

IMPLEMENTING A SUSTAINABLE WASTE REDUCTION STRATEGY: A CASE STUDY AT GENERAL MOTORS

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Abstract: In congruence with General Motors launching a Zero Waste circular economy program, it has committed to diverting more than 90% of operational waste from landfills and thermal processing facilities by 2025. To achieve this goal for GM North America, a methodical waste reduction program was developed through the amalgamation of two interrelated strategies, the Strategic Planning Process and the Operational Strategy Process. This dual approach benefits from a companywide integrated focus on the organization's strategic goals, yet remains efficient and engaging on a facility level, allowing for operational flexibility of design. To implement this novel methodology, GM established the team-of-teams approach to program management, creating roles in both the Sustainability team and Strategic Programs & Partnerships (SP2) team. The Sustainability team took ownership of the Strategic Planning Process, designing the Zero Waste tracking methodology and establishing annual waste diversion targets for the corporation. The SP2 team led the Operational Strategy Process, owning the specific Zero Waste Budget, and creating waste-centric innovation workshops, such as the Zero Waste Treasure Hunt program and Zero Waste Mini-Missions, which focused on quality improvement techniques, such as PDCA (Plan-Do-Check-Act) and DMAIC (Define-Measure-Analyze-Improve-Control). Projects that are ideated through the program are then submitted through the Zero Waste Projects Module, where they are reviewed based on various funding guidelines and prioritization benchmarks, ensuring funds are awarded to high impact ventures. This methodology has proven successful in surpassing 2021 diversion targets, with a real world 2021 diversion rate of 86.4%, and setting the groundwork to further expand support to meet the company's Zero Waste diversion glidepath through 2025.

Keywords: general motors, zero waste practice, waste strategy, waste management

Introduction

General Motors Company (GM) is an automotive manufacturing company founded in 1908, by William C. Durant. The company is headquartered in Detroit, Michigan, United States, and has global manufacturing operations in six continents, employing approximately 155,000 employees worldwide (GM in the U.S., 2020). In the United States, GM has a manufacturing footprint consisting of 11 assembly plants, 25 stamping, propulsion, component, and battery plants; 19 parts distribution centers; and two engineering campuses distributed across 27 states. In the U.S., GM's brands include Chevrolet, Buick, GMC, and Cadillac (GM in the U.S., 2020).

In 2017, GM launched its new corporate vision defined as "Zero Crashes, Zero Emissions and Zero Congestion" (General Motors Corporate Sustainability Report, 2017). These three pillars aim to

advance safety features, low-emissions vehicles, sustainable operations, and autonomous technology (General Motors Corporate Sustainability Report, 2017).

Under the “Zero Emissions” pillar, GM established multiple public sustainability goals targeting a reduction in greenhouse gas emissions from scopes 1, 2 and 3. Included in this pillar is the GM Zero Waste program, which launched in 2019, to support the goal of diverting more than 90% of its manufacturing operational solid and liquid wastes from landfill and thermal processing facilities by 2025 (General Motors Corporate Sustainability Report, 2019).

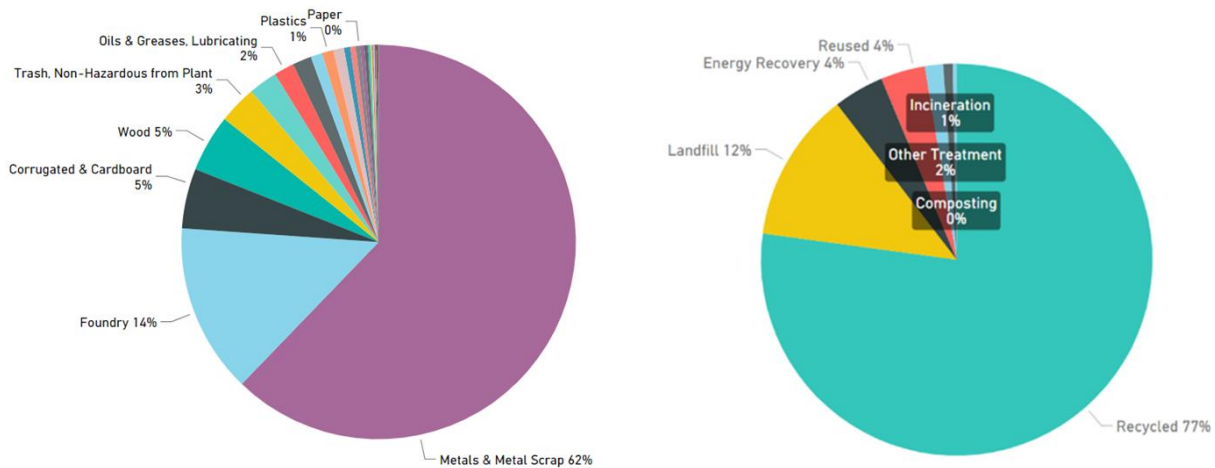


Figure 1. GM's 2019 Waste Stream & Waste Management Method Breakdown

The GM Zero Waste program was developed using concepts of strategic planning and operational strategy. These two combined concepts define the steps and tactics needed to achieve the objectives set by the company’s leadership team. Strategic planning ensures that the company applies broader resources such as core competencies, skilled manpower resources, and business relationships to achieve both short- and long-term goals (Chang, 2010). Operational strategy ensures that the organization uses its resources appropriately to meet the established competitive goals (Nahmias and Olsen, 2015).

The Zero Waste program includes classical lean operation concepts such as the DMAIC (Define-Measure-Analyze-Improve-Control), the PDCA (Plan-Do-Check-Act) process, and an innovative approach of the Genchi Genbutsu or Go-and-See principle. This principle involves an on-site and in person investigation to find the root cause of the problem (Shang, 2013), however, due to the pandemic, this process was done remotely through visual images, videos, and virtual meetings with the manufacturing team. Another innovative process was the implementation of GM’s novel Zero Waste methodology, which allows the capability to simultaneously assess waste diversion rates over time at the plant, regional and global levels. A team-of-teams management approach for project implementation was also employed to allow for further specialization of skill sets, while increasing collaboration towards the overarching objective (McChrystal, 2015).

The team-of-teams approach has emerged in recent years as a new organizational model in which autonomy is decentralized, meritocracy is valued while promoting a sense of partnership.

“Instead of maintaining a traditional structure in which people work in hierarchies based on a function or a formal business unit, an organization operates as a

constellation of teams that come together around specific goals. At the center of this constellation is a coordinating executive team, but the composition of each project team shifts over time. Teams and team members work together in continuously evolving ways” (Meehan and Jonker, 2018).

After a thorough data review process of GM’s global waste footprint, to ensure an accurate baseline, regional and plant targets were calculated, triggering the beginning of the Operational Strategy Process. The core of this plan involves appropriate budget allocation, project management, risk analysis, and broad communication.

Due to the significant variation in standards and operations defined by different industries, it is problematic to scale practical approaches for operational efficiencies on a 1-to-1 basis. Therefore, the objective of this case study is to present the overarching platform of structures, organizations, processes, methodologies, and decisions that have proven successful in a global corporation with a diverse manufacturing footprint, such as GM, to achieve its Zero Waste targets on schedule.

Methods

The Zero Waste program involves two interrelated strategies, the Strategic Planning Process and the Operational Strategy Process. Within each strategy, sub-tasks were developed along with 3 core elements of lean manufacturing: The PDCA process, the DMAIC and Go-and-See.

Strategic Planning Process

The main components of the Strategic Planning Process involve 3 steps:

1. Define the appropriate methodology to track performance
2. Establish goals for the corporation, along with regional and plant targets
3. Define the implementation plan

The first step applied the methodology of using a baseline to improve accuracy of waste diversion rates (Marczewski, 2021). To determine the baseline, GM followed the recommendation of The Greenhouse Gas Protocol and used the average of waste amounts generated between the years of 2017 to 2019 to assuage the variation in the data between these years. (The Greenhouse Gas Protocol, 2015).

The second step utilized real waste data to apply the novel diversion rate equation, using the information compiled from the baseline years. Because GM’s Zero Waste goal aims to achieve a diversion rate greater than 90% by 2025, a linear approach to improve the diversion rate was selected to set yearly targets for the corporation, regions, and plants (Marczewski, 2021).

$$DR_{new} = \left(1 - \frac{\sum m_{ndw} - \sum m_{endw}}{\sum m_{baseline\ waste} - \sum m_{te}} \right) \times 100\%$$

(1)

Where,

m_{ndw} = mass of non-diverted waste (Includes wastes managed by disposition in a landfill and thermal processing facilities)

m_{endw} = mass of exempt non-diverted waste (Includes wastes generated in non-operational activities, such as construction, demolition, or remediation projects)

$m_{baseline\ waste}$ = mass of waste in the baseline period

m_{te} = Total mass of exempt waste

Lastly, using the information from the second step, the targets were communicated to the Sustainable Workplaces team, triggering the launch of the Operational Strategy Process. This involved the creation of a “Zero Waste Team,” consisting of GM engineers from various departments, including: Sustainability, Strategic Programs & Partnerships (SP2), and Environmental Operations. This team collaborated to develop the tools and processes necessary to implement projects at scale, divert waste from landfills and incinerators, and meet annual targets and glidepaths.

Operational Strategy Process

The main components of the Operational Strategy Process involve 4 steps:

1. The creation of a dedicated Zero Waste Budget with accompanying funding guidelines and prioritization benchmarks
2. The formation of specific Zero Waste working teams and ideation platforms
3. The design of all necessary data compilation and tracking tools
4. Reviewal, approval, implementation, and scaling of Zero Waste projects

The first step of the Operational Strategy Process was to create and fund a new Zero Waste Budget. The Zero Waste Team required that all sites participating in the Zero Waste program submit a project proposal to meet their annual Zero Waste target, as provided in step 2 of the Strategic Planning Process. Once this data was compiled, a cost analysis was performed to determine an average cost per ton diverted (\$/US Ton) of all submitted projects. With this information, an annual Zero Waste Budget was established, by multiplying the cost per ton allocation by General Motors North America (GMNA)’s annual Zero Waste reduction target (US Tons). This methodology provided confidence that an accurate funding allowance was allocated to meet the corresponding targets. Furthermore, as these projects are implemented, they often require year-over-year funding. This is because many projects modify the disposal of the waste streams from a non-diverted waste management method (Landfill, incineration, energy recovery, other treatment) to a diverted waste management method (Other treatment, compost, recycle, reuse, reduce). This change in material handling adds additional and permanent costs to the program, therefore, the fund continues to grow, year-over-year, as the program’s scope increases to account for new pricing structures.

The cost per US Ton allocation is also set on a sliding scale to further incentivize efficient and scalable projects. Therefore, the cost per US Ton allocation allows for a \$X/(US Ton) baseline, with an additional sliding scale of \$Y/(US Ton), in Z US Ton increments, based on project diversion of W US Tons, at a max funding limit of \$1.25X/(US Ton).

$$Project\ Funding\ Limit = \left(\frac{\$X}{US\ Tons} + \left(\frac{W\ US\ Tons}{Z\ US\ Tons} * \frac{\$Y}{US\ Tons} \right) \right) \leq \frac{\$1.25X}{US\ Tons}$$

(2)

Projects are also prioritized based on various guidelines, including:

- Projects that move waste management methods up the waste hierarchy
- Projects that require only a singular funding allotment (no year-over-year expenses)
- Projects that eliminate the generation of hazardous waste
- Projects that divert higher waste volumes (and can scale to other facilities)

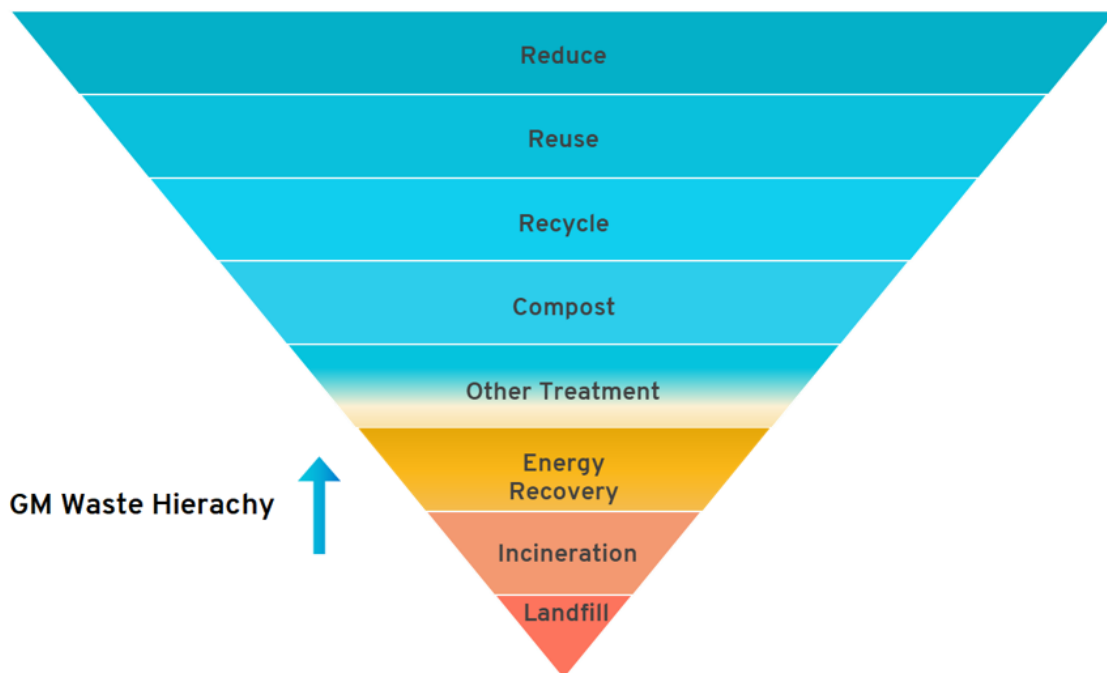


Figure 2. GM's Zero Waste Hierachy

The second step of the process involves creating workspaces and teams to allow for Zero Waste brainstorming, best practice sharing, and project development. To this effect, and through incorporating the PDCA and DMAIC lean concepts, two supporting Zero Waste programs were created: the Zero Waste Treasure Hunt program and the Zero Waste Mini-Missions.

The Zero Waste Treasure Hunt program (ZWTH) is a collaboration between various waste subject matter experts throughout GMNA. Each year, a core team visits a predetermined number of facilities and conducts a deep dive into their waste program. The purpose of the treasure hunt program is to assist each site in achieving its Zero Waste and cost reduction targets, while also identifying best practices to share throughout the company.

The Zero Waste Treasure Hunt is a 4-phase program that emulates the PDCA:

1. **Process Development:** Asks participants to (1) Set goals and review ZWTH timeline, (2) Verify the availability and anticipated level of commitment of all participants, (3) Identify relevant data to collect, and (4) Assign deliverable due dates and roles (points of contact) responsible for completing each task outlined throughout the process;
2. **Data Collection and Validation:** Process to collect site waste data, as well as complete all other tools developed for the ZWTH to (1) Collect, validate, and review site-specific supplemental documentation and (2) Identify focus points during the in-person review;
3. **Action Plan:** Asks team members to: (1) Review the data collected in the previous step, (2) Conduct a site walkthrough to identify best practices, challenges, and opportunities, (3) Create action items based on the data collected, and (4) Generate an action item list and executive summary report of opportunities that were identified;
4. **Findings and Follow-Up:** Asks users to: (1) Present findings to site leadership, (2) Track action items to completion, (3) Disseminate best practices across regions and similar manufacturing footprint, and (4) Schedule an on-site follow-up visit if needed.

Secondly, the Zero Waste Mini-Missions incorporates concepts of the DMAIC process. These are individualized workshops that target the company's high impact waste streams. Each mini-mission focuses on one non-diverted waste stream, and is led by an Environmental Operations engineer, and mediated by an SP2 Engineer. It is a recurring monthly workshop to brainstorm ideas, trial diversion initiatives, share updates on project progress, and scale projects to other facilities. As projects are trialed through all phases of the DMAIC process, and their feasibility are assessed, these waste streams will be transitioned to diverted waste management methods, hence fulfilling the purpose of the mini-mission. At this point the mission will be completed, and a new mission focusing on another waste stream will take its place as part of a continuous improvement plan.

The third step of the process involves creating all necessary tools and worksheets to accurately track waste data, business case proposals, approved projects, and financials. The two primary tools created to fulfil these requirements are the Zero Waste Business Case Template and the Zero Waste Projects Module.

Zero Waste business cases can be ideated through various outlets, such as: Zero Waste Treasure Hunt action items & best practices, Zero Waste Mini-Missions, and relevant manufacturing experience. Once a project has been developed, the relevant engineer/staff member inputs the data into the Zero Waste Business Case Template. This template is a comprehensive document that includes all

necessary data for the Zero Waste team to succinctly review the project for funding. An example of the Zero Waste business case format can be seen in Scenario 2 of the Results section of this paper.

The Zero Waste Projects Module is a comprehensive platform, managed through a compliance and quality management third-party software that houses all GM Zero Waste project data. It has been designed to elevate visibility of Zero Waste projects and allow for increased scalability of projects, as engineers are able to sort through all approved and pending Zero Waste projects to identify scalable initiatives.

The fourth step in the process incorporates the previous three to approve, implement, and scale Zero Waste projects. Projects are created through ideation platforms, such as the Zero Waste Treasure Hunt and Zero Waste Mini-Missions. Information is then entered into the Zero Waste Business Case Template and is submitted for Zero Waste funding. During this final step, each business case is reviewed by the Zero Waste team and assessed through the Zero Waste guidelines and prioritization benchmarks. If approved for funding, the team assists sites with the implementation of the project, and then houses the blueprint for the project in the Zero Waste Projects Module. This allows others to review all Zero Waste options and implement feasible opportunities.

Results

The results from applying an interrelated two-prong approach resulted in the formation of new roles to two separate teams. GM established the team-of-teams concept creating roles for the Sustainability team and the Strategic Programs & Partnerships team. Their main roles, as they relate to Zero Waste, are illustrated in figure 3:



Figure 3. Representation of the “teams-of-teams” concept in GM's Zero Waste program. Highlighted circles represent the core responsibilities

These are the resulting action items of each component under the Sustainability team:

- Program Management: Responsible to implement and report results under the PDCA method

- Waste Data Analysis & KPIs: Reviewal of waste data for accuracy and tracking of performance through key performance indicators (KPIs)
- Target Allocation: The process to manipulate data through a specific methodology to set targets on a corporation, regional, and plant basis
- Strategic Plan Development: Relates to developing high-level activities to support the program, such as communication plans, program updates, and visibility to leadership
- Research & Pilot Programs: Area responsible for advancement of new technologies related to waste management prior to full-scale implementation
- Report Progress: The internal and external communication of progress. Internal refers to plants, senior leadership, and other internal stakeholders. External refers to the public and other stakeholders via the corporate sustainability report and other reporting frameworks

These are the resulting action items of each component under the Strategic Programs and Partnerships team:

- Project Implementation: Refers to all phases of project implementation, from concept to project completion
- Budget Prioritization: Responsible for allocation of resources to create the highest return in value to the waste program. In this case, the least monetary spending to generate the maximum amount of waste diverted from landfill and incinerators
- Zero Waste Treasure Hunt: GM's adaptation of the Go-and-See principle. This workshop brings together a team of subject matter expert engineers to take a hands-on approach at the manufacturing level to identify challenges and opportunities (Liker and Morgan, 2006)
- Strategic Planning: This involves the cost and risk analysis of each project to be implemented
- Zero-Waste Mini Missions: Focus groups dedicated to strategically investigate the diversion opportunities of high impact waste streams
- Partnerships: Establish or enhance third party partnerships to drive innovative approaches towards large scale waste reduction

Target allocation was the main priority of the Sustainability team during completion of the Strategic Planning Process. The calculated baseline, and the targets resulting from the implementation of the baseline method, yielded the results in figure 4:

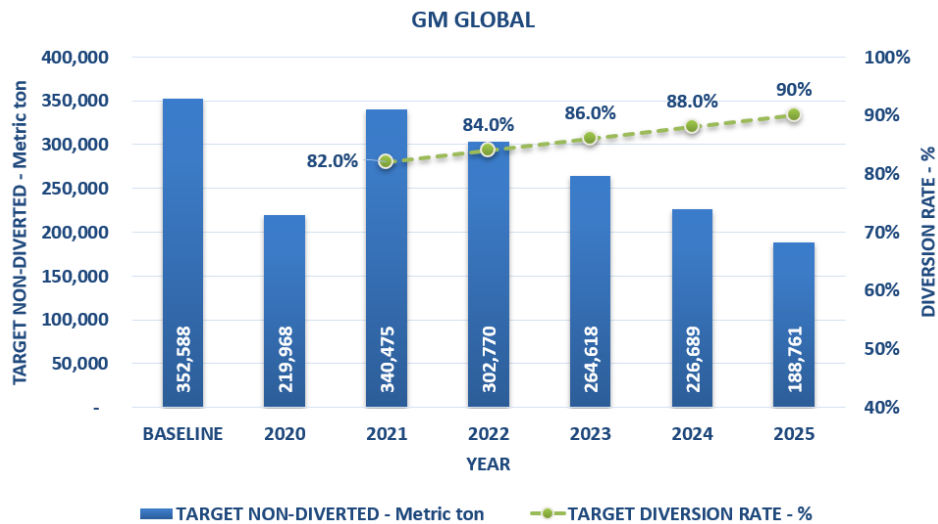


Figure 4. Increments in the diversion rate needed for GM to achieve its Zero Waste goal by 2025

With these targets in place, the Operational Strategy Process could commence, under the leadership of the SP2 team.

As to not disclose proprietary data, but to be able to review the results from the Zero Waste funding guidelines and the Zero Waste Business Case Template, two hypothetical scenarios were developed to illustrate the usage of both tools.

Scenario 1: The Zero Waste funding guidelines allow for a \$100/US Ton baseline, with an additional sliding scale of \$2.5/ US Ton in 50 US ton increments, at a max funding limit of \$150/US Ton. Therefore, if a project proposes a diversion of 250 US Tons, it would be allowed a max funding limit of:

$$\begin{aligned}
 \text{Project Funding Limit} &= \left(\frac{\$X}{\text{US Tons}} + \left(\frac{W \text{ US Tons}}{Z \text{ US Tons}} * \frac{\$Y}{\text{US Tons}} \right) \right) \\
 &= \left(\frac{\$100}{\text{US Tons}} + \left(\frac{250 \text{ US Tons}}{50 \text{ US Tons}} * \frac{\$2.5}{\text{US Tons}} \right) \right) = \frac{\$112.5}{\text{US Ton}}
 \end{aligned}$$

Scenario 2: An example Zero Waste business case is submitted in Scenario 2. As can be seen in the document, all required financial expenses and cost savings are incorporated into the business case. This allows the Zero Waste team to make an efficient and informed decision on project approvals. Funding requirements, costs savings, price differentials, and year-over-year funding requirements also enables proper financial forecasting of the Zero Waste Budget.

Zero Waste Project Business Case

Site Name:	GMNA Assembly Plant	Date:	2/8/2022	Completed By:	Resource Manager																
Proposed Start Date:	3/1/2022	<table border="1" style="font-size: 8px; text-align: center;"> <tr> <td>High</td> <td style="background-color: #90EE90;">3</td> <td style="background-color: #90EE90;">2</td> <td style="background-color: #90EE90;">1</td> </tr> <tr> <td>Medium</td> <td style="background-color: #FFD700;">5</td> <td style="background-color: #FFD700;">4</td> <td style="background-color: #90EE90;">2</td> </tr> <tr> <td>Low</td> <td style="background-color: #FF4500;">6</td> <td style="background-color: #FFD700;">5</td> <td style="background-color: #90EE90;">3</td> </tr> <tr> <td></td> <td>Difficult</td> <td>Medium</td> <td>Easy</td> </tr> </table>	High	3	2	1	Medium	5	4	2	Low	6	5	3		Difficult	Medium	Easy			
High	3		2	1																	
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Priority (See Matrix):	1																				
Yellow Cell Values are Calculated Automatically																					
Project Title: WWTP Filter Cake Recycling																					
In a Few Sentences, Provide the Project Description and the Opportunity This Project Aims to Develop:																					
The assembly plant is currently landfilling their waste water treatment plant (WWTP) filter cake. This project proposes to instead send this material to a local cement manufacturer, who will recycle this material into a constituent in their cement manufacturing process.																					
Zero Waste Project Financial Analysis - Use US Dollars (\$)																					
Impacted Waste Stream Name:	WWTP Filter Cake																				
Current Waste Stream Management Method:	Landfill																				
Proposed Waste Stream Management Method:	Recycle																				
Current Non-Diverted Annual Waste Stream Weight (Tons):	780																				
Proposed Non-Diverted Annual Waste Stream Weight (Tons):	0																				
Current Waste Stream Management Method Annual Expense (\$):	\$	26,005.20																			
Current Waste Stream Transportation Annual Expense (\$):	\$	12,180.00																			
Proposed Waste Stream Management Method Annual Expense (\$):	\$	19,500.00																			
Proposed Waste Stream Transportation Annual Expense (\$):	\$	92,720.40																			
Will Engineering Design Need to be Completed for Project Implementation?	No																				
Description of Required Engineering Design:																					
Engineering Design Costs (\$):	\$	-																			
Will Construction Need to be Completed for Project Implementation?	No																				
Description of Required Construction:																					
Construction Costs (\$):	\$	-																			
Will Equipment Need to be Purchased for Project? If So, List Equipment:	No																				
Description of Equipment and Function:																					
Equipment Installation Costs (\$):	\$	-																			
Equipment Labor/Maintenance Costs (\$/Year):	\$	-																			
Will Additional Labor Need to be Provided for Project? If So List:	No																				
Description of Function and Quantity of Labor Required:																					
Cost of Labor (\$/Year):	\$	-																			
Annual Labor Savings, if Applicable (Hours):	0																				
Will Additional Expenses be Incurred Through This Project That Haven't Been Captured in the Data Above? If So Add/Edit Placeholders Below:	No																				
Placeholder Annual Expenses (\$/Year):	\$	-																			
Will Additional Savings be Realized Through This Project That Haven't Been Captured in the Data Above? If So Add/Edit Placeholders Below:	No																				
Placeholder Annual Savings (\$/Year):	\$	-																			
Does Project Require a One Time Funding Allotment or Year Over Year Funding?	Year Over Year Funding																				

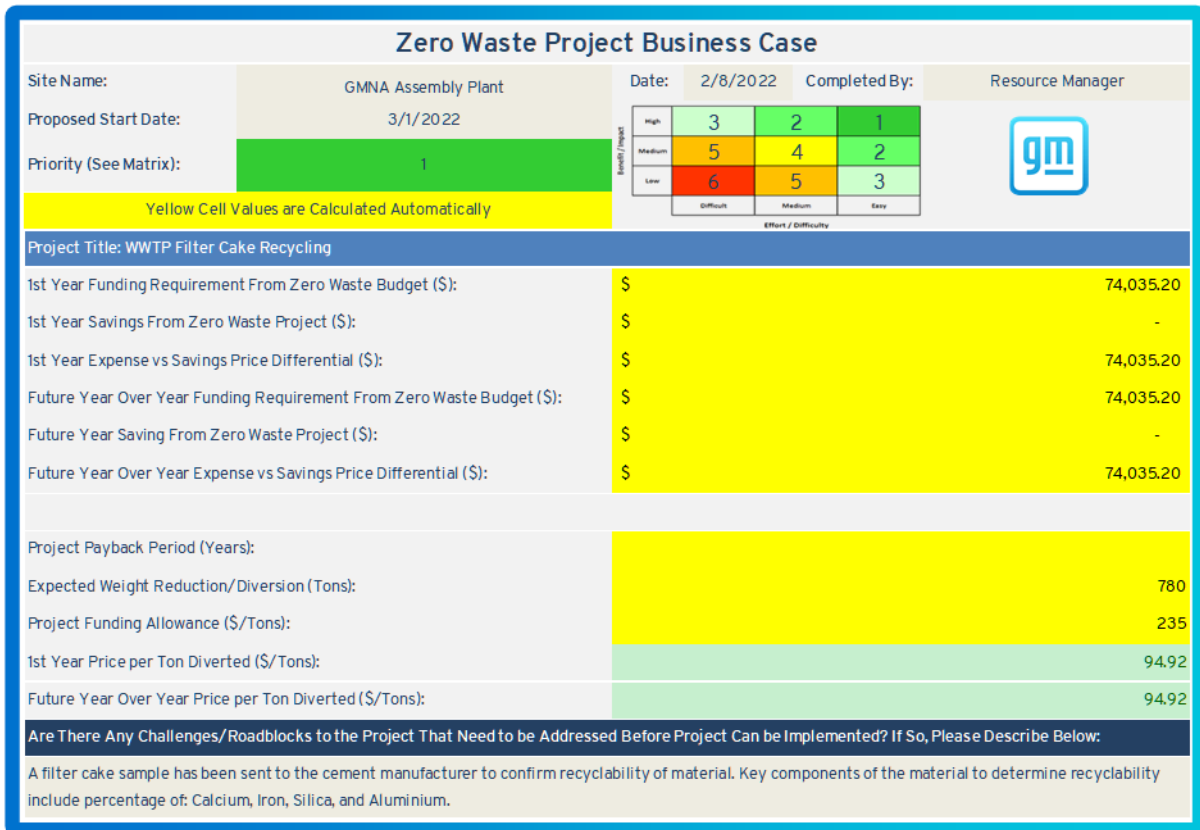


Figure 5. Example Zero Waste business case

Discussion

The results from the strategies outlined above have proven successful at General Motors. The Sustainability team was able to fully develop the pillars and methodology of the Zero Waste program by setting targets for the company, regions, and plants, to track performance and benchmarks. Once the targets were distributed to relevant stakeholders, the SP2 team was successful in securing critical funding for the operational strategy phase of the program and designing and implementing Zero Waste projects to assist sites with achieving their targets.

Another innovate function of the strategy was in the modification of elements, within lean manufacturing concepts, to create programs such as the Zero Waste Treasure Hunt and Mini-Missions. These two activities worked effectively under the team-of-teams concept. Without this structure, a hierarchical approach would not yield the same results, largely due to the plethora of stakeholders involved.

In regard to challenges faced during the implementation of this strategy, it is paramount to align company culture with sustainable ideology. A powerful tool to begin this cultural transformation is to follow a top-down approach, which publicly commits to specific and measurable sustainability targets. This demonstrates, to both internal and external stakeholders, the importance of these programs, and provides them the visibility and support they need to be successful. Without this public commitment and accountability, the impact and reach of the program will be seriously compromised.

Another challenge faced within the program is the reliance on the recycling industry within the United States. Although the US Environmental Protection Agency is currently revamping its national recycling program (EPA, 2022), the country still relies on thermal processing facilities to manage municipal solid waste. This proves a challenge, as GM's Zero Waste program is more robust, and disallows incineration and energy recovery as a final waste management method.

Lastly, there is a benefit caused by the increasing number of companies setting targets to use more post-consumer recycled content in their processes, such as in plastic packaging (AMERIPEN, 2021). This puts pressure on the commodity price, since demand will increase more rapidly than supply. Another pressure point is the elimination of plastic waste, including an endorsement of a new resolution at the United Nations Environment Assembly to negotiate an international legally binding proposal to terminate plastic pollution (Environment Assembly of the United Nations Environment Programme, 2022). These two points can impact the price of certain plastic wastes, which may improve the business case for recycling, thus promoting a circular economy.

Conclusions

With the launch of GM's Zero Waste program, which commits to diverting more than 90% of operational waste from landfills and thermal processing facilities by 2025, new processes and strategies had to be designed and implemented to achieve these publicly set targets. To this effect, two interrelated strategies, the Strategic Planning Process and the Operational Strategy Process, were designed to manage the program and spearhead results. This dual approach was achieved through implementing the team-of-team concept in the program's leadership hierarchy, ensuring subject matter experts are strategically positioned to provide maximum benefit to the program. The purpose of the Strategic Planning Process was to develop the Zero Waste tracking methodology, establish goals for the corporation, and define the scope of the program. Once completed, the program entered the Operational Strategy Process, where a dedicated Zero Waste Budget was created, ideation platforms such as the Zero Waste Treasure Hunts and Zero Waste Mini-Missions were launched, and Zero Waste projects began to be created, reviewed, approved, and implemented.

As the results have demonstrated, the key components of a successful Zero Waste program include a dedicated Zero Waste Budget and specifically designed Zero Waste ideation platforms, that elevate and scale Zero Waste projects across a company's manufacturing footprint. This combined strategy continues to be successful at General Motors, as GM surpassed 2021 diversion targets, achieving a diversion rate of 86.4%, and diverting 1,574,970 metric tons, compared to the 2017-2019 baseline of total operational waste generated. This strategy will continue to set the groundwork to meet the company's Zero Waste diversion glidepath through 2025 and beyond.

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Declaration of Interest Statement

The authors declare that they have no conflicts of interests.

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