OFFICIAL NOTICE AND AGENDA

of a meeting of a City Board, Commission, Department
Committee, Agency, Corporation, Quasi-Municipal
Corporation, or Sub-unit thereof.

Meeting:	**SUSTAINABILITY, ENERGY AND ENVIRONMENT COMMITTEE**
Members:	John Kroll (C), Carol Lukens, Jay Coldwell, Mary Kluz, Jesse Kearns, Jean Abreu
Location:	Board Room of Wausau City Hall, 407 Grant Street.
Date/Time:	**Thursday, February 01, 2024 at 5:00 p.m.**

1. Welcome and Introductions
2. Public Comment
3. Approve minutes of January 11, 2024 meeting
4. Presentation: Blaine Haupt
5. Updates: GHG Baseline, WLGCC, GTLC, Task Force
6. Discussion and Possible Action: 'No Mow May' alternative program selection
7. Discussion: UniverCity Year Program ByBlock report
8. Next meeting date: February 8, 2024
9. Adjourn

It is likely that members of, and a quorum of the Council and/or members of other committees of the Common Council of the City of Wausau will be in attendance at the abovementioned meeting to gather information. **No action will be taken by any such groups.**

In accordance with the requirements of Title II of the Americans with Disabilities Act of 1990 (ADA), the City of Wausau will not discriminate against qualified individuals with disabilities on the basis of disability in its services, programs or activities. If you need assistance or reasonable accommodations in participating in this meeting or event due to a disability as defined under the ADA, please call the ADA Coordinator at (715) 261- 6622 or ADAServices@ci.wausau.wi.us to discuss your accessibility needs. We ask your request be provided a minimum of 72 hours before the scheduled event or meeting. If a request is made less than 72 hours before the event the City of Wausau will make a good faith effort to accommodate your request.

Questions regarding this agenda may be directed to the City Planning Office @ (715) 261-6760.

This Notice was posted at City Hall and emailed to the Media on 01/29/2024
Any person wishing to offer public comment may email City Clerk Kaitlyn Bernarde at clerk@ci.wausau.wi.us with "SEEC comment" in the subject line prior to the meeting start. All public comment, either by email or in person, will be limited to items on the agenda at this time. The messages related to agenda items received prior to the start of the meeting will be provided to the Chair.

Other Distribution: Media, Alderpersons, Mayor, City Departments

City of Wausau **Sustainability, Energy and Environment Committee**

MINUTES

January 11, 2024

Members Present: John Kroll, Jay Coldwell, Jean Abreu, Carol Lukens

Others Present: Andrew Lynch, Brad Lenz, Nancy Stencil

In compliance with Chapter 19, Wisconsin Statues, notice of this meeting was posted and transmitted to the Wausau Daily Herald in the proper manner.

1. Welcome and Introductions

Meeting started at 5:00pm

2. Public Comment

n/a

3. Approve minutes of December 7, 2023 meeting

Motion/second by Kluz/Abreu to approve minutes with change noting that Kluz was not present. Passed unanimously.

4. Updates: GHG Baseline, WLGCC, GTLC

Staff is still waiting on 2023 energy data from WPS to continue working on the GHG baseline. Staff is waiting for more information on the DOE voucher to use on technical assistance on best steps for GHG reduction. Abreu asked what steps could be done now so the committee is not waiting to act. Lukens noted that some departments, like Streets, are suggesting equipment that is more GHG friendly. Lenz suggested getting buy-in from department heads. Lenz recently submitted the GTLC scoresheet to the DNR. This comprised of data pulled from multiple sources in multiple departments. It is anticipated this will continue every year to track progress. Lynch provided an email summary of the WLGCC activities for 2023 which included advocacy, organizing testimony at the Public Service Commission and Assembly, and hiring an executive director.

5. Discussion and Possible Action: 'No Mow May' alternative program selection

Lynch recapped that the discussion of the committee had steered towards not doing the No Mow May program this year and to find a better initiative. Due to timing of elections in April, Lynch asked that the committee decide in either January or February so there would be time to create and promote the initiative before May/summer. Lukens noted that economics of this initiative is important as mowing less and watering less is a cost savings to the residents. Kluz felt the education of what to plant and also where to get it was important. Lynch reminded that the timeline was important for making a decision. February would be ideal due to needing time to develop materials, the elections, and launching the program in May. Coldwell suggested providing alternatives to grass, like clover. Abreu asked if there were funds available to provide seeds or plants. Staff was not aware of any. Lynch suggested that the group needs to decide a slogan, and then a few points to emphasize. This could be refined in the future as needed. Kluz suggested finding other groups to help educate residents. Lukens suggested a demonstration lawn or garden section at City Hall. Kroll suggested a different slogan for each season. No Mow May, Slow Mow Summer, Leave the Leaves, etc.

6. Discussion: Draft website review

Lynch showed the committee the draft version of the Sustainability section on the City website. It was not yet complete but did highlight the main areas the committee had discussed previously: City Info which contains the GHG baseline info and resolution, as well as Awards; Resources for Residents which contains info on local food, events and IRA funding opportunities; Get Involved which has information about the committee and contact information. Lynch did express frustration with the writing of the pages but will have more time going ahead. Kluz asked about adding a local food directory to add. She will send along the link and Lynch will take a look at it.

7. Discussion: Supporting Local Food Systems

Coldwell discussed data that warns of a more rapidly changing climate than expected. Areas that could not support themselves with local food would be especially vulnerable. He feels that Central Wisconsin should pay attention to this. He talked with Kat Becker about ideas on creating a local food system. Suggestions included a central processing facility for farmers that supply to the metro area and a year-round farmers market. He has talked with a few people and discussed a wide range of ideas. Felt there was a lot of ideas and optimism around this topic. Coldwell suggested creating a task force on local food. Lenz noted that the Council and/or Mayor would create the task force. Most recent examples are the Affordable Housing and Solar Array groups. Kluz suggested that this committee explore the need for a task force and make a recommendation to Council. She knows there is a lot of frustration around the farmers market and felt there could be improvements for that service. Kroll asked Coldwell to pick two items to focus on, Coldwell rejected that notion and provided his two points of putting someone in charge of the local food structure and also having local communities become active in protecting their watershed and local food options.

7. Discussion: UniverCity Year Program ByBlock report

This item was tabled to the next meeting due to time constraints.

8. Next meeting date: February 1

Committee decided to have the next meeting on Feb 1.

9. Adjourn

Motion/Second by Lukens/Kluz. Approved unanimously. Adjourned at 6:17 pm

After No Mow May, Should You Do a Slow Mow Summer?

No Mow May is a start, but there's much more you can do to help pollinators.

By Benjamin Vogt | Published on June 14, 2023

The last few years have seen the spread of No Mow May, a campaign that encourages folks to mow their lawns and meadows less in order to reduce fossil fuel emissions and water use as well as help wildlife. On the face of it, it seems almost too good to be true–you could do a lot of good things for the environment by doing literally nothing. So perhaps it's not surprising that letting your lawn grow for a month has fallen short of its promises.

However, No Mow May has provided an important stepping stone for rethinking what pretty means in urban and suburban landscapes, and how these spaces can provide valuable habitat and other environmental benefits. Our yards have the potential to support butterflies, bees, and birds while also cleaning and cooling the air, rebuilding compacted soils, and reducing urban flooding through landscapes that absorb more storm water. To take the next step into creating healthier landscapes for our families and neighbors, we have to understand the flaws of No Mow May and look at these goals with more nuance.

RELATED: Are Robotic Mowers the Future of Lawn Care?

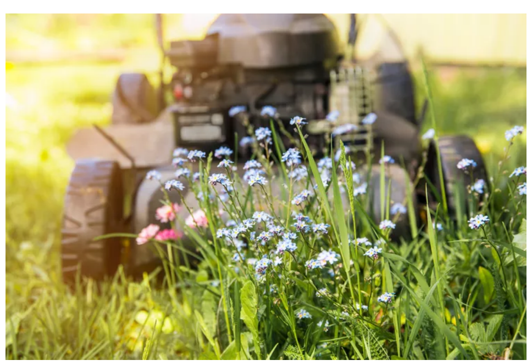

PHOTO: HELIN LOIK-TOMSON / GETTY IMAGES

Why No Mow May Isn't Such a Great Idea

No Mow May has a few issues that may actually do the opposite of its intended goals. For example, according to Sheila Colla, associate professor at York University and a conservation scientist, the initiative to mow less each May began in the UK, where not mowing "doesn't

SKIP TO CONTENT

One challenge is that most of us live on highly altered urban and suburban lots where there is no native plant seed bank. Native plants are critical to feeding butterfly and bee larvae because they co-evolved with many native insect species. What is likely present in the soil are invasive weed seeds–think Canada and musk thistle, as well as aggressive annual weeds like crabgrass–that will provide few resources for wildlife.

Only Temporary Support for Native Bees

In addition, Colla points out that some bee species nest above ground, such as the once-common but now-threatened American bumblebee (*Bombus pensylvanicus*). Their homes will be destroyed when the mowers come back in June.

One primary study often cited as showing the benefit to bees in the United States was conducted on unmown lawns in Appleton, Wisconsin. It argued that there was a significant diversity of bees present on a diversity of native flowers. The paper has actually been retracted due to errors in plant and bee identification, yet the piece is still often cited.

RELATED: 5 Easy Ways to Create Gardens for Bees That You'll Enjoy Too

Promotes Less Valuable Flowers

Heather Holm, author and pollinator conservationist, notes that one of the predominant flowering species we'll see in our lawns are non-native dandelions. While these plants make tasty additions to our salads, and their taproots help amend soil, their pollen is "nutritionally inadequate to support bee larvae on its own, primarily due to the low protein count."

So even if there are lots of dandelions around, bees still have to expend more energy gathering resources from a greater diversity of flowers, which may or may not be present in an unmowed urban lawn. Bees often exhibit floral fidelity when foraging, which means they tend to stick to one species in bloom to make things easier on themselves and use less energy. But when the primary resource lacks the nutrition to support bee larvae growth and development, a lawn full of dandelions may end up in giving us fewer pollinators.

Focus on Plant Diversity

Scientists at the University of Minnesota Bee Lab suggest an alternative: "Slow Mow Summer." This concept advocates for mowing infrequently all summer long while reducing lawn spaces in general. This is where you can take the next, exciting step in your landscape to help wildlife. Consider diversifying your space with an increased number of plant species and plant types (herbaceous perennials, grasses, sedges, shrubs, trees), and not just replacing one monoculture with another.

For example, many folks are broadcasting dutch white clover into their lawns as a lawn alternative in the hopes it also provides floral rewards for insects. However, it's still a near monoculture that also doesn't serve as a host plant for caterpillars (and caterpillars are important baby bird food in nesting season, not to mention those caterpillars turn into butterflies if they survive the birds).

Holm also points out that exotic clover, which honey bees evolved with and thus commonly use, may act as a "pathogen spillover between honey bees and native bees." Due to their large numbers and range, honey bees harbor a variety of diseases that they lay on flowers as they pollinate; when a native bee, such as a bumblebee, comes to forage it picks up those pathogens [1], which can lead to illness, deformity, or death for the bee and its young.

Taken collectively, our native bees provide superior pollination compared to honey bees, while some 25% of them are specialists with specific groups of native plants (meaning the plant and bee rely upon one another as they co-evolved to use each other either for pollen or pollination). One of the best things you can do after being inspired by No Mow May is to garden with plants native to your zip code, and to include a diversity of species that provide floral resources from spring through fall.

RELATED: 10 Native Prairie Plants That Attract Birds and Butterflies

Avoiding Bad Bugs

wooded ones. A 2-year study by the US Forest Service in Massachusetts showed that even lawn/meadow spaces at 10 inches high did not harbor tick populations. [2]

Best practices will always include spraying yourself with a repellent and doing a body check after being outdoors, but there are a few design strategies that also can help:

1. **Create wider paths through the landscape.** Paths help show intention and provide access points, but making them wider helps you avoid brushing up against vegetation where ticks "quest" on leaf edges, reaching out to hitch a ride.
2. **Increase plant diversity and habitat cover.** Encourage predators of species that serve as disease vectors by including habitat for them. Think owls, foxes, and coyotes, who prey on white-footed mice, a vector for lyme disease that ticks catch when feeding on the mice.
3. **Choose shorter plants.** Keep your plants under 2–3 feet tall. Pollinators still will have plenty to forage, but it will reduce the attractiveness to ticks.

TIP

When creating a diverse landscape in place of lawn, a sign explaining what's going on and why helps a lot when it comes to staying on good terms with your neighbors and your local weed ordinance enforcers. A few habitat certification programs offer sturdy ones.

Taking the Next Step

What No Mow May began in other parts of the world we can take to the next level wherever our home landscapes may be. By reducing lawn and using a diverse mix of native plants matched to the site (soil, light, moisture), you'll use less water and fertilizer while supporting bees and caterpillars. You'll also increase ecosystem services through that plant diversity such as mitigating storm water runoff via dense, layered landscapes that also help clean and cool our urban air.

So go ahead and take a Slow Mow Summer if you want to as you think about how you can really move the needle in your yard. I suggest visiting a meadow example nearby wherever you live to get inspiration from the plant species that thrive there. Watch as native bees forage on blooms and birds nab caterpillars and beetles to feed their young. Then, through organizations such as Pollinator Partnership, the Xerces Society, Wild Ones, Audubon, and the National Wildlife Federation, learn more about those plant species and the wildlife they support so you can recreate the ecosystem in your yard.

Why? Because your landscape matters and can help turn the tide for a healthier, more resilient future that a monoculture of lawn (mowed or unmowed) will never provide.

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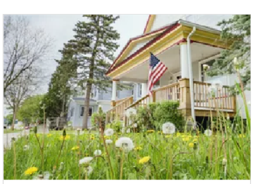
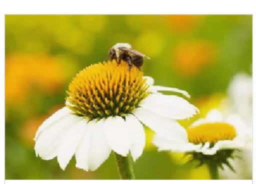


CARING FOR YOUR YARD

5 Ways to Participate in "No Mow May" and Help Bees This Spring

By Anne Readel



POLLINATORS

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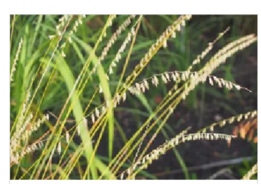

PLANT ENCYCLOPEDIA

How to Plant and Grow Sideoats Grama Grass

By Judy Nauseef

2022–2023

Evaluating the ByBlock plastic waste program for Wausau

Interdisciplinary Engineering 303: Applied Leadership in Engineering

UniverCity Year

BETTER • PLACES • TOGETHER

1. Executive Summary

ByFusion is a start-up company founded in 2017 with the goal of combating the plastic waste contamination that is becoming overwhelming in landfills and spilling into the ocean. They are currently marketing a new product to municipalities, recycling facilities, and waste management operations. This product is the subject of the following report: ByBlock. ByBlock is the resulting product of a proprietary process carried out by the machine being marketed. The output of the machine is a block designed to be able to replace cinder blocks in construction projects.The machine itself works by collecting plastic waste, shedding it into small pieces, distributing the shredded plastic into the ByBlock molds, and steam compressing the plastic to output the final block. This report is an analysis of the feasibility of implementing the production of ByBlock in Wausau using their local plastic waste. Wausau is not the first city to consider the possible benefits of including byBlock in their infrastructure. Tucson, Arizona started a pilot program for ByBlock in 2022.

This report will include an analysis of the material properties and structural integrity of the blocks, the chemical processes required to produce them, the economic impacts of the machine and surrounding infrastructure, as well as a general economic analysis of the plant and new product market. Finally the report will conclude with a final list of questions to consider in future analyses and a conclusion of the findings from the research done.

2. Introduction: ByFusion/ByBlock

ByFusion, a Los Angeles based startup, addresses the problem of non-recyclable plastic by using large machines called Blockers to transform plastic waste into building blocks known as ByBlocks. These ByBlocks, which come in various sizes, are made from nearly any type of plastic except styrofoam. ByFusion aims to combat the issue of plastic waste contaminating landfills and oceans while serving the construction industry's need for durable and low-cost materials (Puiu, 2022). Byfusion's Blockers create 22-pound blocks from recycled plastic without the need for concrete or mortar. The machines can process 90 tons of plastic per month and cost approximately $1.3 million (Caballero, 2021).

This innovative approach is a response to the challenges in U.S. recycling, which has been further strained by China's ban on imports of subpar materials. ByFusion has already recycled over 100 tons of plastic and plans to scale up to 100 million tons by 2030 (Puiu, 2022). While the cost of their large Blocker machines is a hurdle, the long-term benefits in mitigating the plastic waste problem make it a commendable solution. The company envisions placing Blocker machines in cities across the U.S., either within existing municipal waste facilities or at corporate sites looking to manage their waste effectively (Puiu, 2022).

ByFusion has started a pilot program in collaboration with the city of Tucson to pioneer zero-waste construction using recycled plastic using their ByBlocks. The initiative aligns with Tucson's zero-waste policy and aims to use locally sourced plastic for construction. According to Caballero, as of May 2021, Tucson was working to get the machine and hopes to start creating blocks for local projects in the near future. The ByBlocks will be used in projects like new restrooms and ramadas in public parks. Boise, Idaho is also exploring this technology, but Tucson hopes to be the first to implement zero-waste construction using these blocks. Residents of Tucson are encouraged to participate in the pilot program by recycling their plastic waste at a drop-off site (Caballero, 2021).

The material properties of the blocks will determine the optimal use. Standard ByBlock dimensions are approximately 16" width x 8" depth x 8" height. The blocks have undergone independent testing for compression, thermal, acoustic, fastener withdrawal and shear strength, flame spread, smoke density, structural integrity, thermal expansion, and environmental screening to meet building standards. They are designed with interlocking features and anchored with threaded rebar for stability (ByFusion, 2023). According to ByFusion in regards to ByBlock's fire resistance and buoyancy; ByBlock is a Class 5 product and may require a fire retardant in specific applications. It has Class B Flame Spread & Smoke Density with an applied fire retardant. ByBlock is also buoyant due to small air pockets within the shredded plastic (2023).

ByBlock also has advantages when it comes to the strength of the block. Fasteners in ByBlock have high withdrawal and shear strength (ByFusion, 2023). ByFusion claims that ByBlock does not crack or crumble like concrete blocks, reducing material waste. It doesn't require specialized skills, curing time, or binding agents, reducing project cost by approximately 54% and installation time by approximately 65% compared to concrete blocks. In addition, it offers thermal and sound insulation properties. ByBlocks can be cut using standard tools, so additional tool purchases wouldn't be necessary (ByFusion, 2023).

ByFusion explains that ByBlock can be painted with a plastic primer for proper adhesion. ByBlock is compliant with CA Section 01350, GREENGUARD, and GREENGUARD GOLD criteria for indoor air quality. It can also contribute LEED credits to building projects, helping with environmental standards (ByFusion, 2023).

If needed, ByFusion can produce custom-sized ByBlocks for various applications. ByBlock is not intended to be exposed to the elements without an exterior covering to protect it from weather, UV, and environmental degradation. Roughly handled debris can be collected and sent back to ByFusion for recycling (ByFusion, 2023).

3. Material Competency and Structural Analysis

Table 1: Material Competency Values

	ByBlock	Concrete Cinder Block	Mortar
Compressive Strength (psi)	408 psi	1900 psi	305 - 1800 psi
Modulus of Elasticity (psi)	2148	14000 - 41000	—

Note: The material properties of ByBlock are from a ByFusion Global Inc. pamphlet, also cited below. The material properties of concrete cinder blocks are from . The compressive strength of mortar is from ASCE Journal of Materials in Civil Engineering, Volume 27, Number 9.

The material comparison between plastic and concrete is not a direct comparison. For the purpose of this report, the maximum compressive load and the modulus elasticity will be the focus of any material analysis. When plastic and concrete are loaded compressively, there are minute deformations that are elastic, meaning if the load was removed the material would return to its original shape and internal stress, and plastic deformations. Plastic deformations are the cracks and bending that are permanent and lead to material failure. The comparison between the maximum compressive load and the modulus of elasticity demonstrate the material differences that limit the use of cinder blocks' and ByBlocks' interchangeability. For small projects such as park benches or coffee tables this discrepancy is less important as the pieces would not be loaded to their maximum strength (ByFusion Global Inc.).

The material discrepancies become more relevant when used as a structural member in a project such as a structural wall. In a cinderblock wall, the strength is from a combination of the concrete cinder block and the mortar that binds them together. The mortar, being the weaker of the two materials, is the first to fail but the strength of the concrete provides significant resistance to loads even as the mortar chips away. ByBlock is designed to slot together to alleviate the requirement of mortar. The maximum load ByBlock can withstand in axial compression is comparable to that of mortar but not concrete. The simple drawing in FIGURE # shows the reactive forces resulting from a wind force against a ByBlock wall. As there is no mortar and therefore only the self weight of the blocks keep them in contact with each other, the four steel bars provide stability against tension forces. The blocks take the brunt of the compressive forces. A wind force blowing from the right of a wall would create a tensile reactive force over the right side of the wall and a compressive reactive force over the left side of the wall. Most elastic and permanent deformations to the block would occur because of this compressive force. The most stable configuration would have all four bars as shown in FIGURE # but to keep construction material costs and time requirements low, most projects pictured in articles have a single rod through the middle of either indent of the block which would increase the magnitude of the compressive force felt over the left side of each ByBlock. This compressive force is what would require a structural engineer to approve the use of ByBlock in any building, especially if it is used past the maximum recommended height of eight feet provided by ByFusion.

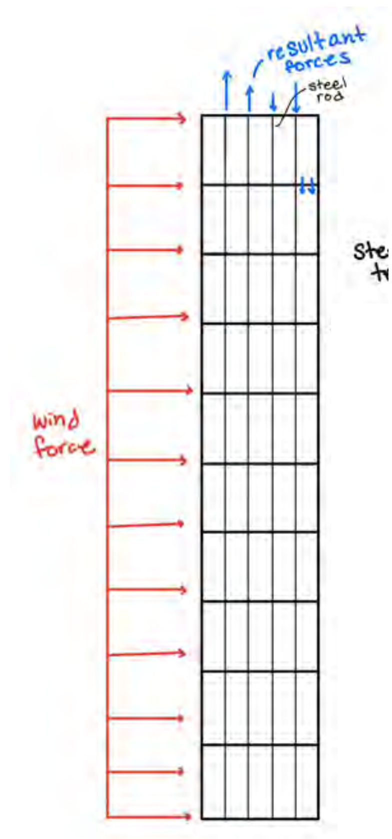

Figure 1: Example drawing of internal forces resulting from an applied wind force

4. Chemical Analysis

The evaluation of ByFusion's recycling technology requires a comprehensive comparison with well-established plastic recycling methods, specifically mechanical and chemical recycling. Chemical recycling entails the transformation of polymeric waste into secondary raw materials, reducing dependence on virgin fossil resources. This process alters the structure of polymeric waste, converting it into chemical building blocks (monomers) which can be usable in subsequent chemical processes (Meerschman, 2023). In contrast, mechanical recycling processes plastic waste into secondary raw materials or products without substantial change to the material's chemical structure. This method involves collection, sorting, washing, and grinding, with steps ordered based on waste origin and composition (Ragaert et al., 2017). Unlike chemical recycling, mechanical recycling operates at the polymer level, without the ability to break down plastics into monomers.

Mechanical recycling, while advantageous, presents notable challenges. The complexity arises from the presence of mixed and contaminated plastic waste streams, creating difficulties in both sorting and recycling processes. The existence of different grades of the same polymer exacerbates material contamination, posing a significant obstacle to the production of high-quality recycled products. Compounding these issues are the constraints associated with mixed plastic waste, grade contamination, and property variations, which collectively limit the market application of recycled materials. Additionally, plastic waste is susceptible to absorbing persistent organic pollutants (POPs) during use or within the waste stream. The intricate task of sorting and separating multi-layer materials, particularly prevalent in packaging, adds another layer of complexity. Furthermore, the recycling of certain materials, such as PET (Polyethylene Terephthalate), is constrained by polymer degradation, including thermal-mechanical degradation, resulting in a limited number of viable cycles. This degradation contributes to quality loss and produces lower-grade polymers (Vollmer et al., 2020).

ByFusion's technology, which is considered a mechanical recycling method, seems to have only solved the issues related to the sorting and washing processes associated with traditional mechanical recycling as it does not require any sorting. However, it is important to highlight that ByFusion's technology does not resolve the broader challenges associated with mechanical recycling, except for the specific aspects of sorting and washing. In fact, it introduces new challenges, particularly in relation to contamination.

Given that the identified disadvantages in mechanical recycling persist in ByFusion's recycling technology, it becomes very important to focus on the issue of polymer degradation given the end product to this process. In mechanical recycling processes, the molecular mass of polymers decreases (Schyns & Shaver, 2020), making chain lengthening processes very important to prevent brittleness and weakness of the final product. This is particularly significant for ByFusion's end product – construction blocks. Notably, ByFusion's technology does not address the degradation issue, which is pivotal for maintaining the strength and integrity of the blocks over time.

Overall, while ByFusion has the potential to improve the process of sorting and washing of mixed materials, it falls short in addressing broader mechanical recycling challenges and polymer degradation. Recognizing these limitations, it becomes evident that ByFusion's technology is not feasible in the broader context of plastic recycling methods. Additionally, the end product, the building blocks, may prove unsuitable as they undergo degradation, resulting in weaker structural integrity compared to the original plastic product.

5. Environmental Analysis

In recent years, the use of plastic as a building material has garnered significant attention, primarily due to its implications for environmental sustainability. This exploration is driven by the growing need to address the twin challenges of waste management and eco-friendly construction practices. Plastic, known for its versatility and durability, offers unique opportunities when integrated into the construction sector. It presents an innovative approach to repurposing waste while potentially enhancing the efficiency and longevity of building materials. However, this utilization also brings forth concerns regarding plastic's environmental impact, particularly its non-biodegradability and the reliance on non-renewable petroleum-based resources for its production. This research aims to provide a comprehensive overview of plastic as a building material, examining its environmental footprint, the potential for recycling and reuse in construction, and the broader implications for sustainable development in the building industry.

Plastic, while extensively used in modern home construction for its advantageous properties, is not employed as a primary material for structural components due to several limitations (Baird, 2014). The use of plastic in home construction is multifaceted, leveraging its water resistance, corrosion resistance, electrical insulation, and durability. Common applications include sewage pipes made of PVC, water supply lines from materials like PEX, fuel supply lines, electrical conduits, insulating coatings on wires, housewrap, thermal insulation, roof underlayment, electrical boxes, wall plates, exterior siding (often vinyl shaped to resemble wood), kitchen and bathroom flooring (like vinyl or Formica), countertops, and frames for doors and windows. Additionally, plastic serves as a key ingredient in composite building materials such as Glass Fiber Reinforced Polymer (GFRP) (Baird, 2014).

Nowadays, plastic as a building material has come to have a transformative role in the construction industry. It has the potential to bridge the gap between waste management and sustainability. The global plastic waste problem is staggering, with approximately 380 million tons produced annually, and only 9% being recycled. This scenario underscores the importance of a circular economy, which aims to minimize waste and maximize the recycling and reuse of materials (Utilities One, n.d.).

The construction industry is increasingly embracing recycled plastic, driven by its durability, cost-effectiveness, reduced environmental impact, flexibility, and versatility. This adoption is evident in various applications including building blocks and insulation materials, roofing, structural components, and outdoor furniture. Recycled plastic offers numerous advantages such as lightweight properties, weather resistance, and ease of fabrication in diverse shapes and sizes (Utilities One, n.d.).

However, when it comes to the structural elements of a house, such as beams, planks, and wall studs, pure plastic is not a viable option. This limitation arises primarily due to plastic's relative lack of strength compared to traditional construction materials like wood, metal, or brick. Plastic also tends to deform permanently under stress, a phenomenon known as creeping. Moreover, working with plastic – including nailing, drilling, and screwing – is more challenging than with wood. These structural drawbacks are significant when considering the stability and longevity of a building (Baird, 2014).

When looking at plastic as a building material, it is often fraught with significant disadvantages that raise environmental and sustainability concerns. One of the primary drawbacks is its non-biodegradability. Plastics do not decompose naturally, leading to their prolonged presence in the environment. This characteristic contributes to the accumulation of waste in landfills and oceans, posing a severe threat to marine life and ecosystems. The durability of plastic, especially in building applications, is also a point of contention. Compared to more robust materials like metal or wood, plastic is less durable, prone to breaking or cracking, which may necessitate frequent replacements and consequently lead to increased waste (Baird, 2014).

Another critical issue with plastic is its origin as a non-renewable resource. Derived primarily from petroleum, the production of plastic not only depletes these finite resources but also requires extensive energy, making it unsustainable in the long run. Furthermore, the process of manufacturing plastic is a significant source of pollution, releasing harmful chemicals into the air and water. This pollution contributes to environmental degradation and poses health risks to both humans and wildlife. Additionally, the recyclability of plastic is limited. While some types of plastic can be recycled, many cannot, leading to a culture of single-use products and exacerbating environmental pollution (EDUCBA, n.d.).

The disadvantages of using plastic as a building material are manifold. Its non-biodegradability, low durability, reliance on non-renewable resources, polluting production process, and limited recyclability pose significant environmental challenges. These factors highlight the need for more sustainable and eco-friendly alternatives in the construction industry, underlining the importance of reducing reliance on plastic to mitigate its long-term environmental impact (EDUCBA, n.d.).

To circumvent the associated limitations of plastic, the construction industry often turns to composite building materials that blend plastic with other substances. These composites can mitigate some of the weaknesses of pure plastic, leveraging its beneficial properties while enhancing strength and stability. As a result, many modern homes, although not constructed entirely of plastic, incorporate a substantial amount of it in their composition through these composite materials. This approach allows for the utilization of plastic's advantageous characteristics in home construction, while overcoming its limitations for structural applications (Baird, 2014).

There are several alternatives that could serve the same purpose that ByBlock is trying to achieve. These include fly ash concrete, an approach that involves using fly ash, a byproduct of coal combustion, in concrete block mixtures. Fly ash reduces CO_2 emissions, improves heat-insulating properties, and decreases maintenance requirements. Another alternative is watershed concrete blocks, which are made from fused soil and rock fragments, clay, and other minerals, using half the cement of traditional concrete blocks while being 30% heavier. Watershed blocks aim to make concrete block production more sustainable and recyclable. Concrete blocks have untapped potential for design and architectural purposes, and the industry is evolving toward greener alternatives to minimize environmental impact (Caballero, 2021).

The role of plastic in the construction industry embodies a complex interplay of innovation, functionality, and environmental stewardship. As this research has highlighted, plastic offers significant advantages as a building material, including its adaptability, cost-effectiveness, and potential for recycling. However, these benefits are counterbalanced by critical environmental concerns, such as its non-biodegradable nature, the pollution associated with its production, and the challenges of waste management. The industry's pivot towards recycled plastic and the development of eco-friendlier composites signal a positive shift towards sustainability. Yet, this transition must be navigated with a nuanced understanding of both the opportunities and challenges presented by plastic. Ultimately, the sustainable integration of plastic in construction hinges on continued innovation, responsible manufacturing practices, and a commitment to reducing the environmental impact of building materials. As the construction sector evolves, the conscientious use of plastic could play a pivotal role in shaping a more sustainable and environmentally responsible future.

6. Economic Analysis

The economic analysis in this report will be largely surface level because of the lack of concrete data. A more detailed analysis is provided by Yinong Ding in a separate document. Forming conclusions based on unreliable information results in inconclusive findings. ByBlock technology will require a substantial initial investment as well as investments of time and money building the required infrastructure to house the production. Paul Ploumis states that Tuscan paid $2.4 Million to set things up and $350,000 for the machine (Ploumis, 2023). Utilities, such as water and electricity, will add to the recurring costs of the machine. Also, processing of the recycled material and maintenance of the machinery will require a workforce to support the mechanical processes.

However, there are possible economic benefits of the investment. They largely depend on the type of deal Wausau makes with ByFusion. The costs of the infrastructure could vary based on the nature of the relationship between Wausau and ByFusion. For example, if Wausau co-invests in the machine and infrastructure with ByFusion, it would lower the initial investment and increase the incoming revenue streams in the long run. This can be accomplished by renting out the storage and production buildings and pursuing the possibility of selling the blocks back to ByFusion.

It is important to reiterate that an economic analysis for a recycling investment is seldom going to come out as being profitable. While there may not be a financial profit, the goal of ByBlock is to minimize the waste ending up in landfills, which can be seen as an environmental benefit to weigh against the financial cost. The specific details of a deal and values for setup costs and purchasing were estimated from ByFusion's website and published information from the Tucson pilot program. Using these values shown in *Table 2* and equivocating the price of ByBlocks to that of concrete cinder blocks, we can estimate the value of the revenue streams depicted in *Table 3*, *Table 4*, and *Table 5*. Each table does not include the utility or labor costs, but the conclusion would be similar to the numbers in the table.

Table 2: Given inputs for tables 3, 4, 5

IRR	10%
Cost of machine	350000
Cost of installation	2400000
Retail price per block	1.95
Tons of waste	24000
Capacity per year	98000

Table 3: Cost and Benefit analysis including the volume of plastic input

Year:	0	1	2	3	4	5
Nbr of blocks		24000	24000	24000	24000	24000
Fixed costs	-2750000					
Variable costs	Utilities and Labor					
Revenue		46800	46800	46800	46800	46800
Cumulative	-2750000	-2703200	-2656400	-2609600	-2562800	-2516000
With interest	-2500000	-2457454	-2414909	-2372363	-2329818	-2287272

Table 4: Cost and Benefit analysis accounting for the max capacity of a single machine

Year:	0	1	2	3	4	5
Nbr of blocks		98000	98000	98000	98000	98000
Fixed costs	-2750000					
Variable costs	Utilities and Labor					
Revenue		191100	191100	191100	191100	191100
Cumulative	-2750000	-2558900	-2367800	-2176700	-1985600	-1794500
With interest	-2500000	-2326272	-2152545	-1978818	-1805090	-1631363

Table 5: Continuous Cost and Benefit analysis introduced in Table 3

6	7	8	9	10	11	12	13	14	15
98000	98000	98000	98000	98000	98000	98000	98000	98000	98000
191100	191100	191100	191100	191100	191100	191100	191100	191100	191100
-1603400	-1412300	-1221200	-1030100	-839000	-647900	-456800	-265700	-74600	116500
-1457636	-1283909	-1110181	-936454	-762727	-589000	-415272	-241545	-67818	105909

As seen in the first example, the limiting factor was the lack of plastic ready to be utilized. This does not tell us a lot, but it does tell that there are many variables that can shift a little and have big effects on the final output. Emphasizing the importance of data we can trust.

The retail price per block should increase in order to cover the utilities, however it is important to note that the price needs to be in line with what the customer would be willing to pay for it. Small price changes in the block for bigger projects result in very big shifts in total costs which would really shift the demand downward.

7. Further Questions & How to Move Forward

Due to the lack of information available, it is impossible to make a final decision on whether or not ByBlock would be a viable option for the city of Wausau. To do so more information from ByFusion would be needed; some information that ByFusion does not yet have at this stage of development. Below is a compiled list of questions that must be answered before this product could be implemented.

Questions regarding ByBlock specific plant logistics include:

- How much energy is required to run the machine (including heating water)?
- How much energy is required to install?
- What is the cost of installation?
- What are the qualification requirements of laborers in the plant?
- How often does the machine require maintenance, and what are the maintenance costs?
- What is the estimated lifetime of the machine?

Questions regarding the ByBlock product:

- How environmentally friendly are the blocks in building processes?
- How contaminated is the water afterwards?
- How much water is used?
- What is the resale price of ByBlock?

Additional Questions:

- Are additional machines required to build with the blocks?
- Are additional machines required to coat the blocks being used outdoors?

Some of these questions can be reformatted to make them more general and answerable. Since the data on ByBlock is unavailable, industry standards and requirements in the field of plastic molding and forming were used instead. These questions are not specific to ByBlock, but rather intended to be a reference point for the city of Wausau to compare to if they do eventually get more data on this product. The following questions have been researched and general guidelines are provided:

How much does it cost to build and run an average recycling plant?

A typical recycling plant will require a purchase of land to build the plant, which can range from $120,000-$1,000,000. It will also require a utilities cost which can range from $90,000- $300,000, but is very dependent on location and size of the plant. Machines required for the recycling process usually cost $170,000-$2,000,000. The price of Blockers is approximately $350,000, which falls within the given range. Finally, labor will cost somewhere from $140,000-$390,000 for the first year for an average recycling plant. All in all, a typical recycling plant will cost somewhere in the range of $600,000 to $4,000,000 to get operational (Ajaero, 2023).

What are the qualification requirements of laborers in a typical recycling plant?

Qualification requirements of recycling plant workers will vary widely depending on position, however, the basic requirements typically include: a high school diploma or equivalent, basic knowledge of recyclable materials and their handling requirements, familiarity with local recycling regulations and guidelines, a valid driver's license, and ability to work in various weather conditions and adapt to the physical demands of the job (Manatal, 2023).

What contaminants are of concern in plastic manufacturing and recycling?

In general, recycled plastics can be very harmful and contain toxic chemicals, "...such as toxic flame retardants, benzene and other carcinogens, environmental pollutants including brominated and chlorinated dioxins, and numerous endocrine disruptors…" (Gayle, 2023).

What contamination is allowed in groundwater and surface water in the industry?

According to the EPA, a plastic processing plant such as a ByBlock plant would fall into the plastics molding and forming (PM&F) industry. The PM&F regulation covers biochemical oxygen demand (BOD5), oil and grease, total suspended solids (TSS), and pH. The EPA splits its regulations into four subcategories: Process Water, Contact Cooling and Heating Water, Cleaning Water, and Finishing Water. These four subcategories have different allowed pollutant loads ().

According to the Code of Federal Regulations: "'Process water' is any raw, service, recycled, or reused water that contacts the plastic product or contacts shaping equipment surfaces such as molds and mandrels that are, or have been, in contact with the plastic product," (National Archives). Contact cooling and heating water refers to water used for heat transfer. Cleaning water is simply water used to clean a plastic product or to clean the surfaces of manufacturing equipment. Finally, "'Finishing water' is processed water used to remove waste plastic material generated during a finishing process or to lubricate a plastic product during a finishing process," (National Archives). The EPA only provides regulation for the last three subcategories. For all three of these, pH must remain within the range of 6.0 to 9.0 at all times. For contact cooling and heating water, the EPA has maximum daily loads of 26 mg/L of BOD5, 29 mg/L of oil and grease, and 19 mg/L for TSS. For cleaning water, the EPA requires that the maximum for any one day be 49 mg/L of BOD5, 71 mg/L of oil and grease, and 117 mg/L for TSS. However, they also require that the maximum monthly average be under 22 mg/L of BOD5, 17 mg/L of oil and grease, and 36 mg/L for TSS. Finally, for finishing water, the EPA has a maximum for any one day of 130 mg/L for TSS, and a maximum monthly average of 37 mg/L for TSS (National Archives).

What permits are required to open a plant such as this?

In Wisconsin, A DNR license is required for a solid waste landfill. A ByBlock processing plant would most likely fall under the solid waste processing facilities category. A DNR solid waste staff member would need to be contacted to set up an initial site inspection. This inspection determines any possible environmental impacts for the proposed area. After the initial site inspection, there will need to be another review done on the initial inspection, a review of the plan of operation for the facility, and finally, the license will be issued (Wisconsin DNR, 2023).

What are the safety concerns associated with a recycling plant?

Finally, there are quite a few safety concerns with recycling plants. These include hazards such as: heavy and moving machinery or vehicles, biohazards or sharp materials put in the wrong bins, repetitive motions that can lead to stress injuries, and respiratory hazards from airborne contaminants. There are many ways to reduce these hazards if the recycling plant is run efficiently and all workers are given sufficient safety training (Plastics Machinery & Manufacturing, 2022).

Many attempts were made to contact anyone in Tucson who worked on or had data about the ByBlock pilot program, but all were unsuccessful. In order to move forward in this process, Wausau would need to somehow get in contact with someone willing to share data. Our team has exhausted all of our means of getting in contact with anyone, but it's possible that someone with more experience or authority might have an easier time. If someone is able to get data from Tucson on the details of their pilot program, one could adjust the data to the size of Wausau to project whether this technology would be feasible on a smaller scale.

8. Conclusion

In summary, the team found that at the current stage of development, it would be unwise to implement ByBlock in the city of Wausau, primarily due to the lack of information and research done on the product. The findings of this report do not definitively rule out ByBlock as a feasible addition to Wasusau's infrastructure, but instead find that it would require more input from officials in Wausau or the recycling industry. Difficulties contacting sources and consultants barred significant progress but could be circumvented by an individual or office with more resources or connections. With regards to the environmental aspects of plastic as a building material, it has its numerous advantages and disadvantages. However, its limitations prevent it from being applied in a large enough scale for it to be definitively and safely used.

9. References

Ajaero, T. M. (2023, September 20). How Much Does it Cost to Build / Open a Recycling Plant?. ProfitableVenture. https://www.profitableventure.com/cost-build-recycling-plant/

Annick Meerschman, A. (2023, October 20). Chemical Recycling: Making Plastics Circular. cefic.org. https://cefic.org/a-solution-provider-for-sustainability/chemical-recycling-making-plastics-circular/

Baird, C. (2014). Why is plastic not used in home construction? Retrieved from https://www.wtamu.edu/~cbaird/sq/2014/02/26/why-is-plastic-not-used-in-home-construction/#:~:text=First%20of%20all%2C%20plastic%20is,to%20form%20composite%20building%20materials.

ByFusion. (2023, June 5). ByBlock FAQ. ByFusion Global Inc. https://www.byfusion.com/faq-byblock/

Caballero, L. (2021, May 8). City of Tucson Could be the First to Use Zero Waste Construction. KGUN 9 Tucson News. https://www.kgun9.com/news/local-news/city-of-tucson-could-be-the-first-to-use-zero-waste-construction

EDUCBA. (n.d.). Advantages and Disadvantages of Plastic. Retrieved from https://www.educba.com/advantages-and-disadvantages-of-plastic/

Fortes, E. S., Parsekian, G. A., & Fonseca, F. S. (2014). Relationship between the compressive strength of concrete masonry and the compressive strength of concrete masonry units. Journal of Materials in Civil Engineering, 27(9). https://doi.org/10.1061/(asce)mt.1943-5533.0001204

Gayle, D. (2023, May 24). Recycled Plastic can be More Toxic and is No Fix for Pollution, Greenpeace Warns. The Guardian.

https://www.theguardian.com/environment/2023/may/24/recycled-plastic-more-toxic-no-fix-pollution-greenpeace-warns

Manatal. (2023). Recycling Worker Job Description Template for Recruiters. https://www.manatal.com/job-description/recycling-worker-job-description

National Archives. (n.d.). Code of Federal Regulations. https://www.ecfr.gov/current/title-40/chapter-I/subchapter-N/part-463

Plastics Machinery & Manufacturing. (2022, August 22). How to Prevent Illness, Injury in Recycling Operations. https://www.plasticsmachinerymanufacturing.com/recycling/article/21277461/how-to-prevent-illness-injury-in-recycling-operations

Ploumis, P. (2023, May 24). *How do you recycle plastic waste? Tucson is working to turn it into building blocks*. Recycling Centers Finder, How To Recycle, Scrap Metal Prices. https://www.recyclingmonster.com/article/how-do-you-recycle-plastic-waste-tucson-is-working-to-turn-it-into-building-blocks/2705

Puiu, T. (2022, January 21). Startup Turns Non-Recyclable Plastic into Building Blocks. ZME Science. https://www.zmescience.com/science/news-science/startup-turns-non-recyclable-plastic-into-building-blocks/

Ragaert, K., Delva, L., & Van Geem, K. (2017). Mechanical and chemical recycling of solid plastic waste. Waste Management, 69, 24–58. https://doi.org/10.1016/j.wasman.2017.07.044

Schyns, Z. O., & Shaver, M. P. (2020). Mechanical recycling of Packaging Plastics: A Review. Macromolecular Rapid Communications, 42(3). https://doi.org/10.1002/marc.202000415

Vollmer, I., Jenks, M. J., Roelands, M. C., White, R. J., van Harmelen, T., de Wild, P., van der Laan, G. P., Meirer, F., Keurentjes, J. T., & Weckhuysen, B. M. (2020). Beyond Mechanical Recycling: Giving new life to plastic waste. Angewandte Chemie International Edition, 59(36), 15402–15423. https://doi.org/10.1002/anie.201915651

Wisconsin DNR. (2023). Solid Waste Management in Wisconsin. https://dnr.wisconsin.gov/topic/Waste/Solid.html

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UniverCity Year is a three-phase partnership between UW-Madison and communities in Wisconsin. The concept is simple. The community partner identifies projects that would benefit from UW-Madison expertise. Faculty from across the university incorporate these projects into their courses, and UniverCity Year staff provide administrative support to ensure the collaboration's success. The results are powerful. Partners receive big ideas and feasible recommendations that spark momentum towards a more sustainable, livable, and resilient future.

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608-890-0330
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Cost Benefit Analysis Report of Wausau ByBlock Project

Yinong Ding

December 2023

Project Proposal

Plastic, an epochal human invention, is now emerging as an environmental challenge. According to the data provided by the UN Environment Program, an annual discharge of 19 to 23 million tons of plastic waste clogs ecosystems, and equivalent to a volume commensurate with 2000 fully loaded garbage trucks. The indiscriminate disposal of plastic poses a threat to global water bodies, such as oceans, rivers, and lakes at risk of congestion.

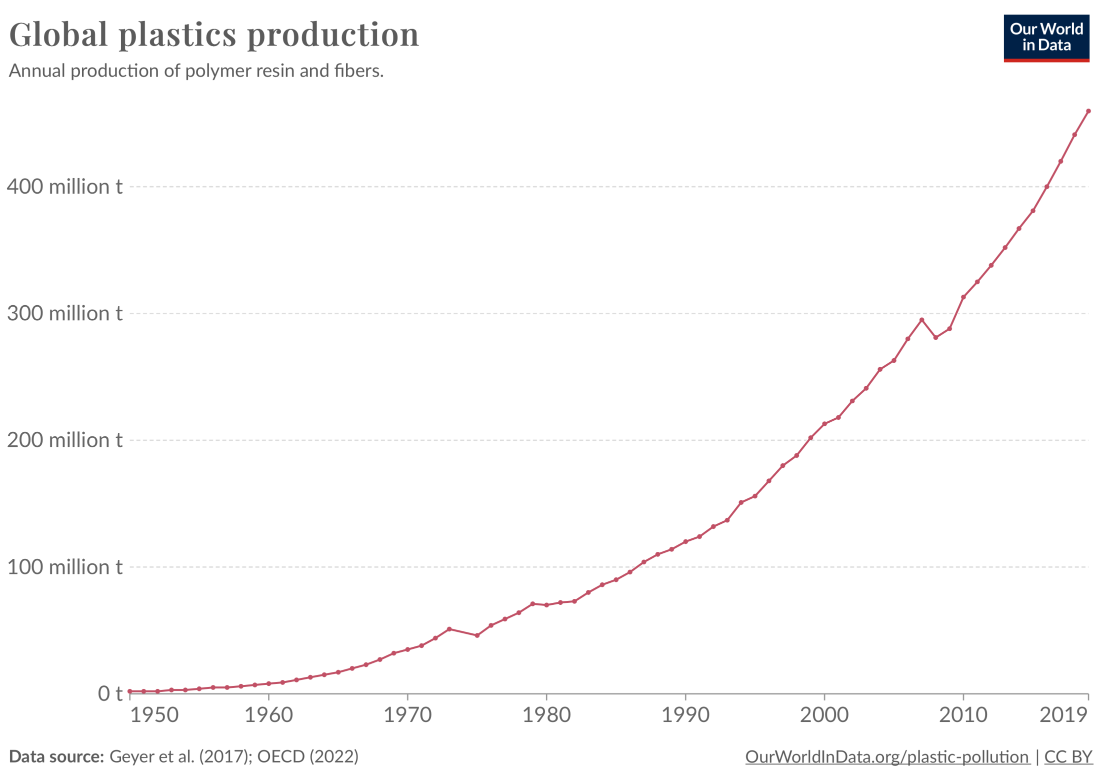

Figure 1: global-plastics-production,Data Source: Geyer et al. (2017); OECD (2022)

Figure 1 is the line chart shows global plastic production. From the source of Our World in Data, during past 70 years, the annual production of plastics has increased nearly 230 times, and global plastic production reaches 459 million tons. If the current waste deposal ratio persists, predictions suggest that by the year 2040, the Earth could accumulate a staggering 710 million tons of solid plastic waste.

Plastic pollution not only have damages upon animal habitats and natural processes, but also directly impacts the livelihoods of millions of human beings. It is noteworthy that among the seven types of plastic, only two are recyclable. Certain plastics, such as polyvinyl chloride (PVC), can pose hazards and generate toxic masses under high temperatures, even at very low concentrations (Groh et al., 2019).

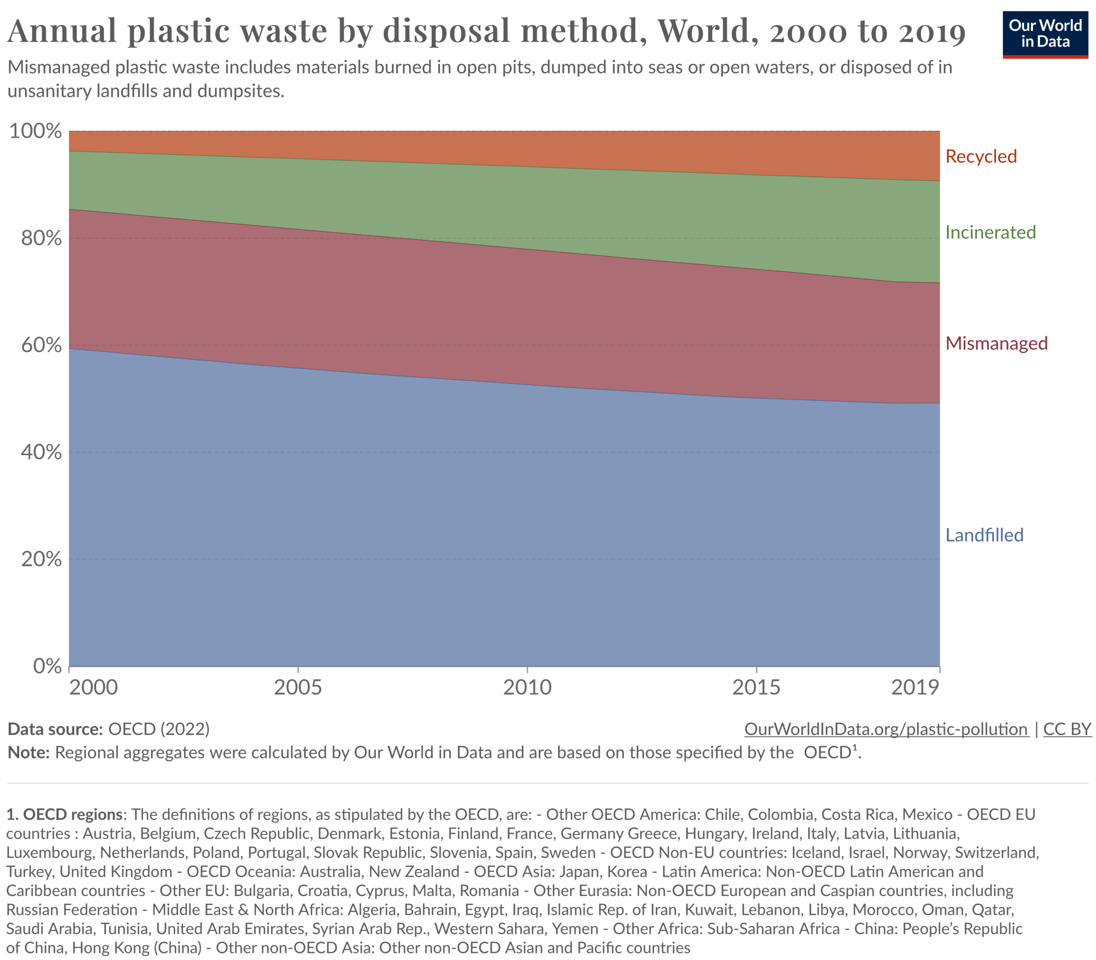

Figure 2: Waste Management Methodd, Data Source: OECD (2022)

From the figure above, it is clear that despite these safety concerns, the prevailing methods for plastic management continue to be land-filling. Up to 40 percent of plastic waste is mismanaged or using combusting methods, potentially giving rise to issues related to food safety and social well-being.

This urgency makes it significant of developing recycling methods to address the challenges posed by plastic pollution. A noteworthy initiative in this regard is a startup company located in Los Angeles, known as ByFusion. Established in 2017, the company has devised a strategy to address the recycling of non-recyclable plastic types. Leveraging the Blocker System machine, virtually all categories of non-recyclable plastics, with the exception of dense foam, can be transformed into 22-pound blocks, referred to as "ByBlock" by ByFusion (ByBlock Product Data Sheet,2022).

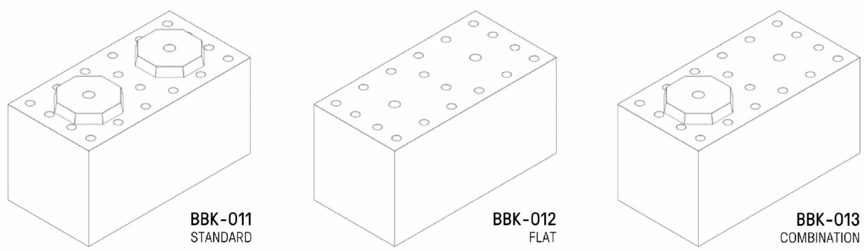

Figure 3: ByBlock Schematic diagram, Source: ByFusion Global Inc (2022)

Theoretically, ByBlocks are structurally equivalence to a hollow-core concrete cinder block, possessing comparable strength. As illustrated in Figure 3, these blocks, fabricated from non-recyclable plastics, can be connected using inner rods to construct various structures such as retaining walls, sound walls, sheds, privacy fencing, terracing and landscaping features, accent walls, and furniture. Notably, ByBlocks offer a solution to the challenges posed by conventional recycling methods, specifically the pre-sorting and pre-washing requirements. The Blocker System machine employed by ByFusion circumvents these processes by steaming and compressing the raw plastic material, enabling the rapid shredding and fusion of plastic into solid blocks within few minutes. This innovative approach obviates the need for specialized labor, and post-production contaminant levels are maintained at a very low level.

ByFusion is actively seeking collaboration with the government of Wausau to establish a new facility in this region. The purpose of this report is to assist the Wausau government analyzing the costs and benefits associated with partnering with ByFusion. The aim is to determine the financial feasibility of initiating the ByBlock project in the area.

Data Description

0.1 Wausau Demography

As Wausau contemplates a potential collaboration with ByFusion, understanding the city's demographic and economic landscape becomes crucial in evaluating the feasibility and impact of the potential partnership.

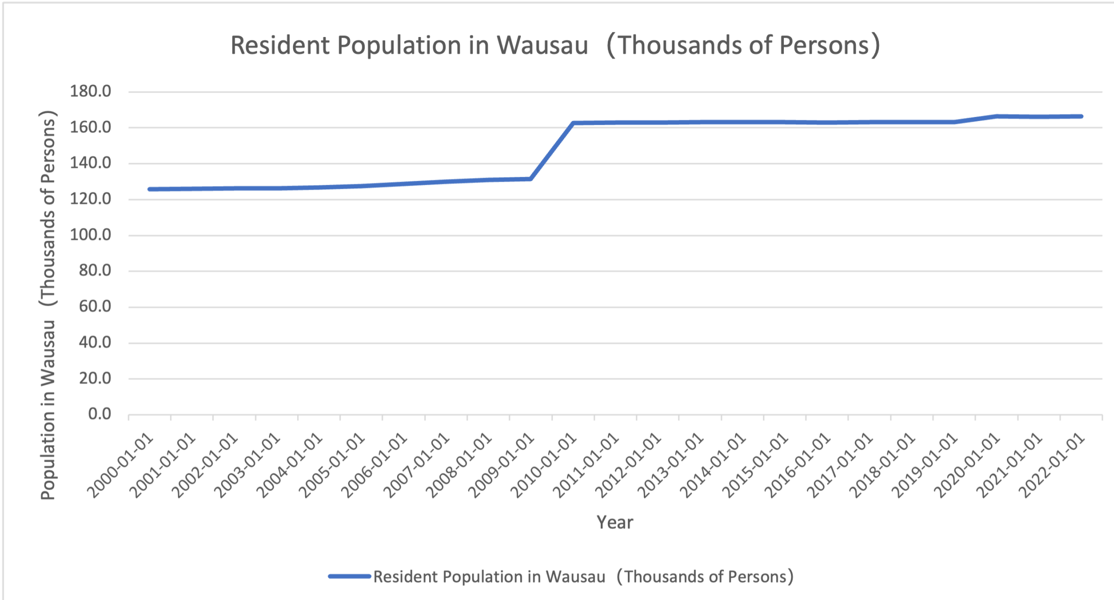

Figure 4: Resident Population in Wausau, Data Source: FRED

Setting along the Wisconsin River, the city of Wausau locates at central Wisconsin, with the rich resources from the Rib Mountain. The city size is relatively small but owns a vibrant community with a diverse economic landscape. Its resident population keeps a stable trend. The city reaches a maximum of 166,476 residents in 2020, averaging around 148,000 individuals.

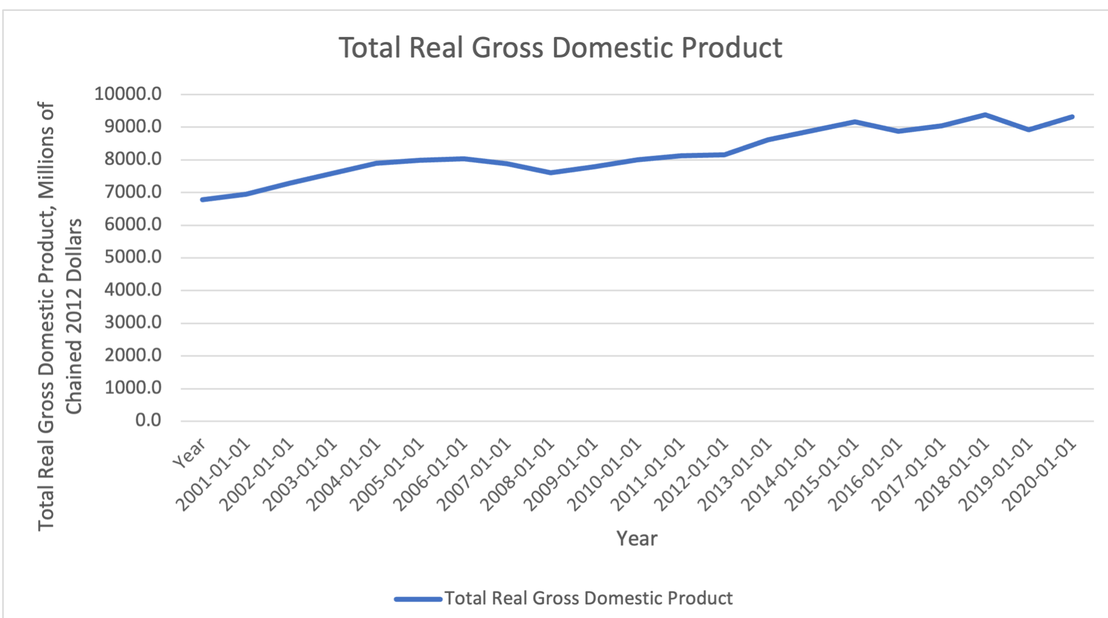

Figure 5: Total Real GDP in Wausau, Data Source: FRED

Figure 5 reflects Wausau's economic vitality. Generally, Total Real Gross Domestic Product (GDP) keeps increasing steadily, the maximum of 9,386 million dollars was reached in 2019, and maintaining an average of 8,205.63 million dollars.

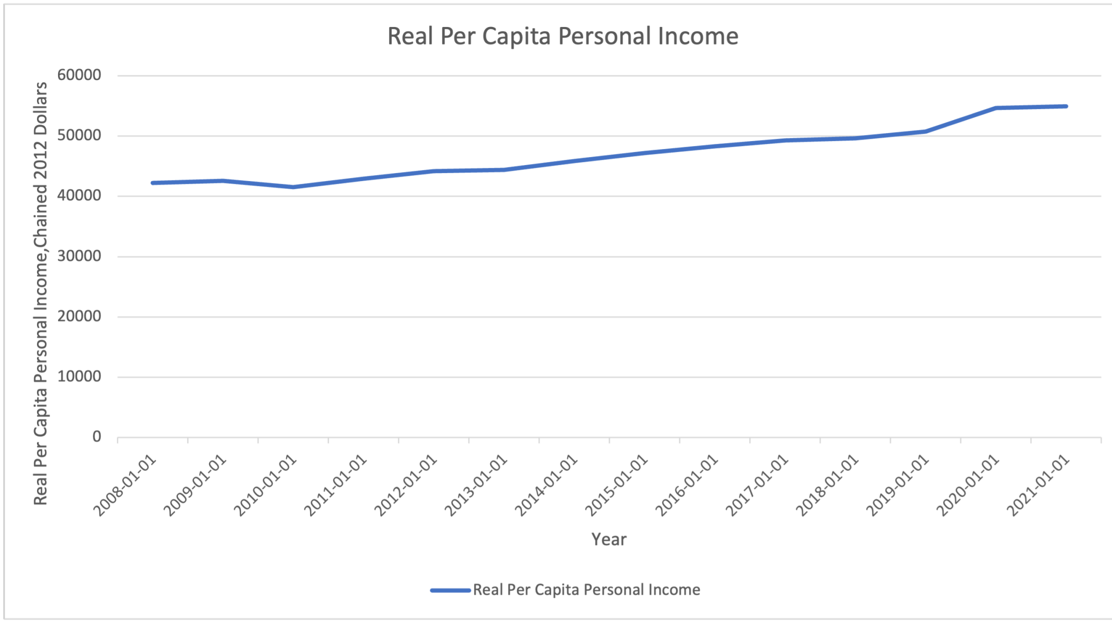

Figure 6: Real Per Capita Personal Income in Wausau, Data Source: FRED

lumber industry is historically rooted in Wausau, the city has a complete industrial park and is seeking to foster industries such as insurance, manufacturing, and healthcare. What's noteworthy is the city's commitment to individual prosperity. in Figure 6, exemplified by an Annual Real Per Capita Personal Income ranging from a maximum of $54,955 to a minimum of $46,530, with an average of $47,028.

0.2 Cost and Benefit

An in-depth analysis of costs and benefits was emerges to evaluate the potential collaboration between the city of Wausau and ByFusion. The costs associated with this venture include several facets. Firstly, buying the ownership of the Blocker System machine could be seen as a financial investment borne by the government. Additionally, the installation and construction of the facility should be a joint responsibility. In this case, the construction fee is shared by both the government and ByFusion, both facility fee and construction fee entail substantial initial investment. The after-production treatment, which might be a part of the construction, is also a shared cost between the government and the company. Furthermore, to avoid the possibility of decoloring, the ByBlocks cannot be exposed to sunlight directly (ByBlock Product Data Sheet,2022). Considering the special characteristics of ByBlock, there will be a need for a storage facility for the ByBlocks, if they were to be sold by the government.

Another nuanced concern involves the potential long-term effects on human health arising from microplastic chemicals runoff (Karbalaei, S et al., 2018). The microplastic runoff, however, is a rather new study so it's hard to say for sure how important the long-term would be. Thus, in this report, ByBlocks will be considered as regular plastic and the microplastic runoff effect will not be further discussed but this effect may require meticulous attention and deeper exploration.

Conversely, benefits from this cooperation is anticipated. What's most stand out is the introduction of new job positions Jobs within both ByBlock production facilities and through ByFusion's theoretical plastic waste pick-up service not only addresses unemployment concerns, but also contributes to the overall economic vitality. If inviting this new facility manages unemployment rate, the community will earn benefits and corresponds to the Wausau government's expectation of industry transformation. With new job positions, there will create new tax revenues. The outcome of the collaboration is anticipated as the improvement of city's financial standing. Via the contract from the pilot cooperation program with Tucson, the company agreed that the government owns part of the blocks created locally (N. Ludden, 2023). Assuming Wuasau will have a similar contract, owning those blocks establishes a revenue stream for Wausau. Additionally, the utilization of government-owned industrial parks or transportation infrastructure by ByFusion, entailing rent payments, represents a mutually beneficial arrangement.In terms of ongoing financial dynamics, the company should cover the utilities fees, which further boosts the economic partnership.

In addition, spurred by the creation of new job positions, the collaboration is expected to enhance local purchasing and encourage recycling-related businesses.Moreover, the venture aligns with environmental stewardship goals, with the potential to reduce greenhouse gas emissions, an outcome that may yield economic benefits not only for the local government, but also for the entire state in the long run.

However, it is crucial to acknowledge the opportunity costs associated with diverting resources from existing recycling partnerships. This entails a careful consideration of the collaboration on current waste management ecosystem in Wausau. The comprehensive assessment of these costs and benefits is pivotal for the Wausau government to make informed decisions about the feasibility and desirability of partnering with ByFusion.

Wausau's collaboration with ByFusion holds direct impacts through the creation of job positions, tax revenue generation, and the establishment of a new revenue stream through the sale of ByBlocks. Indirectly, the cooperation may stimulate economic growth in related industries, enhance local purchasing for the reduced unemployment rate (Al-Maaded,. et al, 2012). Foster recycling-related businesses and contributing to social and economic development are also expedcted. The induced impacts include potential changes in community behavior and values, fostering a more environmentally conscious and sustainable ethos. Pointing out the comprehensive effects of the collaboration, aligning with both economic prosperity and environmental improvement will help the future decision making in Wausau.

Model and Methodology

0.3 WARM

To better anticipate the potential economic impact of ByFusion to Wausau, the Waste Reduction Model (WARM) was utilized. WARM is a tool developed by the U.S. Environmental Protection Agency (EPA), it provides estimates of greenhouse gas (GHG) emissions reductions, energy savings, labor hours, wages, and taxes associated with alternative end-of-life waste management decisions (U.S. EPA Office of Resource Conservation and Recovery, 2020). The model employs a life-cycle approach, comparing traditional methods such as landfilling and combustion to recycling practices, including source reduction, anaerobic digestion, and composting. It has built-in, embedded multipliers, facilitate a thorough evaluation of the impacts across diverse waste management scenarios. WARM's versatility extends to mixed material categories, allowing users to individually assess and implement source reduction strategies for specific components, and guide decision-makers to understanding the environmental benefits of adopting alternative waste management strategies.

0.4 Net Present Value

Due to the natural limitations of the WARM model, to better predict the viability and profitability of ByBlock project, Net Present Value (NPV) serves a significant role. NPV is employed to evaluate the present value of anticipated cash inflows and outflows within the a certain period of time. (Sudong Ye et al., 2000).

$$NPV = \sum_{t=0}^{T} \frac{CF_t}{(1+r)^t} - C_0 \tag{1}$$

(1) shows the basic form of NPV, where CF_t is the net cash inflow during the period t, r is the discount rate, T is the total number of periods, and C_0 is the initial investment cost. For the ByBlock project, the cash inflows could be generated by revenues of industrial park lending, selling ByBlocks, potential tax revenues, and other financial benefits resulting from the collaboration. On the other hand, cash outflows comes from initial investments in machinery, construction, storage, and after production treatment. The discount rate applied to these cash flows reflects the opportunity cost of capital and the required rate of return. A

positive NPV would signify that the ByBlock project is expected to generate value and is financially worthy investment for the Wausau government. Conversely, a negative NPV would signal potential financial risks or inadequate returns.

NPV, by accounting for the time value of money and providing a more comprehensive outlook on the project's financial implications than WARM model alone.

Results

0.5 WARM

By contacting the Wisconsin area recycling company, an average of 260 short tons of total plastic waste was give. WARM model provided comparative analysis of the baseline and recycling results for most common plastic materials, that are, HDPE, PET, PP and mixed plastics. The result reveals substantial reductions in annual greenhouse gas (GHG) emissions after employing recycling practices.

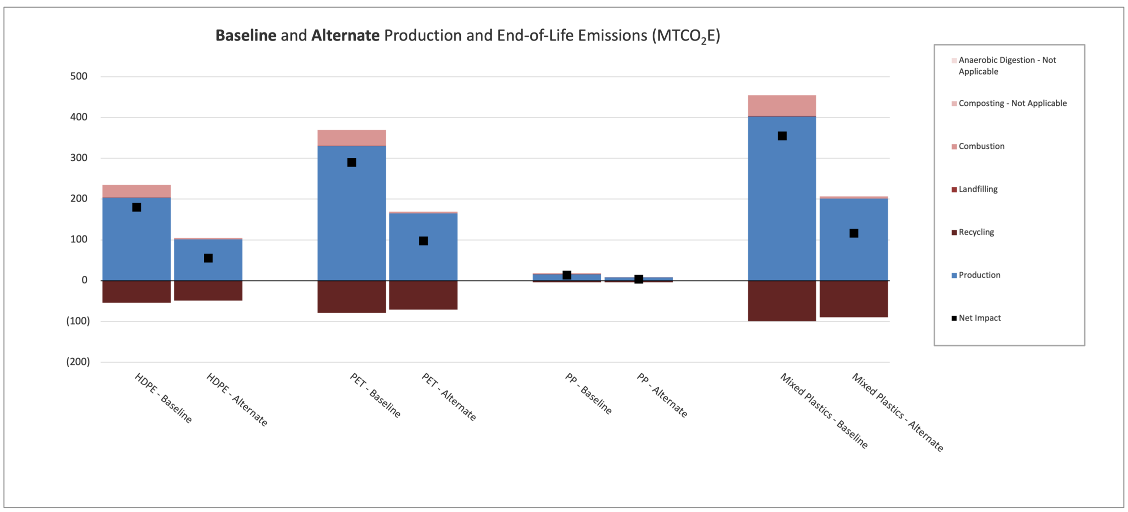

Figure 7: Annual GHG emission analysis

Plastic management significantly reduces GHG, the result is clearly shown in the graph above. The High-Density Polyethylene (HDPE), the baseline GHG emissions from production and end-of-life impacts total 180.19 MTCO2E, while recycling slashes this figure to 55.82 MTCO2E, marking a notable reduction of 124.37 MTCO2E. Similarly, Polyethylene Terephthalate (PET) drops from 290.63 MTCO2E to 98.13 MTCO2E through recycling, reflecting a substantial reduction of 192.50 MTCO2E. Polypropylene (PP) and Mixed Plastics follow suit, with recycling yielding reductions of 10.59 MTCO2E and 238.29 MTCO2E, respectively. Overall, the reduction in carbon dioxide across these plastic types aggregate to 564.74 short tons, underscoring the effectiveness of recycling effect on environmental footprint associated with plastic waste management.

Comparing between baseline plastic management and recycling-specific waste management, WARM gives a notable reduction in labor hours per year as well. Using HDPE, PET, PP, and Mixed Plastics as standard measurement, traditional waste management methods involve substantial labor efforts for tasks such as landfilling and combustion. However, when adopting the recycling methods, WARM demonstrate a shift towards greater efficiency.

Table 1: Comparison of Baseline and Recycling Labor Hours

Material	Tons Recycled (Baseline)	Tons Recycled (Recycling)	Total Labor Hours (Baseline)	Total Labor Hours (Recycling)
HDPE	71.50	64.35	4,484	3,957
PET	75.92	68.33	4,761	4,202
PP	5.20	4.68	326	288
Mixed Plastics	107.38	96.64	6,606	5,827

As the table 1 present, in HDPE, labor hours decrease from 4,484 hours to 3,957 hours, and for PET, the labor hour decrease from 4,761 to 4,202. The trend is consistent across Polypropylene (PP) and Mixed Plastics, in total for all types of plastics recycled, labor hours decreased 778 hours.

0.6 NPV

To utilize the result from WARM model and calculate Net Present Value (NPV), the discount rate is required. As a start-up, ByFusion don't have data related to the company's specific discount rate, so an average recycling industry discount rate provided by Alphaspread is adopted. Generally, the recycling industry have a discount rate of 7.12%Ȧnd according to the contract from Tucson, the government provided in total of $3,400,000 to build the facility (C. Migoya,2023) which will be considered as the project initial investment. By comparing the general industry construction duration, we assume that building the Blocker System takes three contract years. In this way, although from WARM model there are significant reduction of greenhouse gas emission, but the revenue brought by building the new facility will not start till the third year. Data from Ministry for the Environment stated that 1 short ton of greenhouse gas reduction brings $12 to 25$ economic benefit (Ministry for the Environment, 2007). So, start from the 3rd year of the project, in the NPV, the maximum of $25 is used to calculate the environment benefit.

Tax and wages are predicted based on labor hours calculated by WARM. According to website ZipRecruiter, the beginning three years of constructing period, average construction worker hourly salaries in Wausau are currently range $25.4, and the average hourly wage for recycling industry in Wausau is $17. Based on the national policy encouraging recycling industry and carbon neutral act, there is a different tax rate correspond to traditional industry and recycling industry. In Wisconsin, tax rate of normal industry is 17.53%, while recycling industry has a tax rate of 16.9% (J. CARON et al., 2018).

Table 2: First NPV Scenario

Year	**Cash Flows**
year0	(2,975,986.55)
year1	424,013.45
year2	424,013.45
year3	297,907.28
year4	297,907.28
year5	297,907.28
year6	297,907.28
year7	297,907.28
year8	297,907.28
year9	297,907.28
year10	297,907.28

In the initial scenario, with only the construction investment is $3,400,000, the NPV for a 10 year period is calculated as -$612,717.96, a negative value. Indicating that at a 7.00% discount rate, the project may not meet the required rate of return and could potentially result in a financial loss. And the project's present value of cash inflows is less than the initial investment. It is noteworthy that to if the government decided to take the risk and invest this project, the rent and utilities fees covered by ByFusion must cover the $612,717.96 financial loss.

From a report in pilot program in Tucson, the government chose to relocate the ByFusion facility address, and saved more than $1,000,000 initial investment (N Ludden, 2023). If the government of Wausau takes the experience by building the new facility next to existing landfill and utilize current gauge, it is reasonable to assume there will be a second scenario with less initial investment.

Table 3: Second NPV Scenario

Year	Cash Flows
year0	(1,575,986.55)
year1	424,013.45
year2	424,013.45
year3	297,907.28
year4	297,907.28
year5	297,907.28
year6	297,907.28
year7	297,907.28
year8	297,907.28
year9	297,907.28
year10	297,907.28

In the revised scenario, with a reduced initial construction investment of $2,000,000, presents a more favorable NPV trajectory. Starting at -$118,229.56 at starting point, the NPV steadily climbs. Although the NPV of beginning five years keeps being negative, but it reaches $695,693.25 in 10th year, implying that the project has the ability to reach the break-even point.

The contrast in NPV outcomes between the two scenarios underscores the pivotal impact of location selection on the financial viability of the project. The initial construction investment, driven by the chosen facility location, substantially influences the project's upfront costs and, consequently, the overall financial performance.

Conclusion and Limitation

While the Waste Reduction Model (WARM) and Net Present Value (NPV) analysis have provided valuable insights into the environmental and economic aspects of plastic waste management, it is crucial to be aware of their inherent limitations. WARM is a model relies on generalizations and assumptions. The smallest scale multiplier in the model is the state-level multiplier, the city of Wausau, however, is a small city comparing to Wisconsin State. Potentially WARM may overlook site-specific factors and variations in recycling practices. Moreover, the model's estimates are based on average values, limiting its precision. Based on WARM used manual, the model frame only include part of the indirect economic impacts (US EPA, 2022), impact such as local purchasing power relies on more accurate data and the access to detailed ByFusion multipliers.

On the other hand, the limitation to NPV that it is sensitive to factors such as discount rates and uncertainties in long-term projections. The use of average discount rates and existing prices from a different city affecting the accuracy of investment prediction. Since size of Wausau is smaller to the size of Tucson, and the fact that facility size in Wausau is not settled. The initial investment and discount rate may not be as large as in Tucson. Recognizing these limitations is essential for informed decision-making, prompting the need for complementary approaches and continued refinement of tools to address the complex challenges posed by plastic recycling.

To enhance estimation accuracy, first of all, more in-depth investigation to ByFusion data, and negotiation with the company about contract details (such as whether the block ownership) is essential. Machine learning algorithms with WARM could enable the model to adapt more specific regional characteristics and dynamic waste management practices. Additionally, incorporating real-time data collection methods, such as IoT devices, would provide more precise information for input parameters. For NPV, a sensitivity analysis considering various discount rates would mitigate uncertainties. So far, the nationwide recycling industry is still at initial stage, thus the accessible data and information is limited. The combining with not only economic impact, but also with wisdom from environmental science, and insights of industry future development could better support the investment decision making of the government.

Reference

UN Editors. (Date Unknown). "Plastic Pollution." UN. [Online] Available at: https://www.unep.org/plastic-pollution

Moore, Charles. (Dec. 2023). "Plastic Pollution." Encyclopedia Britannica. [Online] Available at: https://www.britannica.com/science/plastic-pollution. Accessed 20 December 2023.

Unknown. (2018). "Types of plastic: Learn what is plastic made of." A&C Plastics Inc. [Online] Available at: https://www.acplasticsinc.com/informationcenter/r/7-different-types-of-plastic-and-how-they-are-used

Groh, K. J., Backhaus, T., Carney-Almroth, B., Geueke, B., Inostroza, P. A., Lennquist, A., Leslie, H. A., Maffini, M., Slunge, D., Trasande, L., Warhurst, A. M., & Muncke, J. (2019). "Overview of known plastic packaging-associated chemicals and their hazards." Science of The Total Environment, 651, 3253–3268. https://doi.org/10.1016/j.scitotenv.2018.10.015

Hannah Ritchie, Veronika Samborska, and Max Roser (2023). "Plastic Pollution." Our World In Data. [Online] Available at: https://ourworldindata.org/plastic-pollution

ByFusion Editors. (Date Unknown). "ByBlock Product Data Sheet." [Online] Available at: https://www.byfusion.com

FRED Resources. [Online] Available at: https://fred.stlouisfed.org

United States Census Bureau. [Online] Available at: https://www.census.gov

Karbalaei, S., Hanachi, P., Walker, T.R. et al. (2018). "Occurrence, sources, human health impacts and mitigation of microplastic pollution." Environ Sci Pollut Res 25, 36046–36063. https://doi.org/10.1007/s11356-

018-3508-7

Nicole Ludden. (May 2023). “Firm that turns plastic trash into building blocks to set up operations in Tucson.” [Online] Available at: https://tucson.com/news/local/firm-that-turns-plastic-trash-into-building-blocks-to-set-up-operations-in-tucson/article-bccc6c80-ef64-11ed-93f4-1f66f8eb0f85.html

Al-Maaded, M., Madi, N.K., Kahraman, R. et al. (2012). ”An Overview of Solid Waste Management and Plastic Recycling in Qatar.” J Polym Environ 20, 186–194. https://doi.org/10.1007/s10924-011-0332-2

Maria Ljunggren Söderman. (2003). ”Including indirect environmental impacts in waste management planning.” ISSN 0921-3449. https://doi.org/10.1016/S0921-3449(02)00149-0.

Amelia L. Craighill, Jane C. Powell. (1996). ”Lifecycle assessment and economic evaluation of recycling: A case study.” ISSN 0921-3449. https://doi.org/10.1016/0921-3449(96)01105-6.

U.S. Environmental Protection Agency Office of Resource Conservation and Recovery. (2020). ”Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM) Management Practices Chapters.” [Online] Available at: https://www.epa.gov

Sudong Ye, Robert L. K. Tiong. (May 2000). ”NPV-at-Risk Method in Infrastructure Project Investment Evaluation.” Journal of Construction Engineering and Management. https://doi.org/10.1061/(ASCE)0733-9364(2000)126:3(227)

David Bogataj & Marija Bogataj (2019). ”NPV approach to material requirements planning theory – a 50-year review of these research achievements.” International Journal of Production Research, 57:15-16, 5137-5153. DOI: 10.1080/00207543.2018.1524167

Kyle Pomerleau, Elke Asen. (2019). ”Carbon Tax and Revenue Recycling: Revenue, Economic, and Distributional Implications.” taxfoundation.org. [Online] Available at: https://files.taxfoundation.org/20191105134952/Carbon-Tax-and-Revenue-Recycling-Revenue-Economic-and-Distributional-Implications-PDF.pdf

Clara Migoya. (2023). ”How do you recycle plastic waste? Tucson is working to turn it into building blocks.” azcentral. [Online] Available at: https://www

JUSTIN CARON, STUART M. COHEN, MAXWELL BROWN, and JOHN M. REILLY. (2018). ”EXPLORING THE IMPACTS OF A NATIONAL U.S. CO2 TAX AND REVENUE RECYCLING OPTIONS WITH A COUPLED ELECTRICITY-ECONOMY MODEL.” Climate Change Economics. https://doi.org/10.1142/S2010007

Alphaspread. [Online] Available at: https://www.alphaspread.com/security/nyse/wm/discount-rate

Ziprecruiter. [Online] Available at: https://www.ziprecruiter.com/Salaries/Construction-Worker-Salary–in-Wisconsin

Ministry for the Environment. (2007). ”Recycling: Cost Benefit Analysis.” COVEC. [Online] Available at: https://environment.govt.nz/assets/Publications/Files/recycling-cost-benefit-analysis-apr07.pdf