Recommendations for Sustainable Restrooms In Future Development at Western Michigan University

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Executive Summary

The goal of this project was to determine the best practices for a more sustainable restroom that could be implemented in future buildings on Western Michigan University’s campus. Currently WMU has varying degrees of dual flush toilets, paperless hand dryers and low flow faucets in buildings around campus. We propose that by following a set of sustainable standards for the construction of future restrooms on campus Western Michigan University can take one more step towards a more sustainable tomorrow. Through extensive research we suggest the implementation of, commercial composting toilets, sensory activated low flow faucets and Xelerator Eco high speed hand dryers in all future restrooms on Western Michigan’s campus.
**Introduction**

Western Michigan University is home to nearly 23,914 students and approximately 4,143 faculty and staff members. Most of these individuals spend more than half of their day on campus grounds. What do all of these people have in common? At some point during the day they will use a restroom. WMU has over 100 different buildings including 13 high traffic residence halls on the main campus in Kalamazoo Michigan. Each of these buildings home to several restrooms. What do all these restrooms have in common? They are mostly unsustainable and environmentally unfriendly. These differing restrooms have inefficient toilets that use too much water, lead crafted old leaking faucets wasting water, paper towel dispensers that contribute to the already large amount of paper products used on campus and bacteria ridden warm air hand dryers that successfully spread germs to students and staff alike. Not only are these inefficient appliances wasting water and spreading germs they are using unnecessary amounts of energy and costing Western Michigan thousands each year. In an effort to rectify this unsustainable environment we propose setting new sustainability standards for all future restrooms constructed and or renovated on Western Michigan University’s campus. We suggest that sustainable appliances be considered during the planning and construction process of any new buildings on campus.

Implementation of these sustainable restroom amenities will lower energy costs due to increased efficiency, save water lowering over all water consumption on campus and decrease the amount of garbage in the form of paper towels that come directly from WMU’S campus. Addition of these more sustainable practices is a onetime expense that would save money and natural resources in the future. This change would also aid in WMU’s efforts to maintain gold standard under the Sustainability Tracking and Rating System (STARS) by reducing water waste and energy loss. In addition to maintaining the gold standard creating a more sustainable restroom will also aid in reducing the spread of bacteria and germs giving rise to a healthier environment for students, staff and faculty. The cost of not implementing these changes are, continued water and energy waste, over use of natural resources like those used to make paper towels and overall lower sustainability standards on campus. We are not suggesting that current restrooms on campus be renovated completely, however we do propose that future buildings and renovations to existing buildings account for additions of more efficient toilets, lower flowing lead free faucets and more environmentally friendly methods for hand drying. Western Michigan University cannot afford to ignore this issue, for the health and wellness of its students and staff and for and overall more sustainable future.
Methodology and Data:

- Toilets:

A main way to reduce the impact that a restroom has on the environment is to reduce the amount of water consumption used by the toilet system. According to the Environmental Protection Agency a household of 4 uses 400 gallons of water a day on average and toilets make up one fourth of that consumption. At Western Michigan University the forms of water consumption use per building vary based on the building type. This means the residential/dormitory buildings will have a smaller percentage of its overall water usage being from toilets because the use of showers in those buildings. However in buildings that use are not residential or dormitory more of the overall consumption of water will be from the flushing of toilets. There are various toilet fixture options that will reduce the amount of water consumption from toilets. The three main forms of toilets the currently exist on the market are the composting toilet systems, the dual flush toilet fixtures, and the low flow toilets. All of these options have advantages and disadvantages that are analyzed in this section to determine the most sustainable option for a toilet in future buildings at Western Michigan University.

Current Practices at WMU:

Currently Western Michigan University has a many different types of toilet fixtures across its campus. These options are different types of dual flush along with low flow toilet fixtures. WMU follows the minimum standards as specified by the State of Michigan for efficient toilet practices. In an interview with Anand Sankey, The Director of maintenance at WMU, he stated that current practices are trending towards the dual flush toilet systems. With no real standard for best toilet fixture buildings such as Sangren Hall have installed almost exclusively dual flush toilets whereas older building have low flow fixtures that are added after restroom renovations or toilet fixture enhancement projects. With there being a variety of different forms of fixtures across campus it is clear to see that WMU has yet to decide on a best cost option to implement in both new buildings along with renovated buildings. The recommendations made in this paper will help to establish a most sustainable toilet option to be implemented into design standards for WMU’s development.

Example of Best Practice:

Currently the best practice for less waste in a toilet system is at the Bullitt Center in Seattle Washington. Here is the first and currently only six story composting toilet system. This composting toilet system is completely waterless and works by having a system of vertical pipes that deposits the waste into large Phoenix Composting Systems composting bins. The Bullitt Center has ten composting bins in the basement of it building where the solid and liquid waste is combined with wood chips and mixed regularly. As the decomposition process takes place the particles reduce in size and naturally filter down through the compost. Air needed for the compost process comes from the toilets themselves and is drawn through the waterless piping system. When this waste is decomposing it is important for the amount of liquid to be closely monitored to ensure that the adequate amount of air is within the system. The liquid waste becomes a leachate and must be spread throughout all of the composting storage tanks and any excess liquid is pumped into a reserve leachate storage tank. Removing the excess leachate allows for the system to only be an aerobic process and removes to risk of producing dangerous gases and odors that would typically occur. All excess leachate is taken to a liquid waste facility where it is used in a bird sanctuary.
Additional biosoild waste from the compost is mixed with sawdust and made into a fertilizer. The Bullitt Center estimates that it will take two of more years before they will have to empty the composting system.

Using this composting system allows for all of the human waste to be recycled and used in a different sustainable way. Creating fertilizer from the composted waste allows for a zero waste system in which every aspect of the process results in an completely usable organic material. This composting toilet system is clearly the best practice for restroom sustainability because there is no wasted material nor does there need to be a connection to a sewage treatment facility. All toilet systems that uses water in an urbanized area must be connected to so form of sewage treatment facility. Sewage is treated through a process that creates toxic chemicals and allows for a potential of these chemicals damaging fresh water reserves. According to the EPA “Chlorine is fed into the water to kill pathogenic bacteria, and to reduce odor. Done properly, chlorination will kill more than 99 percent of the harmful bacteria in an effluent. Some municipalities now manufacture chlorine solution on site to avoid transporting and storing large amounts of chlorine, sometimes in a gaseous form. Many states now require the removal of excess chlorine before discharge to surface waters by a process called dechlorination. Alternatives to chlorine disinfection, such as ultraviolet light or ozone, are also being used in situations where chlorine in treated sewage effluents may be harmful to fish and other aquatic life.”

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Options for increased sustainability:

- Composting Toilet / Urinal System:

Composting toilet systems are a great way for eliminating water use, eliminating waste, and promoting a green environment. These toilet systems are highly sustainable in that they produce no waste and use very little material in their operation. Composting toilet systems are completely waterless and work by having a system of vertical pipes that deposits the waste into large composting bins in the basement of the facility. Because of how this system is installed into buildings it would be highly expensive to add a composting toilet to an existing building. This system would best be installed in a new building or a building undergoing a significance renovation.

The composting system works by the solid and liquid waste is deposited into the compost bin in the basement and need to be combined with wood chips and mixed regularly. As the decomposition process takes place the particles reduce in size and naturally filter down through the compost. Air needed for the compost process comes from the toilets themselves and is drawn through the waterless piping system. When this waste is decomposing it is important for the amount of liquid to be closely monitored to ensure that the adequate amount of air is within the system. The liquid waste will become a leachate and must be spread throughout all of the composting storage tanks and any excess liquid needs to be pumped into a reserve leachate storage tank. Removing the excess leachate allows for the system to only be an aerobic process and removes to risk of producing dangerous gases and odors that would typically occur. Excess leachate that can not be utilized in the composting system can be repurposed for other uses. Additional the biosolids waste from the compost needs to be mixed with sawdust and can be made into a fertilizer.

When implementing a composting toilet into a commercial or institutional building such as the buildings managed by Western Michigan University there my by conflict with following current building regulatory codes. Buildings that have composting systems installed may still have to connect to sewer lines in order to meet the building codes. Needed to install a connection to sewer lines will
increase the cost of the toilet system and the line may never need to be used. When the composting toilets are implemented they do not add any odors or inconveniences to guest or users. The main burdens that occur with the composting system is the additional maintenance that is unnecessary with a standard toilet. In a building which has high occupancy and high restroom traffic wood chips would need to be added every day to ensure the composting process is properly working. With WMU’s large maintenance staff facilitating the addition of wood chips daily should not be to large of a burden. However in high traffic composting toilets the compost will need to be well-maintained meaning that moisture and temperature will need to be monitored, mixing will need to occur when needed and emptying the composting bins when filled. The Bullit Center estimates that most central systems will only have to be emptied every two years. With this additional maintenance there may need to be a specialized staff member with knowledge of the system as a whole which would create an additional cost. The greatest downfall to the composting toilet system is the cost of implementation and the additional maintenance. The Bullit Center estimates that commercial/institution composting toilets will range in cost from $1,500 to $8,000 depending on the the complexity of the system. This is a huge financial investment compared to the traditional cost of a toilet ranging from $100 to $2000. Composting toilets add huge advancements in sustainability and produce a fertilizer which could be utilized across campus by Landscaping Services.
-Low flow toilets

Low flow toilets are often used and considered to be a standard in most new development. This is because the low flow toilets traditionally only use 1.28 to 1.6 gallons per flush and that is significantly less compared to the pre 1994 toilets that used 3.5 gallons per flush. Because of the low flow toilets operation and usage being the same as a traditional toilet it has become the common option. In addition the low flow toilet uses the minimum water to flush solid waste. This means that compared to a traditional toilet there are savings every flush and compared to a dual flush toilet the low flow toilets use less water to remove solid waste if the low flow toilet in use is 1.28 gallons per flush. Low flow toilets have essentially been the standard for toilets since 1995 and many states have even mandated that toilets must be low flow. These toilets promote reduced water consumption however the reduced amount of water in the bowl could require the fixture to be cleaned more regularly. Also with this being a traditional toilet system the waste has to go into either a septic system or to a waste water treatment facility resulting in additional environmental costs. Low flow toilets can range in cost from $100 to $300 dollars making is a cheep system to implement.
Dual flush toilets are a system that have been installed onto some toilets on Western Michigan University’s campus. This system has two different flush systems. If the handle is pushed up then the toilet only uses 1.1 gallons of water and that is enough to remove liquid water and toilet paper. If the handle is pulled down then it flushes 1.6 gallons of water and is enough to removed solid waste and toilet paper. The handle also has a antimicrobial coating that last the life of the product and protects against bacteria. The dual flush toiled system has advantages in giving the users the option of increased water for solid waste or a smaller amount of water for liquid waste however this system is traditionally not fully utilized. A study titled “Flush: Examining the Efficacy of Water Conservation is Dual Flush Toilets” was preformed by Masaye Harrison from the University of Oregon at Portland. This study research the total amount of water savings that come from the dual flush toilet systems. The study found that overall the system was used correctly by 50% of users for water reduction is flushing the liquid waste. While if any user operates the system correctly there is a slight amount of water saving the savings are fairly minimal and do not offer a lot in increased sustainability. Harrison concluded her study by stating that increase education would need to occur in order for the system to be utilized correctly and more drastically save water. In addition the dual flush system has potential problem if used incorrectly. If the low water option is used for solid waste there is an increased risk of clog along with adding more waste that isn’t fully washed away into municipal sewage systems. Dual flush toilets do require a connect to a sewage or septic system which adds the increase environmental cost of wastewater treatment plants to handle the waste. According to Western Reserve Plumbing the average cost of a dual flush toilet will range from $100 to $1000 dollars depending on its design.
**Cost Benefit:**

<table>
<thead>
<tr>
<th></th>
<th>Cost</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composting</td>
<td>• Large upfront cost for the system</td>
<td>• Water conservation</td>
</tr>
<tr>
<td>Toilet / Urinal</td>
<td>• The direct handling of waste</td>
<td>• Lower monthly water bills</td>
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<tr>
<td></td>
<td>• Increased maintenance and maintenance cost</td>
<td>• All waste generates a nutrient-rich fertilizer</td>
</tr>
<tr>
<td></td>
<td>• Potential for error resulting in problems with odor, insects, or a</td>
<td>• Extremely sustainable</td>
</tr>
<tr>
<td></td>
<td>poor compost.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Can not easily be added to existing buildings.</td>
<td></td>
</tr>
<tr>
<td>Low Flow</td>
<td>• May require additional cleaning</td>
<td>• Every flush uses minimal water</td>
</tr>
<tr>
<td>Toilet</td>
<td></td>
<td>• Low cost to implement</td>
</tr>
<tr>
<td>Dual Flush</td>
<td>• Increase risk of clogs</td>
<td>• Provides option for decreased water usage for liquid waste.</td>
</tr>
<tr>
<td>Toilet</td>
<td>• Not utilized correctly by users</td>
<td>• Low in cost to implement and can be implemented in existing buildings.</td>
</tr>
<tr>
<td></td>
<td>• Minimal increase to sustainability.</td>
<td></td>
</tr>
</tbody>
</table>
Final Best Option:

After reviewing the cost and benefits of composting toilet fixtures, dual flush fixtures, and low flow fixtures it was clear to see what is the best option for increased sustainability on WMU’s campus for future development and significant renovations. Composting toilets are by far the most sustainable option. This is because composting toilets have no waste since the organic material that is deposited into the system is composted and can be used as a fertilizer around campus. In addition the composting system does not require a connection to a wastewater treatment plant which is damaging to the environment through the use of chemicals along with practices that if miss managed can damage water systems an over all environmental quality.

The composting toilet system does, however, have disadvantages which could hinder implementation at Western Michigan University. One of the main disadvantages is the up front cost of the system. The Bullit Center estimates that a composting toilet system can range in cost from $200 to $2000 dollars per fixture depending on the complexity of the system. If implemented in an institutional building at WMU the system would be highly complex which multiple restrooms and multiple levels. A composting toilet system to this scale would be significantly more expensive that traditional toilet fixtures. To add to the cost more a composting toilet system required a significant amount of maintenance in there is higher risk with the compost. In an institutional building with high restroom traffic wood chips or sawdust would need to be added to the compost daily to ensure that the compost process is working effectively. Also the compost would need to be stirred periodically to allow for the proper aeration to effectively compost correctly. Which this additionally maintenance the would need to be a staff member at WMU who is familiar with the system and can ensure the system is working correctly. If the compost is not properly maintained then if could result in odor, poor compost, or increased insects with in the building. In addition to cost it would be difficult to install the composting system legally because current building codes require a connection to municipal sewer lines along with other code issues that hinder waste treatment on site.

With these disadvantages comes great rewards. The composting system do not use water making it completely water sustainable. In addition the fertilizer generated in the system could be used by WMU landscaping services across campus allowing for reduced spending on fertilizer and a more organic fertilizer being used on campus. The compost only needs to be emptied every two years according to estimations from the Bullit Center which means that there will be low cost in emptying the system. However this also shows that the fertilizer generated would not significantly alter the fertilizer usage from WMU landscaping services. If WMU wishes to makes efforts to increase overall campus sustainability then composting toilets would be a great stride in reduced waste, and environmental impact.

The composting toilet system is a new technology and because of the upfront cost of implementation along with the restrictions in currently building codes which could hinder the implementation of the system the best option for increased campus sustainability after the composting toilet system would be the simple low flow toilet fixtures. The low flow toilets are not nearly as sustainable as composting systems because the is still water used to flush the waste and the waste need to be handled at a wastewater treatment plant. How ever the cost to install low flow toilets is much lower than a composting system and ranges from only $100 to $300 dollars per fixture. In addition the new low flow toilets only use 1.28 gallons per flush(GPF) for both solid and liquid waste. This 1.28 GPF is significantly less than the 1.6 GPF used for solid waste in a dual flush fixture and removes the human error in usage since there is only a single flush setting.

In future development and significant building renovations on WMU campus the overall best option for increased restroom sustainability is the composting toilet. The composting toilet
does have the highest cost in maintenance and price per fixture but is the more environmentally sustainable. The low flow toilet fixtures are a more cost effective and lower maintenance option which could be installed more easily across campus in existing buildings. In order to make a large step in overall campus sustainability composting toilets are the most effective option for future development and significant building renovations.
**Vanity**

**Methodology and Data:**

The goal of this portion of the sustainable restroom report was to analyze best practices for water saving faucets, more environmentally friendly and bacteria resistant sinks and preferred counter top materials. In order to gather this information we created best practice charts and pro con lists that allowed us to compare and contrast different faucet, sink and counter top options in a way that was clear, concise, and easy to replicate if need be.

To begin our research we first looked into the types of sinks and faucets used on Western Michigan University’s campus already. We asses several different buildings on campus including, Wood Hall, Sangren Hall, the Chemistry Building, and the Bernhard Center. From this research we were able to conclude that the preferred brands for faucets was Delta and the preferred brand for sinks was Kholer. The next step was to look into different sustainable practices for all three aspects of the vanity being done in different universities, office complexes and other buildings with high traffic restrooms. After this preliminary research we were able to narrow down some of the most used as well as some of the best options for each aspect of the vanity. Then with the knowledge this research provided we were able to narrow down the exact sustainable goals and parameters we wanted to focus on for each aspect, faucet, sink and counter top.

In the case of the faucets we wanted to ensure that water waste was minimal, that each faucet was low lead compliant and that bacteria accumulation was limited. For the sink types we were most concerned with bacteria accumulation, durability and noise pollution and for the counter tops we wanted a counter top that was easy to clean, durable and ideally created from recycled materials. With these goals in mind we used online sources as well as examples of best practices at other universities to compile a list of several different options for faucet, sink and counter tops.

For faucets we narrowed our search down two three different options. One, the standard turn knob style seen in most commercial and residential restrooms, two the push button style that allows for timed water flow, and three the sensory activated model that is more commonly seen in newer commercial restrooms. The sink category was filtered down to two different types each offering their own advantages and disadvantages, one, the standard porcelain sink bowl and two a newer stainless steel sink bowl style.

The counter tops were highly varied and we had to be very specific about what would fit best in our sustainable restroom. We narrowed the options for counter tops down to four basic models, one a laminate plastic polymer used in standard commercial restrooms, two a heavy duty granite, three the use of recycled materials such as broken glass or porcelain mixed with an industrial slurry sealant to costume form our own counter tops and finally a newer product called Corian. Once we had a list of different options for each that fell mostly within our needs and goals we then began a cost benefit analysis of each option comparing these important factors. The final cost benefit analysis can be found on page (ENTER PAGE LATER). Analyzing these differing factors allowed us to come to a conclusion on which option would be the ultimate best practice for our sustainable restroom.
Examples of current WMU practice:

Currently at Western Michigan University the best practice in place for sustainable vanity options in restrooms are sensory activated faucets that reduce wasted water as a result of faucets being left on during hand washing and other activities. The faucets are found in several buildings on campus. However these faucets are not yet found as a standard throughout campus restrooms. In order for this type of water saving method to be successful we suggest that all faucets be converted to water saving sensory activated models.

Examples of Best Practice:

Some of the best practices found outside the University are those that have happened in the past several years in major hotel chains around the world. Hotels are seeking to lower their carbon footprint and they are starting with the restrooms used in their facilities. The Savoy Hotel and Resort in London has made a change to water efficient aerated taps that reduce water usage by 4 liter/min (Sloan design CO.). Another example is that of Wrigley Field in Chicago, in recent years they have begun to renovate there ball park and a big part of those renovations centered around the restrooms. Wrigley introduced electronic sensor faucets to cut down on water loss from leaking faucets of faucets left unattended and running. The examples of best practice are numerous around the world, from transportation centers like O’Hare airport to correctional facilities and hospitals (Sloan design CO.). There are also prime examples found at other universities, one is the implementation of more sustainable faucet fixtures in the restrooms on the University of California Santa Barbara campus. With the addition of these low flow fixtures they were able to achieve LEED platinum standing. Our goal was to take the examples set by the many different locations using these technologies already and alter them to fit and function on Western Michigan University’s campus.
Options for increased sustainability:

-Faucets
The options we narrowed down for faucet style are listed below. Each of the differing options had positive and negative aspects. The first option we looked into was the standard turn knob style that is found in most commercial restrooms including many of the buildings found around Western Michigan University's campus. The particular style we looked into was the “Delta 2500LF Classic two handle center set Lavatory faucet.” This model was the most affordable option of the three. This style also has the EPA’s water sense label dictating that it is low flow compliant having a flow rate of 1.5 gallons per minute. Other advantages for this model include meeting Americans with Disabilities Act standards (ADA) and a lifetime warranty through Delta. However this model does not fit the desire for reduced bacteria accumulation due to the direct contact between users and the faucet turn knobs and it still leaves room for wasted water as a result of leaking faucets and or turn knobs being left on and unattended.

The second option, the push button style faucet, “Delta 701LF-HDF single handle self-closing faucet” offered only a few of the aspects we deemed important for our sustainable efforts. This model has the EPA’s water sense label, combat the issue of unattended running water because of the self-closing feature and has a lifetime warranty though Delta. However it does not meet the low lead standard, it is not ADA certified and the bacteria accumulation was still an issue due again to direct contact of the user and the push button.

The third and final option is a sensory activated faucet model “Delta 590LF Battery electronic Lav Faucet.” While this model is the most expensive of the three options and only offers limited time warranty though Delta, it meets ADA criteria, is EPA water sense certified and has the lowest rate of water flow, 0.5 gallons per minute, it’s lead free compliant it has low opportunity for bacteria buildup because of its sensory activated turn on that doesn’t require direct contact with the fixture and there is little room leaking or water left running due to again the sensory activated turn on.
-Sinks
The narrowed down options for sink types are listed below, each has its own set of positive aspects and negative aspects.
The first type by Kohler, is a round drop in porcelain style sink. This style of sink is the most affordable of the two options however it got a low consumer rating for durability and according to a study published in the Journal of bioadhesion and biofilm research porcelain requires a higher concentration of disinfectant in order to properly clean.

The second option is a stainless steel model by Kohler, the same round drop in as the porcelain style. However the stainless steel option got a higher durability rating and also offers an optional noise cancellation backing that can be applied to the underside of the sink that would successfully reduce noise pollution. Finally according to the same study published in Journal of Bioadhesion and Biofilm research stainless steel can be effectively sanitized with minimal chemicals.
Counter tops
The four options for countertop types are listed below.

The first option we considered for our bathroom remodel was a plastic byproduct laminate. This countertop type was the most common in commercial restrooms. It was also the most affordable option. However the reviews of laminate suggested that it scratched easily and seem to thin and weaken as time passed. It also did not have the bacteria resistance that we were looking for.

Granite was the second option we considered, this type of countertop offered the durability and bacteria resistance, it can also be purchased as a recycled product which met the more sustainable aspect we were hoping for. However this counter type was by far the most expensive option.

Recycled material, this option was considered based on the counter types currently installed in the Office for Sustainability by Building Restoration Inc. This kind of counter top is produced from a byproduct of concrete grinding combined with recycled glass and other materials. Our idea for this type of counter top was to incorporate the slurry byproduct with recycled porcelain pieces form old toilets, that would ideally be removed from the currently unsustainable restrooms, and use this mixture to create wholly recycled counter tops. These counters would be very durable and bacteria resistant. However upon further investigation we concluded that these counter tops would be extremely expensive due to their customized nature.
Corian countertops were the final option we considered. These are a fairly new option for countertops. Corian is very similar to granite in its durability, and resistance to bacteria however Corian is more affordable than granite. Corian is also made from a recycled material. This type of countertop however is not scratch resistant and must be installed by a professional which can drive the price up.
Cost, benefit analysis for all options:

### Faucets

<table>
<thead>
<tr>
<th>Style</th>
<th>Pro</th>
<th>Con</th>
</tr>
</thead>
</table>
| **Turn Knob**    | • Most affordable  
                    • EPA water sense  
                    • ADA compliant  
                    • Low Lead compliance  
                    • Lifetime warranty | • Bacteria more easily spread from contact with knob  
                    • Potential for wasted water if knobs are left on |
| **Push Button**  | • Less room for wasted water from running faucets  
                    • EPA water sense | • Bacteria on push button |
| **Sensory activated** | • No room for wasted water from running faucets  
                      • Low lead  
                      • Low flow .5GPM  
                      • EPA water sense  
                      • ADA  
                      • Low bacteria accumulation  
                      • Battery or AC powered | • What to do with battery waste  
                      • How much energy each faucet uses |

### Sinks

<table>
<thead>
<tr>
<th>Style</th>
<th>Pro</th>
<th>Con</th>
</tr>
</thead>
</table>
| **Stainless steel** | • Bacteria resistant  
                      • Made in USA  
                      • Insulated against noise | • More expensive |
<p>| <strong>Porcelain</strong> | • Most affordable | • Harbors bacteria |</p>
<table>
<thead>
<tr>
<th>Countertops</th>
<th>Pro</th>
<th>Con</th>
</tr>
</thead>
</table>
| **Corian** | • affordable $40 to $60 per square foot  
• Made from recycled materials  
• Naturally resistant to water and bacteria | • Shows scratches  
• Has to be installed professionally |
| **Granite** | • Extremely durable  
• Recycled material | • Most expensive $50 to $100 per square foot  
• Difficult to transport due to fragility |
| **Laminate** | • Most affordable option $25 to $50 per square foot  
• water resistant | • weak, thinning and dulling over time  
• Made from plastics |
| **Recycled material** | • Totally recycled | • Very expensive |
Final best option:

With all of our data compiled we were able to decide on what applications would be the best for the vanity in our sustainable restroom. The sensory activated faucets were the best decision based on our cost benefit analysis. The sensory activated style met all of the desired functions we deemed important for a sustainable faucet. The low lead chrome materials cut down on the change of chemical contamination as a direct result from the faucet, EPA water sense certification satisfies the low flow standard for a more sustainable faucet type and the sensory activation for water turn on and off eliminates bacteria transfer as a result of direct contact from users to the appliance. For the sink types, stainless steel stood out as the best option after reviewing the paper published in the Journal of bioadhesion and biofilm research that determined stainless steel required a less concentrated cleaning solvent to remove bacteria efficiently (Peterman 2009). Finally for the countertops the best option was the Corian. This type of counter top has the bacteria resistance we wanted, is durable enough to stand up to the everyday wear and tear that a commercial restroom endures and is inexpensive enough to be realistically placed in restrooms on a large scale on our campus. This type of countertop also satisfies our desire for a recycled material as well since Corian is 6 to 20% recycled material. Combining these products will create a more sustainable vanity that is functional clean and ecofriendly.
Hand Drying Techniques

With paper towels still the most commonly used technique for drying hands, much research has been done to see how sustainable, or unsustainable, paper towels are and what possible sustainable alternatives there are. Western Michigan University currently uses paper towels in all or nearly all bathrooms and only a small handful have hand dryers. However, even the hand dryers that are used are hot air dryers which bring about its own host of unsustainable issues. A few alternatives have gained some traction in the last decade or so. Jet air dryers, which blow out air at high speeds for a very short time (usually around 10-12 seconds). Cloth roll towels which allow the user to pull down on a certain amount of cloth, wipe their hands, and when they release the towel, it will snap back up into the cabinet. The used part of the towel is rotated up into the cabinet and a clean piece of the towel is ready for the next user. With this report, we want to narrow in on analysis of jet air dryers and cloth roll towels and compare them to the techniques already being used here at Western Michigan University.

For analysis of hand drying techniques, data and screens used will be built upon a past ENVS 4100 study done by former student Leigha Jones. In 2013 she conducted a LCA for paper towels and hot air dryers that are currently used here at Western. The variables she looked into regarding the assessment of hot air dryers vs paper towels were cost, environmental impact, energy, hygiene, user preference, noise, and skin irritation. While many of the reports and studies that she cited in her report were also mostly the ones we found, more attention was put into calculating results, specifically for cost and energy output for jet air hand dryers and cloth roll towels. The goal was to show in numbers, how jet air hand dryers and cloth roll towels compare to paper towels and hot air hand dryers. We want to calculate the same type of metrics found in this past report for cloth roll towels and jet air dryers to see how they would look here at Western. One issue with some of the main professional studies on hand drying techniques is that they are sponsored by major hand drying companies most notably Dyson and Excelerator. While that does not automatically mean that these reports are biased and even parts of these studies go against hand dryers, with the exception of hygiene, we are choosing to rely more on our own numbers we found.
**Methodology**

We decided to stick to the three biggest factors when analyzing hand drying methods:

- Cost
- Energy Output
- Hygiene

When analyzing what is most important and what would be looked at most if the university decided to switch to a new sustainable hand drying option for future bathrooms, these factors are probably the three biggest. Leigha Jones in her report also mainly stuck to these three categories while including a few other smaller metrics.

The first step was to analyze the past report and simply confirm that the techniques mentioned in that report are still what is being used here at Western. The past report was still accurate and no to very little change has occurred since that report. All of the calculations for cost and energy were correct as well. When trying to find professional reports to analyze hand drying methods, many of the reports that we found were also the ones Leigha used in her report. Very few new articles or studies have come out since the fall of 2013.

With that in mind that a lot of the studies that we found were also used by Leigha, we wanted to focus more on our own calculations of how these new methods would fit in to a new bathroom here at Western and what their costs might be.

The jet high speed air dryers were slightly easier to calculate because with hot air hand dryers already in place on campus, we could simply plug the numbers from the jet high speed air dryers (drying time, watts, cost per unit) into the formulas Leigha used for hot air hand dryers to calculate energy, carbon output, cost, etc. To determine the hygiene impact of jet air dryers, we did rely on professional studies and reports.

In our analysis of cloth roll towels, we tried to customize it more for Western. A lot of the information we wanted for analysis on cloth roll towels was not readily available online on any company’s websites. This forced us to contact multiple companies about costs and services which created a headache at times. The two companies that we settled on for information were Darman Manufacturing, a company from Utica, New York that specializes in making cloth roll towel cabinets and CLS, a linen and uniform company right here in Kalamazoo that also does cloth roll towel service.

If either new method is to someday replace paper towels or hot air hand dryers then their operating system as a whole would need to be more cost effective than what is being done now and show that
it will offset the carbon footprint and waste produced by current methods. There are certainly more alternatives such as composting of paper towels and gasification, but if we want this to possibly become campus wide one day, then those alternatives present their own issues that make them not feasible which we looked at briefly in our research.
General Summary of Paper Towels vs Hot Air Hand Dryers Report

Ultimately what Leigha Jones recommended based on her analysis between paper towels and the hot air hand dryers already in place on campus was that paper towels are still probably the best option. In terms of hygiene and user preference, paper towels were easily the better option. The only thing that hot air hand dryers were better in was cost. All hand dryers can be cost effective based on unit price because barring any maintenance needed, they are one time investment to install and can last usually 5-10 years. What hot air hand dryers do have going for them, is the costs to run and operate the dryers. Most hot air hand dryers are cheaper, or as cheap as even the cheapest high speed jet dryers. The cheapest hot air dryer was just under $500 with the most expensive one being $563. This is really the only reason why hot air dryers are preferred. Yearly costs of paper towels from production, manufacturing, transportation, and disposal were over $115,000.

Hygiene, which was a major criteria for her study indicated that paper towels and hot air hand dryers were on completely different sides of the spectrum. Paper towels, in study after study were found to be the best when it came to bacteria removal, reducing bacteria up to 77 percent opposed to 254 percent increase from hot air hand dryers. Hot air hand dryers rely on air that is sucked into dryer and then blown onto the users hand thus creating more bacteria than it is getting rid of. Hot air hand dryers require a lot more time to actually dry someones hands. Around 40 seconds compared with 10-12 seconds for pretty much every other method. Hot air dryers were comparable in cross contamination and did not spread bacteria around more so than jet air dryers did. Overall paper towels were superior in hygiene to all other methods.

Hot air hand dryers were found to release around 12.8 pounds of carbon dioxide emissions each year based on a specific kWh formula: E(kWh)=P (w) x t (hr.) / 1000. It was found that electricity sources emit 1.222 lbs CO2 per kWh which is where the 12.8 pounds is taken from. This same formula and other will be used for further analysis for high speed jet air dryers and the cloth roll towels. Environmentally and energy concerning, paper towels were far worse. While many efforts have been made by paper companies, like Wausau which supplies WMU, to be more eco friendly, the fact is that it is still far more energy intensive to manufacture and produce paper towels. Not to mention the constant transportation needed to deliver the paper towels to campus and the disposal into landfill which over time can add to greenhouse gases produced. While hot air hand dryers might not be the best in this category, it is clear that paper towels, even if composted, still have a sizeable carbon footprint.

While based on the analysis we tend to mostly agree that paper towels are still the best especially when it comes to hygiene and user preference. The difference in cost and environmental impact is what is so striking as to why WMU would not try to invest in more hand dryers or another alternative to paper towels despite their superiority on hygiene. Currently Wester has no set standard on hand drying technique but are currently working to form a group to determine the best practice for hand drying materials. With that being said, it dosent appear that hot air hand dryers are that much better of an alternative. Yes they are cheaper but they are only slightly better environmentally. That is why when looking at future bathroom recommendations, we are confident that cloth roll
towels and high speed hand dryers when all is said and done will be more sustainable than either method used currently.

**High Speed Hand Dryers**

When looking at high speed jet air dryers, the three dryers we analyzed were the Dyson Airblade dB, Dyson Airblade V, and the Excel Xlerator Eco Model XL-SB-Eco.

<table>
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<tr>
<th>Table 1</th>
<th>Hot Air Hand Dryers</th>
<th>Dyson Airblade dB</th>
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<th>Xlerator Eco</th>
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<td>Lifetime Usage</td>
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Looking at the three high speed air dryers, it is clear that with the exception of unit cost that they are simply better than hot air hand dryers. Unit prices (which were totaled assuming that each bathroom would have two units, individual prices would be figure above divided in half), Lifetime usage, and drying times were pulled from the manufacturers websites directly. The calculations on kWh as mentioned is E(kWh)= p (w) x t (hr)/1000. The assumed usage for the hand dryers were 150 per month (5 uses per day). Certainly use of hand dryers vary day to day and are probably more than 5 times a day, but we chose 5 to have a simple base number for calculations. The amount of hours for the kWh calculation was drying time x use per day x 365/60, /60 again. .10 cents per kWh was determined as the cost per kWh/month based on numbers from the Energy Information Agency. Co2 impact was determined from the EPA’s eGRID emissions factors to come up with 1.222 lbs CO2 per kWh average from electricity sources nationwide (carbonfund.org).
• Hot air hand dryers: 18s drying time average x 5 = 90 x 365 = 32,850 seconds/60=547.5/60=9.1 hrs. 1917 average watts x 9.1 hrs/1000= 17.4 kWh. kWh per month was found as 18s x 150 = 2700 seconds which is equal to 0.75 hrs. 1917w x 0.75hrs/1000=1.4 kWh per month. CO2 impact was calculated as 17.4 kWh x 1.222 lbs CO2 = 21.3 lbs of CO2 every year.

• Dyson Jet air dryers: 12s x 5 = 60 x 365 = 21900/60= 365/60= 6.1 hrs per year. 1400 watts for both Dyson Airblade x 6.1hrs/1000= 8.54 kWh per year. 12s x 150 uses = 1800 seconds which is roughly 0.5 hrs per month. 1400w x 0.5hrs/1000= 0.7 kWh per month. 0.7 kWh x .10 = $0.07 per kWh/month. CO2 impact determined as 8.54 kWh x 1.222 CO2 = 10.4 lbs of CO2 per year.

• Xlerator Eco: Only 500 watts needed for the Exelerator Eco. That is due to the no heat technology that the Eco line has. Same drying time as Dyson Airblades= same 6.1 hrs per year. 500w x 6.1hrs/1000= 3.05 kWh per year. 500w x 0.5hrs/1000= 0.25 kWh per month. 0.25 kWh x .10= $0.025 per kWh/month. CO2 impact is determined as 3.05 kWh x 1.222 CO2 = 3.7 lbs of CO2 per year.

The three high speed jet air dryers are all comparable in hygiene and in many regards better than hot air dryers, but still lack in comparison to paper towels as mentioned in the previous study. For example, in a widely cited report by Redway and Fawder from the University of Westminster in 2008, when determining the total removal of all bacteria from the fingertips and palms, the results went as; Paper towels saw a reduction in mean number of all types of bacteria from 44.6% to 91.5% in the fingertips and 32.8% to 85.2% in the palms. The hot air hand dryers saw an enormous increase in the mean number of all bacteria after use. The results were an increase of 114.1% to 414% in the fingertips and an increase of 230.4% to 478.8% in the palms. High speed jet air dryers were better in this metric, still seeing an increase in the mean number of all types of bacteria after use but no where near as high as hot air dryers. The results were a mean increase of 28.0% to 193.3% in the fingertips and 9.1% to 82.2% in the palms. The area where jet air dryers were not as hygienic or better than hot air dryers were contaminating the surrounding restroom. This study found that jet air dryers dispersed bacteria throughout the bathroom up to 2 meters or 6 and ½ feet.

A robust study done by MIT, sponsored by Dyson conducted a Life-cycle assessment on seven different hand drying methods which included all of the methods being reported on in this paper. The Dyson Airblade dB and a regular Xlerator hand dryer were both looked at. The study analyzed several different metrics including global warming potential, human health potential, ecosystem quality, cumulative energy demand, land occupation, water consumption, and production of the methods. The Dyson Airblade and the Regular Xlerator dryer were consistently the best in almost every category. However for our study we looked at the Xlerator Eco line which uses significantly less energy and electricity than both Dyson Airblades. Ultimately a full LCA which include the Xlerator Eco would need to be conducted, but based on the numbers that we were able to calculate, both cost and energy consumption, we don’t see why the Xlerator Eco would not be the best choice to go with in terms of electric hand dryers. The differences in hygiene we think between the jet air dryers that are hands under dryer versus the Dyson Airblade dB which the user puts their hands in the dryer are miniscule. Both types of jet air dryers have a number of green certifications such as
multiple LEED certificates, Carbon Trust seal, GreenSpec listed, etc. Both have HEPA filters which is what separates them hygienically at least from hot air dryers. They are clearly cheaper and more energy efficient than hot air dryers. While many users would still prefer paper towels, when talking about sustainability either high speed jet air dryer would be a better investment than paper towels. The lower energy used and the low costs are what we think separates the Xlerator Eco apart from the Dyson Airblades.
Cloth Roll Towels

Cloth roll towels are a reusable 37 yard long towel that is made of cotton and polyester in which the user pulls down the towel from the cabinet a certain length, wipes their hands, and when finished the used part of the towel snaps back up into the cabinet allowing for a clean portion of the towel to be available for the next user. Cloth roll towels are not that prevalent right now and not many public places use cloth roll towels. That made researching certain metrics like price and total environmental impact tricky. However with that being said, we were able to find two companies that would be practical should WMU decide to invest in cloth roll towels. Those two companies are Darman and CLS. Darman is a leading manufacturing company of cloth roll towel cabinets and towels in the United State. CLS is a linen and uniform service company in Michigan, and specifically Kalamazoo that does cloth roll towel service. CLS has Darman as their manufacturer already and CLS already does work with Western because a lot of linens for example such as tablecloths are already washed and processed through CLS, so it would make sense to stick with them should cloth roll towels be added to campus.

The financial costs that WMU would have to pay for cloth roll towels follow as such. One cabinet from Darman with a small mirror would cost $108.95. So that would be $217.90 for two units in a bathroom. Darman has two different cloth towels to choose from, white and blue. White towels cost $22.00 and the blue cost $32.00. We will go ahead and use the blue towels for this report. If four towels are purchased, allowing for them to be switched out, that brings the prices of towels to a total of $128.00. Add that to the cabinet prices and we stand at $345.90 so far. Clearly that is already cheaper than any of the hand drying systems and the yearly costs for paper towels. The second half of costs which is the transportation, washing, re-rolling, and overall processing is another thing.
Quoting a representative from CLS directly “CLS would rent the toweling for approximately $2.50 each, depending on quantity requested. This would include CLS purchasing the inventory, washing, re rolling and delivery”. One piece of information that was hard to find was how much part of the towel is used per one use. The cloth roll towels are 11” wide, so we don’t think that it is unreasonable to assume that 12” or 1 foot could be used for one use. Now as with paper towels and hand dryers use in any bathroom will vary from day to day, so we will stick with our base assumptions used for hand dryers of 5 uses a day, 150 uses a month.

- The whole towel is 37 yards long. 1ft=0.3 yds. 5 uses = 1.7yds 150 uses = 50 yds. 150 uses per month x 12 months = 1800 uses a year. 1800ft = 600yds. 600yds/37yds per roll = 16.2. We will round this down to 16 which would translate to the cabinet needed to be changed 16 times a year. $2.50 for all services related to changing the cabinet then 16 x $2.50 = $40 a year. Two cabinets would bump that up to $ 80 a year. $80 plus $ 345.90 = $434.90.
- For cloth roll towel purposes only let us look at these prices if this new bathroom was a high traffic bathroom where the towels were used more than 5 times a day. Let’s use 30 times a day for one cabinet. 30 times a day, 900 times a month, 10,800 times a year. 30ft a day = 10yds a day. 900ft per month = 300yds per month. 10,800ft a year = 3600yds a year. That is looking at changing the cabinets over 8 times a month and over 97 times a year. 97 x $2.50 = $242.50 per year. Two cabinets at that traffic would cost $485.00. $485.00 plus $345.90 = $830.90.

So certainly and as expected the traffic flow of the bathroom will have an impact on the price of the cloth roll towels. This did not take into consideration the time for when new towels will need to be purchased which according to a study done at MIT a few years back is around 103 cycles in the cabinet. With that being said, at least on the end for Western, cloth roll towels seem to be more cost effective than hand dryers and paper towels over the course of a year.

The overall environmental costs of cloth roll towels take in number of factors. Production, transportation, electricity and water needed to wash them, etc. was a little tough to pin down. CLS at the time of this data being gathered were not able to provide us fully with how much water and electricity is used to wash and dry the towels. It should be assumed already that this would take a good amount of energy to refresh the towels and the more cabinets that are on campus would certainly require more energy for this process. The transportation to and from the site where they process the towels would certainly add up over a year, but since CLS already delivers other linens to campus already, we can go ahead assume that the towels could be included onto those deliveries which would not add to the carbon output already in place. So to get some gauge on how sustainable or environmentally friendly cloth roll towels are, we can turn back to the MIT study of different hand drying methods that took into account global warming potential, water consumption, land occupation, etc. Global warming potential which is the impact of all gaseous emissions relative to carbon dioxide in their ability to contribute to overall climate change. In this category cloth roll towels were lower than paper towels and conventional hot air dryers but higher than both the Dyson.
Airblade and the regular Xlerator hand dryer. Cumulative Energy Demands, which include energy and electricity calculations with the exception of emissions statistics, follow gwp in pattern. Cloth roll towels were lower than paper towels and hot air dryers but higher than the Dyson Airblade and Xlerator dryer. The study does note what was initially to be suspected from cloth roll towels, that much of the global warming potential comes from the laundering and transportation of the towels. The electricity needed to heat the water to disinfect the towels along with the electricity to dry it afterwards can create a lot of emissions. The precise numbers on this process from CLS would give us a more personalized look at how much energy would be used if WMU switched to cloth toll towels which is something that needs to be explored more.

The hygiene performance of cloth roll towels from study to study vary. Some older studies done on cloth roll towels deemed them very hygenic, even more so than paper towels. Some newer studies suggest otherwise. Cloth roll towels were effective in removing residual water from the hands. After 10 seconds residual water was reduced to just 4% and 1% after 15 seconds of drying (Patrick, et al). A problem that hand dryers have, particullary high speed jet dryers, is the spreading and contamination of the rest of the bathroom. Cloth roll towels, like paper towels were found to have no negligible contamination on the surrounding bathroom environment (Hanna, et al). The main hygenic drawback with cloth roll towels however is that they can become common use towels once they are used and those dirty parts of the towel, while snapped back into the cabinet, can still run a risk of transferring bacteria and pathogens to clean hands (Huang, et al).

User preference might be the most damning statistic that holds cloth roll towels back. A 2008 study of European citizens found that just 10% preferred cloth roll towels (Intermetra) and another 2009 study of American citizens found that just 1% preferred cloth roll towels (Harris Interactive). The reasons for these low numbers could possibly be that just not many people are exposed to cloth roll towels, but the biggest reason might be the stigma that people feel they are wiping their hands on a dirty, used towel every time they go to dry their hands. That kind of stigma would need to clearly be disproved or heavily advertised against if cloth roll towels are to be a possible option here on campus.


**Discussion**

In order to maintain gold standard for sustainability on campus Western Michigan University needs to seriously consider where they are wasting energy, water, and natural resources. Currently WMU has varying options for toilets, vanities, and hand dryers around campus. Each of these methods is wasteful in regards to both finical and environmental sustainability. By creating a set standard to be implemented for future restrooms western will save not only energy and natural resources but finically the change to more sustainable techniques for restrooms on campus will have a great impact. Making a change to composting toilets completely reduces the need for water in toilets and promotes sustainability campus wide. It will also decrease spending in landscaping services because the waste from the toilets can be used as an all-natural fertilizer. Implementation of faucets with low flow, .5gpm, will meet current standards and reduce water consumption from sinks.Use of the sensory activated model will reduce the chance for wasted water from sinks that are left running and unattended and will reduce the spread of bacteria that occurs with other methods that require physical contact with the on off knobs. The addition of stainless steel sinks and Corian counter tops will be a onetime expense for the life of the building because of the materials extreme durable. Hand drying techniques will also add to saved money because the suggested model, Xelerator Eco, has the lowest energy usage in watts of any other method. It will also cut down on the amount of natural resources used because there will be no need for paper towels in restrooms across campus, in addition this model has the lowest carbon foot print of all methods and will be a onetime insulation cost whereas other methods such as paper towels and cloth roll paper towels would need additional cost to maintain. Overall these implementations will save Western a vast amount of money, conserve energy and water and create a more sustainable environment on campus.
Limitations

When researching environmentally sustainable restroom practices there were no significant limitations to the study. Restrooms and restroom fixtures are a well studied aspect of building development which allowed for many sources to be available for reference. The only limitations encountered in this study was the disability to predict future restroom practices. This results in this study having a time in which the information may not be valid because current available technology is surpassed by newly created technology. In addition the research on the composing toilet is limited because there is currently only one existing building that has a composting toilet system larger than two stories. This results in a lack of information from various sources which could bias the information. In addition the information on hand drying technics was limited because some companies which were contacted to find out their environmental cost did not respond with their practices and energy uses making it hard to fully personalize our analysis to Western.
Conclusion

After reviewing all of the options for toilets, vanities, and hand drying techniques through the cost benefit method we determined the best practices for future restrooms. When exploring the best option for toilets we determined the most sustainable option is the composting toilet. Using the Composting system creates zero waste and allows for the organic matter to be converted into a fertilizer that could be used across campus by Landscaping Services. Composting toilet systems are very expensive and have to be built into the design of the building. In addition these systems require significantly more maintenance than traditional toilets. However even with this issues noted the composting system is by far the most environmentally friendly with all waste being managed on site instead of in a wastewater treatment plant.

The final best practices for a vanity set up including faucets, sinks and countertops are, the sensory activated faucet style, the stainless steel sink option and the Corian countertop design. We chose the sensory activated sinks because they meet the EPA water sense low flow standard, are certified low lead compliant and eliminate bacteria transfer due to the loss of direct hand to sink contact with the on off mechanism. The sink type was chosen after reviewing an article on bioadhesion that confirmed stainless steel requires a less concentrated cleaning solvent to remove bacteria efficiently. We also determined that stainless steel is the most durable of all sink options; instillation of this material for sinks would be a onetime expense. Finally, for the countertops the best option was the Corian, this type of countertop has the bacteria resistance we wanted, is durable and is composed of recycled material making it the most sustainable option.

Concerning hand drying, there is not going to be any one method that is going to be completely sustainable, cost effective, and hygienic however we recommend the Xlerator Eco in future bathrooms and heavy renovations on campus. It is clear that paper towels, while the most hygienic of all methods, are not sustainable or cost effective. Paper towels cost Western tens of thousands every year while adding to landfills. The assessment of cloth roll towels and high speed jet air dryers as a possible alternative to current practices at WMU showed that a need for replacing paper towels with one of these methods can be more cost effective and less environmentally impacting. Creating a least cost analysis was limited by not being able to compile all the needed information due to reasons outside our control. However based on the available information combined with major studies allowed us to get a better picture of the impact each method would have on campus. Taking all of the available data, we recommend that Western look into the Xlerator Eco. Considering that hand dryers are a one-time investment and are much more sustainable than hot air dryers, we can assume that they are going to be more cost effective than paper towels and cloth roll towels. Even a very low use estimate with cloth roll towels would still produce costs that would overtake hand dryers after a few years. The Xlerator Eco uses significantly less electricity than other hand dryers. The Xlerator Eco as seen has a significantly less impact than other hand dryers and paper towels.
References


Carbonfund.org Howe we calculate https://www.carbonfund.org/how-we-calculate


Appendix 1-Current Contact List

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<td>Shannon Patterson</td>
<td>269-655-5270</td>
<td><a href="mailto:Shannon.l.Patterson@wmich.edu">Shannon.l.Patterson@wmich.edu</a></td>
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<tr>
<td>Zachary Santen</td>
<td>513-378-4344</td>
<td><a href="mailto:Zachary.W.Santen@wmich.edu">Zachary.W.Santen@wmich.edu</a></td>
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<tr>
<td>Kevin Looney</td>
<td>734-778-2209</td>
<td><a href="mailto:Kevin.P.Looney@wmich.edu">Kevin.P.Looney@wmich.edu</a></td>
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Appendix 2-Contact List and Logs

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Appendix 3-Image Archives


