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SUSTAINABILITY IN INDUSTRIAL ARCHITECTURE

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HONORS PROJECT

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Abstract

The goal of this project is to complete an in-depth study and analysis on sustainable industrial architecture. Currently, sustainable industrial architecture is an emerging topic amongst architects and industry leaders. Topics involve battling with ideologies and company policies to better the sustainability of industrial architecture. This project will help fill the gap between industrial design and sustainability by creating research and project-based examples of how sustainable industrial design can be completed. The project will be a result of a thorough research study in current sustainable industrial design, and a proposal for new efforts that can be implemented. The goal of this research is to conclude on how sustainable design can be implemented more often in industrial architecture.
Sustainability in Industrial Architecture

Today, sustainability is a topic discussed all over the world. Many associate sustainability with protecting the life on earth for future generation. To do this, the world needs to take a greener perspective when it comes to bettering the life of those in the future. One of the greatest ways to create a positive impact would be to look at the built environment. The built environment includes the buildings, structures, and urban design that is created for humans worldwide. The built environment encompasses all aspects of architecture and the several types within. One of the greatest pieces of architecture that can be made more sustainably falls within the industrial design category. This category of architecture has immense potential for growth now and in the future. It is also a category that already greatly impacts the world we live in. The category that will be focused on is sustainability in industrial architecture.

Before diving into sustainability in industrial architecture, one must first understand what defines an industrial architectural project. Architecture in general can be broken up into various categories. The three main categories include residential architecture, commercial architecture, and industrial architecture. A residential architecture project includes homes and private places of living. A commercial architecture project includes mixed use buildings, offices, and places of commerce. Outside of residential and commercial falls industrial architecture. An industrial architecture project can be categorized as either a manufacturing building, warehouse, or distribution centers (“Industrial Facilities,” n.d.). Manufacturing buildings are categorized as those that house machines and tools to produce goods for use or sale. Today, most manufacturing facilities are involved in industrial production through which raw materials are transformed into finished goods on a larger scale (“Industrial Facilities,” n.d.). Warehouse and distribution centers are buildings that store goods, manufactured products, merchandise, raw materials, or personal
belongings, such as self-storage centers (“Industrial Facilities,” n.d.). It is important to note that manufacturing and industrial facilities work on a vastly different scale than homes, offices, buildings, or even universities. Majority of the focus when designing industrial facilities is placed on the good being produced versus the people working in the building. Creating more sustainable industrial buildings will not only affect the people working in them, but also the environment that surrounds the building.

**History**

To further understand industrial architecture, it is important to look at its beginning. The start of industrial architecture can be traced all the way back to the industrial revolution. The industrial revolution brought the production of steel that revolutionized architecture as we know it. Before the 1850’s steel could be made only in small batches and was so expensive that it was limited to specialized applications like tools (Gordon, J. S, n.d.). In 1857, the English engineer Henry Bessemer developed a way to make steel in enormous quantities at a fraction of the cost of the old price (Gordon, J. S, n.d.). This created an industrial boom in the production of steel. Steel began to be used increasingly in architecture. Longer spans allowed for bigger working spaces and mills. This steel boom allowed for more buildings to be designed at a record-breaking pace. With these buildings, came many industrial factories. Often, these factories were not inviting to the labor workers. The factories resulted in poor and dangerous working conditions. Figure 1 shows an example of just how jammed workers were forced to work during the industrial revolution. As a result, several architects began to pave the path to a more sustainable working environment.

One notable architect who paved the path for more sustainable working environments was Albert Kahn. Albert Kahn and his brother, Julius, designed a concrete reinforcing system
that revolutionized industrial design. This system was known as the Kahn Bar System. The Kahn Bar System was first used in Packard Plant Building number ten, and the system allowed for a visual expression of function and ushered in a new era of industrial design. (“Albert Kahn,” n.d.). The newly invented building spans created an open floor plan that allowed for more light to flow into the space. Kahn’s designs soon caught the attention of Henry Ford, who was interested in building an automobile plant that could house his groundbreaking idea for an assembly line system of production (“Albert Kahn,” n.d.). Kahn’s first factory for the Ford Motor Company was the Highland Park Plant in 1909 (Figure 2). The design integrated reinforced concrete that allowed for large spans and open floor spaces. This type of design began to think about the employees who worked in the industrial buildings. Natural light began to flood the interior spaces and allow for less cramped working conditions. This type of design started to put an emphasis on the employees rather than simply the product being designed.

Following in the footsteps of Albert Kahn, Walter Gropius was another architect who started to pave the path towards sustainable industrial architecture. Gropius was a German American architect known as one of the leaders of modern functional architecture. A Walter Gropius design that further pushed the envelope for industrial architecture would be the Fagus Factory buildings. Fagus Factory was designed in 1911 and is currently recognized as a UNESCO World Heritage Site. The Fagus Factory consists of glass walls, metal spandrels, and discerning use of purely industrial features (Figure 3). The design was one of the firsts to consider the requirements associated with light, air, and clarity. From a sustainable aspect, building users were given access to fresh air and daylighting. This greatly improved the employees’ thermal comfort and allowed for a safer working environment. These conditions
were favorable given because once again, emphasis was placed on the people working in the factory.

**Sustainability Today**

When looking at sustainability in industrial architecture today, it is important to note that there is still a long way to go. One of the first pieces that can be brought to attention when grasping the idea of sustainability is the triple bottom line. The triple bottom line refers to the people, planet, and profit of a building. In terms of industrial design, the people, planet, and profit differ than other buildings such as commercial and residential. The people portion in the triple bottom line refers to the workers, the jobs, and the community that an industrial facility impact ("Scope and Opportunity," n.d.). Green buildings positively affect occupant health, safety, well-being, and overall experience of the users. Green buildings also help ensure manufacturers are good stewards for their communities ("Scope and Opportunity," n.d.). Green facilities projects protect residents and promote a healthy environment and economy. The next triple bottom line piece is the planet. The planet involves the impact, materials, and site selection of industrial facilities. Manufacturers consume more than 30 percent of the nation’s energy and present a greater opportunity for efficiency on sustainability. According to the USGBC, in 2010, industrial water withdrawals amount to approximately 15,900 million gallons per day ("Scope and Opportunity," n.d.). Green industrial facilities are often sited to reduce the environmental impact of the development or to remediate and redevelop brownfields, or previously contaminated areas. The profit piece of the triple bottom line includes the scale, payback, and savings. Manufacturers contributed 7 trillion to the U.S. economy ("Scope and Opportunity," n.d.). Green buildings are worth the investment and sustainable manufacturers understand the value of pursuing LEED certification to ensure each investment is sound. LEED buildings
provide increased cost savings, decreased annual operating costs, a higher return on investment overall, and increased asset value over time. (“LEED Certification,” n.d.) A leading manufacturer saw 33 percent savings on energy costs after making changes to a buildings baseline design in pursuit of LEED Gold Certification (“Scope and Opportunity,” n.d.). With that being said, the transition to more sustainable buildings will not only help the people and the planet, but also the profitability of the design. This can be utilized in the future to encourage more industry leaders to make the move towards greener design.

Sustainability in industrial design has taken steps in the right direction through history. One most notable step occurred in with the addition of a new user group in LEED. In 2012, the LEED User Group: Industrial Facilities was launched. The goal of this user group was to expand the usage of LEED throughout the world within industrial design. Currently, there are more than 1,755 LEED Certified industrial facilities globally, making up more than 496 million total square feet (“Project Spotlight,” n.d.). The opportunities for savings and efficiencies are great for industrial facilities – but they are complex since manufacturing spaces are vastly more complicated buildings than an average commercial office space. USGBC knows this and actively works with the LEED user group: industrial facilities and other owners in the marker to ensure that LEED is accessible to all industrial facilities that wish to take part in the verification and certification process (“Project Spotlight,” n.d.). Today, there are over a thousand projects that have further adapted the idea of sustainability in industrial architecture. One such design is the FCA US LLC Trenton South Engine Plant (Figure 4). Located in Trenton, Michigan, the plant is an ultramodern facility and the first engine plant to obtain LEED Gold. The plant employs 1,500 people and manufactured nearly 520,000 3.6-liter V-6 Pentastar Engines in 2015 (“Project Spotlight,” n.d.). The overall annual CO2 emissions were reduced greatly as were the overall
energy use. The plant saw a 39 percent reduction of annual energy use which saved the company $1.25 million per year. With these many features, it is important to note that the company chose to create a more sustainable environment for all connected to the project. As industrial architecture continues to grow in the future, it is important to note that these choices can continue to be made.

**Sustainability in New Industrial Design**

As previously discussed, incorporating sustainability into today’s projects can help the people, planet, and profitability of a project. However, there are still thousands of industrial leaders who are missing the mark on sustainability. The following study focuses on incorporating aspects of sustainability into a project that is in the middle of being designed. During the first phases of design, sustainability was not heavily noted or even thought of. This type of thinking can be detrimental to the triple bottom line introduced in the previous section. The recycling facility being redesigned is in Bowling Green, Ohio. The recycling facility is used to show an application of how an industrial design can be created in a more sustainable way. To make the design more sustainable, the LEED for New Construction and Major Renovations checklist was used. The checklist was not followed to a tee, but many aspects were noted when looking at the design of the new building. The LEED v.4 rating system was also used as a guideline to walk through the project and come up with a set of examples on how to make the design into a more sustainable project. The LEED v.4 rating system is broken up into various categories. The categories focused on for this study include the following: location and transportation, sustainable sites, water efficiency, energy and atmosphere, materials and resources, and thermal comfort. In the following paragraphs, these categories are summarized when it comes to the new
recycling facility sustainable implementations. Images of these implementations can be found in the Project Application section following the Images section.

**Location and Transportation**

The location of a building provides foremost importance to sustainability. When designing a site, it is important to look at the use the existing site holds. A sustainable feature of the site location is the intent to channel development to urban areas with existing infrastructure (LEED for New Construction, n.d., pg. 10). The building location is found within a ½ mile radius of a residential zone and within a ½ mile radius of several basic services. To require fewer parking spaces, bicycle racks and storage will be provided for five percent of all building users. With these bicycle racks, there will also be a shower and locker provided near the main entrance of the building to accommodate employees cycling to work. Along with the bicycle facility option, low-emitting and fuel-efficient vehicle parking spaces will be provided for five percent of the total vehicle parking capacity of the site. To lower the total parking capacity, parking will be sized to meet, but not exceed, minimum local zoning requirements.

**Sustainable Site**

When looking at the site of a building, it is important to note the use that the site already holds. For a site to be considered a sustainable site, it must avoid development of inappropriate sizes and reduce the environmental impact from the location of a building on a site (LEED for New Construction, n.d.). The least preferred sites would be prime farmland, previously undeveloped land, land that is a habitat for a species, land within 100 feet of a wetland, or land that is undeveloped by a body of water. For the proposed project, the land that is being built upon can be determined as half developed and half farmland. To preserve the farmland, the building
footprint will encompass the developed part of the property. The farmland will be either untouched or reserved as a location for rainwater collection. To further protect and restore the land, 50% of the site area will be restored with native or adapted vegetation. Native/adapted plants are plants indigenous to a locality or cultivars of native plants that are adapted to the local climate and are not considered invasive species or noxious weeds (LEED for New Construction, n.d., pg. 16). The building will also retain a reduced development footprint. Vegetated open spaced area will be next to the building that is equal to the building footprint. More sustainable features will be found through stormwater design. A stormwater management plan that prevents the post-development peak discharge rate and quantity from exceeding the pre-development peak discharge rate and quantity for the one and two-year 24-hour design storms (LEED, for New Construction, n.d., pg. 18). To allow for this, the design will incorporate a vegetated roof and pervious paving. The storm water runoff will be treated through constructed bioswales. To reduce the heat island effect of the site, the design will provide an open grid pavement system and paving materials with a Solar Reflectance Index of at least 29 for 0% of the site hardscape. Finally, the last piece that will define our sustainable site, is through light pollution reduction. The exterior lighting for the site will be designed so that all site and building mounted luminaires will produce a maximum initial illuminance value no greater than 0.10 horizontal and vertical footcandles at the site boundary and no greater than 0.01 horizontal footcandles 15 feet beyond the site (LEED, for New Construction, n.d., pg. 23).

**Water Efficiency**

Water efficiency is an important concept when it comes to designing a sustainable building. To become a more sustainability building the design will aim to achieve a 20% reduction in the use of water. The recycling facility will incorporate several water efficient
methods to reduce the total amount of water used on the site. In terms of landscape irrigation, there will be no use of potable water, or other natural surface, or subsurface water resources available on or near the project site (LEED, for New Construction, n.d., pg. 24). The site will capture rainwater and use native plants to avoid overwatering. From an interior building perspective, high efficiency fixtures will be used to reduce wastewater volumes (LEED, for New Construction, n.d., pg. 26). The use of water saving fixtures such as dual-flush water closets, low flow urinals, and sensor faucets are key to reduce indoor water use. All installed fittings will have the Water Sense Label and will meet the baseline water consumption of fixtures and fittings. Another feature that will be used will be the capture of rainwater runoff. The rainwater runoff water captured in the cistern can be recycled and used in flush fixtures in the toilet rooms. Having this feature, will greatly reduce the use of potable water. To further reduce the amount of potable water, use on the site, cooling tower water use will be cycled multiple times. By using ten cycles of water going through the tower, water will be saved.

**Energy and Atmosphere**

The energy and atmosphere designs of the building pertain to how the building uses energy and how that energy creates an environment to work in. The building envelope will be designed to maximize energy performance. The building envelope includes HVAC, lighting, and other systems. To maximize performance, a computer simulation model will be used to access the energy performance and identify the most cost-effective energy efficiency measures (LEED, for New Construction, n.d., pg., 35). To reduce ozone depletion, there will be zero use of CFC-bases refrigerants. The fire suppression system will also not have HCF’s or Halons (LEED, for New Construction, n.d., pg., 40). Due to the site, on site renewable energy is a possibility. A solar field will be implemented on the south roof of the design. This will allow access to non-
polluting and renewable energy. Adding in a solar array system will also allow for net metering with the local utility. When the on-site energy produced does not meet the demands of the site, then a green power contract will be used. The energy needed will be bought from the surrounding areas’ green power resources.

Material and Resources

The materials and resources that flow in and out of the building design will be noted. Since the facility is to be a recycling facility, it can be easily noted to look at the storage and collection of recyclables. To become more sustainable there will be dedicated areas to recycle materials for the entire building. The materials that will be collected for recycling will be mixed paper, corrugated cardboard, glass, plastics, and metals. Another key piece will be the collection of electronics (“LEED v4,” n.d., pg., 91). From a building construction standpoint, there will be building life cycle impact reduction. A cradle-to-grave life cycle assessment of the project’s structure and enclosure will be conducted (“LEED v4,” n.d., pg. 95). To lower the carbon footprint of trucking materials to the site, many building materials will be either extracted, manufactured, or bought within 100 miles of the project site. To figure out the 100-mile location, the calculation is based on location distance and not distance traveled. For example, building elements such as socal panels, roofing material, flooring material, siding material, and office equipment will be bought all within the locality of Toledo, Ohio. Doing so lowers the cost of travel and the environmental impact that traveling is associated with.

Indoor Environmental Quality

When it comes to a sustainable building, the people who use that building shall work in a comfortable environment. The indoor environmental quality is thus important. This section puts
emphasis on air quality performance, smoke control, air quality enhancement, low-emitting materials, indoor air quality management, thermal comfort, interior lighting, daylight, and acoustic performance. First, minimum indoor air quality performance will be set up to enhance indoor air quality in buildings. Doing so will contribute to the comfort and well-being of occupants (LEED for New Construction, n.d., pg. 59). Next, environmental tobacco smoke control will be needed. Smoking will be prohibited in the building, and any designated smoking areas will be at least 25 feet away from entries, outdoor air intakes and operable windows (LEED for New Construction, n.d., pg. 58). To help sustain occupant comfort and well-being, carbon dioxide and airflow measurement equipment will be installed to feed the information to the HVAC system and Building Automation System. To supply employee comfort, acoustical performance will be measured controlled. The first step to achieve acoustic performance will be to limit the HVAC background noise. Another key part is to have a separation between the office spaces and the warehouse/factory space. There will be acoustical paneling placed on the separating wall to avoid the transfer of sound. A commercial acoustics sound barrier is a specially designed mass loaded vinyl product engineered to block the transmission of sound waves. (“Mass Loaded Vinyl,” 2021) A vinyl type of sound barrier is also cost effective to the overall project cost. Daylighting will also be used throughout the building to connect building occupants with the outdoors, reinforcing circadian rhythms. Daylighting will help reduce the use of electrical lighting by introducing daylight into the space. Light sensors will play a significant role in allowing for dimming controls. For example, as the daylight becomes brighter, less interior lighting will be used. A Kalwall system will also be implemented in the warehouse part of the building. The Kalwall will supply natural light to flood the space throughout the day. The
system is constructed of translucent face sheet that retracts sunlight to supply a balanced, diffuse wash of glare-free, usable light, deep within spaces.

**Conclusion**

Sustainable industrial architecture has steadily increased throughout history. With many laws and regulations, buildings are no longer designed the way they were during the industrial revolution. One of the biggest pieces to note is that sustainable industrial architecture still has a long way to go. As the world continuously needs more buildings, it’s important to take into consideration on how an industrial architecture building can be adapted to help the environment. Even minor changes to adapt more sustainably will help overall. If each modern design were to implement just one of the pieces discussed, then the world would be that much better for it. One topic that was not discussed in this research that can be further developed is life cycle cost. When designing sustainable buildings, it is important to note the life cycle cost of any part that will be implemented into the building design. Life cycle cost calculations can help sway industry owners to head towards more sustainable designs rather than simply putting up another warehouse or factory that has negative effects on the triple bottom line.
Images

Figure 1: Dense factory conditions during the industrial revolution.

Figure 2: Ford Motors Highland Park Plant designed by Albert Kahn.
Figure 3: Fagus Factory operable window designs by Walter Gropius

Figure 4: Trenton South Engine Plant with natural light and open space to accommodate employees.
Project Application Pages

Location and Transportation: Neighborhood Development

Location of building’s provide great importance to sustainability. The site of the recycling facility is located in Bowling Green, Ohio within a quarter mile radius of several shops and businesses. This is preferred because it allows for a greater walk score and allows for employees to have easy access to other amenities.

Location and Transportation: Parking and Transit

Bicycle racks will be provided for employees commuting to work. Providing these will allow for a alternative transportation method then driving cars. Even if some employees choose to bike to work, green house gas emissions can be lowered.

The parking lot of the site will also provide electric vehicle charging services spots. Everyday, more and more people are choosing to drive electric cars. Having a space as a company for employees to charge their cars will further encourage people to choose electric cars over gas powered cars.
**Sustainable Sites: Protect and Restore Habitat**

Protecting and restoring the habitat of any site is important to the overall biodiversity of a site. Utilizing the most eastern part of the site as a native green space area will allow for some biodiversity to remain. Since the site is located on a prime farmland lot, allowing for a biodiversity space will make the site more sustainable.

**Sustainable Sites: Rainwater Management**

Bowling Green, Ohio has water issues when there is a lot of rain. This is in part due to the history of the Black Swamp area. To help avoid rainwater runoff, a cistern will be used to catch rainwater from the roof system. This rainwater can then be used to irrigate the newly developed land.

A bioswale will be placed on the front west and south side of the site. A bioswale is a channel designed to concentrate and convey storm water runoff while removing debris and pollution. The bioswale for this project would be vegetated and will have a gentle slope inward.
Sustainable Sites: Light Pollution Reduction

The amount of up lighting on the site will be reduced for exterior lighting to avoid pollution onto the adjoining sites. Light levels will also be controlled outside to reduce the light pollution. Exterior lights will use covered bulbs that face the light downwards. This will help reduce the brightness of the skies as it eliminated the light that reflects into the sky. Warm colored LED lights will also be used. LED lights reduce luminance levels without compromising visibility. Finally, an automatic system will be used to turn off exterior lights when there is enough natural lighting.

Sustainable Sites: Pervious Pavement

To provide a more sustainable site, majority of the area needs to be constructed with pervious pavement. To accomplish this, a pervious paver system will be implemented. Designed to handle heavy truck traffic, the paver system will allow for rain water to be absorbed into the ground beneath the site. Being in Bowling Green, Ohio, this feature is important.
**Sustainable Sites:** Reduced Heat Island Effect

A green roof will be located on the lower portion of the structure. By implementing a green roof, the structure will have more shade, reduced temperatures, and access to filtered rain water runoff. Particularly during the day, the green roof will lower the heat island effect.

The portion of the roof that does not have the capabilities of implementing a green roof will be constructed using a roofing material with a high solar reflectance value.

**Water Efficiency:** Outdoor Water Use Reduction

The outdoor water use of the site will be greatly reduced through the plantings of native plant species. Native plants do not require as much irrigation services as does non-native plants. This is due to their survival rate in Bowling Green’s climatic area.

The site will also be relying heavily on rainwater runoff to natural water the vegetated areas. The rainwater runoff will be captured from the green roof system and will allow for natural irrigation.
Water Efficiency: Indoor Water Use Reduction

There will be indoor water use reduction to reduce indoor potable water consumption and preserve no and low-cost potable water resources. The use of water saving fixtures, such as dual-flush water closets, low flow urinals, and sensor faucets are key to reduce indoor water use. All installed fittings and fixtures will have the WaterSense Label and will meet the baseline water consumption of fixtures and fittings.

EPA WaterSense

To further reduce the potable water consumption, gray-water will be used for flush fixtures. The gray-water will come from the collected water from the green roof. This water can then be recycled and used in the system. Doing so, will greatly reduce the use of potable water.

Water Efficiency: Cooling Tower Water Use Reduction

To further reduce the amount of potable water use on the site, cooling tower water use will be cycled multiple times. By utilizing ten cycles of water going through the tower before exceeding limits for compounds such as calcium, silicon dioxide, and total alkalinity, water will be saved. To allow for the ten cycles, the cooling tower water will be softened. The softened water can be used to provide an increase in cycles to the maximum level.
Energy and Atmosphere: Renewable Energy Production

Renewable energy production will take place on the south part of the roof structure. A solar array system will be placed on the roof structure to allow access to non-polluting and renewable energy. Adding in a solar field will also allow or net metering with the local utility. When the on-site energy produced does not meet the demands of the site, then a green power contractor will be utilized. Currently, the city of Bowling Green has access to harvested wind energy as well.

Indoor Environmental Quality: Acoustic Performances

To provide workplaces that promote occupant’s well being, productivity, and communications through effective acoustic design, several different measures will be implemented. The first step to achieve acoustic performance will be to limit the HVAC background noise. Another key component to achieve acoustic performance is to have a separation between the office spaces and the factory space. There will be acoustical paneling placed on the separating wall to avoid the transfer of sound. A commercial acoustics sound barrier is a specially designed mass loaded vinyl product engineered to block the transmissions sound waves. A vinyl type of sound barrier is also cost effective.
Indoor Environmental Quality: Daylighting

Daylighting will also be used throughout the building to connect building occupants with the outdoors, reinforce circadian rhythms. Daylighting will help reduce the use of electrical lighting by introducing daylight into the space. Light sensors will play a big role in allowing for dimming controls. For example, as the daylight becomes brighter, less interior lighting will be utilized.

A Kalwall system will also be implemented in the warehouse portion of the building. The Kalwall will provide natural light to flood the space throughout the day. The system is constructed of translucent face sheet that refract sunlight to provide a balanced, diffuse wash of glare-free, usable light, deep within spaces.

Material and Resources: Environmental Product Declarations

To lower carbon footprint of trucking materials to the site, many building materials will be either extracted, manufactured, or purchased within 100 miles of the project site. To determine the 100 mile location, the calculation is based of location distance and not distance traveled. For example, building elements such as the solar panels, roofing material, flooring material, siding material, and office equipment will be purchased all within the locality of Toledo. Doing so, lowers the cost of travel and the environmental impact that traveling is associated with.
Bibliography


'industrial facilities in Motion' from 'LEED in Motion Industrial Facilities' by USGBC. LEED in Motion Industrial Facilities. (n.d.). Retrieved April 2, 2022, from https://readymag.com/usgbc/industrial/about/


'project spotlight' from 'LEED in Motion Industrial Facilities' by USGBC. LEED in Motion Industrial Facilities. (n.d.). Retrieved April 1, 2022, from https://readymag.com/usgbc/industrial/projects/


'scope & opportunity' from 'LEED in Motion Industrial Facilities' by USGBC. LEED in Motion Industrial Facilities. (n.d.). Retrieved April 14, 2022, from https://readymag.com/usgbc/industrial/scope/