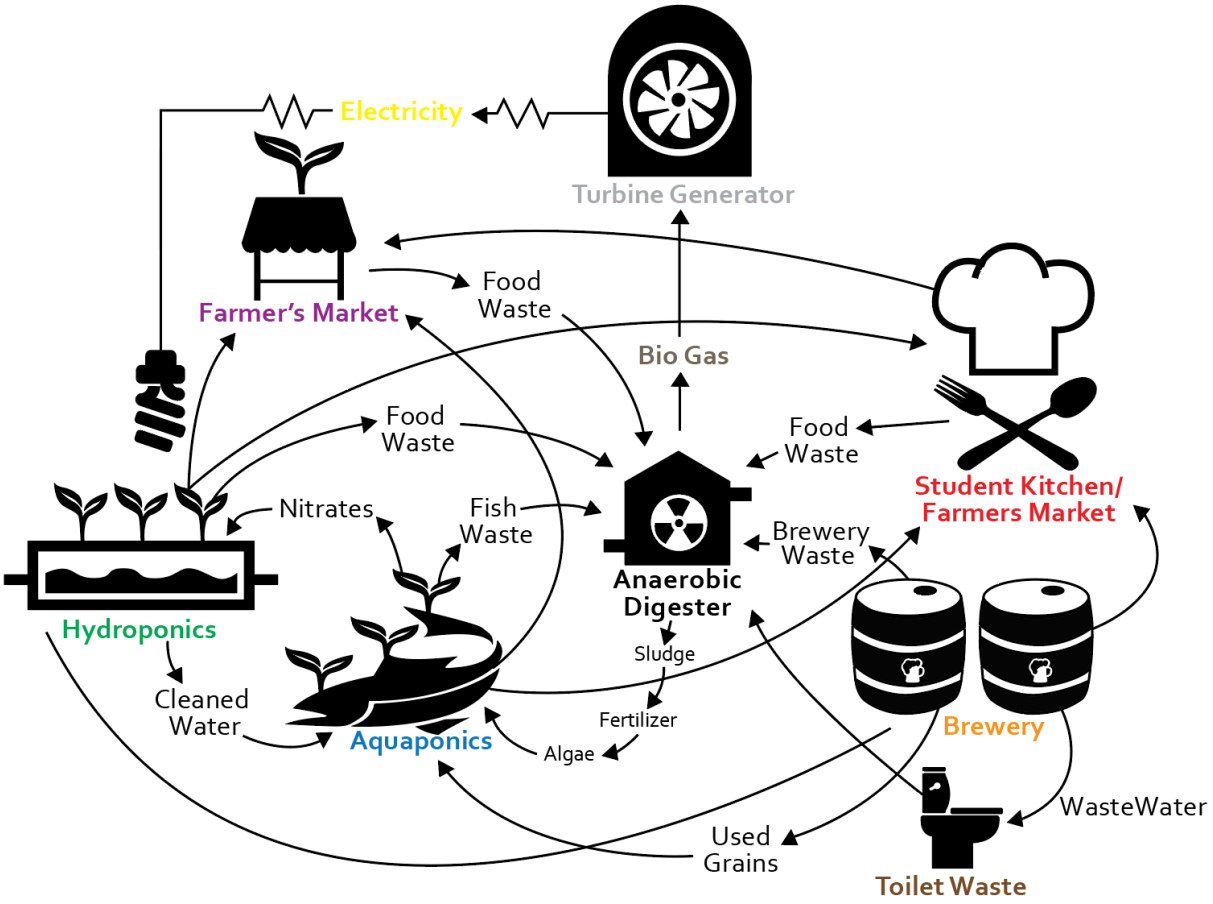
Symbiosis of Systems



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Introduction:

While investigating the brewery building in Sault Ste Marie there was the opportunity to introduce several different strategies in order to maintain a well tempered environment while striving to achieve a net zero building. As a means of achieving this end goal the building was designed as an ecology of systems, each with inputs and outputs of resources. The idea is to take a regenerative approach, creating a self sustaining system with each individual component within the building benefiting another. This creates a symbiosis within the building environment that generates power, and uses significantly less resources, all while producing a fraction of the waste compared to if the systems were independent of one another. The building also employs a selective approach, taking advantage of solar gain, as well as excess heat from the brewery as a means of passively heating the building during the winter. The brewery building's objective is to serve as an example to the community of a net zero-building that exemplifies the 'cradle to cradle' approach while establishing the idea of sustainable agriculture within an urban environment.

HydroPonics:

Urban agriculture is a term used for food that is produced in or around urban areas. In reference to the building design this encompasses community supported agriculture, community gardens, and urban farming. Sustainable food production is a significant aspect of any community, especially as people are becoming increasingly concerned about where their food comes from and how it is grown. Not only is locally grown food healthier for people, the extremely high energy costs of transporting the food are reduced significantly. In the U.S. and Canada the average

conventional produce item travels 2,400 km, consuming 3.8L of fossil fuel per 45 kg of produce[1]. By establishing a location for urban agriculture the brewery building does not only benefit towards achieving net-zero, but it also sets a standard for a more sustainable community as a whole.

There are many benefits for using hydroponics in order to grow fresh produce versus traditional farming. The Association for Vertical Farming, states that vertical farms use 98 percent less water and 70 percent less fertilizer on average than outdoor farms. In addition, weather is not a factor and neither is soil management. A hydroponic farm can harvest crops as often as 20 times a year, while occupying a fraction of the land traditional agriculture requires[2]. While hydroponics are a more efficient use space for growing food, they require large amounts of energy to maintain. According to the Groucher College report, "Economic Assessment of Hydroponics Lettuce Production", 90% of production costs of hydroponics are composed of energy (20%) and labor (70%)[3], by reducing the use of paid labour by participating in community supported agriculture the costs become more feasible for implementation in the Sault.

Inputs:

There are several systems that feed into the hydroponic portion of the building, these include; the aquaponics, the brewery's excess heat and CO2, as well as the electricity generated

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[1] "From U R B A N F A R M I N G T O C A N A D I A N RAILWAYS." Cyansolutions. May 2014. Accessed December 1, 2016. http://uturn2.cyansolutions.com/cip/plancanada/spring2014/7C898F0BD4E59BAE95431EE1F86EB2E9/8WCadvertposterFINAL.pdf.

[2] Wells, Jeff. "Indoor Farming: Future Takes Root In Abandoned Buildings, Warehouses, Empty Lots & High Rises." International Business Times. 2015. Accessed December 02, 2016. http://www.ibtimes.com/indoor-farming-future-takes-root-abandoned-buildings-warehouses-empty-lots-high-rises-1653412.

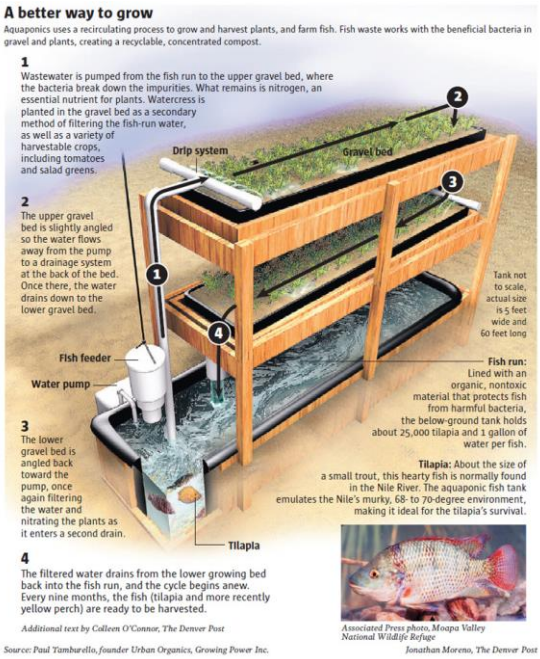
[3] Wells, Jeff. "Indoor Farming: Future Takes Root In Abandoned Buildings, Warehouses, Empty Lots & High Rises." International Business Times. 2015. Accessed December 02, 2016. http://www.ibtimes.com/indoor-farming-future-takes-root-abandoned-buildings-warehouses-empty-lots-high-rises-1653412.

by the turbine generator. The aquaponic system puts nitrates in the water that the hydroponics filter out and benefit from, and return the water to the hydroponics; this process happens between the two for several yields, allowing for there to be considerably less waste water. The brewery creates large amount of excess heat during the fermentation process, this heat rises up since the brewery is open to the second floor, where it can benefit the different plants that must maintain a temperature between 70-80 degrees Fahrenheit. During the fermentation process waste Co_2 can also be put in canisters for application on some of the different vegetation. This technique has seen produce growth enhancement as high as 40% in some cases4. Finally the turbine generator, which is powered by biogas as a by product of the anaerobic digester creates electricity to be used for the hydroponics.

Outputs:

The Hydroponics produce large amounts of produce, which can be sold, as well as dispersed throughout the community as part of community supported agriculture. The people involved in the community garden portion of the hydroponics take a share of the yield, while a percentage is sold for profit and donated to soup kitchens throughout the Sault. The fresh produce can also be used by the community and student kitchen, with any food waste being put into the anaerobic digester; once again to be turned into electricity for the hydroponics.

[4] "Issue 52: ADM – Turning Waste into Growth | Hydroponics." Hydroponics. 2010. Accessed December 01, 2016. http://www.hydroponics.com.au/issue-52-adm-turning-waste-into-growth/.



AquaPonics:

Aquaponics is the combination of aquaculture and hydroponics, and is often used in vertical farming, with benefits beyond the production of vegetables. In aquaponics, fish provide the nutrients that plants need to grow, and the plants filter the nutrients out to improve the water quality for the fish. Essentially, the fish are fed food, the fish produce waste, that waste is filtered, and the remaining nutrient rich water is used to grow plants. AeroFarms, a company based out of New Jersey uses this same closed loop system and has found that it uses 95% less water than field farming would to produce the same yields[5].

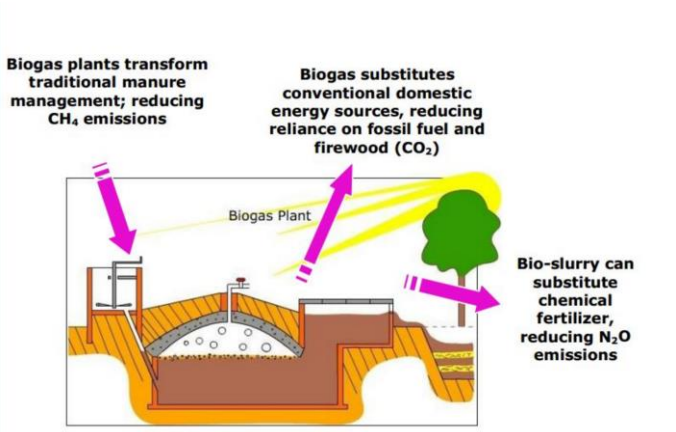
[5] Clarkin, Elizabeth. "The Next Generation of Vertical Farming - Creating a Regenerative Typology of Urban Space and Programming." 2013. Accessed December 1, 2016. https://getd.libs.uga.edu/pdfs/clarkin_elizabeth_201605_mla.pdf.

Inputs:

The buildings aquaponics system is fairly traditional, except the food for the fish Is produced using spent grains from the brewery to create a protein rich fish food.

Outputs:

The fish and vegetation produced will be used in a similar fashion to the hydroponic yield, except this component will not be based around a community garden. The fish can be sold at the market, as well as used in the kitchen, with any waste being put into the anaerobic digester to be converted into electricity.



The benefits of agricultural small-scale biogas plants. Source: PBPO (2006)

<u>Anaerobic Digester:</u>

An Anaerobic Digester uses the biological conversion of organic compounds by anaerobic microorganisms into biogas. In other words, it breaks down any organic matter in an oxygen free

environment; the digester then produces nutrient rich fertilizer and biogas, which is composed mainly of methane (55-75 vol%) and carbon dioxide (25-40 vol%)[6].

Inputs:

Almost anything can go into an anaerobic digester, however ideal materials include: food waste, municipal wastewater solids, fats, oils, grease, and livestock waste. In reference to the building brewery waste, food waste, and toilet waste are all put into the digester.

Outputs:

The Anaerobic digester produces a biogas, which is mostly composed of methane, this gas is contained and then used with the turbine generator to create electricity for the building's power needs. The anaerobic digester also produces a nutrient rich fertilizer that can be sold or returned to the surrounding landscape.

Brewery:

While the Brewery is not a vital part of the building programatically, it still plays a key role in the cradle to cradle approach of the building.

Inputs:

The brewery receives its water municipally and in association with the brewing ingredients are used to produce beer. While the brewery does not have many inputs from other components, it is still an important part of the group of systems within the building.

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[6] "Water and Wastewater: Treatment/Volume Reduction Manual." 2013. Accessed December 2, 2016. https://www.brewersassociation.org/attachments/0001/1517/Sustainability_-_Water_Wastewater.pdf.

Outputs:

Spent grain from the beer making process, can constitute as much as 85% of a brewery's total waste[7], this grain can be used in a number of ways throughout the building. First of all the grains can be converted into a protein rich fish food that feeds the aquaponic fish. A Denver based company called Nutrinsic has partnered with MillerCoors in order to use its wastewater and spent grains to create single-cell proteins to make a fish food. This food is actually 25% higher in protein than traditional fish food[8] and makes use of one of the largest wastes produced by the building. The grains can also be put into the anaerobic digester or even used in the community kitchen in order to create bread.

Beer is about 95% water in composition, however, the amount of water used to make beer is far greater than the amount of water contained in the beer itself. In addition to the water used in production, wastewater is a huge by product of breweries.The disposal of waste water presents another opportunity to be regenerative throughout the building. Most breweries discharge roughly 70% of their incoming water as effluent[9]. The effluent is quite contaminated with organic waste, and can become unbalanced in terms of acidity, so it cannot just be poured down the drain.

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[7] Fuller, Janet Rausa. "Boom in Breweries Leads to Growing Problem: What to Do With Spent Grain? - Chicago - DNAinfo Chicago." DNAinfo Chicago. 2014. Accessed December 01, 2016. https://www.dnainfo.com/chicago/20141020/chicago/boom-breweries-leads-growing-problem-what-do-with-spent-grain.

[8] Leech, Eric. "Struggling Fisheries Could Make a Comeback Using... Beer!" TreeHugger. 2009. Accessed December 01, 2016. http://www.treehugger.com/corporate-responsibility/struggling-fisheries-could-make-a-comeback-using-beer.html.

[9] "Water and Wastewater: Treatment/Volume Reduction Manual." 2013. Accessed December 2, 2016. https://www.brewersassociation.org/attachments/0001/1517/Sustainability_-_Water_Wastewater.pdf.

Disposal of this wastewater is quite expensive therefore the water should be filtered and reused as greywater throughout the building. After the wastewater has first undergone chemical, and physical treatment, it can be biologically treated. The treatment of the wastewater can either be done through the aquaponic system where the plants will filter out any impurities, or the waste water can be put into the anaerobic digester to create electricity. The brewery will also create Co2 that will be repurposed to benefit the hydroponic plants on the second floor. Waste heat will also be used to warm hydroponics to around 20°C, for use during the cold winter months.

Toilet System:

The building features a composting toilet system to work in association with the anaerobic digester included in the building.

Inputs:

The toilet will receive either municipal water or grey water after treatment from the brewery process.

Outputs:

The toilet waste will be put into the anaerobic digester where it can be turned into electricity to benefit the rest of the building.

Student/Community Kitchen:

The kitchen included in the building will be for the community (community support agriculture) as well as students of local culinary schools. A community kitchen will provide the opportunity for locals to learn to cook cheap healthy meals while the students gain an opportunity to improve their dishes and even sell them at the weekly market.

Inputs:

The kitchen will receive vegetation as well as fish from the Hydro/Aquaponics systems, as well as waste grains from the brewery.

Outputs:

The food produced will either be consumed by the community, sold at the market or put into the anaerobic digester.

Farmers Market:

Inputs:

The weekly market hosted in the building will not be like that of a traditional market, the idea is for people to come into the hydroponic portion on the second floor and pick their own fresh produce, paying for what they pick out. The market will otherwise be an opportunity for local culinary and art students to get exposure by either selling their food or their artwork. Creating community involvement was a key aspect of the programmatic design. The building is not only supposed to set an example for sustainable design, but also act as a catalyst for building a stronger community within the Sault.

Outputs:

Any waste as a result of the farmer's market will be put into the digester to help power the building.

Turbine Generator:

The turbine generator is an integral part of the building design as it allows for all the waste by product to go to use and create electricity.

Inputs:

Biogas from the anaerobic digester is used by the turbine generator, allowing for a reusable source of electricity that can be maintained as long as the digester continues to produce gas.

Outputs:

The generator produces electricity to be used by all of the other systems within the building.

Other Strategies:

Green Roof:

An extensive green roof was included in order to reduce the need for rainwater management as well as to reduce the power and heating cost of the building. The National Research Council of Canada's Institute for Research conducted a study that found green roofs reduced stormwater runoff by 57% on average, and as much as 90% during the summer months, this decreases the use of local infrastructure[10]. Green roofs have also been found to reduce energy consumption of buildings and keep buildings cooler during the summer. Keeping the building cool is important because with the heat generated from the brewery and the large amount of windows, it is vital that the brewery maintains a tempered environment and does not overheat during the summer.

[10] Mentens, Jeroen. "Green Roofs as a Tool for Solving the Rainwater Runoff Problem in the Urbanized 21st Century?" Laurentian University Library Licensed Resource / Réseau Réservé De Bibliothéque Université Laurentienne. August 30, 2006. Accessed March 18, 2016. http://www.sciencedirect.com.librweb.laurentian.ca/science/article/pii/S0169204605000496.

Passive heating:

The final system in the building is the use of passive heating by achieving maximum solar gain. There are plenty of windows along the south face of the building with the hydroponic greenhouse also on this face. The windows would have a glazing that optimizing solar gain, allowing for the building to be tempered in the cold winter months. In order for the greenhouse to not overheat some of the windows will be operable, so excess heat can be released when necessary.

Conclusion:

The old brewery building in Sault Ste. Marie provided the opportunity to establish a sustainable building in the downtown core of the city that can set a standard for sustainable living and food production throughout the region. In order to achieve this goal the building was designed as an ecology of systems, taking a regenerative approach, creating a self sustaining building with each individual component within the building benefiting another. In the end the building is able to sustainably produce food for the community, while generating its own electricity on site through the use of an anaerobic digester and turbine generator. The building also employs a selective approach to design, taking advantage of solar gain, as well as excess heat from the brewery to passively heat the building during the winter. The end result is a building that exemplifies the 'cradle to cradle' approach while establishing the idea of sustainable agriculture within the urban core of Sault Ste. Marie.