ten years and cost of installation for both cash or financed payment methods. Figure 2 shows cost savings over ten years and cost of installation, both cash or financed, of converting the department to solar power assuming the department uses about 11% of the center's total energy. In either case the solar system cost savings, before tax rebates, would pay off installation charges within six to seven years and would save over $200,000 after accounting for the cost of installing the solar system.

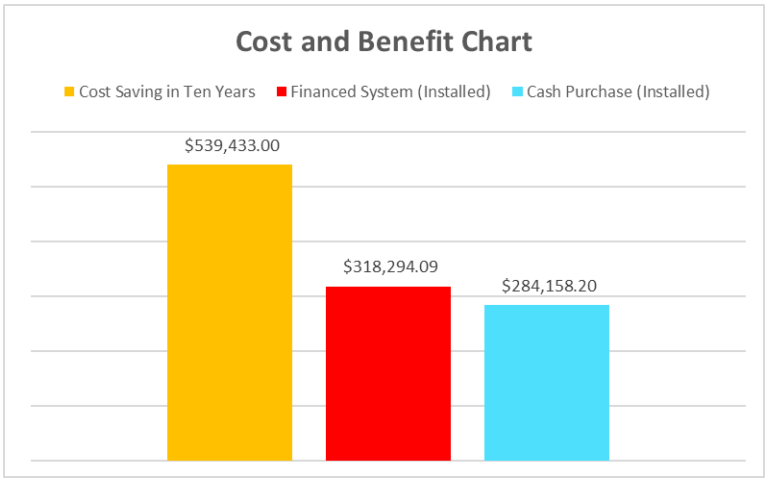


Figure 1 Cost Benefit of solar power conversion for food department assuming 6% consumption rate

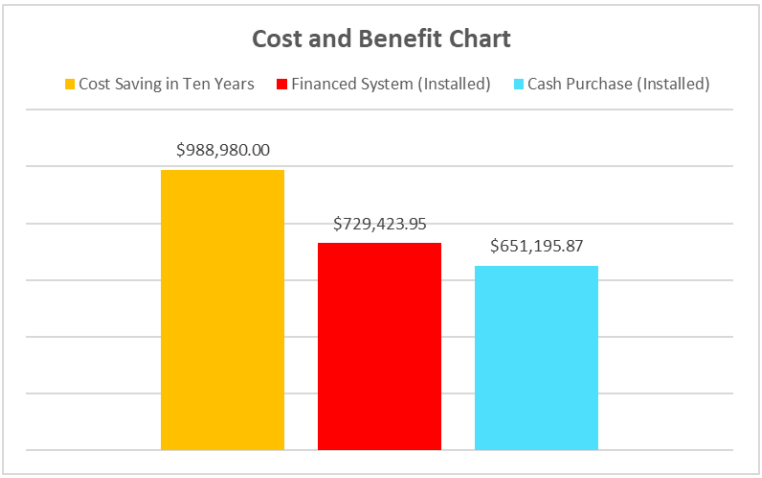


Figure 2 Cost Benefit of solar power conversion for food department assuming 11% consumption rate.

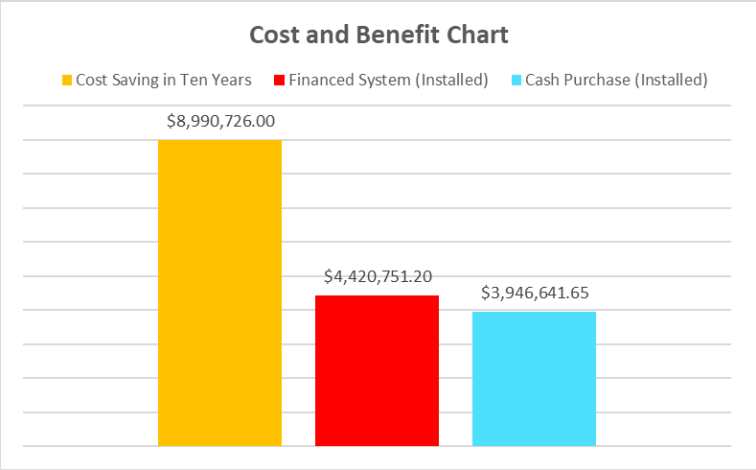
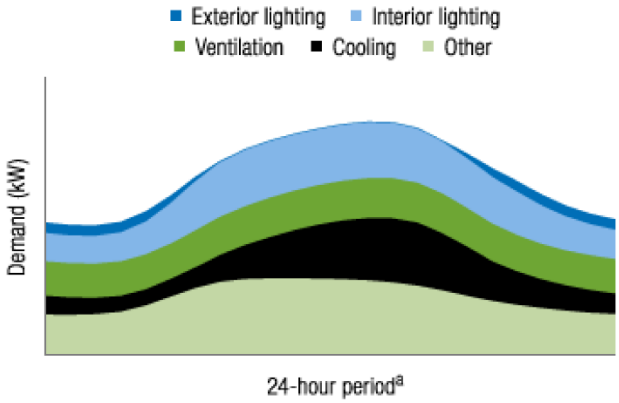


Figure 3 Cost Benefit of solar power conversion for entire medical center.

Figure 3 displays the amount saved if the entire facility converted to solar power over ten years and shows the installation costs for either cash or financed buying options. The savings seen by the center would be more significant if the entire operation converted to solar power, with the system paying itself back in about a year less than if only the Food and Nutrition Services Department switched to solar power. The entire hospital would save nearly $5,000,000 after accounting for the cost of installation, making it worthwhile to implement these changes.

Reducing demand for electricity at peak times would also reduce electric energy costs. Entities like hospitals and medical centers are charged by both amount of energy delivered and demand of power within a payment cycle. Demand charges can range from $2.92 per kW-month to $23.40 kW-month and add a considerable amount to an electric bill. Figure 4 shows an average hospital's demand for power over a usual day. Lighting and cooling were the major factors that influenced demand of power, with peak demand occurring throughout the day, usually a time when electric companies have the highest demand rates. Reducing light use and increasing cooling temperatures in the summer and decreasing heating temperatures in the fall and winter would reduce the departments demand portion of the bill, thereby reducing electric costs. These changes are low-cost and can save a significant amount of money for the medical center. These



procedures interest most businesses due to their benefits to the environment, their ease of implementation, and the reduction of operating costs.

Figure 4 Electric power demand for an average hospital over an average 24-hour day [8].

The students discussed the recommendations given by the senior staff and gave additional recommendations based their own analysis of the assessment. They learned that it was important to analyze not just one department in isolation, but the entire location and determine how changes for the entire site could substantially improve individual departments. Advice given by the students also improved recommendations for the assessment. Students discussed the importance of using solar power for a large site and advised that the location should invest in upgrading current appliances. Students not only learn how to conduct efficient walkthroughs but can also advise senior members in incorporating updated technologies that have just been introduced to the market. The students have stated after conducting an assessment that the knowledge gained from this program has helped them improve aspects of their projects by increasing energy efficiency and using more environmentally friendly materials.

Conclusion

The engineering extension service process developed to provide P2 and E3 business assistance has proven broad enough for application across business sectors yet dynamic enough to adapt as needed when inspecting different aspects of client's work area. Further, effective implementation requires buy-in from business management prior to conducting a multi-day on-site assessment. This Case Study presents an application of the developed process, along with examples of potential operational and cost savings realized by implementing recommendations from the ENMRN team. Overall, the developed on-site assessment process has proven effective in businesses with varied stages of P2 and E3 protocols, i.e. the process is works for those without existing protocols as well as for those operating at high standards of efficiency. The approach taken by the ENMRN team not only encourages clients to aim for a higher standard of sustainability, but also provides management the final decision on implementation of recommendations. Lastly, the engagement of graduate and undergraduate students provides experiential learning within a real-world application that increases awareness of environmental sustainability Best Practices as well as opportunities for broad career applications. In conclusion, this Case Study provides a systematic approach to engineering extension services for businesses that can result in cost savings, while reducing environmental impact.

References

[1] "E3 Assessments and Analysis | Engineering Business Assistance." [Online]. Available: https://engrbusinessassistance.nmsu.edu/assessment-e3-system-and-analysis/. [Accessed: 08-Nov-2018].

[2] P. US EPA, OCSPP,OPPT, "Pollution Prevention (P2)." [Online]. Available: https://www.epa.gov/p2. [Accessed: 08-Nov-2018].

[3] P. US EPA, OCSPP,OPPT, "Grant Programs for Pollution Prevention." [Online]. Available: https://www.epa.gov/p2/grant-programs-pollution-prevention#result.

[Accessed: 08-Nov-2018].

[4] P. US EPA, OCSPP,OPPT, "E3: Economy - Energy - Environment." [Online]. Available: https://www.epa.gov/e3. [Accessed: 08-Nov-2018].

[5] L. T. M. Bui and S. Kapon, "The impact of voluntary programs on polluting behavior: Evidence from pollution prevention programs and toxic releases," *J. Environ. Econ. Manage.*, vol. 64, no. 1, pp. 31–44, Jul. 2012.

[6] P. US EPA, OCSPP,OPPT, "FY 2014 Pollution Prevention Grant Results Summary." [Online]. Available: https://www.epa.gov/p2/fy-2014-pollution-prevention-grant-results-summary. [Accessed: 21-Feb-2019].

[7] S. Dasgupta, H. Hettige, and D. Wheeler, "What improves environmental compliance? Evidence from Mexican industry," *J. Environ. Econ. Manage.*, 2000.

[8] "Hospitals | Business Energy Advisor." [Online]. Available: https://ouc.bizenergyadvisor.com/hospitals. [Accessed: 05-Apr-2019].

JALAL RASTEGARY

Jalal Rastegary serves as a Research Scientist and co-lead for the College's engineering extension pollution prevention and energy efficiency programs. His background is in renewable energy, bio-energy, and the sustainable management of integrated water and energy use. Jalal provides on-site technical assistance in the area of energy efficiency and pollution prevention, helping business/industry minimize their negative impact on the environment and reducing energy consumption and cost. Currently, Jalal serves as co-chair of the NMSU Sustainability Council and is an active member of the High-Tech Consortium. rastegar@nmsu.edu

PATRICIA A. SULLIVAN

Patricia Sullivan, PhD serves as Associate Dean for Outreach and Recruitment in the College of Engineering. As Associate Dean, she leads the College's undergraduate recruiting efforts and statewide engineering extension programs focused on STEM outreach, technical business assistance, and professional development for business/industry professionals. She has extensive ties with industry organizations across NM and the Western states, including her current role as a commissioner with the Western Interstate Commission on Higher Education. Her academic background is in energy policy and renewable energy integration.

CHRIS CAMPBELL

Chris Campbell is a Senior Program Manager who provides on-site technical assistance in areas of Pollution Prevention. Specifically, he leads and conducts assessments for business/industry focusing on environmental and P2 performance with the goal of providing recommendations for improvements and related cost-savings. Mr. Campbell has been directing the NMSU P2 Resources

Center since 1999, conducting such assessments successfully for New Mexico manufacturers and other sectors through funding provided by EPA.

EDWARD ROJAS

Edward Rojas is a PhD candidate employed for the Engineering New Mexico Resource Network.

AMIRREZA BARIN

Amirreza Barin is a PhD candidate working for the Engineering New Mexico Resource Network.