How Manufacturers are Finding New Energy Savings by Engaging On-site Teams through Crowdsourcing and Gamification

Mitch Brown, ICF
Jesse Gubert, ICF
Clifton Yin, ICF

ABSTRACT

A motivated workforce is an essential component of improving energy efficiency in the industrial sector. In recent years, there has been a trend for organizations in both the public and private sectors to facilitate knowledge sharing and crowdsourcing for energy efficiency solutions, which encourages participation and identifies new opportunities for energy savings. As companies act towards decarbonization goals through corporate energy and sustainability programs, manufacturers are increasingly drawing on novel strategies to motivate employees to reduce energy use and produce new project ideas.

Our paper examines the effectiveness of crowdsourcing and gamification to spur energy efficiency actions in the industrial sector. We survey four examples from industrial partners in the U.S. Department of Energy's Better Buildings, Better Plants Program and Challenge (Better Plants). These programs include ArcelorMittal USA's "Power of 1 Contest," Legrand North America's "Energy Marathon," Celanese Corporation's "Energy Sparks," and Saint-Gobain Corporation's "Compress It" competition. These case studies are analyzed to develop a potential model for successful replication across the industrial sector. The paper will highlight specific approaches that have been used to motivate plant teams and encourage positive behavior change towards energy-saving actions. We also identify benefits from implementing crowdsourced and gamified energy efficiency solutions, including fulfillment of ISO 50001 tasks, workforce empowerment to achieve energy savings, and fostering a culture of innovation and collaboration.

Introduction

Industrial companies use a variety of methods to engage their workforce to drive sustained energy savings. An integral part of energy management is to empower employees for broad-based action in support of energy-saving activities (Björkman et al. 2016). Competitions and targeted campaigns are common mechanisms to motivate plant teams to find new efficiency opportunities, engage more occupants and operators, and increase savings from equipment upgrades and capital improvements. The U.S. Department of Energy's (DOE) Better Plants program regularly recognizes participating partners for implementing competitions and other innovative employee engagement campaigns. Using games and rewards to engage employees in energy efficiency continues to be a popular activity among industrial companies participating in Better Plants. In 2020, for example, the program awarded five companies with Better Practice Awards for innovative and industry-leading accomplishments in implementing and promoting practices, principles, and procedures of energy management. Two of these Better Practice

Awards were given for employee engagement activities that led to more significant energy savings and organizational change.

This paper surveys four specific case studies taken from Better Plants partners—ArcelorMittal USA's "Power of 1 Contest," Legrand North America's "Energy Marathon," Celanese Corporation's "Energy Sparks," and Saint-Gobain Corporation's "Compress It" competition. It then applies an organizational change framework to identify ways industrial companies can effectively engage and empower their employees to drive energy management successes across their organizations. The examination will use John Kotter's model for organizational change to identify ways that crowdsourcing and gamification approaches that Better Plants partners have field-tested can be designed and implemented more widely as part of an organization's energy management program.

History of Gamification as a Tool for Organizational Change

From the ancient Olympics in Greece and the origins of chess in Persia to modern youth soccer leagues and poker competitions, games have been an important part of how people interact for millennia. Recreational games promote teamwork, problem-solving, and decision-making (Bruner et al. 2019). Moreover, games with a social component foster creativity (Roth, Schneckenberg, and Tsai 2015). Organizations have noticed the beneficial outcomes of recreational games and begun to leverage game design to better engage with their customers and employees and promote organizational change. The process of using game design in non-game settings is known as gamification (Deterding et al. 2011), a term coined in the last twenty years. Gamification has expanded rapidly with the increased prevalence of the internet and real-time geo-tracking, leading to a broader set of situations that lend themselves to digital gamification (Nacke and Deterding 2017).

The private and public sectors have utilized game structures to promote innovation through competition. XPRIZE, sponsored by Musk Foundation, has a $100 million Carbon Removal competition alongside other less lucrative contests (XPRIZE Foundation 2021). The U.S. Department of Energy sponsors a collegiate Solar Decathlon competition to inspire students to pursue clean energy careers and promote innovation in the renewable energy sector (U.S. Department of Energy 2021b). In May of 2021, DOE announced another department-sponsored competition, the L-Prize, to advance lighting innovation in the commercial sector (U.S. Department of Energy 2021c; 2021a).

Other publicly sponsored initiatives include a subterranean challenge through the Defense Advanced Research Projects Agency and a spacesuit detection challenge through the National Aeronautics and Space Administration (NASA). Dozens of other federally sponsored competitions are posted at Challenge.gov (Challenge.gov 2021). These competitions are highlighted as beneficial to the individual competitors, the sponsoring organization, and society. Specifically, they are examples of gamified crowdsourcing.

Crowdsourcing is a process by which an activity is reassigned from a single agent to a larger, more dispersed group or crowd (Mount, Round, and Pitsis 2020). The digital component of modern gamification has enabled expanded crowdsourcing efforts that are more compelling for the individual members of the crowd. Gamifying crowdsourcing has been utilized to design t-shirts (Kavaliova et al. 2016), gather geographic information (Martella, Clementini, and Kray 2019), and translate websites (Olson 2013).

While gamified crowdsourcing is a means to gather information or outsource a specific task, gamification is often used to drive engagement, promote learning, and elicit behavior

change on the part of the participant (Wang et al. 2017; Connolly et al. 2012). Gamification has also been shown to improve team dynamics in collaborative learning settings (Uz Bilgin and Gul 2020). Because of these benefits, many companies are leveraging gamification to promote employee engagement, development, and performance.

Gamification has been used to promote many aspects of employee development. CISCO uses gamification to improve the social media skills of their employees, by IBM to introduce new hires to the company, and by Xerox to train new managers (Dubey, Chavan, and Patil 2016). Silic et al. (2020) found that employees at a large multinational company were more engaged when their human resource system included game components such as challenges, leaderboards, and badges. Moreover, employees rated the gamified system as more useful than their prior, non-gamified system. The authors point to earlier studies that established a strong link between the perceived usefulness of tools and employee performance (Silic et al. 2020). In the manufacturing setting, Liu et al. (2018) found that gamified computer numerical control (CNC) operations improved employee motivation, satisfaction, and performance.

Opportunities to Gamify Employee Engagement

Despite gamification's potential to improve employee engagement, successfully introducing game structures into organizational systems requires a dedicated and deliberate effort (Morschheuser and Hamari 2019). Joining a voluntary program like Better Plants or following a standard like ISO 50001 can provide direction and impetus for action. These programs require management commitment and encourage greater awareness around an organization's commitment to energy performance improvement (ISO 50001, 2018). However, driving organizational change and creating a culture that recognizes and values energy-efficient behaviors is not a one-size-fits-all process. It involves participation and reinforcement from multiple parts of an organization—from corporate executives and managers to technicians, engineers, operators, and maintenance staff.

Employee engagement efforts may also require financial justification and a clear business case. Energy efficiency investments are typically evaluated based on their energy-saving potential. Industrial organizations often have restrictive financial hurdles and non-energy projects are often prioritized over hard-to-quantify energy efficiency interventions. As a result, employee engagement programs could run up against restrictive financial criteria such as two-year payback periods (Lung, Nimbalkar, and Wenning 2019). Calculating net financial savings from employee engagement can be challenging on the front end; however, the case studies we examine show significant savings with limited capital investment (Baker 2017).

Once the organizational support and financial barriers are overcome, organizations will face the challenge of mobilizing plant staff to take on energy management tasks focused on production metrics and other performance indicators. Structuring a campaign that uses games and crowdsourcing enables staff to participate through behavioral interventions and changes to day-to-day practices (Weiss, Stephens, and Stowe 2017). The four case studies from Better Plants partners viewed against John P. Kotter's model for organizational change reveal some key tactics that help organizations overcome these barriers and achieve energy management successes through employee engagement.

The Eight Steps in Kotter's Organizational Change Model

Organizational change is an inherently complex and multidimensional process, as theorized by John P. Kotter. Kotter's 8 step change model is a popular framework for successfully implementing organizational change and can be used to understand how employee engagement can be structured and implemented for maximum impact and sustained energy savings. Just as ISO 50001 fosters a change in culture that engages and empowers employees to identify and address energy-saving opportunities, organizations can use targeted gamified and crowdsourcing campaigns to accelerate organizational change and increase energy savings. The steps Kotter identified to successfully implement organizational change are 1. Establishing a sense of urgency; 2. Creating the guiding coalition; 3. Developing a vision and strategy; 4. Communicating the change vision; 5. Empowering employees for broad-based action; 6. Generating short-term wins; 7. Consolidating gains and producing more change; and 8. Anchoring new approaches in the culture (Kotter, 1996). Overlaying these steps with the Better Plants case studies from ArcelorMittal USA, Celanese Corporation, Legrand North America, and Saint-Gobain Corporation, it is possible to pull out best practices common to industrial energy employee engagement campaigns.

The U.S. Department of Energy Better Plants Program and Challenge

Better Plants is a partnership initiative to improve energy efficiency in the domestic industrial sector. As Better Plants partners, almost 250 industrial companies and water and wastewater treatment organizations have voluntarily set ambitious energy intensity reduction goals – typically a 25% reduction at U.S. facilities within ten years. DOE supports partners' energy efficiency activities by providing technical assistance, offering specific tools and resources, facilitating peer networking and solutions sharing, and highlighting partner achievements. Partners have reported cumulative energy savings of 1.7 QBTU, or more than $8.2 billion in cost savings (U.S. Department of Energy 2021d).

In addition to setting energy efficiency goals, Better Plants Challenge partners commit to publicly sharing energy performance data and proven case studies on the DOE website. Almost 100 case studies have been published from industrial sector partners, representing a cross-section of innovative energy efficiency solutions from leading energy management practitioners. Four of these case studies demonstrate how employee engagement can make a substantial energy efficiency impact and lead to sustained energy savings.

Using Kotter's organizational change model as a framework, the first step—establishing a sense of urgency—is uniform for all Better Plants partners. By publicly committing to ambitious energy intensity reduction targets within a set period through Better Plants, participating organizations establish a sense of urgency to accelerate energy savings. While Better Plants is a purely voluntary initiative that does not penalize partners that fall short of their goals, the public-facing and high-profile status of the program exerts pressure and accountability to succeed. Better Plants partner agreements also require a signature from senior-level executives or leaders to prove high-level organizational buy-in. After the first step of establishing a sense of urgency, each Better Plants case study presents a unique approach to fulfilling each step in Kotter's model, suggesting that organizational change can be pursued in various ways.

Better Plants Employee Engagement Examples

ArcelorMittal USA

Before being acquired by Cleveland-Cliffs in December 2020, approximately 15% of ArcelorMittal USA's overall production cost was attributed to energy, the second-highest driver behind labor. Energy reduction activities are led by a team that includes a continuous improvement manager, an energy procurement manager, a USA energy committee representative, and local facility energy champions. With a limited capital budget for equipment upgrades, ArcelorMittal looked for new ways to engage employees on energy efficiency, specifically around low- and no-cost project opportunities.

As part of the annual ArcelorMittal Energy Fair in October (National Energy Awareness Month), the company launched the "Power of 1" contest to encourage individual employees and teams to submit new low- and no-cost energy savings ideas for their plants. Submissions were then rated 0-4 based on cost-effectiveness, replicability, and creativity. The appointed judge was the ArcelorMittal Global Chief Technology Officer, and winning employees received prizes, including an Amazon Echo Dot and WaterHawk smart shower head. Winners also received recognition through internal and external communications (ArcelorMittal USA 2020).

The Power of 1 contest provided a forum for employees to engage and be recognized for their contributions to energy efficiency and energy management. In three years, ArcelorMittal USA implemented 15 projects from the contest, resulting in total savings of approximately $500,000. This is a particularly significant figure since each project was a low and no-cost solution, with low paybacks and high cost-effectiveness.

The contests also helped facilities take action towards achieving DOE's 50001 Ready designation. This designation recognizes facilities that have voluntarily implemented an ISO 50001-based energy management system using DOE's 50001 Ready Navigator online application. Task 15 of the online system requires that the facility demonstrate action to promote Awareness and Communication related to energy policy, which the contest fulfills. ArcelorMittal's Cleveland facility subsequently achieved DOE 50001 Ready designation, and the Burns Harbor facility is working towards designation as well. The Cleveland facility is the first steelmaking facility in the nation to earn 50001 Ready designation (ArcelorMittal USA n.d.).

Table 1. Kotter's Organizational Change Model and ArcelorMittal USA's Power of 1 Contest

Kotter's Steps for Organizational Change	ArcelorMittal USA Employee Engagement Strategy
Establish a sense of urgency	Publicly set time-constrained energy intensity reduction goal through Better Plants
Create the guiding coalition	The energy team includes a manager of continuous improvement, a manager of energy procurement, a USA energy committee representative, and local facility energy champions
Develop a vision and strategy	"Power of 1" contest set clear goals to generate new low- and no-cost energy savings ideas

Communicate the change vision	Employees were encouraged to submit ideas in October as part of National Energy Awareness Month before the company's annual energy fair
Empower employees for broad-based action	Winning projects are implemented, and winning employees receive prizes and recognition
Generate short-term wins	In three years, 15 implemented projects from the contest resulted in total savings of approximately $500,000
Consolidate gains and produce more change	The contest helps fulfill a task on the path to DOE "50001 Ready" designation
Anchor new approaches in the culture	Power of 1 becomes an annual contest, and Cleveland Cliff's Cleveland, Ohio, facility has achieved 50001 Ready designation

Celanese Corporation

Over time, Celanese Corporation found that while employees are often eager to contribute to energy efficiency goals, they do not always have enough information to feel like they can effectively participate. "Energy Sparks" was created to be a one-page, "Did You Know" format conversation-starting and fact-sharing tool about energy topics relevant to a manufacturing plant. The concept was developed over two months by a specialized team within the Celanese Global Energy Council. The information is communicated in a simple format to stimulate conversation, initiate action at the shift team level, and ultimately engage employees and change their behavior. The prototype Energy Spark on the topic of steam condensate was first created for a specific training need at the company's Narrows, Virginia, plant. Through this trial, the team realized the tool's value, and suggestions for other topics were solicited from across the company. Employees competed for their submitted ideas to be turned into Energy Sparks and topics ultimately selected by the Global Energy Council team included steam traps, compressed air, insulation, valve throttling on pumping systems, and more.

After the Energy Sparks program was shared at a Celanese Energy Council team meeting, several sites immediately started implementing them within their plants. Energy Sparks are often shared at shift toolbox meetings at the beginning of the day and displayed on bulletin boards. Spanish versions of the tools were also created for use at plants where Spanish is spoken at the operations level. An online storage location was set up to store training materials and enable Celanese teams across the company to easily access and utilize Energy Sparks.

The steam traps Energy Sparks tool was shared with shift operators at one facility, covering how steam traps work and how to inspect and detect a failed trap. The site has a maintenance program for an annual inspection of all their steam traps, completed by an external company. In just one example of the tools' impact on their initiative and inspired by what they learned from the steam trap Energy Spark, Celanese operators suggested conducting further checks when there was time available on shift. Only two weeks after the external steam trap inspections, an operator found a critical broken steam trap and had it repaired immediately, saving nearly a year of energy losses and approximately $7,000.

Given Energy Sparks' success and popularity, facility managers are now trained on the newly available resources and strategies for implementation at the site level, including initiating conversation and action within site teams. Fifteen Energy Sparks were ultimately developed by employees as of this writing, covering a variety of manufacturing-based energy topics, with plans to translate them into Chinese, Dutch, and German to further expand their reach ("Celanese

Corporation: Raising Energy Engagement in Plant Operations Teams with 'Energy Sparks' Training Tools | Better Buildings Initiative" n.d.).

Table 2. Kotter's Organizational Change and Celanese Corporation's Energy Sparks

Kotter's Steps for Organizational Change	Celanese Corporation Employee Engagement Strategy
Establish a sense of urgency	Publicly set time-constrained energy intensity reduction goal through Better Plants
Create the guiding coalition	Create a dedicated team within the Celanese Global Energy Council
Develop a vision and strategy	Develop crowdsourced "Energy Sparks" one-pagers to disseminate energy efficiency solutions
Communicate the change vision	Initiative details shared at a Celanese Energy Council team meeting before implementation began at several sites
Empower employees for broad-based action	Energy Sparks are translated into Spanish and stored online for easy access
Generate short-term wins	15 Energy Sparks developed, covering a wide variety of manufacturing-based energy topics
Consolidate gains and produce more change	Energy Sparks led to an employee performing his own impromptu steam trap inspection, finding a critical broken steam trap and repairing it himself immediately
Anchor new approaches in the culture	Celanese plans to translate Energy Sparks into Chinese, Dutch, and German, and site managers are trained on newly available resources and strategies for implementation at the site level

Legrand North America

On November 29, 2012, Legrand asked more than 2,500 employees to "Power Down," with company sites challenged to aim for the lowest possible energy consumption in a single day. In one 24-hour period, participating employees collectively achieved a 24% reduction in energy intensity across the company. The success of that initiative inspired the company's energy leaders to launch an "Energy Marathon" in October 2014, with a full 26.2 days dedicated to employees identifying energy savings. In a toolkit developed and released after the fact, Legrand identified four "key leadership roles" necessary for a successful Energy Marathon: executive staff to help support and launch the competition; a core team leader serving as project manager; a core team to support the leader; and site leaders at each participating facility (Legrand North America 2015).

The Energy Marathon is an energy-saving competition that empowers employees to implement technology and process changes while reshaping their energy-related behaviors, with participating sites competing to save the most energy. The first marathon in 2014 featured 18 facilities. Energy Marathon 2.0, in 2016, was held at 22 Legrand locations. Energy Marathon 3.0 in 2019 included a new twist. That year, 26 Legrand sites across the U.S. worked in pairs to build relationships and share best practices. To allow for an accurate comparison, pairs were determined based on 2018 kilowatt-hour (kWh) usage as well as facility type: manufacturing, warehouse, or office space. Sites competed within their building category to see which team

could reduce the most energy over the 2018 baseline. Legrand incorporated a series of weekly competitions to educate employees on its Corporate Social Responsibility initiatives to maintain engagement and avoid event fatigue. The company offered prizes for employees who developed sustainable habits like carpooling to work, packing zero-waste lunches, and creating water awareness signage (U.S. Department of Energy n.d.).

During three Energy Marathons, Legrand North America saved over 1.8 million kWh and $185,000 in energy costs. The company has encouraged its sites to sustain their reduction practices beyond each competition and helps by widely sharing best practices and evaluating their applicability across different facilities. Legrand also released a comprehensive "Energy Marathon Toolkit" that lays out the steps for any organization seeking to conduct a similar competition.

Table 3. Kotter's Organizational Change Model and Legrand North America's Energy Marathon

Kotter's Steps for Organizational Change	Legrand North America Employee Engagement Strategy
Establish a sense of urgency	Publicly set time-constrained energy intensity reduction goal through Better Plants
Create the guiding coalition	Establish four leadership roles for each year's Energy Marathon campaign: executive staff, core team leader, core team, and site leaders
Develop a vision and strategy	"Energy Marathon" energy-saving competition launched with clear goals and process in place to participate
Communicate the change vision	All of Legrand's now-26 North American sites participate over 26.2 days
Empower employees for broad-based action	Participating employees implement energy-saving solutions in real-time during the marathon
Generate short-term wins	Legrand has saved over 1.8 million kilowatt-hours (kWh) and $185,000 in energy costs over the course of three energy marathons
Consolidate gains and produce more change	Best practices derived from the energy marathons are widely disseminated, and the program's pairing structure enables knowledge sharing
Anchor new approaches in the culture	Legrand compiled an "Energy Marathon Toolkit," and the competition has regularly expanded and evolved each year

Saint-Gobain Corporation

Saint-Gobain Corporation has a long history of energy management initiatives and in 2006, with senior leadership support, the company designated energy champions at every plant and across every business unit (Saint-Gobain Corporation n.d.). When an internal sustainability survey conducted in 2017 revealed widespread concern about compressed air efficiency, Saint-Gobain energy champions and management sprang into action. A compressed air challenge, "Compress It," was launched with teams of up to five employees each from 19 company facilities.

Facility teams competing in Compress It were awarded points for completing the following actions and achievements:

- Submit team name and photo (5 points)
- Compressed air audit completed in past two years (20 points)
- Form a compressed air team and/or leak detection and repair program (30 points)
- Presence of compressed air system monitoring through sensors and meters (10 points)
- Showcase use of at least two (internal database) Sustainability Network compressed air resources (20 points)
- Find leaks (2 points) and fix found leaks (8 points)
- Develop an innovative way to engage employees to participate in the challenge (40-100 points)

To foster an engaged and active competition, the company distributed a monthly internal newsletter with updates and held biweekly mini-contests with sustainability-related prizes for superlatives such as "Most Innovative Employee Engagement" and "Best Team Name." Noteworthy names of Compress It teams included "Weeki Leaks" (Oxford, North Carolina, facility), "Full of Hot Air (Ennis, Texas), and "The Avery Avengers" (Avery, Ohio) (Compressed Air Best Practices n.d.).

During the three-month Compress It challenge, a total of 26 GWh and $2.5 million in electricity costs were saved by fixing compressed air leaks, approximately 5% of the total energy spend of all sites participating for 2018 (Saint-Gobain Corporation n.d.).

Table 4. Kotter's Organizational Change Model and Saint-Gobain Corporation's Compress It Challenge

Kotter's Steps for Organizational Change	Saint-Gobain Corporation Employee Engagement Strategy
Establish a sense of urgency	Publicly set energy intensity reduction goal through Better Plants
Create the guiding coalition	Saint-Gobain committed to appoint and maintain an energy champion in every U.S. plant as part of its corporate energy management strategy
Develop a vision and strategy	After an internal sustainability survey revealed compressed air efficiency as an area of concern, the company launched a "Compressed Air Challenge" with 19 participating sites
Communicate the change vision	The company sent out a monthly internal newsletter that promoted the program and held biweekly mini-contests with small sustainability-related prizes
Empower employees for broad-based action	Teams competing in the Challenge were given points for designing a plan to improve compressed air system operations and management, with an emphasis on fixing leaks over simply identifying them
Generate short-term wins	In total, sites reduced 26 GWh of electricity and saved $2.5 million by fixing compressed air leaks, approximately 5% of the total energy spent of all sites participating for 2018

Consolidate gains and produce more change	The Challenge established best practices that other sites can use in their adoption of compressed air best practices, and they are now accessible in one place for sites to access
Anchor new approaches in the culture	Participating sites alternately schedule compressed air audits, form permanent compressed air teams and continuous leak tracking systems, and use a training webinar to develop skills

Emerging Approach: Serious Game-based Learning

The Better Plants case studies primarily used competitive games to engage employees and crowdsource new ideas for energy efficiency projects. Another way industrial companies are gamifying energy management is by using simulated games to provide employees with experiential learning opportunities. Serious games are simulations of real-world processes designed to solve a problem (Wu, Liu, and Shukla 2020). Better Plants partner 3M developed a training workshop using a serious game that simulates the process of taking a completed energy assessment at a plant and presenting the energy efficiency projects for approval. A unique feature of 3M's approach is how they use the serious game module to train staff to account for the multiple benefits of energy efficiency (B. Lung, Senior Technical Advisor, BGS, pers. comm., May 13, 2021). The simulation aims to bridge the communications gap that sometimes exists between different stakeholders, particularly between energy management staff that look for energy efficiency opportunities and staff in other areas of the company that do not usually work on energy-related projects. 3M uses an online training module with virtual stakeholders in a fictitious company to train employees on communicating the multiple benefits of energy efficiency projects. For example, when a project yields better employee safety or working conditions that reduce the number of sick days (B. Lung, Senior Technical Advisor, BGS, pers. comm., May 13, 2021).

Another important goal of the workshop is to connect energy efficiency with the strategic priorities of the company. The teams go through multiple modules and receive new clues and access to additional stakeholders at each completion point that help them make a convincing business case for the energy efficiency recommendations. As part of 3M's workshop, each team integrates the non-energy benefits they quantified into a financial spreadsheet to determine the ROI calculations. The teams take their ROI metrics and qualitative information with energy efficiency recommendations to present to senior management. The simulation forces energy staff to make connections between energy efficiency and the company's strategic goals through non-energy benefits (B. Lung, Senior Technical Advisor, BGS, pers. comm., May 13, 2021). This gamified training approach is one additional way manufacturers can use games to train staff and expand energy management programs beyond just Btu and dollar savings.

Conclusion

Strategies for engaging employees to save energy abound, but many fail to create long-term organizational change. Applying Kotter's 8-step change model to the Better Plants case studies highlights how leading industrial companies are engraining energy management in their corporate culture and finding new efficiency opportunities. Interest and activity around this topic will likely grow as manufacturers look beyond capital upgrade opportunities and focus on new ways to train and develop staff for energy management roles. The Kotter model can be used to

test and refine organizational change efforts as they are designed and implemented, and the structure fits well with industrial sector employee engagement initiatives.

As the case studies prove out, gamification, crowdsourcing, and serious games can be used effectively to find energy savings and promote the benefits of energy efficiency to broader groups across an organization. Further analysis can be done to evaluate the energy and cost savings from these employee engagement initiatives and to investigate the non-energy impacts that accrue. Examples of these may include improved product quality, faster line speed, and less production waste. The non-energy benefits can be challenging to quantify and measure but should be considered when reviewing the impact of employee engagement activities going forward.

References

ArcelorMittal USA. 2020. “Cleveland Employees Recognized for Simple, Low-Cost Energy-Saving Projects through ‘Power of 1.’” January 24, 2020. https://usa.arcelormittal.com/news-and-media/our-stories/2020/jan/cleveland-power-of-1.

———. n.d. “ArcelorMittal USA: Power of 1 Contest Increases Employee Engagement and Generates Low- and No-Cost Project Ideas | Better Buildings Initiative.” U.S. Department of Energy. Accessed May 5, 2021. https://betterbuildingssolutioncenter.energy.gov/implementation-models/arcelormittal-usa-power-1-contest-increases-employee-engagement-and-generates.

Baker, G. 2017. “Tools to Build the Framework for Engaging Employees in Making Industrial Buildings Better,” 8.

Bruner, M. W., R. Lovelace, S. Hillier, C. P. T. Baillie, B. G. Bruner, K. Hare, C. Head, A. Paibomsai, K. Peltier, and L. Lévesque. 2019. “Indigenous Youth Development through Sport and Physical Activity: Sharing Voices, Stories, and Experiences.” *International Journal of Indigenous Health* 14 (2): 222–51. https://doi.org/10.32799/ijih.v14i2.31945.

Challenge.gov. 2021. “Challenge Challenges, Your Solutions.” 2021. https://www.challenge.gov/.

Compressed Air Best Practices. n.d. “Saint-Gobain Makes Solving Sustainability Competitive and Fun | Compressed Air Best Practices.” Accessed May 5, 2021. https://www.airbestpractices.com/energy-manager/corporate-sustainability-programs/saint-gobain-makes-solving-sustainability-competiti.

Connolly, T. M., E. A. Boyle, E. MacArthur, T. Hainey, and J. M. Boyle. 2012. “A Systematic Literature Review of Empirical Evidence on Computer Games and Serious Games.” *Computers & Education* 59 (2): 661–86. https://doi.org/10.1016/j.compedu.2012.03.004.

Deterding, S., D. Dixon, R. Khaled, and L. Nacke. 2011. “From Game Design Elements to Gamefulness: Defining ‘Gamification.’” In *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments*, 9–15. MindTrek ’11. New York, NY, USA: Association for Computing Machinery. https://doi.org/10.1145/2181037.2181040.

Dubey, M., V. Chavan, and D. Y. Patil. 2016. “A Conceptual Study of Selected Companies Using Gamification for Employee Training & Development as Engagement Approach.” *Amity Global HRM Review* 6 (September): 73–80.

Kavaliova, M., F. Virjee, N. Maehle, I. A. Kleppe, and T. Nisar. 2016. “Crowdsourcing Innovation and Product Development: Gamification as a Motivational Driver.” *Cogent*

Business & Management 3 (1): 1-N.PAG. https://doi.org/10.1080/23311975.2015.1128132.

Legrand North America. 2015. "Legrand Energy Marathon Toolkit." Alliance to Save Energy. https://www.ase.org/sites/ase.org/files/resources/Media%20browser/energy_marathon_toolkit.pdf.

Liu, M., Y. Huang, and D. Zhang. 2018. "Gamification's Impact on Manufacturing: Enhancing Job Motivation, Satisfaction and Operational Performance with Smartphone-Based Gamified Job Design." *Human Factors & Ergonomics in Manufacturing & Service Industries* 28 (1): 38–51. https://doi.org/10.1002/hfm.20723.

Martella, R., E. C., and C. Kray. 2019. "Crowdsourcing Geographic Information with a Gamification Approach." *GEOGRAFSKE INFORMACIJE MNOŽIČNIH VIROV S PRISTOPOM NA TEMELJU IGER.* 63 (2): 213–33. https://doi.org/10.15292/geodetski-vestnik.2019.02.213-233.

Morschheuser, B., and J. Hamari. 2019. "The Gamification of Work: Lessons From Crowdsourcing." *Journal of Management Inquiry* 28 (2): 145–48. https://doi.org/10.1177/1056492618790921.

Mount, M., H. Round, and T. S. Pitsis. 2020. "Design Thinking Inspired Crowdsourcing: Toward a Generative Model of Complex Problem Solving." *California Management Review* 62 (3): 103–20. https://doi.org/10.1177/0008125620918626.

Nacke, L. E., and S. Deterding. 2017. "The Maturing of Gamification Research." *Computers in Human Behavior* 71 (June): 450–54. https://doi.org/10.1016/j.chb.2016.11.062.

Olson, P. 2013. "Language App Duolingo To Translate More Sites After Buzzfeed And CNN." *Forbes.Com*, November, 12–12.

Roth, S., D. Schneckenberg, and C. Tsai. 2015. "The Ludic Drive as Innovation Driver: Introduction to the Gamification of Innovation." *Creativity & Innovation Management* 24 (2): 300–306. https://doi.org/10.1111/caim.12124.

Saint-Gobain Corporation. n.d. "Saint-Gobain Corporation: Compressed Air Challenge | Better Buildings Initiative." U.S. Department of Energy. Accessed May 5, 2021a. https://betterbuildingssolutioncenter.energy.gov/implementation-models/saint-gobain-corporation-compressed-air-challenge.

———. n.d. "Saint-Gobain Corporation: Energy Champions At All Plants | Better Buildings Initiative." U.S. Department of Energy. Accessed May 5, 2021b. https://betterbuildingssolutioncenter.energy.gov/implementation-models/energy-champions-all-plants.

Silic, M., G. Marzi, A. Caputo, and P. M. Bal. 2020. “The Effects of a Gamified Human Resource Management System on Job Satisfaction and Engagement.” *Human Resource Management Journal* 30 (2): 260–77.

U.S. Department of Energy. 2021a. “American-Made Challenges: Lighting Prize.” American-Made Challenges. 2021. americanmadechallenges.org/lprize.

———. 2021b. “Solar Decathlon: Solar Decathlon Challenges.” 2021. https://www.solardecathlon.gov/event/challenges.html.

———. 2021c. “DOE’s Better Buildings Initiative Saves $13.5 Billion in Energy Costs.” May 17, 2021. https://www.energy.gov/articles/does-better-buildings-initiative-saves-135-billion-energy-costs.

———. n.d. “Legrand’s Energy Marathon Nets Savings, Instills Long-Term Best Practices | Better Buildings Initiative.” Accessed May 5, 2021. https://betterbuildingssolutioncenter.energy.gov/beat-blog/legrand%E2%80%99s-energy-marathon-nets-savings-instills-long-term-best-practices.

Uz B., C., and A. Gul. 2020. “Investigating the Effectiveness of Gamification on Group Cohesion, Attitude, and Academic Achievement in Collaborative Learning Environments.” *TechTrends: Linking Research & Practice to Improve Learning* 64 (1): 124–36. https://doi.org/10.1007/s11528-019-00442-x.

Wang, X., D. H. Goh, E. Lim, A. Vu, and A. Chua. 2017. “Examining the Effectiveness of Gamification in Human Computation.” *International Journal of Human-Computer Interaction* 33 (10): 813–21. https://doi.org/10.1080/10447318.2017.1287458.

Weiss, J., P. Stephens, and M. Stowe. 2017. “Realigning Utility Incentives for Industrial Customers: Using Strategic Energy Management to Increase Customer Participation in Energy Efficiency Programs,” 12.

XPRIZE Foundation. 2021. “Prizes Page | XPRIZE Foundation.” 2021. https://www.xprize.org/prizes.