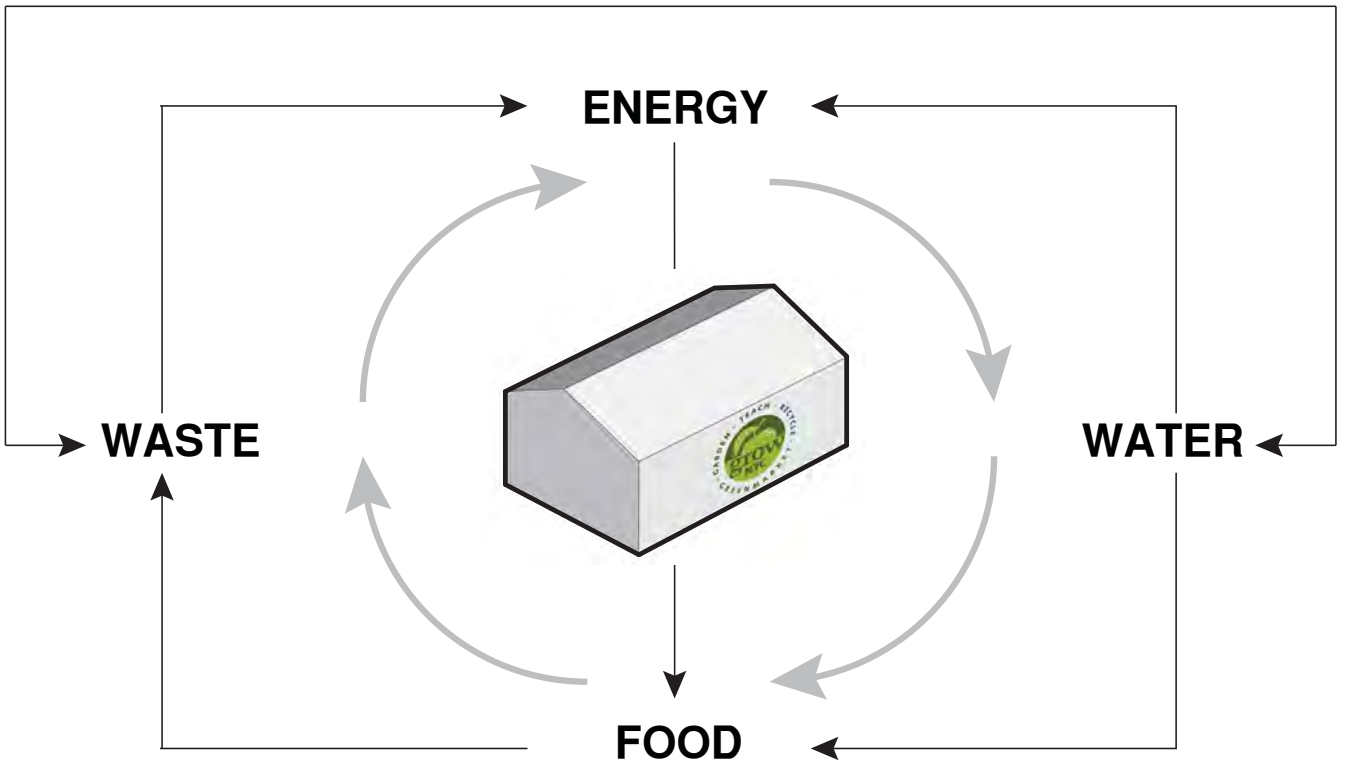

GROWNYC FOOD HUB: Early Adoption Study for Integrated Systems

ORE DESIGN: **THOMAS KOSBAU,** RA; DERRICK TANG, AND DHEERAJ BAJAJ

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PURPOSE OF REPORT

This report was developed to illustrate the selection of innovative sustainable systems and present (at a high level) how they can be incorporated into the building's design. The framework for evaluating the building systems contained in this report is a balance between three areas: **goals** expressed by GrowNYC, applicability based on **site conditions**, and ultimately if the system is using an **existing technology** that has been applied in existing, analogous projects.

GrowNYC has expressed the **goal** of an onsite Bio-digester as the main source of the GrowNYC facility's power (not including other tenants' needs). GrowNYC has also expressed interests in reducing atmospheric carbon, minimizing municipal water usage, creating pollinator habitats, using photovoltaics to generate power on-site, employing the most efficient warehouse operational systems (lighting, heating, cooling), and designing a façade that will reflect the special nature of GrowNYC's Foodhub program and the building that houses it.

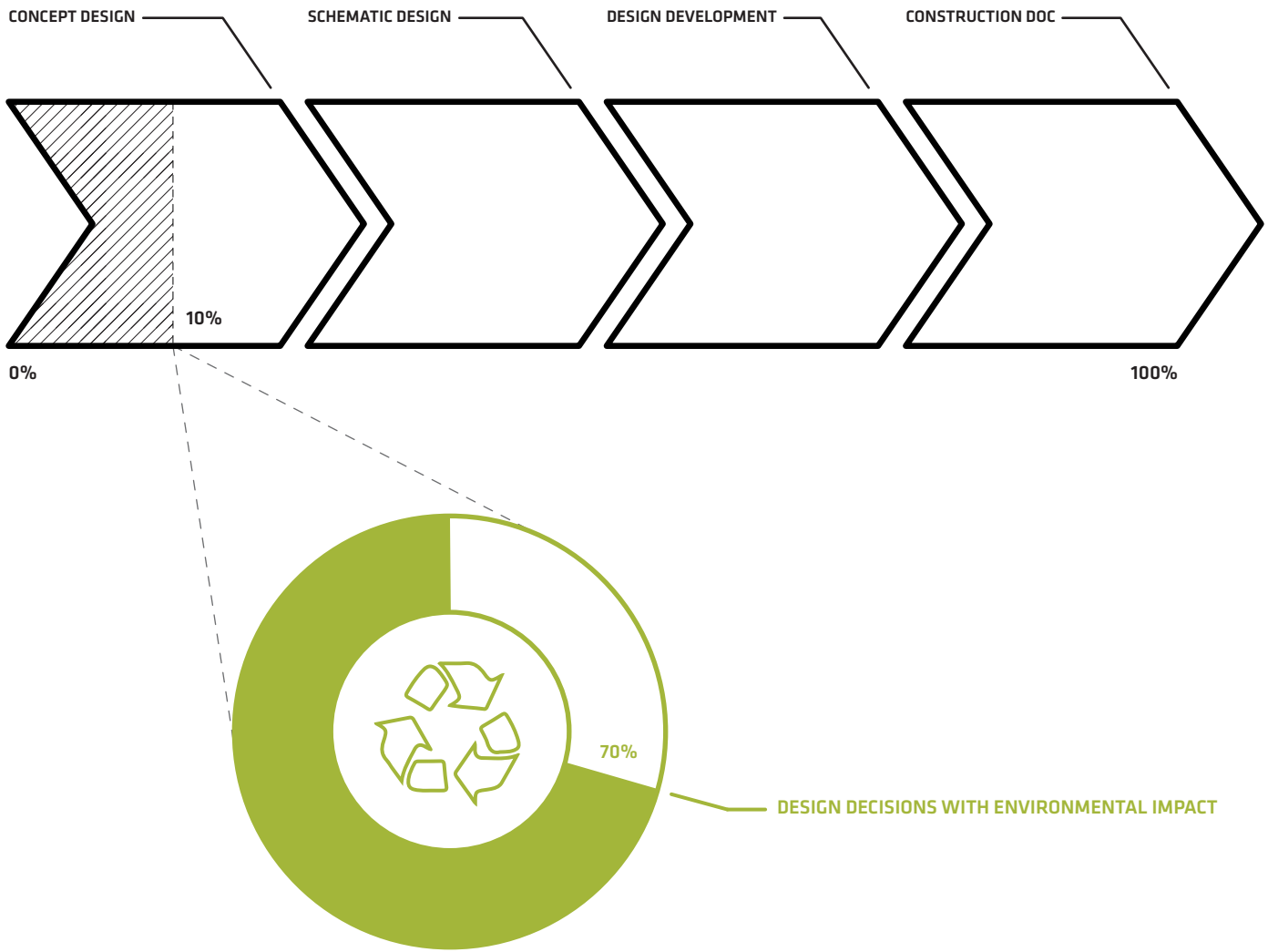
> **After preliminary reviews with the GrowNYC team we have reduced our initial report's breadth and focused this draft on key areas: Onsite power generation using an off-the shelf biodigester, augmented (for maximum power output) by an off-the-shelf algae lobby feature, and a supplemental powersource from solarpanels integrated into a vegetated roof.**

Understanding **site conditions** is vital to choosing the right technology to power, heat, cool, or clad your building. Site conditions are both as large scale as latitude coordinates and climate zone, and as specific as the solar angles, prevailing winds, and ground conditions at 1418 Viele Avenue, Bronx and its adjacent lots. In this report we've only begun the process of evaluating site conditions to the point of informing further design decision making. A thorough site evaluation will need to be conducted, via testing agencies and engineers, prior to designing an integrated system reliant on local climate, weather, and infrastructural conditions so that it may function optimally.

Lastly, in order to identify a truly unique integrated building strategy befitting the significance of the GrowNYC FoodHub project, it is important that **existing technologies** are employed to ensure proper utilization and reduce the risk of underperformance or periods of maintenance during operations. Therefore the most important aspect of this report is to identify sustainable technologies currently on the market and in use in projects that can provide a sense of applicability, life cycle cost and return on investment. To achieve this we went to sources including, but not limited to: The USGBC, the Living Building Institute, the National Renewable Energy Lab, the National Institute for Building Sciences, and Green Star.

After this report is received and evaluated we recommend further intensive study of the site and a push to flesh-out GrowNYC's project goals and the program of the FoodHub. These will be the key to driving design decisions early in the design process regarding which and to what scale these precedent technologies should be incorporated. The earlier these systems are designed into the building, the higher the likelihood that the budgetary and performance criteria are met. Additionally, the candidate technologies will require cost-benefit and life-cycle analyses to maximize long term savings and potential return on investment, ensuring GrowNYC's FoodHub as an educational marker for sustainable development.

EARLY DESIGN PHASE: LOW COST, HIGH IMPACT



INTEGRATED DESIGN

What is Integrated or "Whole Building Design"?

Per the Green Building Alliance "Around 70% of the decisions associated with environmental impacts are made within the first 10% of the design process."

Integrated or "Whole Building Design" (WBD) is a design stratagem to plan for (and thereby design to) high-performance systems in a building from the initial design phase through construction. The advantages of WBD are that early design decisions and criteria can be vetted, tested, and reconfigured to meet goals during the least expensive phase of creating a new building. Additionally, WBD allows for a more seamless integration of systems into the building's over-all design.

Integrated Design involves multiple areas of a project working together from the start towards one major goal. In regards to green building, this approach is commonly taken to allow a building achieve maximum efficiency, maintain lower costs, and increase overall performance. It can also help achieve LEED points if a building is seeking that certification. Many factors are considered when designing a building including but not limited to: mechanical and electrical systems, building occupancy, sustainability efforts, overall climate, and cost. With the use of an integrative design process, all factors are combined into four main areas: climate, use, building design, and systems. These areas are then analyzed by all team members to find synergies and similarities between them. By doing so, different strategies can be utilized to design a more healthy and energy-efficient facility.

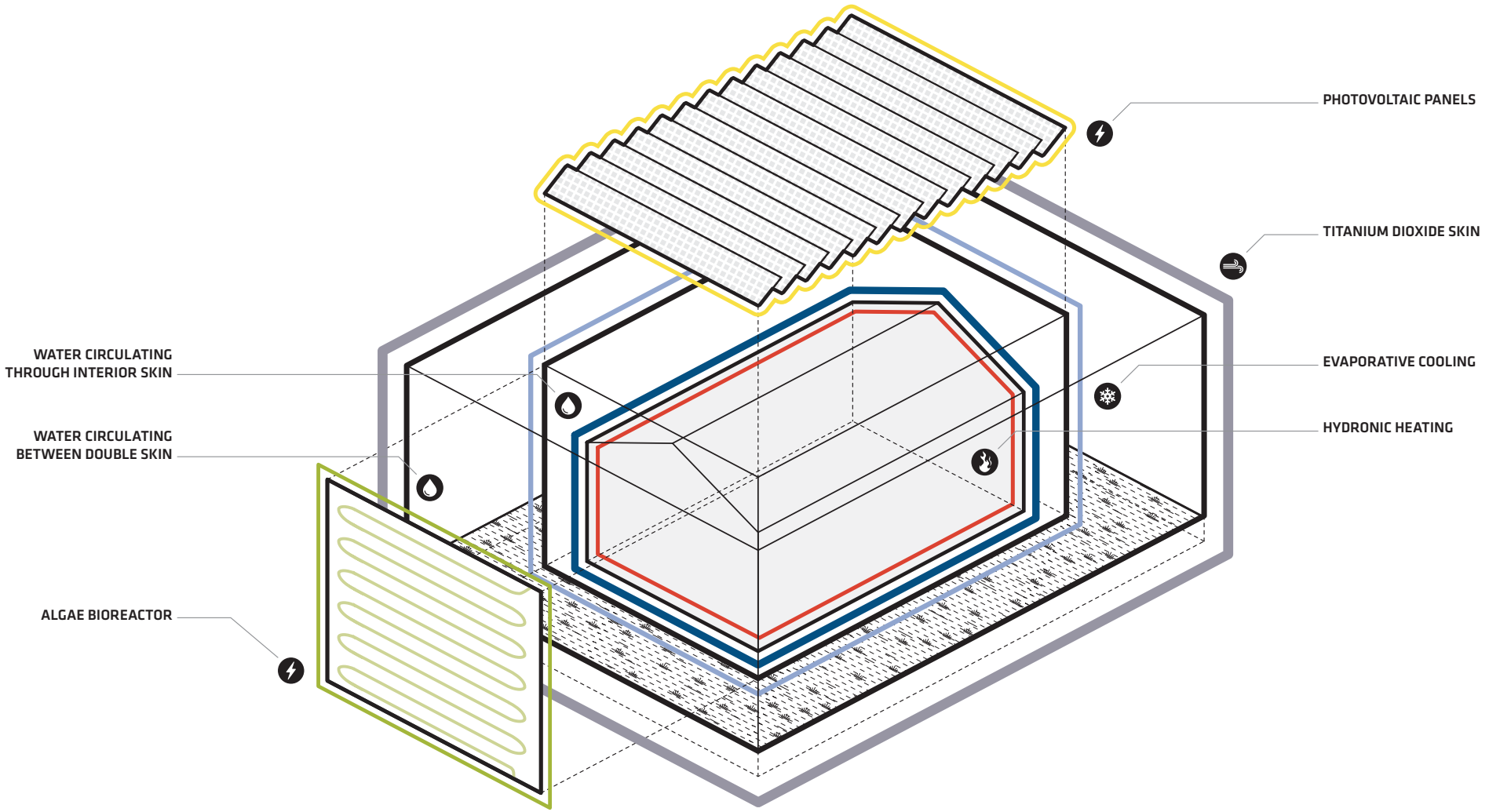
Multidisciplinary team members – often including an executive architect, a design consultant/architect (ORE), structural and civil engineers, mechanical and electrical engineers, quantity surveyors and an energy specialist. In this interactive working relationship, the executive and design architects' roles are not limited to the generation of built form and spatial layout, but also include the reconciliation and incorporation of ideas/inputs from other team members into the building design. The engineers assume the role of providing of systems and solutions to make a design work but are also expected to go beyond that role and take initiative in putting forward conceptual ideas to contribute to the high performance objective from the early design stages. The quantity surveyor's roles are extended from construction cost calculation to life cycle analyses and life cycle assessment of the building materials and other technological systems to be incorporated into the design. The building developer must also take on an active role in performance goal settings. The high performance goals, life cycle consideration and other design targets should be the ultimate objectives to direct the interaction and working relationships of the team members.

During the integrated design process, the time taken for the earlier design stages i.e., conceptual and schematic design, is inevitably longer than that of the conventional linear design process. However, this additional time is made up for by the shorter coordinating time at later design stages i.e., detailed design and documentation for construction. Furthermore, due to the involvement of the contractor (builder) in the early design stage, the construction period can be shortened with less coordination, fewer call-backs and variation orders, and so on.

Computational simulations should not just be used at the end of the design stage for verification and presentation purposes. They are particularly useful in simulating the performance of various design strategies and technological systems for comparison and can also be applied at the macro level during the conceptual design stage to show general/overall building volume for quick outcomes and overall direction. Therefore, computational simulations should be deployed during the integrated design process as a design assisted tool to provide feedback to the team for design improvement and decision making. Later in the process, when moving to schematic and detailed design stages, more detailed computational simulations will be required to support design improvements and fine tuning.

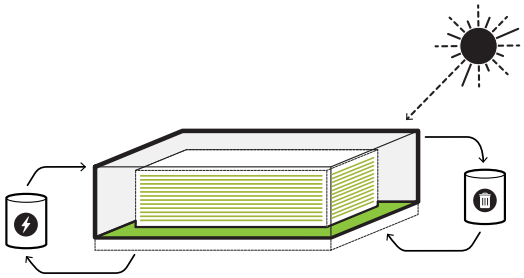
The design of buildings requires the integration of many kinds of information into an elegant, useful, and durable whole. An integrated design process includes the active and continuing participation of users and community members, code officials, building technologists, contractors, cost consultants, civil engineers, mechanical and electrical engineers, structural engineers, specifications specialists, and consultants from many specialized fields. The best buildings result from continual, organized collaboration among all players throughout the building's life cycle.

SYSTEMS INTEGRATED INTO BUILDING ENVELOPE



PASSIVE SYSTEMS INTEGRATED INTO A DOUBLE SKIN SYSTEM

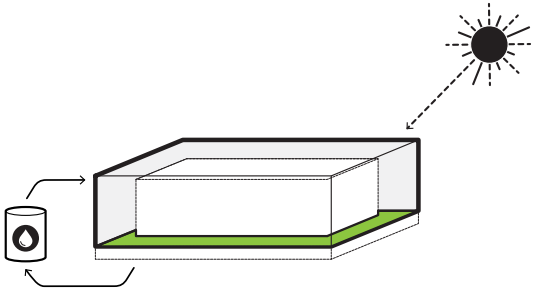
BIOMASS STRATEGY



ALGAL BIOREACTOR
Consumes carbon emmisions and sunlight to produce biomass



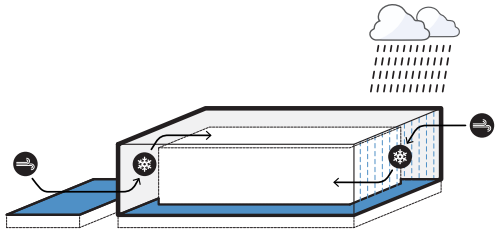
WATER STRATEGY



Algae and planting within double skin also provide
WASTE WATER FILTRATION



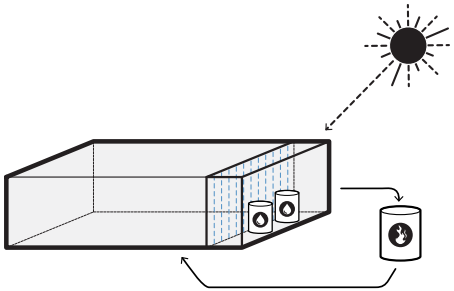
PASSIVE COOLING STRATEGIES



Water circulating within double skin provides
EVAPORATIVE COOLING

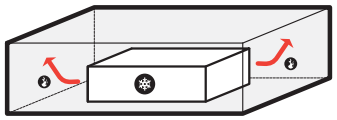


PASSIVE HEATING STRATEGIES

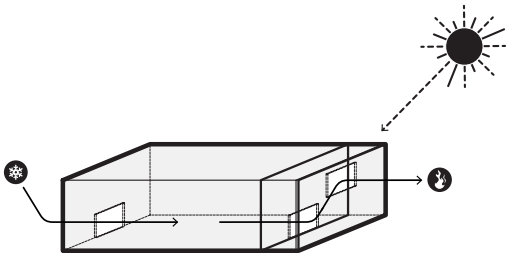


Water undergoes solar heat gain within the double skin for
SOLAR HYDRONIC HEATING





To thermally condition double skin space, the system
RECOVERS WASTE HEAT
from appliances, generators, and refrigeration



Strategically placed apertures allow for
STACK VENTILATION
where the evacuation of warm air draws in cool air



WHY CONSIDER A DOUBLE SKIN?

Not only do double skins improve building enclosure performance (reduce heat loss and gain, reduce particulate and noise infiltration, added security, etc.), they also allow for a richer building facade design and experience.



Activated Facade from standard materials

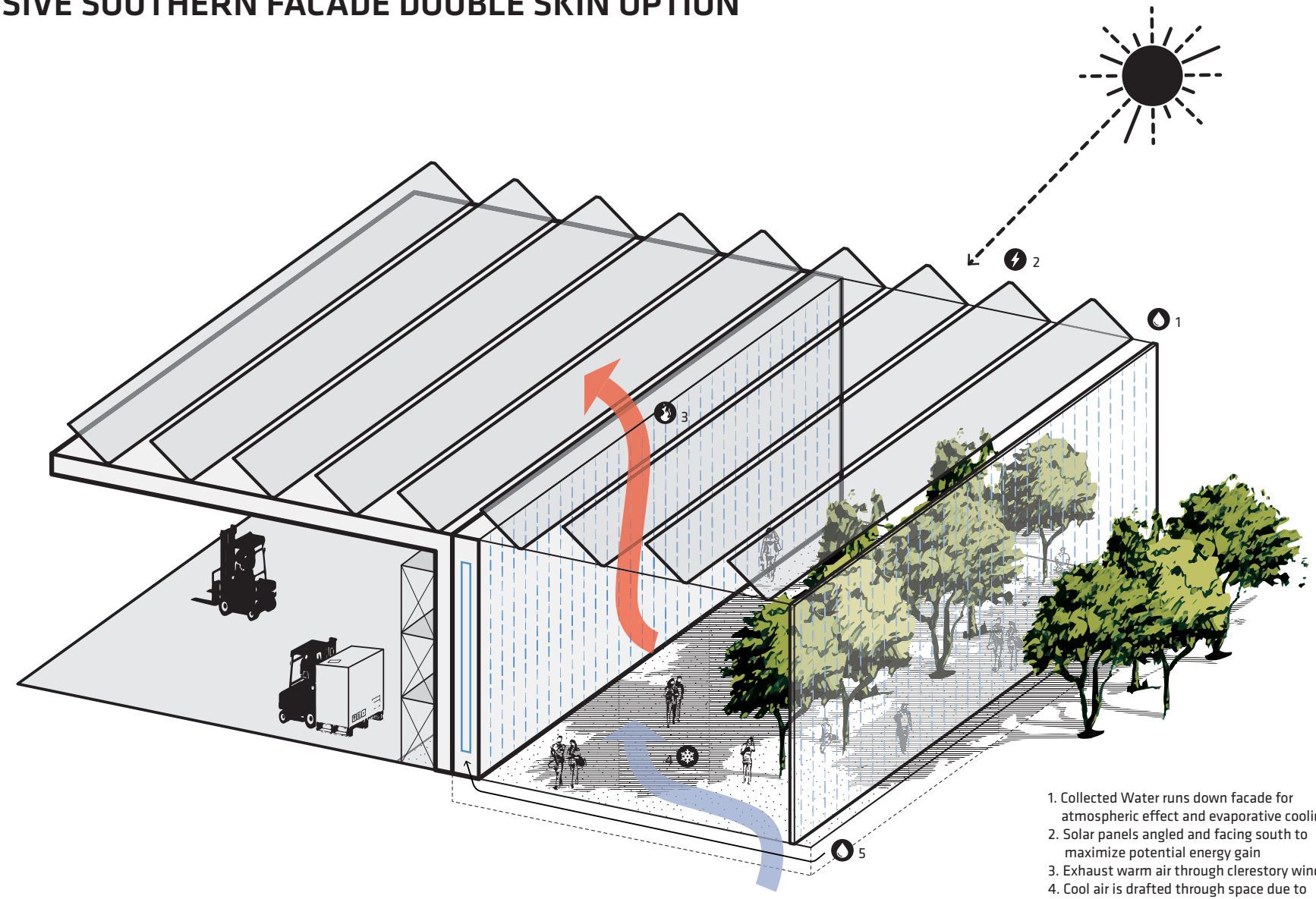


Vegetated Public Space / Cooling Performance



Occupiable Public Space (Enjoying High Performance Buildings)

PASSIVE SOUTHERN FACADE DOUBLE SKIN OPTION



1. Collected Water runs down facade for atmospheric effect and evaporative cooling
2. Solar panels angled and facing south to maximize potential energy gain
3. Exhaust warm air through clerestory windows
4. Cool air is drafted through space due to stack ventilation effect
5. Water is biofiltered and UV filtered as it passes through double-skin space and stored within wall cavity for to thermally condition interior

WHY CONSIDER ALGAE BIOREACTORS?

Algae Bioreactors eat CO2, purify waste water, and serve as a consistent source of biomass for Anaerobic Digesters. A study conducted by Washington State University's Department of Biological Systems Engineering, has shown that algal biomass serves as an effective digestate despite concerns of the fatty acids released by algae in the digestion process. Operation and Maintenance of algae cultures can also be included in the package provided by BioFerm.



CO2 Absorber on highway in Geneva, Switzerland



Varicon Aqua, Phyco-Lift Photobioreactor



SCHOTT Glass Algae Reactor Tubes



AlgaePARC Bonaire, Netherlands

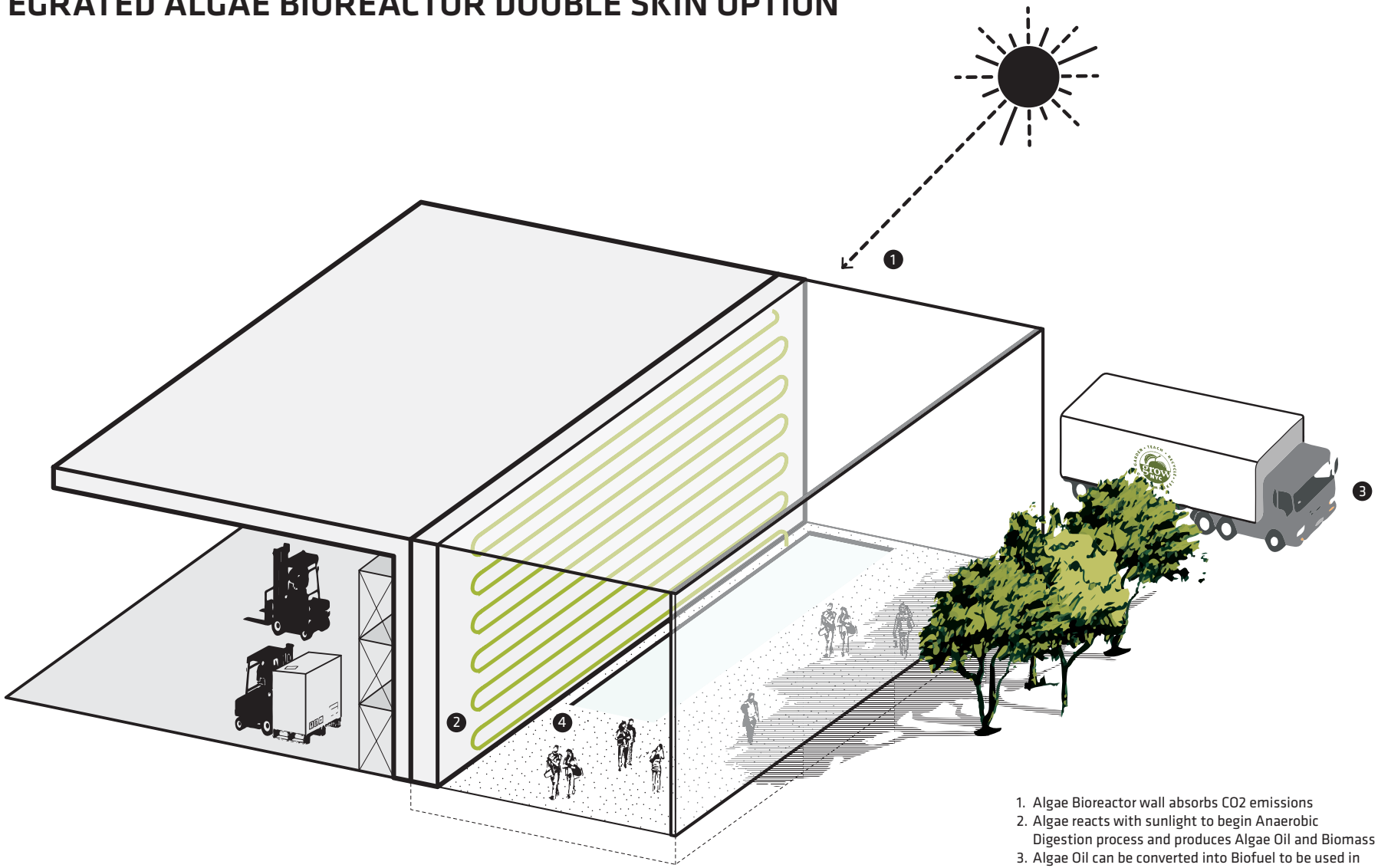
POSSIBLE FACADE VISUALIZATION



The building skin illustrated here demonstrates the possibility of a fully integrated design. Functioning as a set of layers woven around the core programmatic space, the skin could be developed as a closed loop system (centered around a wall of algae reactor tubes and in conjunction with the landscaping design and planned on-site biodigester) which collects storm water, cleans and heats water for recirculation, removes CO2 emissions, produces biofuel for the Grow Trucks, and produces biomass for the biodigester which in turn generates heating and power for the building, fertilizer for the landscape elements, and CO2 for the algae tubes.

Aside from technical benefits, a double skin system as demonstrated creates an aesthetically and experientially pleasant space for employees to circulate through. The channel glass and sawtooth roof allow for indirect daylighting while vertical planters behind the glazing provide shade and clean air within the space. Additionally, the light refracting off of the algae tubes and filtering through the layers of greenery and transluscent channel glass, which also reflects the sky and surrounding landscape, produces a dynamic visual effect projected on the exterior facade.

INTEGRATED ALGAE BIOREACTOR DOUBLE SKIN OPTION



1. Algae Bioreactor wall absorbs CO2 emissions
2. Algae reacts with sunlight to begin Anaerobic Digestion process and produces Algae Oil and Biomass
3. Algae Oil can be converted into Biofuel to be used in shipping trucks
4. Greywater is treated as part of the digestion process and in the algae ponds
5. Algal remains are recycled into Biodigester as biomass to generate energy for the Food Hub

VISUAL IMPACT OF FACADE

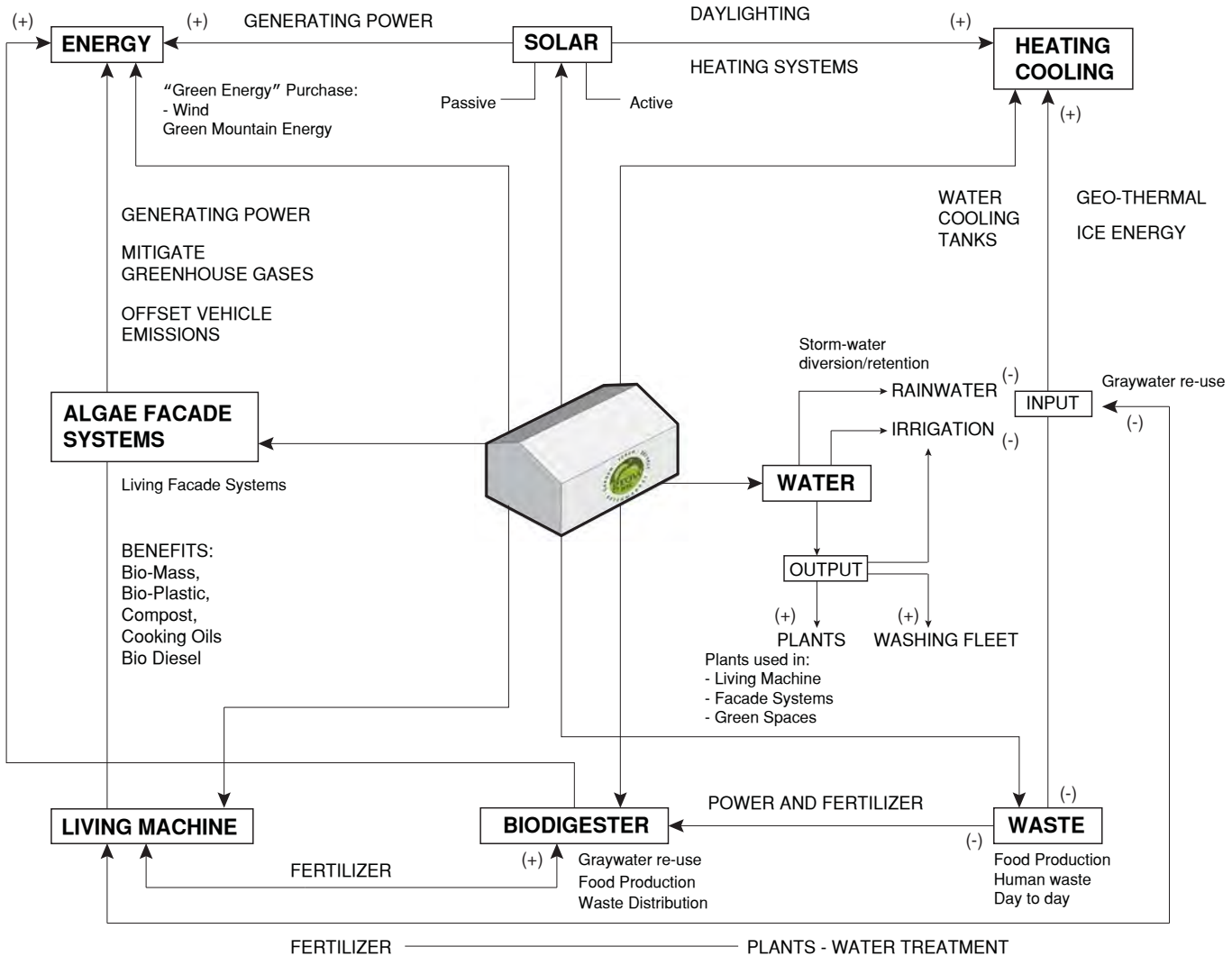


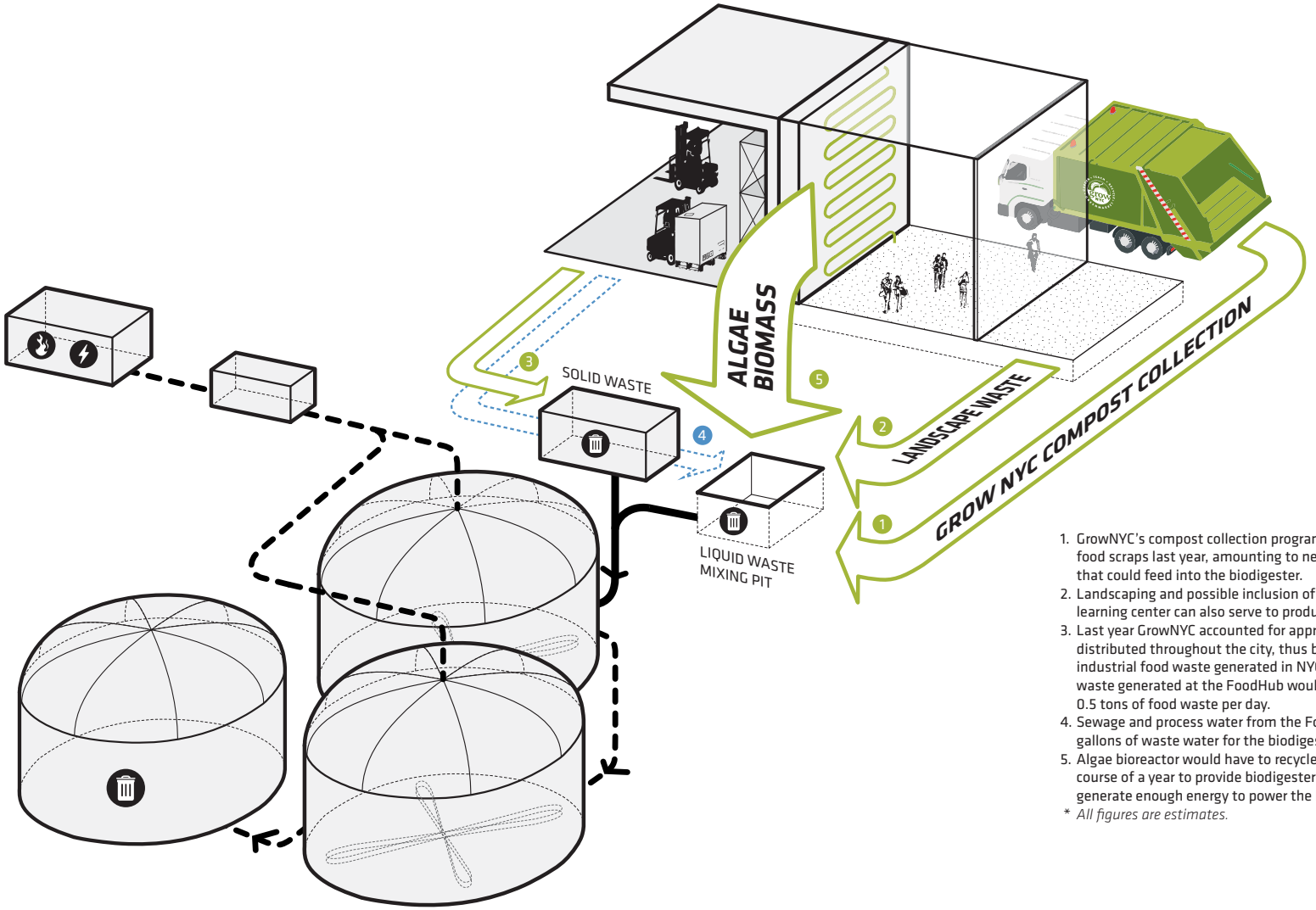
1. Algae Bioreactor Wall
2. Double Skin Occupiable Space
3. Vertical Planters Along Outer Facade
4. Channel Glass Outer Facade
5. Glazed Roof w/ PV Shading
6. Bioswales
7. Permeable Pavers
8. Native Plants

SELECTED STRATEGIES FOR INTEGRATED SYSTEMS

COMPONENT	DETAILS	PRECEDENT PROJECTS
ENERGY	• **Photovoltaics** - Converts solar radiation into usable direct current electricity. • **Algae Bioreactor** - Use of algal photosynthetic process to produce biomass / biofuel. *(removes CO2 from the system)* • **Biodigester** - Converts organic waste into biogas. *(produces sludge that can feed into landscape system as fertilizer)*	• David and Lucile Packard foundation Headquaters, California • Algal Haus, Hamburg, Germany • UC Davis Campus
WATER	• **Green Infrastructure / Bioswales** - Collects and controls water runoff while removing pollutants. • **Constructed Wetlands** - Treats and denitrifies wastewater; microorganisms break down organic waste, plants filter out pollutants. • **Biofiltration** - Uses an anaerobic bioreactor to treat wastewater and break down sludge. *(produces biogas to be used in other processes)* • **Local Water Treatment** - On site equipment treats and recycles greywater. *(can be used for heat reclamation from hot water in system)*	• Biosciences Research Building • Sarah E. Goode Stem Academy • Emory University, Georgia
HEATING	• **Waste Heat Recovery** - Recovers process heat to be reintroduced and reused within the system. • **Solar Hydronic Heating** - Uses solar radiation to heat process water for both radiative space heating and hot water to be used. • **Geothermal** - Makes use of the constant temperature in the top layer of the Earth's crust to maintain room temperature.	• Stanford Energy Facility, California • Siemens Headquarters, Munich • Lion House, Bronx Zoo
COOLING	• **Adsorption / Absorption Chiller** - Makes use of heat transfer and the evaporative process to remove heat from water • **Ice Energy** - Takes advantage of lower cost nighttime energy to produce ice which is then used for space cooling throughout the day. • **Evaporative Cooling** - Uses evaporative state change to draw heat from a space. *(can tie into water filtration system)* • **Stack Ventilation / Solar Chimney** - Exhausts hot air and draws in cold air by making use of the bouyant principle.	• Univesity of Melbourne, Neuroscience Institute • Ice Energy • British Pavilion 1992, Spain • Genzyme Center, Massachusetts
AIR QUALITY	• **Titanium Dioxide Skin** - UV light releases electrons from TiO2 film which interacts with H2O in the air to break apart pollutants. • **Natural Ventilation** - Makes use of Bernoulli's principle to control cross ventilation through the space. *(can integrate with stack vent.)* • **Living Green Wall** - Acts as a biofilter, metabolising harmful pollutants and releasing oxygen into the air. *(can tie into greywater reuse)*	• Precedent • Marvin Hall, Lawrence, KS, USA • Urban Farm, Tokyo, Japan
WASTE	• **Biodigester** - Converts waste from food processing, algal bioreactor, and landscaping waste into biogas. *(byproduct rich soil can feed into landscape system as fertilizer)* • **Composters** - Converts organic waste into fertilizer. • **Packaging**	
GREENING	• **Heat Island Reduction** - Utilization of green space and reduction of carbon footprint and energy usage to reduce heat island effect. • **Pollinator Gardens** - Providing resources for pollinators within landscaping such that they may survive and continue to function	

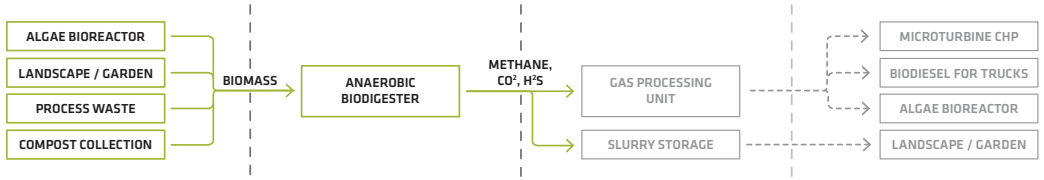
SIMPLIFIED - BLOCK FLOW DIAGRAM

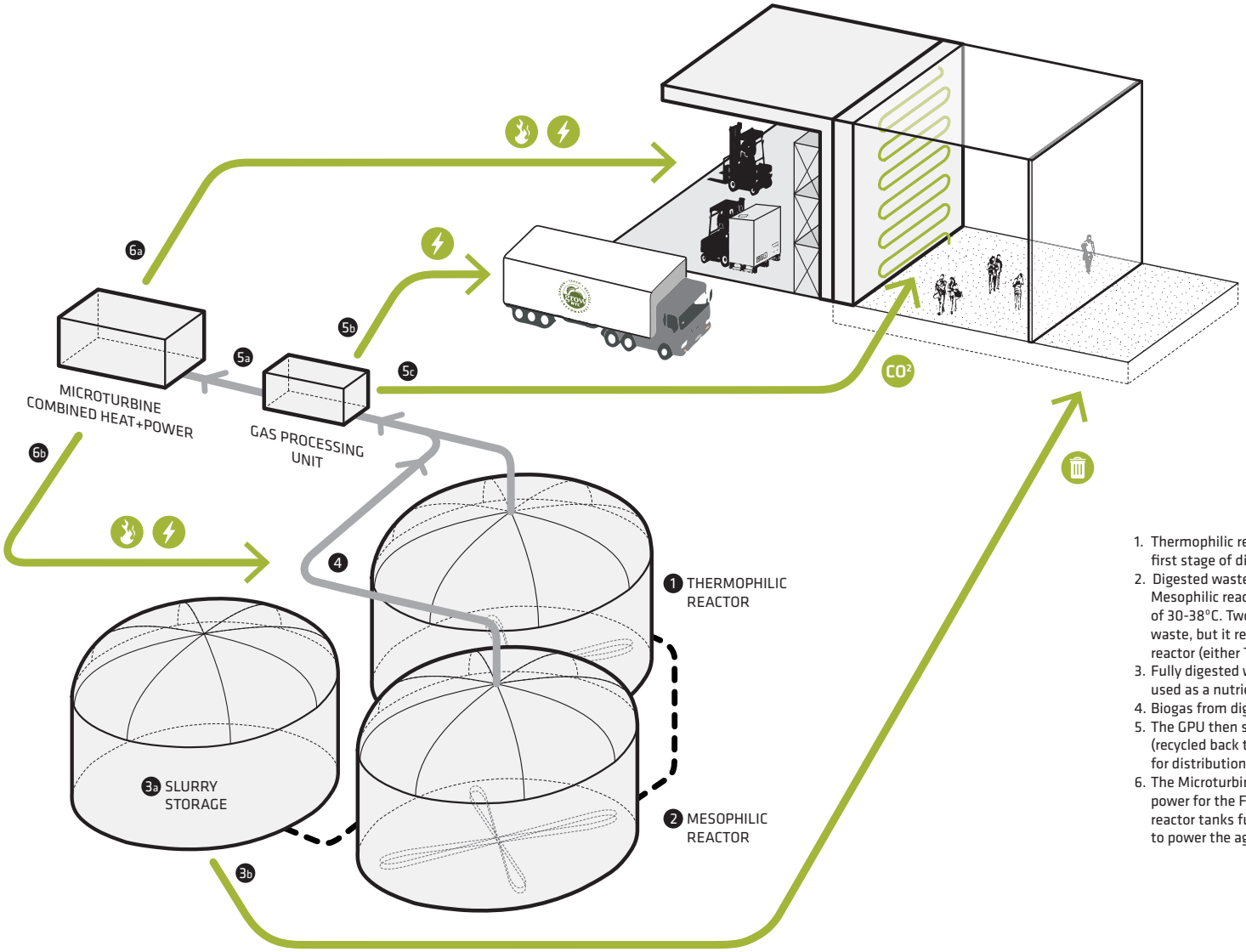




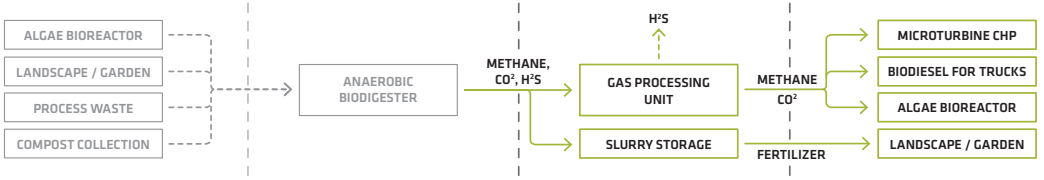
1. GrowNYC's compost collection program amassed over 1000 tons of food scraps last year, amounting to nearly 3 tons of waste per day that could feed into the biodigester.
2. Landscaping and possible inclusion of community gardens as a learning center can also serve to produce biomass on site.
3. Last year GrowNYC accounted for approximately .02% of all food distributed throughout the city, thus based on USDA estimates for industrial food waste generated in NYC a conservative estimate for waste generated at the FoodHub would amount to approximately 0.5 tons of food waste per day.
4. Sewage and process water from the FoodHub can generate 20M gallons of waste water for the biodigester over the course of a year.
5. Algae bioreactor would have to recycle 9000 tons of algae over the course of a year to provide biodigester with enough biomass to generate enough energy to power the FoodHub.

* *All figures are estimates.*

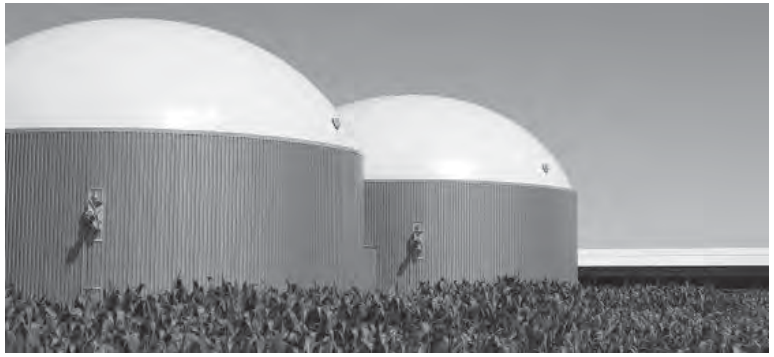




1. Thermophilic reactor functions at 50-65°C and serves as the first stage of digestion.
2. Digested waste from Thermophilic reactor is transfered to the Mesophilic reactor where it is further digested at temperatures of 30-38°C. Two-step digestion produces more biogas from input waste, but it requires a higher initial investment. Use of just one reactor (either Thermophilic or Mesophilic) is another option.
3. Fully digested waste moves to Slurry Storage which can then be used as a nutrient rich fertilizer for on-site landscaping/gardens.
4. Biogas from digester moves on to Gas Processing Unit.
5. The GPU then separates out H2S (odorous and dangerous), C02 (recycled back to algae), and Methane which is used as biofuel for distribution trucks and the Microturbine.
6. The Microturbine then uses the biogas to generate heat and power for the FoodHub as well as for the biodigester as the reactor tanks function at high temperatures and require energy to power the agitators.



OVERVIEW: DIGESTER TYPES



Complete Mix Digester:

A complete mix digester is a tank in which manure is heated and mixed with an active mass of microorganisms. Incoming liquid displaces volume in the digester, and an equal amount of liquid flows out. Methane forming microorganisms flow out of the digester with the displaced liquid. Biogas production is maintained by adjusting volume so that liquids remain in the digester for 20 to 30 days. Retention times can be shorter for thermophyllic systems. The digester can be continuously or intermittently mixed. Intermittent mixing means the tank is stirred during feeding and only occasionally between feedings. Sometimes the process takes place in more than one tank. For instance, acid formers can break down manure in one tank, and then methane formers convert organic acids to biogas in a second tank. Complete mix digesters work best when manure contains 3 percent to 6 percent solids. Digester size can be an issue at lower solids concentrations. Lower solids mean greater volume, which means you need a larger digester to retain the microbes in the digester for 20 to 30 days.



Plug Flow Digester:

The idea behind a plug flow digester is the same as a complete mix digester – manure flowing into the digester displaces digester volume, and an equal amount of material flows out. However, the contents of a plug flow digester manure are thick enough to keep particles from settling to the bottom. Very little mixing occurs, so manure moves through the digester as a plug – hence the name "plug flow." Plug flow digesters do not require mechanical mixing. Total solids (TS) content of manure should be at least 10 or 15 percent, and some operators recommend feeding manure with solids as high as 20 percent. This means you may need to add extra material to manure to use a plug flow digester. This is not always a bad thing if you consider the added material may also be biodegradable. More degradable material means more biogas. Plug flow digesters are usually five times longer than they are wide. Recommended retention time is 15 to 20 days.



Sequencing Batch Digester

An anaerobic sequencing batch reactor, or ASBR digester, is a variation on an intermittently mixed digester. Methane forming microorganisms are kept in the digester by settling solids and decanting liquid. An ASBR operates in a cycle of four phases. The digester is fed during the fill stage, manure and microbes are mixed during the react phase, solids are settled during the settle stage, and effluent is drawn off during the decant stage. The cycle is repeated up to four times a day for nearly constant gas production. Liquid retention times can be as short as five days. Although ASBR digesters work well with manure in a wide range of solids concentrations, they are particularly well suited for very dilute manures (< 1 percent TS), and if filled with active microbes during start-up, can even produce biogas with completely soluble organic liquids. Sludge must be removed from the ASBR digester periodically. Concentrated nutrients are harvested during sludge removal.



Covered Lagoon Digester

This system takes advantage of the low maintenance requirement of a lagoon while capturing biogas under an impermeable cover. The first cell of a two-cell lagoon is covered, and the second cell is uncovered. Both cells are needed for the system to operate efficiently. A lagoon is a storage as well as a treatment system; the liquid level on the second cell must rise and fall to create storage, while the level on the first cell remains constant to promote manure breakdown.

Since they are not heated, the temperature of covered lagoons follows seasonal patterns. Methane production drops when lagoon temperatures dip below 20 degrees C. A covered lagoon located in the tropics will produce gas year-round, but gas production will drop considerably during the winter farther north. Since sludge is stored in lagoons for up to 20 years, methane-forming microorganisms also remain in the covered lagoon for up to 20 years. This means that much of the fertilizer nutrients, particularly phosphorus, also remain trapped in the covered lagoon for a long time. If lagoon effluent is recycled to remove manure from buildings, liquid retention time is generally 30 to 60 days – depending on the size and age of the lagoon.



Plug and Play Digester

The Plug and Play digester is prefabricated modular design that is delivered to site ready for connection. It is suitable for smaller scale liquid feedstock applications (e.g. slurry). Digesters can be installed above or below ground (ground conditions permitting) and can be 'stacked' to increase plant output.

The digester tank is fitted with a controller to continuously record the level, a high-level electrode for emergency protection, a transducer to continuously record temperature, a gas pressure/vacuum relief valve and an emergency relief valve. To maintain even temperature distribution and prevent stratification the digester contents are mixed by the recirculation of biogas through a series of nozzles fixed to the floor of the digester. Each nozzle is mixed sequentially. Digester temperature is maintained by the circulation of hot water through an internal heat exchanger. Hot water is circulated through the heat exchanger by a central-heating pump. There is no mechanical equipment within the digester tank. The digester is discharged by a dedicated pump which withdraws digestate from the base of the digester; the slurry output is measured via an inline flow meter. The digester discharge is variable and can be adjusted by the operator. The biogas flow is measured at the gas consumers from the double membrane gas holder, capacity 100m3, via low level condensate traps. The gas holder is inflated by an air blower and its pressure is maintained at a constant level of 20mbar by a control valve.

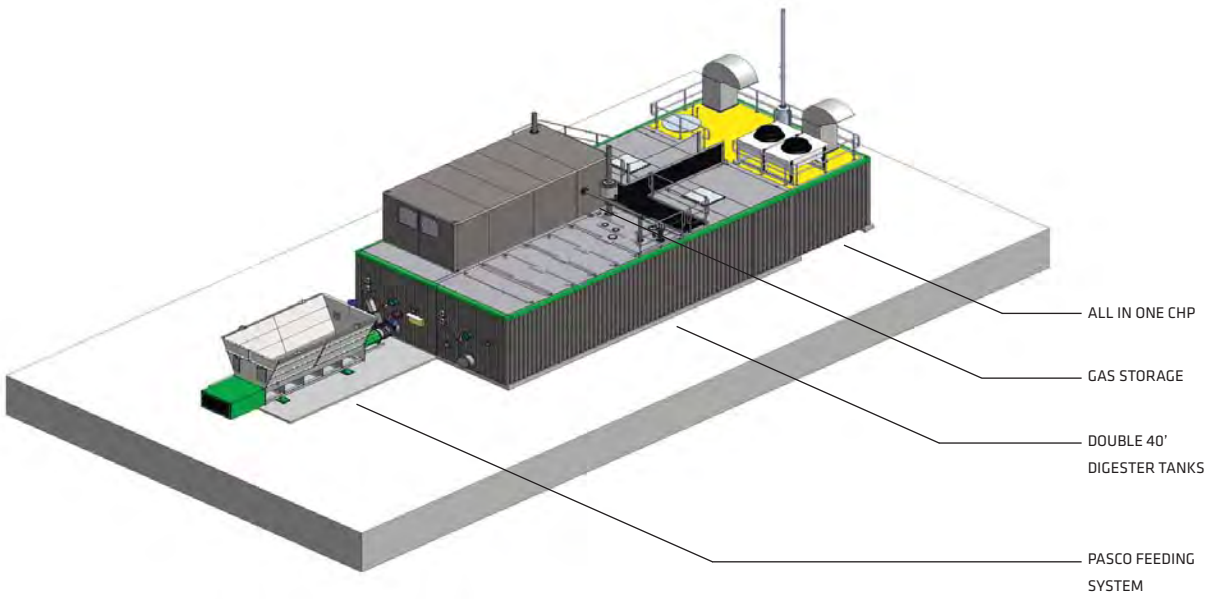


Semi Plug Flow

The Semi-Plug Flow (SPF) Digester is an exclusive 'ring in ring' Marches Biogas design that brings all the anaerobic digestion processes within a single digester. The plug flow design maximises feedstock retention times which, when combined with Marches Biogas gas mixing technology and other SPF efficiencies, leads to significantly increased biogas output over conventional CSTR systems. The SPF digester also has a smaller footprint and lower landscape impact than CSTR systems and can be partially buried if required.

The tank has a fixed roof on the outer two thirds of the area and a flexible membrane on the remainder centre section which acts as the biogas storage. The digester is fed in two ways: Liquid feedstock is pumped by a lobe pump once per hour and solid feedstock is augured directly once per hour. The circular Plug Flow system allows feedstock types to be inputted at different points, optimising retention times and the digestion process. Included within the digester are internal hydrolysis compartments, de-grit pipework, liquid level control, digester temperature control and gas holder level control.zz

IDENTIFIED DIGESTER FOR FOODHUB APPLICATION: BIOFERM EUCOLINO



System Overview

Compact and small-scale, the EUCOlino anaerobic digester is shipped from the supplier and arrives on site as a complete, pre-assembled containerized unit. EUCOlino is ideal for operations with limited amounts of biomass or a small footprint. It is capable of processing a wide range of feedstocks, and operates between 15-20% True Solids. EUCOlino a great fit for: municipalities, campuses, wastewater treatment facilities, food processors, dairies, and more.

EUCOlino's prefabricated system is simple, flexible and easily integrated into already-established operations. System components are pre-manufactured units shipped as complete systems from the supplier. The modular components can be combined according to specific needs and many combinations of input materials are possible.

Depending on the availability of organic waste, different engine sizes can be used, typically ranging from 50 kW up to 100 kW.

- PASCO Feeding System: 27' x 8'
- (2) EUCOlino tanks: 40' x 16' x 12' Combined
- Digestate Separator: 20' x 8'
- Combined Heat and Power: 40' x 9'

WHY WAS BIOFERM SYSTEM CHOSEN?

PRO:

- Off the shelf product makes it easy to install and removes engineering costs.
- Modularity allows for flexibility of system size
- Small footprints of modules.
- Mesophilic digestion can digest multiple feedstocks and requires less energy due to lower operating temperatures.
- Can be fully automated.
- Can be expanded from 1-3 modules to triple waste removal/power generation.

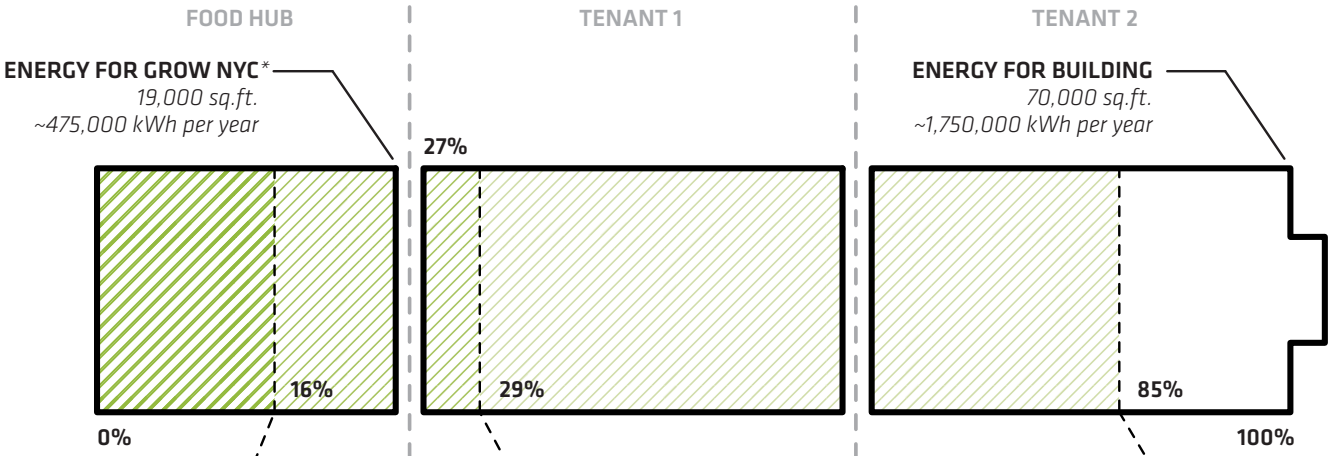
TO CONSIDER:

- Requires consistent maintenance to function at peak efficiency: approximate operation and maintenance cost = $25000 / year.
- Expansion beyond 4 modules raises questioning cost/benefit of modular system vs custom build.

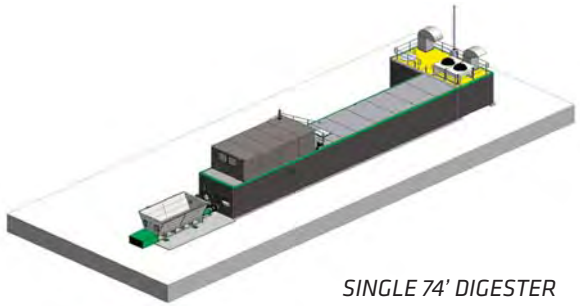
PRICE:

• PASCO Feeding System:	$120,000
• (2) Short EUCOlino tanks:	$340,000
• Digestate Separator:	$70,000
• Combined Heat and Power:	$130,000
• Process Controls:	$95,000
• Varicon Algae Bioreactor:	$150,000
BIODIGESTER TOTAL:	***~$900,000***
O+M (QUOTED BY BIOFERM):	***~$25,000 / yr***

BIOFERM EUCOLINO PLUG AND PLAY DIGESTER

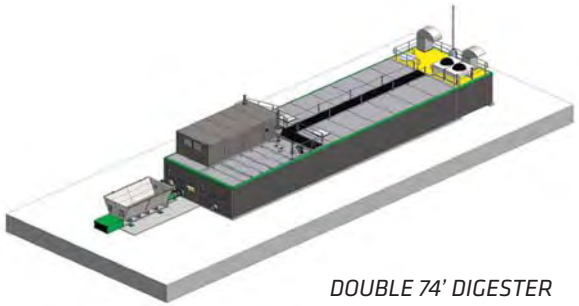


NORTH ELBA CASE STUDY
1 digester tank (200 m³)
900 tons of waste converted into
290,000 kWh of energy in first year



SINGLE 74' DIGESTER

ALLEN FARMS CASE STUDY
2 digester tanks (400 m³)
2000 tons of waste converted into
512,000 kWh of energy in first year

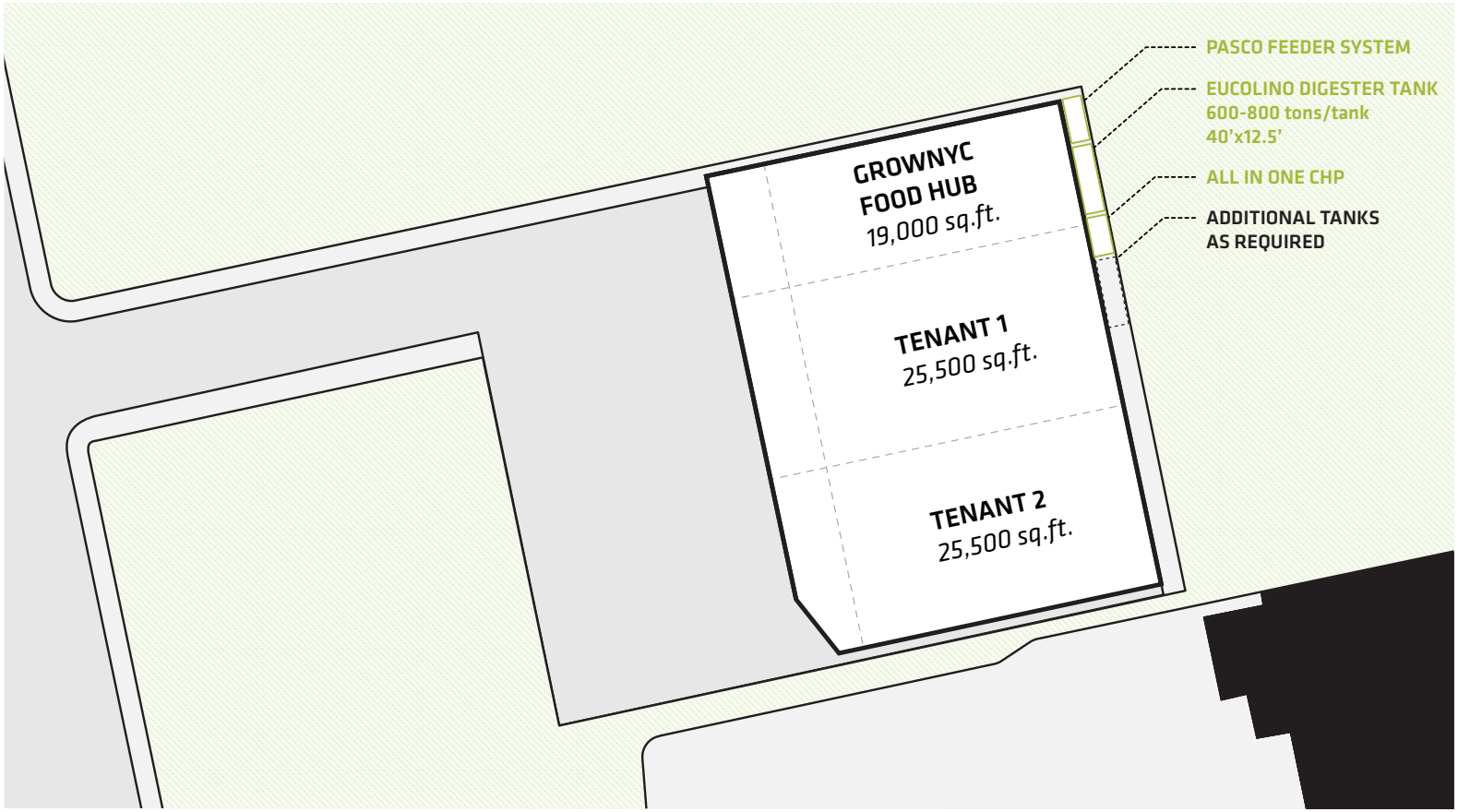


DOUBLE 74' DIGESTER

ESTIMATED MAXIMUM OUTPUT
6000 tons of waste converted into
~1,500,000 kWh of energy per year

**Based on typical baseline energy usage for industrial buildings and food distribution centers per square foot of floor area.*

POTENTIAL DIGESTER SITING STUDY

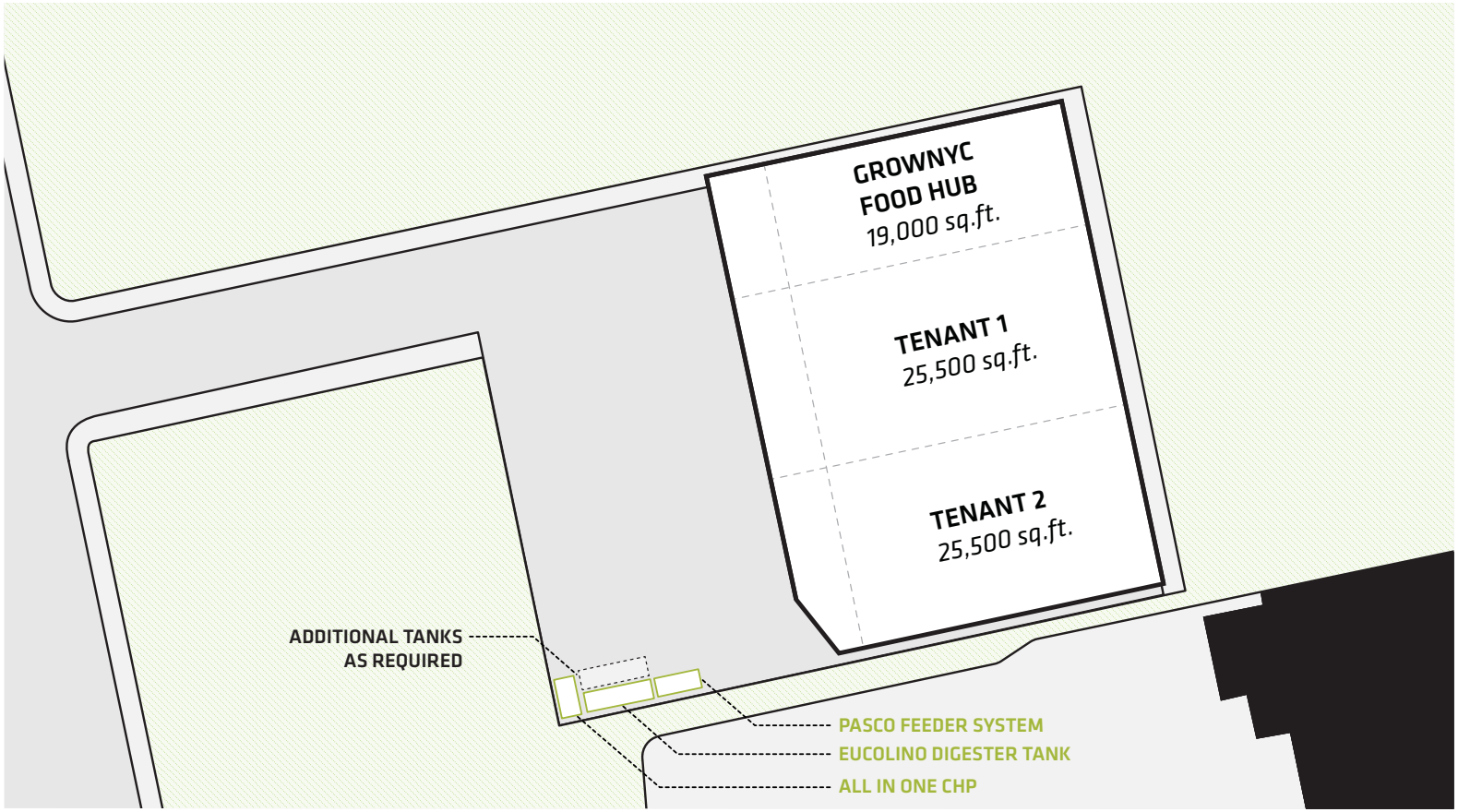


OPTION 1: BACK OF BUILDING

PRO:
- Most convenient location for waste disposal (through rear door).
- No impact on parking and truck traffic.

CON:
- Unclear if allowable per zoning easement.

POTENTIAL DIGESTER SITING STUDY

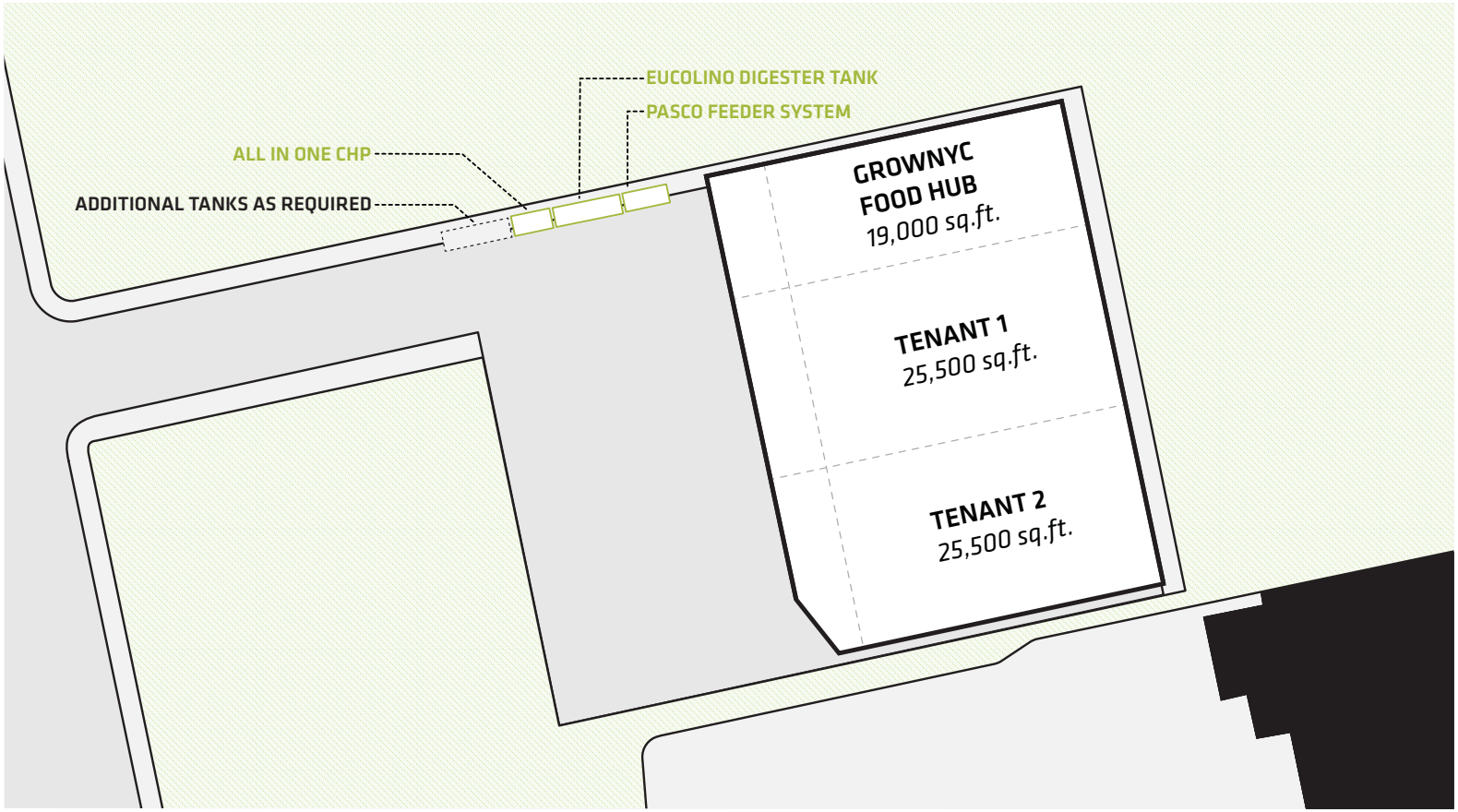


OPTION 2: FURTHEST FROM DELIVERY TRUCK TRAFFIC
(if installation at back of building not allowable)

PRO:
- Placement of digester system in Southwest corner of site has minimal impact on parking and truck access.

CON:
- Furthest point from FoodHub makes this location the most expensive to install and operate.

POTENTIAL BIOREACTOR SITING STUDY

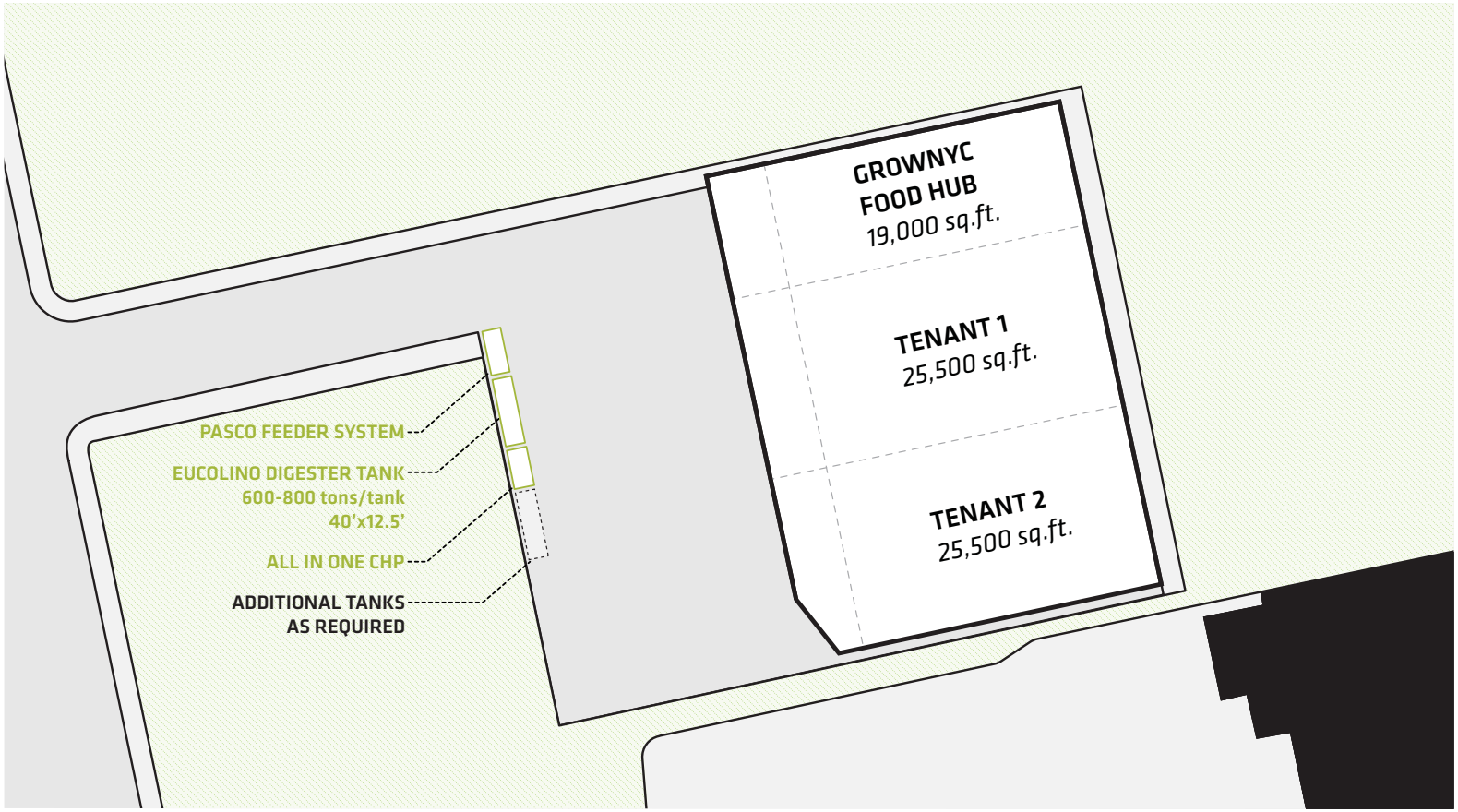


OPTION 3: ADJACENT TO FRONT OF BUILDING

PRO:
- Placement of digester at closest point to FoodHub allows for the easier system integration.
- Has the opportunity to be designed to be part of the public interface as entrance to FoodHub

CON:
- Potentially odorous process located at the forefront of the site.
- Complicates entrance to site and building.

POTENTIAL BIOREACTOR SITING STUDY

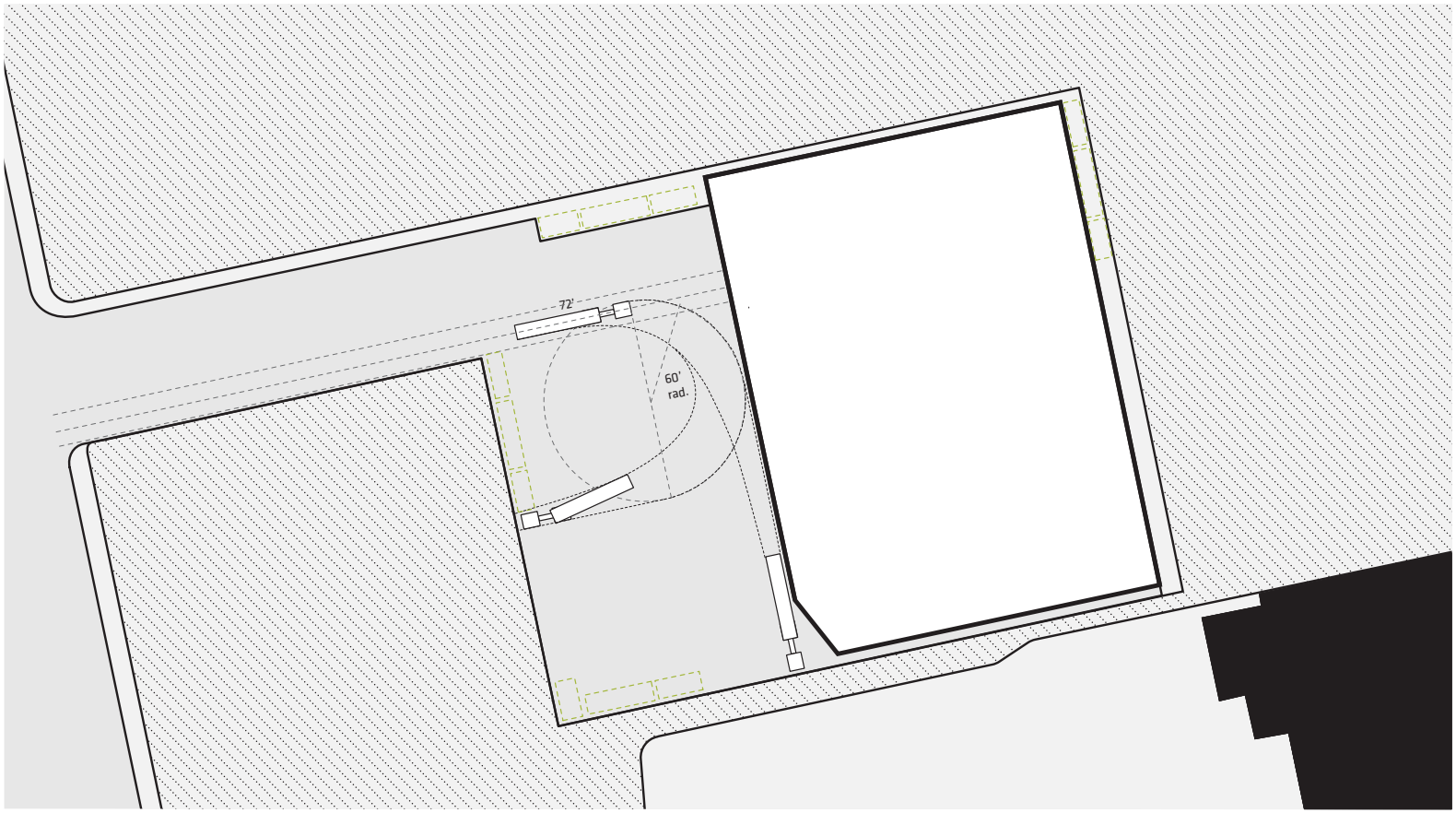


OPTION 3: OFFSET FROM BUILDING

PRO:
- Middle ground between Southwest and Northeast corners of the site.
- Maintains proximity to FoodHub while remaining discretely located.

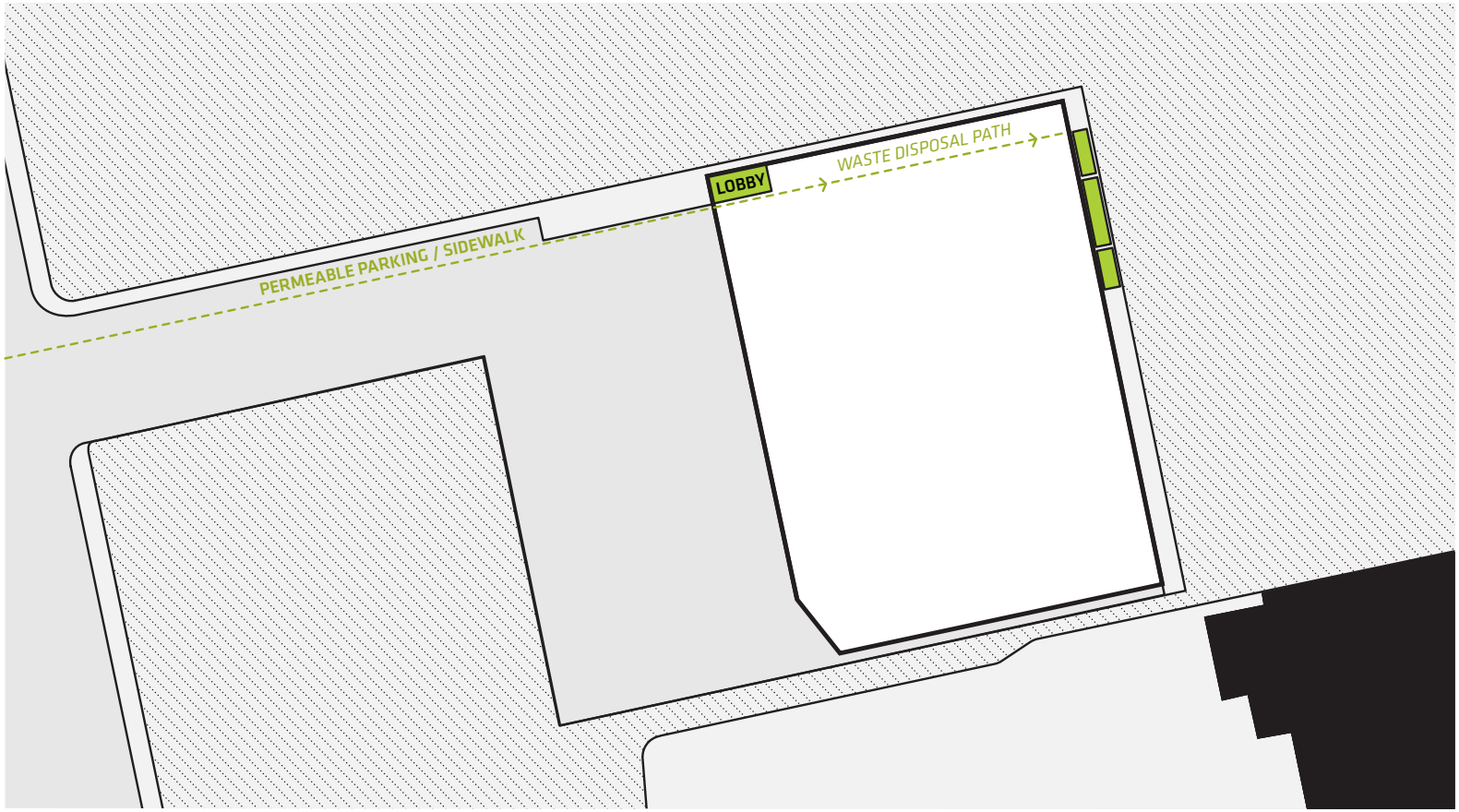
CON:
- Not as efficient as placement directly adjacent to building.
- Has largest impact on parking and truck access.

TRUCK TURNING RADIUS STUDY



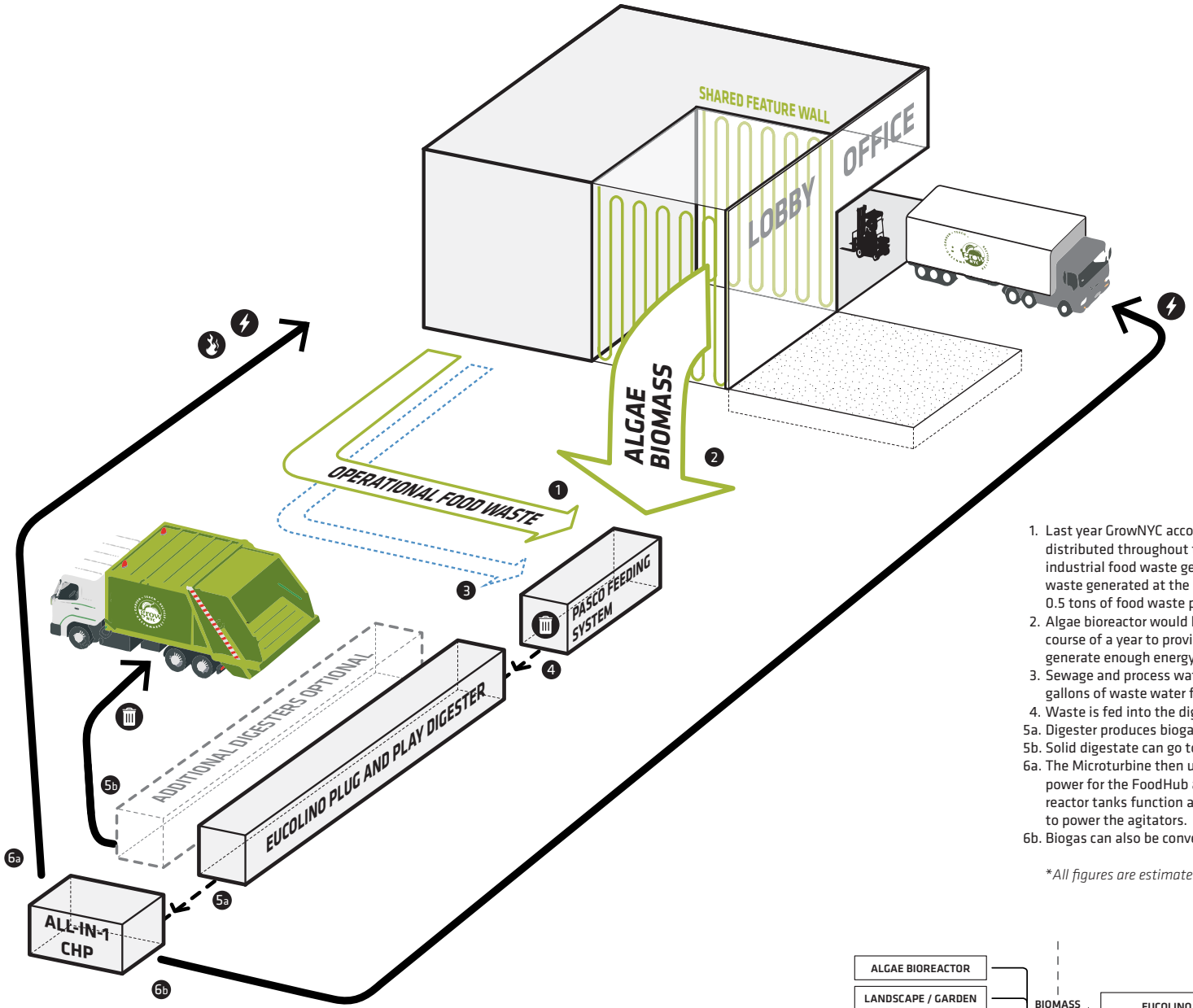
- In evaluating the site for locating the biodigester, it seems that the current site access does not allow the necessary area for the 72' truck shown in plans. *(see above)*
- Truck access and size must be addressed before ORE can finalize location for biodigester system.

POTENTIAL ORE INTERVENTION



PROPOSAL:

- Lobby provides the opportunity for a combination feature / productive green energy solution.
- Proposed algae feature will provide consistent biomass to be fed into on-site biodigester while also creating a beautiful feature and compelling narrative in a minimal public space.
- Lobby intervention could conceptually extend out onto site as a band of permeable pavement and minimal site greening.



1. Last year GrowNYC accounted for approximately .02% of all food distributed throughout the city, thus based on USDA estimates for industrial food waste generated in NYC a conservative estimate for waste generated at the FoodHub would amount to approximately 0.5 tons of food waste per day.
2. Algae bioreactor would have to recycle 1500 tons of algae over the course of a year to provide biodigester with enough biomass to generate enough energy to power the FoodHub.
3. Sewage and process water from the FoodHub can generate 20M gallons of waste water for the biodigester over the course of a year.
4. Waste is fed into the digesters either manually or automatically.

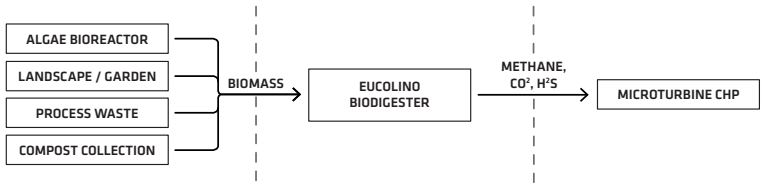
5a. Digester produces biogas to be used as fuel for the CHP.

5b. Solid digestate can go towards GrowNYC Compost Collection Program.

6a. The Microturbine then uses the biogas to generate heat and power for the FoodHub as well as for the biodigester as the reactor tanks function at high temperatures and require energy to power the agitators.

6b. Biogas can also be converted into biodiesel for shipping trucks.

**All figures are estimates.*



ENTRY VISUALIZATION SHOWING BIOREACTORS AS LOBBY FEATURE



ALGAE BIOREACTORS ARE PRODUCTIVE ARCHITECTURAL ELEMENTS

LOBBY VISUALIZATION SHOWING BIOMASS PRODUCING ALGAE CULTURES AS LOBBY FEATURE



ALGAE BIOREACTORS ARE PRODUCTIVE ARCHITECTURAL ELEMENTS

COST ESTIMATE: $150,000

OFFICE VISUALIZATION SHOWING VIEW OF ALGAE FEATURE FROM WITHIN THE SPACE



ALGAE BIOREACTORS ARE PRODUCTIVE ARCHITECTURAL ELEMENTS

PRECEDENT STUDY - ON SITE BIODIGESTER

UC DAVIS CAMPUS

- It is the third commercial biodigester CleanWorld has opened using Zhang's technology within the past two years and is the nation's largest anaerobic biodigester on a college campus.

- The system is designed to convert 50 tons of organic waste to 12,000 kWh of renewable electricity each day using state-of-the-art generators, diverting 20,000 tons of waste from local landfills each year.

- The facility took unique advantage of its location at the now closed UC Davis landfill by blending landfill gases - primarily methane - with the biogas to create a total of 5.6 million kWh per year of clean electricity. It is expected to reduce greenhouse gas emissions by 13,500 tons per year.



STOP & SHOP

The Stop & Shop Supermarket Co.'s new green energy facility in Freetown, Mass., converts food scraps from all 212 of the Ahold USA banner's New England stores into energy that will help power the company's distribution center in Freetown. The facility is expected to process an average of 95 tons of inedible food daily, an estimated 34,000 tons per year. Inedible food products from all of the New England stores that can't be sold or donated to area food banks or local farms will go to the facility and turned into energy via anaerobic digestion.

The energy produced by the 12,000-square-foot facility will provide as much as 40 percent of the 1.1 million-square-foot DC's energy needs, enough power to run the facility for four months. Once fully up and running, the facility will create about 1.25 megawatts of clean electricity.





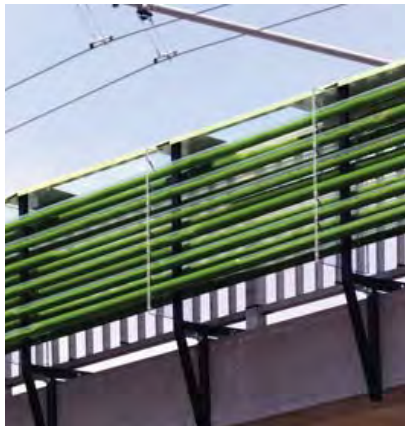
PRECEDENT STUDY - ALGAE BIOREACTOR

CULTURE URBAINE

An installation done for the Garden Festival Geneve, the "garden" is situated along a highway overpass where it makes use of a closed system of transparent tubes, clinging onto the bridge, for the cultivation of algae. The algae grows exclusively on sunlight and CO2, both abundantly present on the site. These organisms are used to filter air and produce combustible biomass, or even as raw material for different cosmetic and alimentary products. A steel structure, supporting all the secondary equipment such as pumps, filters, and solar panels, functions as a marker for the quickly passing traffic and provides explanations on a more detailed level for pedestrians and cyclists.

The movement and placement of this bioreactor signals practices of the future: the harvesting of goods in the dense environment of a metropolis, the conservation of green space, and the reinterpretation of existing infrastructures. However, the installation is still just a small scale proof of concept and as such does not respond to issues of scale and economic feasability in a commercial setting.







SITE CONDITION - SHADOW CASTING

OVERVIEW

Shadow casting is helping to analyize the shade casted on the site by adjacent buildings and structures.

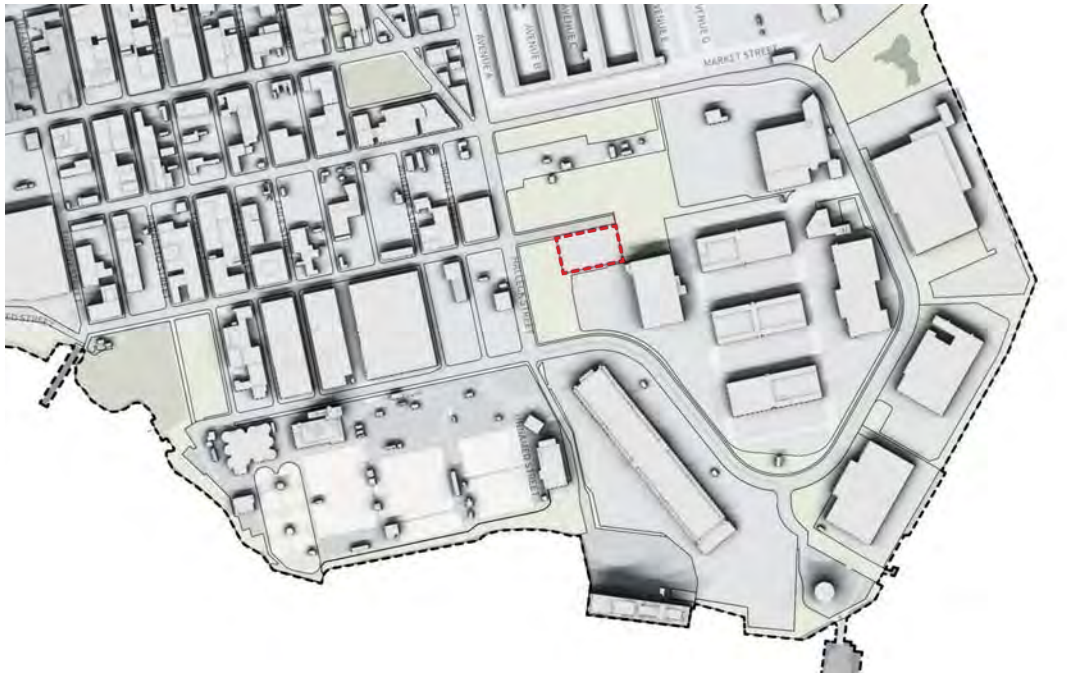
EFFECT ON THE SITE

As shown in the diagrams above the site is not affected by shadow casting. This result can be seen as positive and negative,

Positive - Full solar insulation area for solar power plant or Photovoltaics
Negtive - No shade which increase the heat island effect

APPLICABLE STRATEGIES

- **Solar roof**
- **Photovoltaics**
- **Increase shade around**
- **Install green roofs**
- **Install Cool/Reflective roofs**

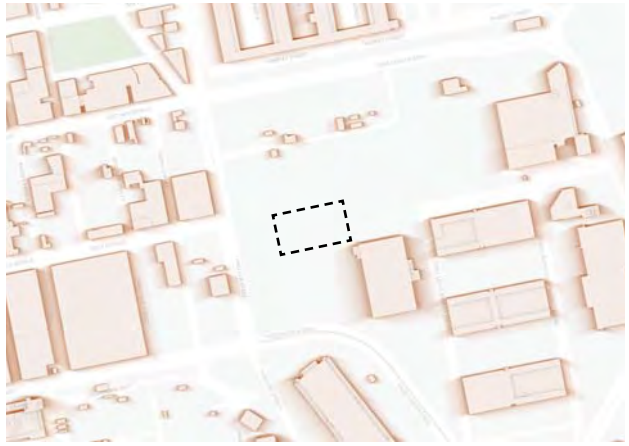




WINTER SHADOW CASTING

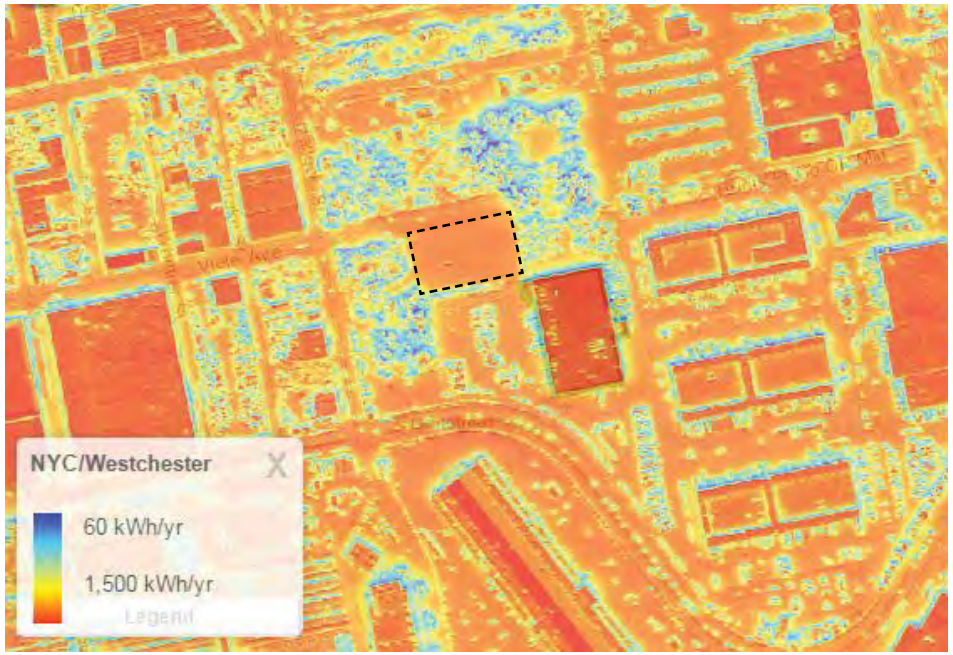


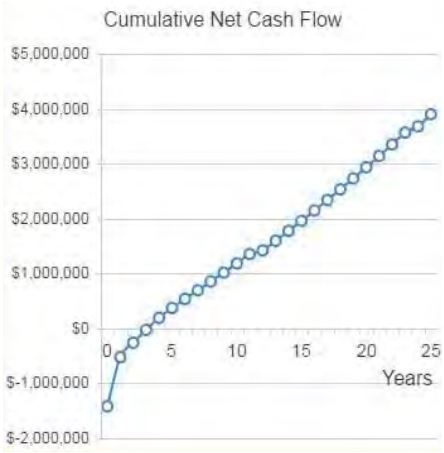
SPRING SHADOW CASTING

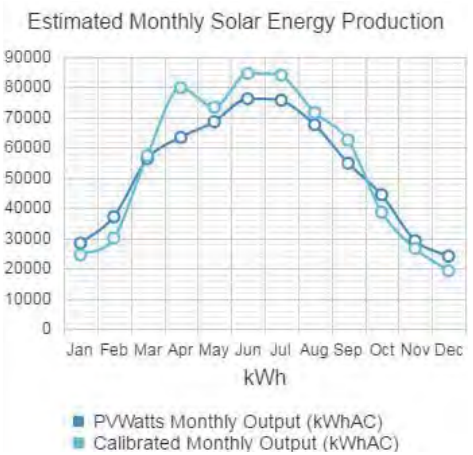


SUMMER SHADOW CASTING

POTENTIAL PHOTOVOLTAIC STRATEGIES



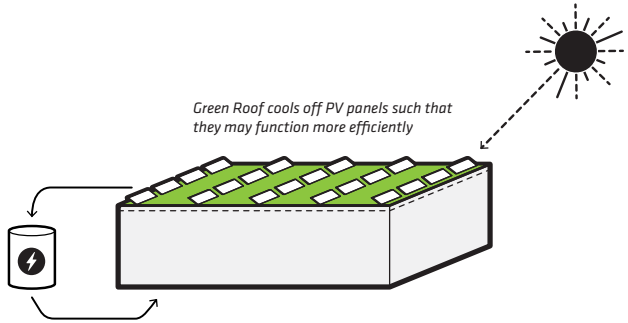




Payback Period: 4 Years
Annual Savings: $196,615

Out-of-Pocket Cost: *$1,419,660*
Net Cost After Incentives & Taxes: *$341,563*

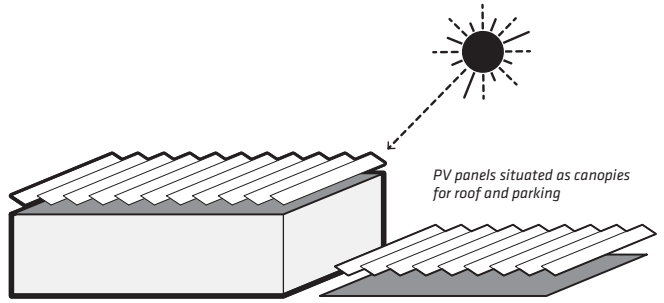
1 SOLAR GREEN ROOF



PRO:
- Green Roof cools and removes pollutants in ambient air, allowing PV panels to function more efficiently
- Can retain up to 70% of total rainfall
- Can generate up to 600,000 kWh/yr

CON:
- Expensive initial investment
- Requires constant maintainence to ensure efficient operation
- Possibility of leakage

2 SHADE CASTING PV PANELS



PRO:
- Serves secondary function of shading the space to reduce cooling loads
- Can be integrated with a sawtooth roof system which allows indirect daylighting of the space and exhaust vents for rising hot air

CON:
- Expensive initial investment
- Requires constant maintainence and cleaning to ensure efficient operation
- Takes up roof space that could be occupied or used for a Green Roof

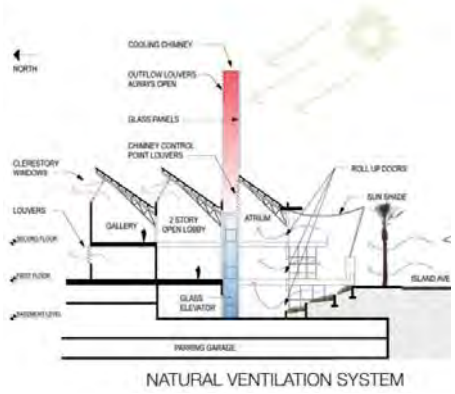
PRECEDENT STUDY - PHOTOVOLTAICS

SAN DIEGO CHILDREN'S MUSEUM

The museum boasts a saw-tooth roof that features photovoltaic panels that generate 144,000 kWh of electricity per year, about half the building's electricity needs. Glass walls and north-facing clerestory windows provide natural daylight to the interiors, and sixty percent of the building utilizes a natural ventilation system. Fresh air enters the museum through lower-level windows and doors, and as it heats up, rises and exits the building through upper-level openings and a solar cooling chimney. A computer fine-tunes the comfort level by opening or closing windows and louvers as needed.

Paul Linden, professor in at UCSD in mechanical and aerospace engineering and principal at NaturalWorks used principles of fluid dynamics to model ambient air currents as part of his contribution to design of the new Children's Museum of San Diego. He performed simulations for thermal, outdoor airflow, and passive heating and cooling system design. The California Energy Commission funded Linden's participation with design engineers at Rob Wellington Quigley, the architecture firm that designed the building. The atrium-style building does not have conventional heating and cooling; instead, it relies on computer-controlled windows and Linden's sophisticated model of the prevailing breezes in the city's Marina District that will pass through those windows as they open and close under automatic control. A 92-foot-tall elevator tower acts as a cooling chimney exhausting interior air as sunlight warms it. During the hottest weeks of the year, outside air will replace the inside air ten times per hour. The assessment of the ventilation system consisted of an initial analysis of the stack-driven ventilation. It was found that using only stack-driven ventilation led to predictions of significant periods of overheating in the museum.





NATURAL VENTILATION SYSTEM

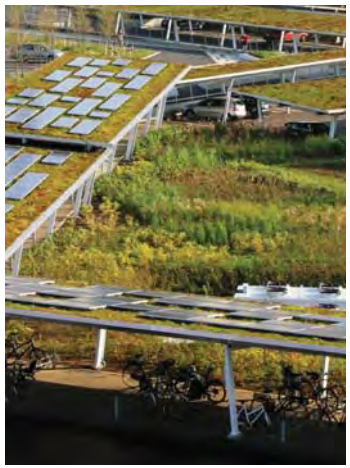


PRECEDENT STUDY - PHOTOVOLTAICS

VIBORG TOWN HALL

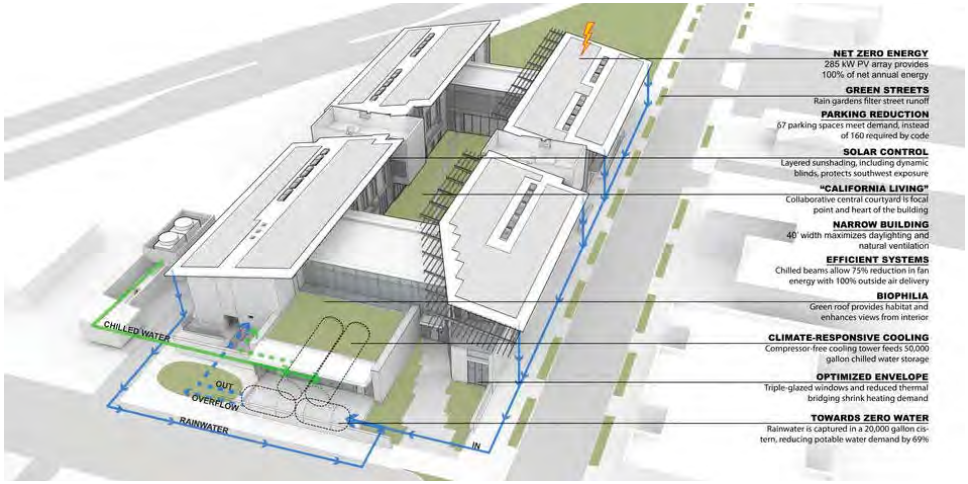
The building opens up to the town hall square and the new green park. Employees and visitors are invited into a building characterised by brightness, openness and flexibility. The green roof running from the building base beautifully interacts with the landscape and the green parking roofs surrounding the front square. The interplay between house and park creates a new place in the town where the large inner atrium is the heart that joins the town hall's professional community with the community of the citizens. The energy consumption of Viborg Town Hall will meet the requirements for low-energy class 1 according to Danish building regulations (max (50 +1100 / A) kWh/m2a (A = the heated floor area).





THE DAVID AND LUCILLE PACKARD FOUNDATION HQ

The headquarters for The David and Lucile Packard Foundation in Los Altos, California brings staff, grantees and partners together to solve the world's most intractable problems. Passive, bioclimatic design strategies support the core philanthropic mission while serving as the basis of the net zero energy (NZE) and LEED Platinum building performance.



SITE CONDITIONS - CSO AND FLOOD MAPS

OVERVIEW

121 days with rainfall per year
46 inches of annual rainfall
400000 Cu.Ft. Rain = 3000000 Gallons of water that could be harvested per year.

Multiple CSO points surround the site, as well as a waste water treatment plant,

CONCLUSION

CSO model fails every year and sustains heavy outfall.
Implementation of green infrastructure, more porous paving, and grey water recycling could harvest rain water energy while also helping to limit CSO outfall

APPLICABLE STRATEGIES

- **Rainwater Collection**
- **Green Infrastructure, Roofs / Bioswales**
- **Constructed Wetlands**







SITE CONDITION - GREEN SPACE VS GROUND TEMPERATURE

OVERVIEW

Research by Stuart Gaffin, an associate research scientist out of the Earth Institute at Columbia University, on the use of green roofs and green infrastructure to mitigate the urban heat island effect determined that the surface temperature of a green roof can be up to 70 degrees (F) cooler at peak hours than that of a standard roof in New York City. Interior temperatures can also vary by 4 degrees (F) with just the addition of a green roof, which could drastically affect space cooling energy usage as energy usage rises exponentially with indoor temperature. Usage of green roofs and green infrastructure can also affect aid in the evapotranspiration of storm water, preventing CSO outfalls.

EFFECT ON THE SITE

The area around the site includes, parking lots, empty concrete lots, roads and pavements. These areas covered with concrete increase the heat island effect of the area, which raises the temperature of the site.

APPLICABLE STRATEGIES

- Increase shade around
- Install green roofs
- Install Cool/Reflective roofs
- Use energy-efficient appliances and equipment
- Trees and Vegetation
- Cool/Reflective Pavements
- Constructed Wetlands

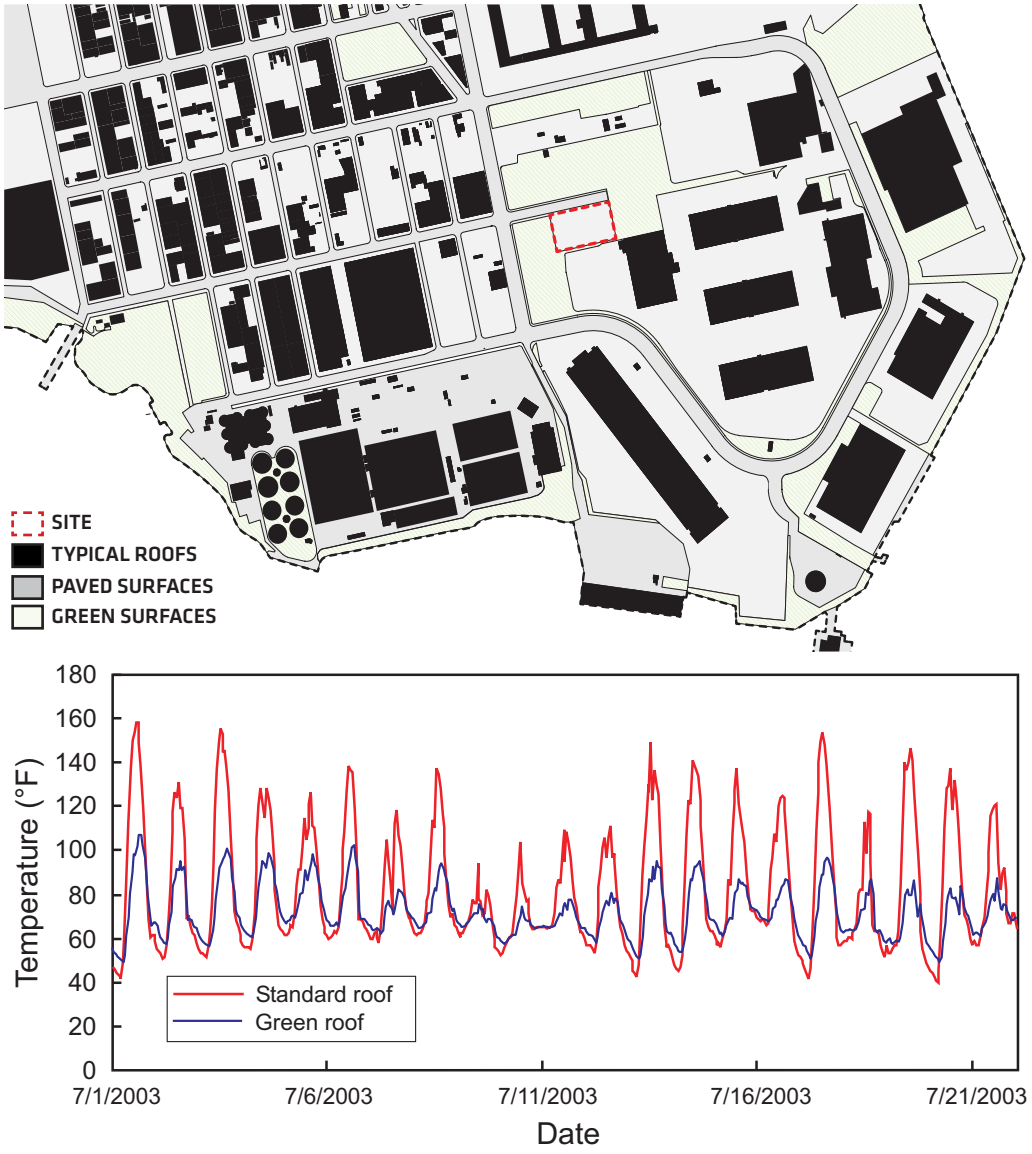
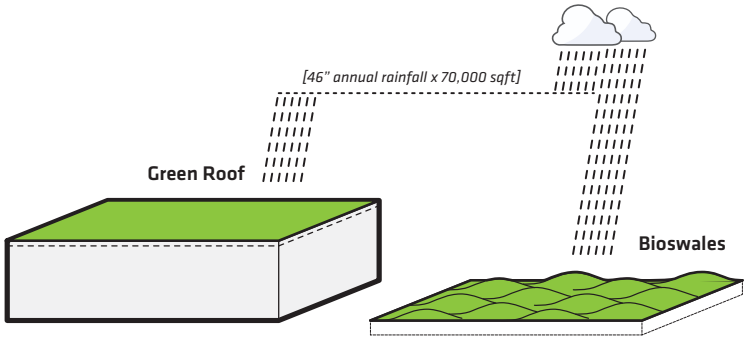


Figure E-1. Average surface temperature on green roofs and standard roofs at Penn State Center for Green Roofs Research. (Data provided by Dr. David Beattie.)

DIAGRAMS

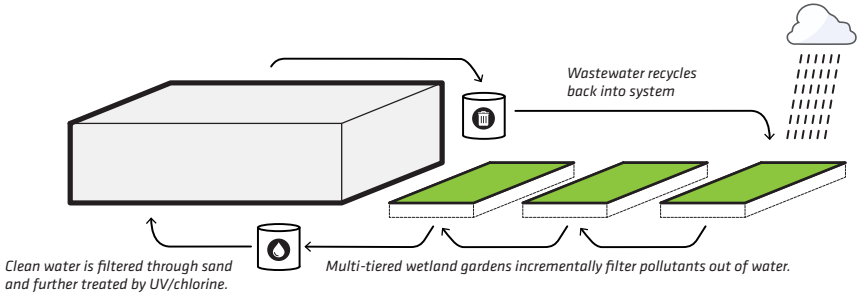
1 GREEN ROOF / BIOSWALES



PRO:
- Effecient harvesting of rainwater
- Helps to limit CSO outfall
- Reduces Heat Island Effect
- Can cool down *Solar PV Panels*

CON:
- High maintenance
- Expensive
- Possibility of leakage

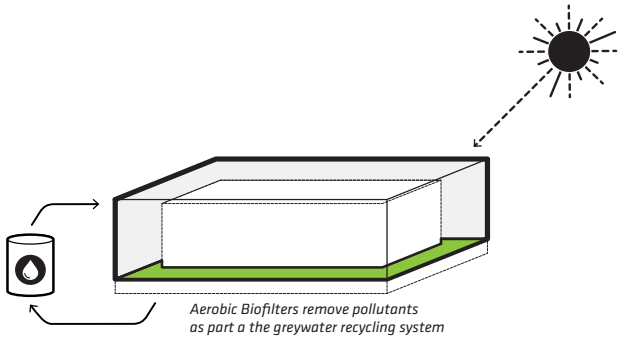
2 CONSTRUCTED WETLANDS



PRO:
- Uses organic process to treat and reuse waste and storm water
- Can tie into *Anaerobic Biodigester*

CON:
- Wetlands not native to site
- Low runoff reduction
- Requires Baseflow

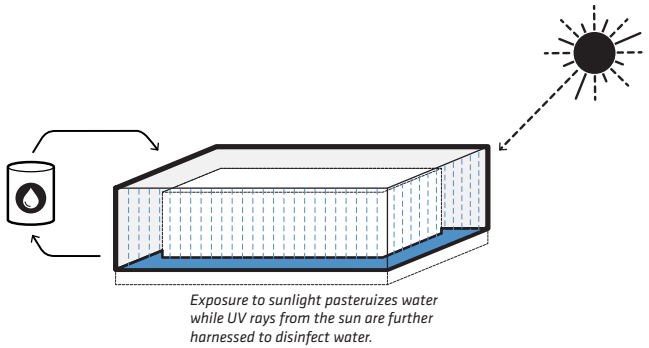
3 BIOFILTRATION SKIN



PRO:
- Uses organic process to treat and reuse storm and waste water
- Can function as an *Aerobic Bioreactor*
- Can be used for *Evaporative Cooling*

CON:
- Accumulation of matter in the filtering media, bioclogging.
- Expensive

4 SOLAR WATER TREATMENT



PRO:
- Effective – Destroys 99.99% of microorganisms
- Low energy usage – low electrical needs
- No chemicals and conserves water

CON:
- UV water systems need electricity to operate.
- UV light is only able to eliminate microorganisms in water, does not remove any other non organic contaminants

PRECEDENT - GREEN INFRASTRUCTURE / BIOSWALES

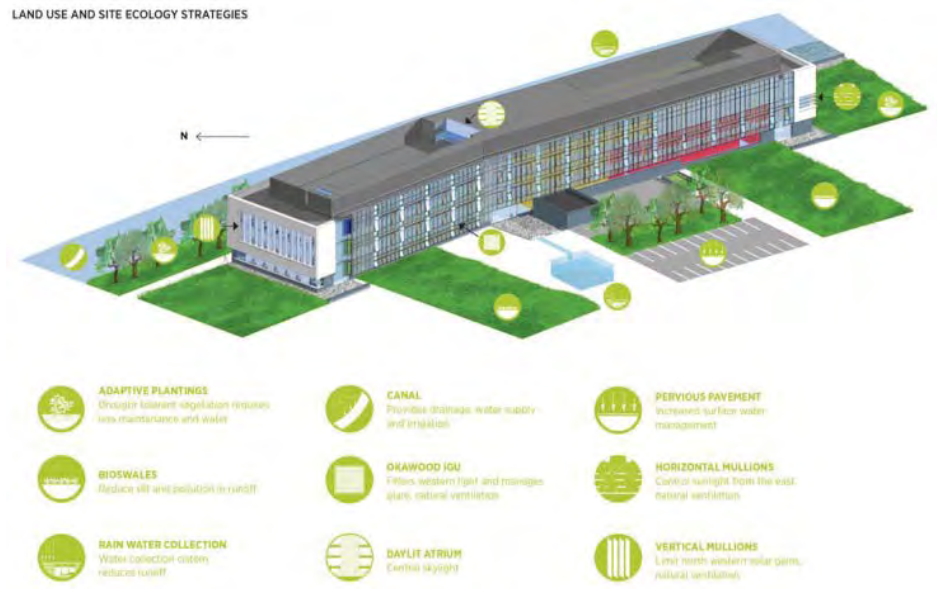
BIOSCIENCES RESEARCH BUILDING

Sited in a rolling meadow in Galway, Ireland, with uninterrupted views in four directions, the Biosciences Research Building (BRB) is the first phase of a new North Campus Science Precinct at the National University of Ireland, Galway (NUIG). The BRB provides high technology science research space dedicated to cancer research, regenerative medicine, chemical biology and BSL3 animal research, and is one of the most energy efficient research buildings in the world dedicated to such an intense scientific agenda. It was also constructed for an extremely low cost per SF ($413), as compared to similar facilities, which typically cost $600-800/SF. In fact, 89% of the building is used for research space.

The average annual rainfall in Ireland is over 50 in. per year. The local requirements were to size the system to the 100-year storm with a 10% increase for climate change, as well as shorter intense storms that can drop rain at the rate 6 in./hr on the site. To deal with these large quantities of water, the team designed a stormwater management system with a series of treatment options.

Porous paving and bioswales pretreat and infiltrate much of the rainfall, and then overflow to an underground filtration and attenuation system then filters 100% of the stormwater and slowly releases 25% of the rainfall in a 110% of the 100-year storm, exceeding local stormwater requirements and replicating the site's natural hydrology.

In addition, the BRB captures rainwater off the building roof for the flush fixture and other building uses, meeting 100% of the flush fixture demand. Coupled with dual-flush toilets and low flow fixtures, the building uses 75% less water than the LEED 2009 baseline. A low maintenance landscape was designed to require no irrigation, further minimizing the building's demand on potable water supplies.





PRECEDENT - CONSTRUCTED WETLANDS

SARAH E. GOODE STEM ACADEMY

Sarah E. Goode STEM Academy was designed as part of the $1 Billion Chicago Public Schools' "Modern Schools Across Chicago" Initiative. Headed by the Public Building Commission of Chicago, a strong interdisciplinary collaborative design process and sustainable design ethos led to integrated, sustainable building and site design strategies. As a result, the high school is the first Chicago Public School to achieve a LEED Platinum rating. The 17.2-acre former brownfield features numerous athletic fields set within a landscape of educational, native gardens. Special features include a biology garden, community vegetable gardens, an outdoor classroom/ picnic area, built bleachers and custom concrete sport seating, a council ring, rain gardens, a cistern, a geothermal field, and native plant education signs. The site is designed to also function as a neighborhood park and recreation center.

ENVIRONMENTAL
- Reduces stormwater runoff by 38.9% or 311,683 gallons for a 2-year, 24-hour storm event.
- Captures and treats 100% of stormwater runoff from average annual rainfall, removing an estimated 80% of total suspended solids (TSS).
- Reduces annual irrigation needs by 3.45 million gallons as compared to a landscape of fully irrigated, non-native plants.
- Increased ecological quality by over 10 times that of the former industrial site based on the Floristic Quality Assessment, a measurement of native biodiversity of plants.
- Diverted over 20,700 tons of materials from landfills by reusing 90% of concrete, asphalt, and aggregate excavated from the site as backfill and recycling other site preparation materials.
- Reduces urban heat island effect by using a green roof and materials with a solar radiation index (SRI) of at least 29 on over 70% of all hardscape and roof surfaces.

SOCIAL
-Projected to yield nearly 3,500 pounds of food, which has an estimated value of $9,850, through community garden plots







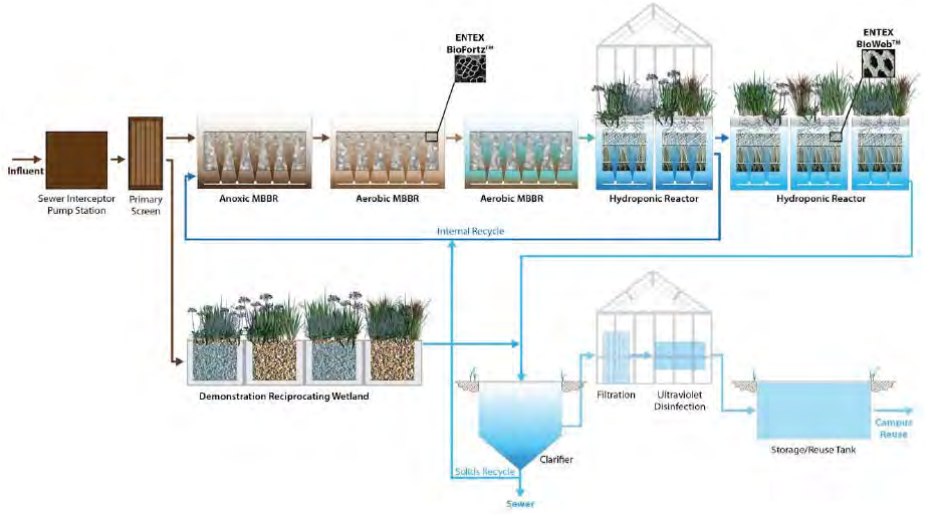
PRECEDENT STUDY - BIOFILTRATION

EMORY UNIVERSITY WATERHUB

Emory University, located on approximately 700 acres in DeKalb County, Georgia, is a top-tier institution recognized for its medical school and various professional programs, as well as its commitment to environmental sustainability. Over the last decade, sustainable water management has become a critical issue for the metro-Atlanta region, which has struggled with drought, legal disputes over water supply and EPA consent decrees on water quality issues. As a pioneer, community leader and home of the world renowned Center for Global Safe Water, Emory is seeking to comprehensively address local and global water challenges. The WaterHub project is an innovative, on-site solution designed to treat and reuse up to 400,000 gallons of water per day, and decrease potable water demand by over 1/3.

In 2011, Emory used an estimated 390 million gallons of water per year, equating to approximately 1.1 million gallons per day (GPD). Nearly 40% of this use (over 400,000 GPD) is considered non-potable water demand, and can thus be replaced with alternative water supplies. WaterHub reduces Emory's dependence on potable water by reclaiming campus wastewater for non-potable reuse applications. The facility extracts wastewater from the municipal sewer system and treats it through adaptive, ecological technology. Once treated, reclaimed water is reused primarily as process make-up at three central chiller plants and the campus steam plant. Additional uses for reclaimed water include toilet flushing at select residence halls, all compliant with stringent Georgia plant regulations.





SITE CONDITIONS - SLING PSYCHROMETRIC ANALYSIS

OVERVIEW

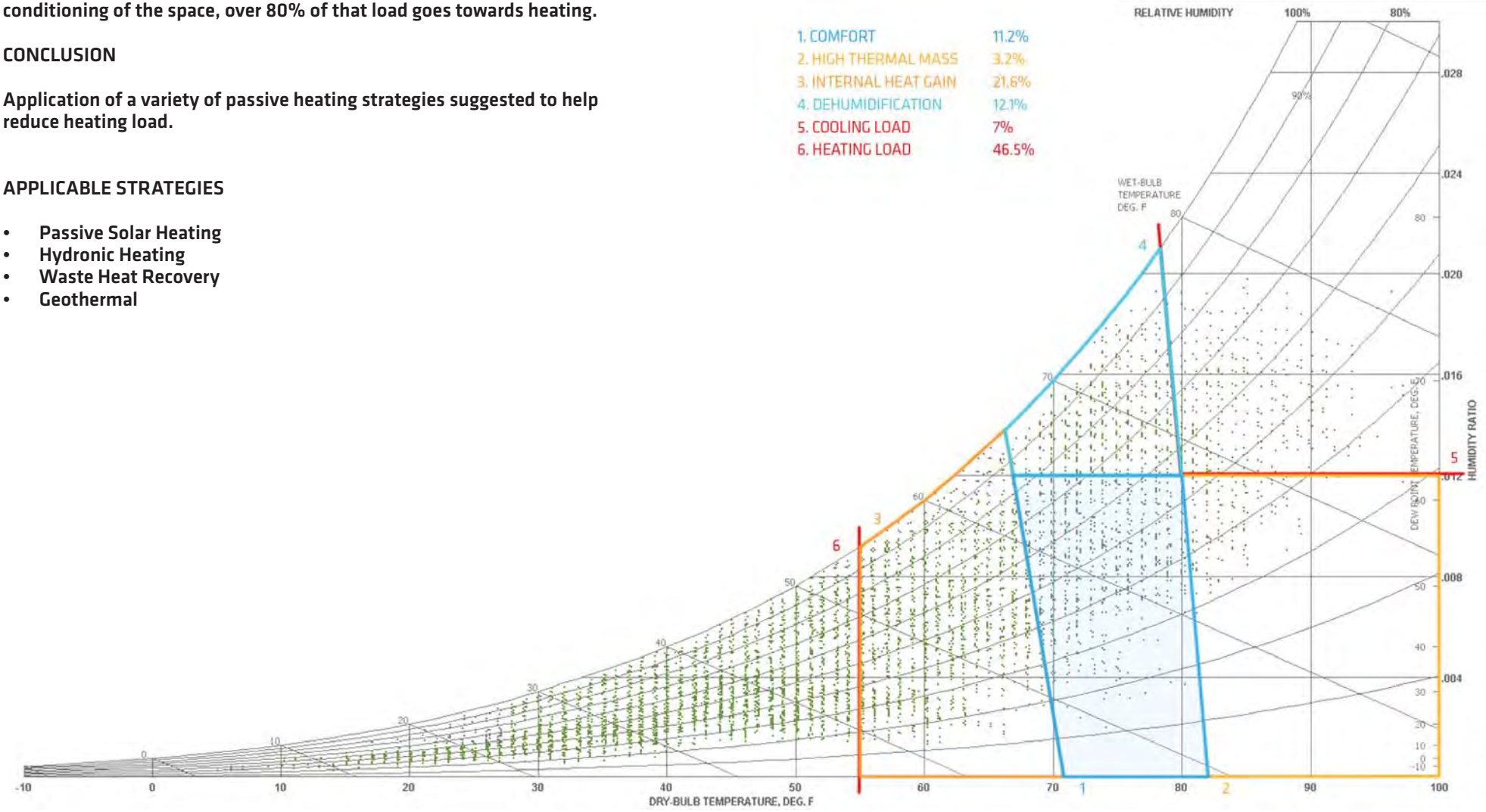
53.5% of the hours in a year require either mechanical heating or air conditioning of the space, over 80% of that load goes towards heating.

CONCLUSION

Application of a variety of passive heating strategies suggested to help reduce heating load.

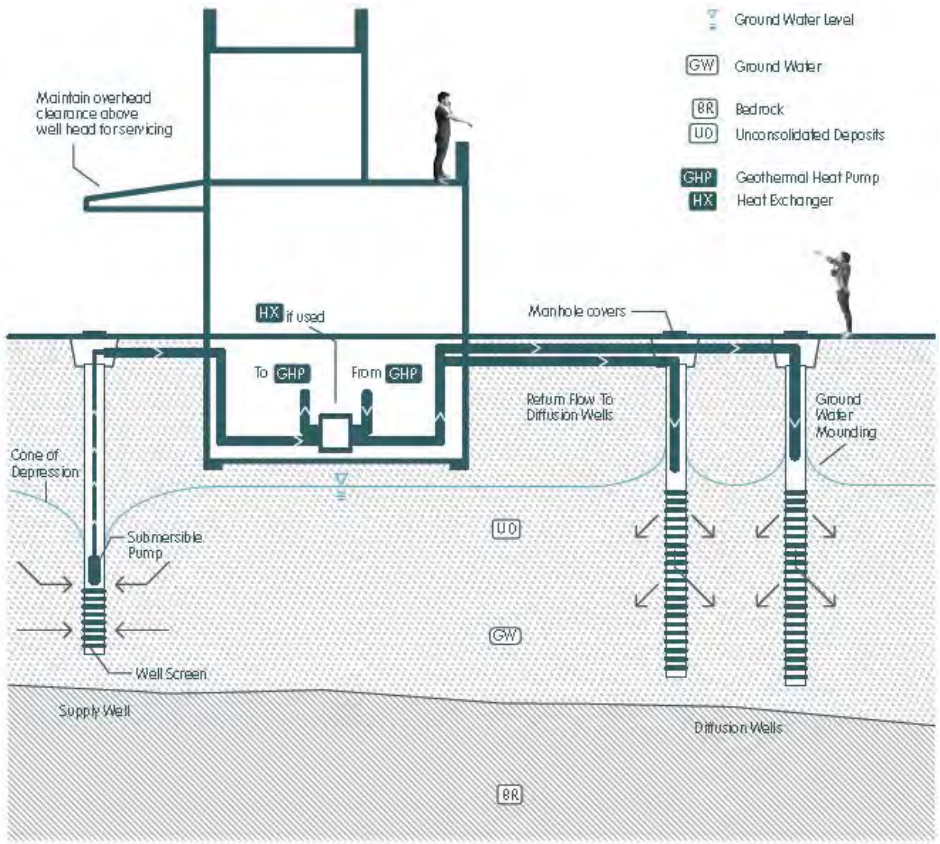
APPLICABLE STRATEGIES

- **Passive Solar Heating**
- **Hydronic Heating**
- **Waste Heat Recovery**
- **Geothermal**



DIAGRAMS

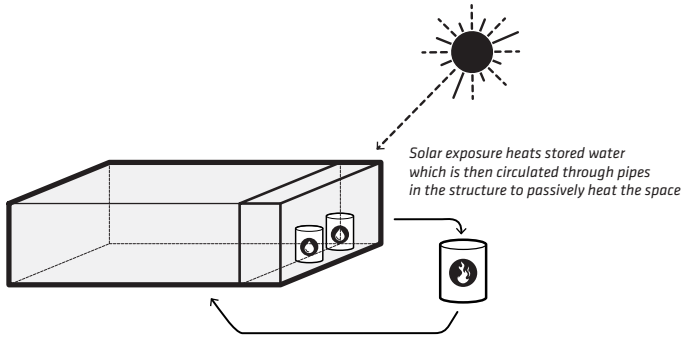
1 GEOTHERMAL



PRO:
- Provides both heating and cooling
- Geothermal heating and cooling systems have few moving parts, so they are highly reliable.
- High efficiency, low energy

CON:
- Very expensive
- Open loop systems can require consistent maintainence
- Installation can be difficult

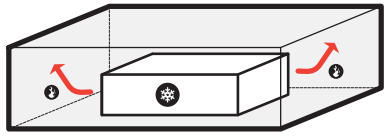
2 HYDRONIC SOLAR HEATING



PRO:
- Hydronic heat is more efficient than traditional air heating,water is a better heat conductor than air.
- If placed in floors, heat will rise so no extra energy required to push air down
- Versatile Installation

CON:
- Possibility of leakage
- Pipes can corrode if air gets into the system

3 WASTE HEAT RECOVERY



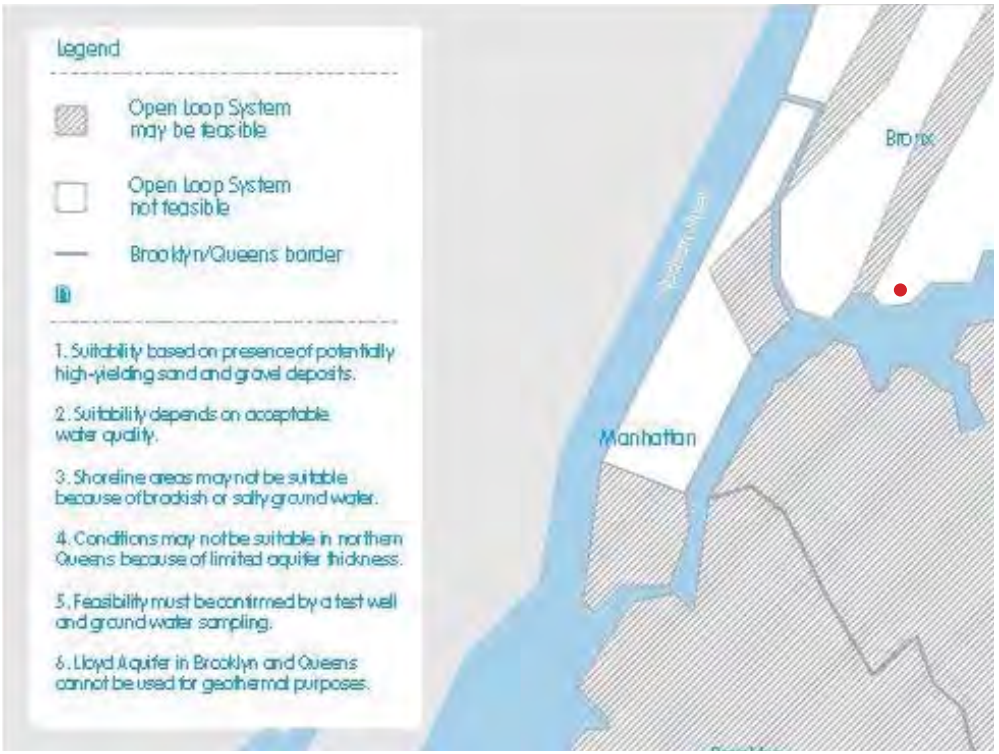
Process heat given off by equipment is harnessed to heat other spaces.

PRO:
- Recaptures heat given off by the variety of appliances required in our program, specifically refrigeration.

CON:
- Low grade heat
- Not every industry can gain a potential out of heat recovery as the cost of installation may be higher than the amount saved.

SITE CONDITIONS - GEOTHERMAL FEASABILITY





Elevation: 0 to 150 feet
Mean annual precipitation: 40 to 52 inches
Mean annual air temperature: 47 to 62 degrees F
Frost-free period: 216 to 234 days
Farmland classification: Not prime farmland
Laguardia and similar soils: 60 percent
Urban land, till substratum: 25 percent
Minor components: 15 percent
^Au - 0 to 8 inches: cobbly-artifactual coarse sandy loam
^BCu - 8 to 26 inches: very cobbly-artifactual coarse sandy loam
^Cu - 26 to 79 inches: very cobbly-artifactual coarse sandy loam
Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to moderately high (0.01 to 1.42 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 19 percent
Available water storage in profile: Low (about 3.1 inches)

Geothermal System Summary Results

Approx. Inside Cost: All parts inside your home such as the heat pump, duct work, and labor.	**Approx. Outside Cost**: The loop field drilling/excavation	**30% Tax Credit** **Currently Unavailable in 2017	**Total Investment if Tax Credit is reenacted.**	**Approx. Total System Cost**
$405450	$306000	$213435	$498015	$711450

Approx. Cooling load	**Approx. Heating load**	**Approx. Size**	**Approx. Size of the Heat pump**
1533000 btu/hr	469000 btu/hr	70000 Sq Ft	153 ton

PRECEDENT STUDY - GEOTHERMAL

LION HOUSE AT THE BRONX ZOO

With its adjustable skylights, greywater recycling system, low-flow fixtures, and geothermal wells – it is a model of environmental sustainability. The architects added 4,800 square feet of new exhibit space, 6,700 square feet of plant and animal support space, 3,500 square feet of event space, and 6,700 square feet of mechanical space – all within the existing footprint. They excavated four feet beneath the cellar, expanded space under the terrace, stabilized the foundation, and added steel beams to shore up the structure. The mechanical systems and supports were designed to disappear. Structural columns and duct work are disguised as trees. Sprinklers are integrated into acoustic panels. The geothermal system eliminates the need for an obtrusive cooling tower. The Lion House received a LEE D Gold rating. It also received an American Institute of Architects' New York State Award of Merit for Adaptive Reuse, the Municipal Art Society of New York's MAS terwork Award for Best Restoration, and a City of New York/US EPA Green Building Design Award.

Total Building Area: 40,000 sq. ft.
Building Loads: 1,057,000 Btu/h for heating,
56 tons for cooling
Number of Wells: 5 Standing Column Wells
Number of Heat Pumps: 6 units LEED Certification: Gold





PRECEDENT STUDY - SOLAR HYDRONIC HEATING

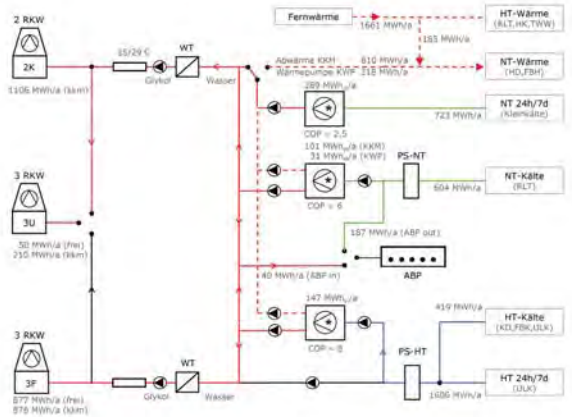
SIEMENS HEADQUARTERS, MUNICH

The Siemens Headquarters forms a city block with a total of 6 incised courtyards - two covered inner courts exclusively for Siemens, the remaining four courtyards, including the ground floors are accessible to the public. The new building will be a showcase for sustainable and innovative construction; eco-friendliness and energy efficiency play a key role. For the project, Siemens has set the highest sustainability goals - a certification in Platinum LEED & DGNB.

The EU Buildings Directive 2010/31/ EU "European Directive Energy Performance of Buildings" (EPBD) calls for all new buildings from 2020 to be so-called zero-energy buildings. Therefore, an annual primary energy balance of less than 50 kWh / m² has already been specified as a planning goal.

The heating system is based on district heat by the municipal utilities of the city of Munich - generated by cogeneration and geothermal heat pumps, which is favorable in terms of primary energy. The cooling is done free through cooling towers or indirectly through groundwater via a thermally activated floor plate that stores cooling load peaks in summer and serves as a low-temperature source for heat pumps in winter.





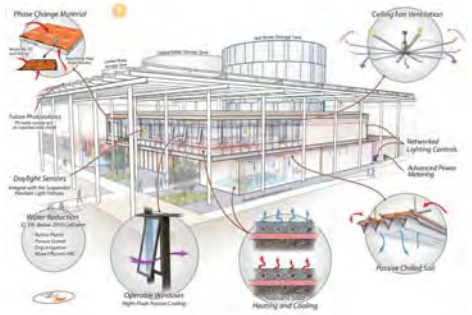
PRECEDENT STUDY - WASTE HEAT RECOVERY

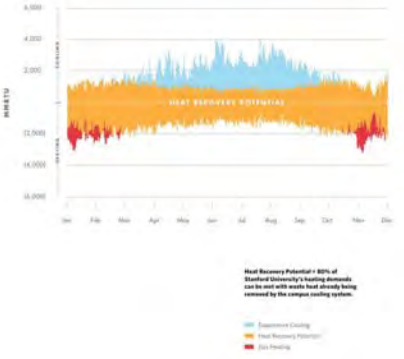
STANFORD UNIVERSITY CENTRAL ENERGY FACILITY

Stanford University has just completed a transformational campus-wide energy system– replacing a 100% fossil-fuel-based combined heat and power plant with grid-sourced electricity and a first-of-its-kind heat recovery system. Positioning Stanford as a national leader in energy efficiency and carbon reduction, the results are impressive: greenhouse gas emissions are slashed by 68%; fossil fuel use by 65%; and campus-wide water use by 15%. This comprehensive Stanford Energy System Innovation (SESI) initiative will eliminate 150,000 tons of carbon dioxide emissions annually, the equivalent of removing 32,000 cars from the road every year. Expected energy savings to Stanford over 35 years is $425 million.

SESI combines an o site, dedicated solar farm producing 68 megawatts of clean renewable electricity via 150,000 high-eficiency photovoltaic panels; conversion of the heat supply of all buildings from steam to hot water; and an innovative heat recovery loop that captures nearly two-thirds of waste heat generated by the campus cooling system to produce hot water for the heating system. At its heart is a new Central Energy Facility that embodies the latest technological advances in heat recovery. Heated and chilled water is stored in three massive water tanks totaling 12 million gallons. A patented technology developed by Stanford continuously monitors the plant's equipment, predicts campus energy loads, grid prices and weather, steering the system to optimal efficiency. The automated software also reviews its own performance.







SITE CONDITIONS - PREVAILING WINDS

OVERVIEW

Prevailing winds blow from the West and Northwest directions at average speed of around 10 mph.

CONCLUSION

Design decisions that aim to harness those winds for space cooling are potentially appealing.

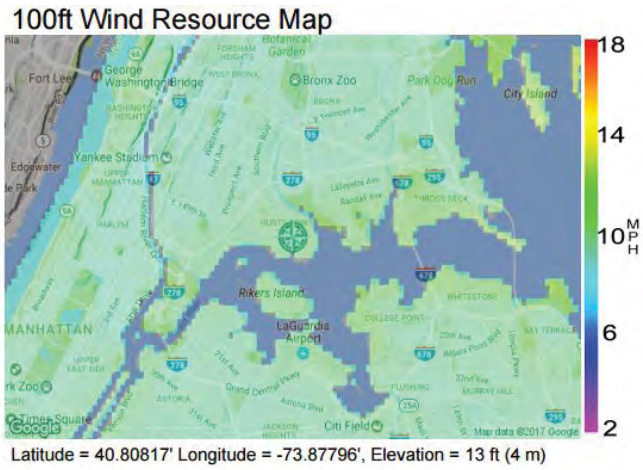
APPLICABLE STRATEGIES

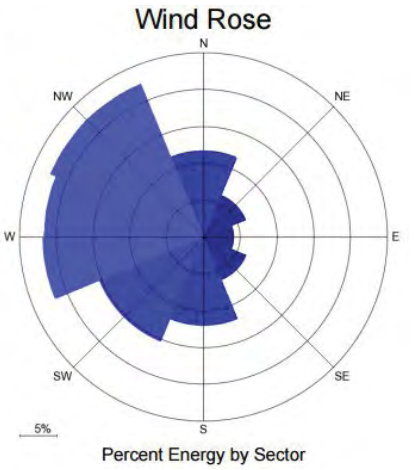
- **Evaporative Cooling**
- **Stack Ventilation**
- **Cross Ventilation**

OTHER COOLING SYSTEMS

- **Absorption Chiller**
- **Adsoroption Chiller**
- **Ice Energy**

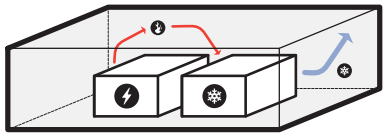






DIAGRAMS

1 ABSORPTION CHILLER

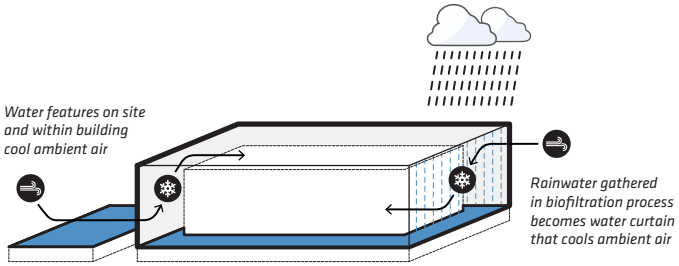


Waste heat from other appliances is used to drive the absorption chiller

PRO:
- Can use low grade steam or hot water heat to drive the process so can tie in with waste heat recovery or solar hydronic heating.
- Use less energy to drive the cooling process

CON:
- Lower cooling efficiency
- Maintainence and installation can be costly or difficult

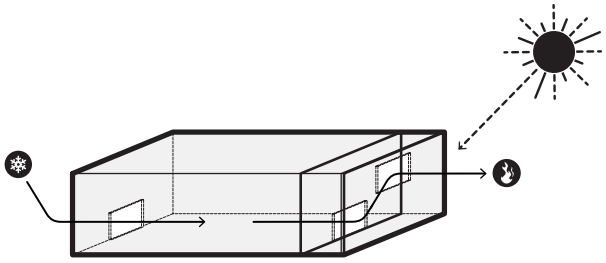
2 EVAPORATIVE COOLING



PRO:
- Passive system, requires no energy

CON:
- Requires a lot of exposed water or water features on site.
- Dependent on dry air for stronger cooling effect.

3 STACK VENTILATION

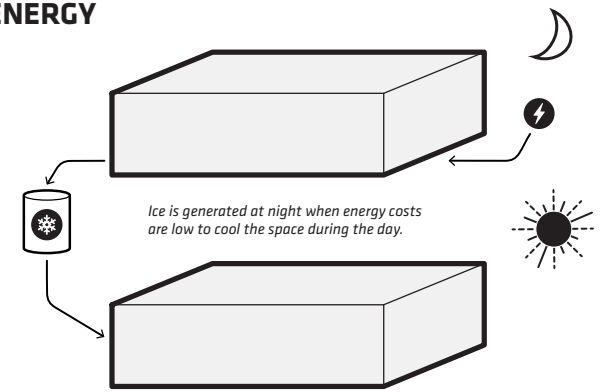


Solar exposure heats air which creates and updraft whereby hot air is evacuated and cold air is then pulled into the space

PRO:
- Passive system requires little to no energy
- Improves air quality by drafting in fresh air
- Solar chimney can increase effect.

CON:
- Difficult to control.

4 ICE ENERGY



PRO:
- More efficient use of energy towards space cooling

CON:
- Dependent on price differential between time of energy use.
- Susceptible to spikes in energy use and billing

PRECEDENT STUDY - ADSORPTION CHILLER

UNIVERSITY OF MELBOURNE NEUROSCIENCE INSTITUTE

There are many different types of Absorption chillers but they all work on a similar principle. In a low pressure system an absorption fluid is evaporated, removing heat from the chilled water. A heat source such as steam, exhaust gas or hot water is used to regenerate the Absorption solution.
Goldman Energy source our Absorption Chillers from World Energy. As leaders in their field, World Energy's Absorption Chillers are highly efficiency heat driven Chillers. They use heat sources such as hot water, exhaust gas, gas and oil firing and Steam.

Goldman Energy can supply a wide range of Absorption Chillers and Heat Pumps from World Energy that can be adapted to your specific needs.

World Energy has also supplied products to major players of fuel cell and Cogeneration system industry in Australia, America, Asia and Europe.

GOLDMAN ENERGY ENGINEERS:
Size the Absorption chiller based on your consumption
Source the Chiller from World Energy
Install and Commission the Chiller into your plant
Complete any ongoing maintenance required





PRECEDENT STUDY - EVAPORATION COOLING

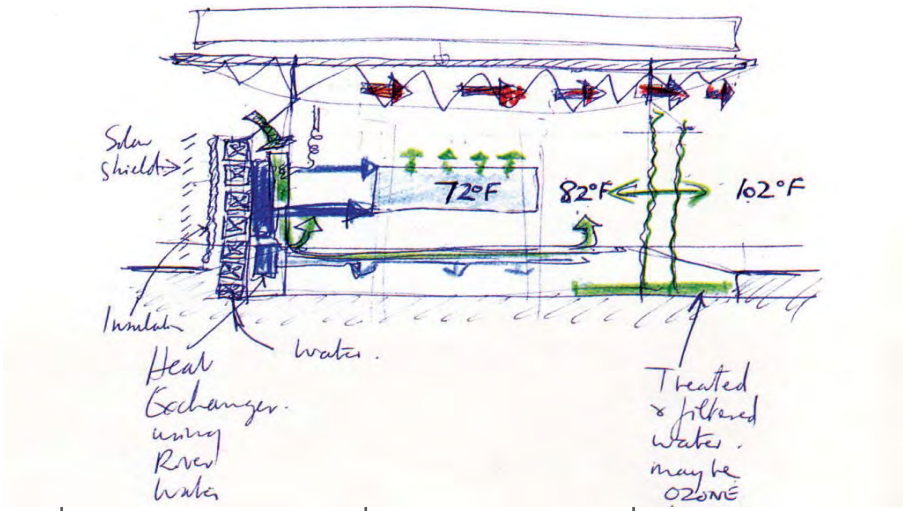
BRITISH PAVILION AT THE 1992 EXPO IN SEVILLE

The project responded to Seville's typically hot climate. Its simple, rectilinear facades were clad with a range of materials to moderate diurnal change and extreme temperatures.

A kinetic water wall spanning 65 metres announced the principal east face and pavilion entrance. Animating its entire length, the sprays of falling water created changing patterns and reflections, as well as providing passive cooling to the glazing and the ambient environment.

In contrast to the sculptural water facade, the west wall was formed from a deep shield of freight containers that protected against strong afternoon sun. Both north and south facades and the roof introduced filtered, soft light to the pavilion through envelopes of PVC coated polyester fabric, stretched between steel masts and rigging.





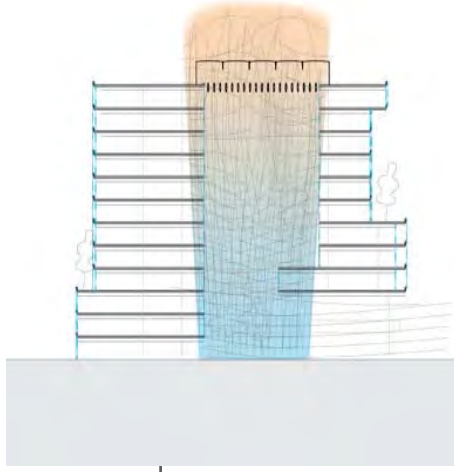
PRECEDENT STUDY - STACK VENTILATION / SOLAR CHIMNEY

GENZYME CENTER

Genzyme Center is the corporate headquarters for a biotechnology company, with offices, an employee cafeteria, a library, gardens, training rooms, a conference center, cafes, and public retail space. Genzyme Center was created as a symbol of progress to represent a point of identification for the company, its employees, and visitors. The goal of the design was to develop a building from the inside out, from the individual working environment to the overall complex structure of the building. Largely due to the collaboration of the design team, developer, client, and construction team, this led to an environmentally friendly, highly communicative, and innovative signature building.







PRECEDENT STUDY - ICE ENERGY

ICE BEAR

Ice storage is a clean, reliable and least-cost distributed energy storage solution for the grid. Since 2005, Ice Bears have been installed in more than 40 utility services, transforming inefficient and polluting air conditioners into efficient and clean cooling systems. With a reliability record in excess of 98%, they benefit both utilities and their customers. Ice batteries improve the efficiency and resiliency of the grid, lower cooling bills and reduce carbon emissions.

Put another way, the company wants to freeze water at night in refrigerator-like boxes adjacent to commercial air conditioners and then thaw it during the day, when power demand is highest. This would theoretically allow AC-hungry commercial buildings in warm climates to cut energy use during heat waves, by shutting air conditioners down while still providing cool air to buildings from melting ice.



SITE CONDITIONS - AIR QUALITY

OVERVIEW

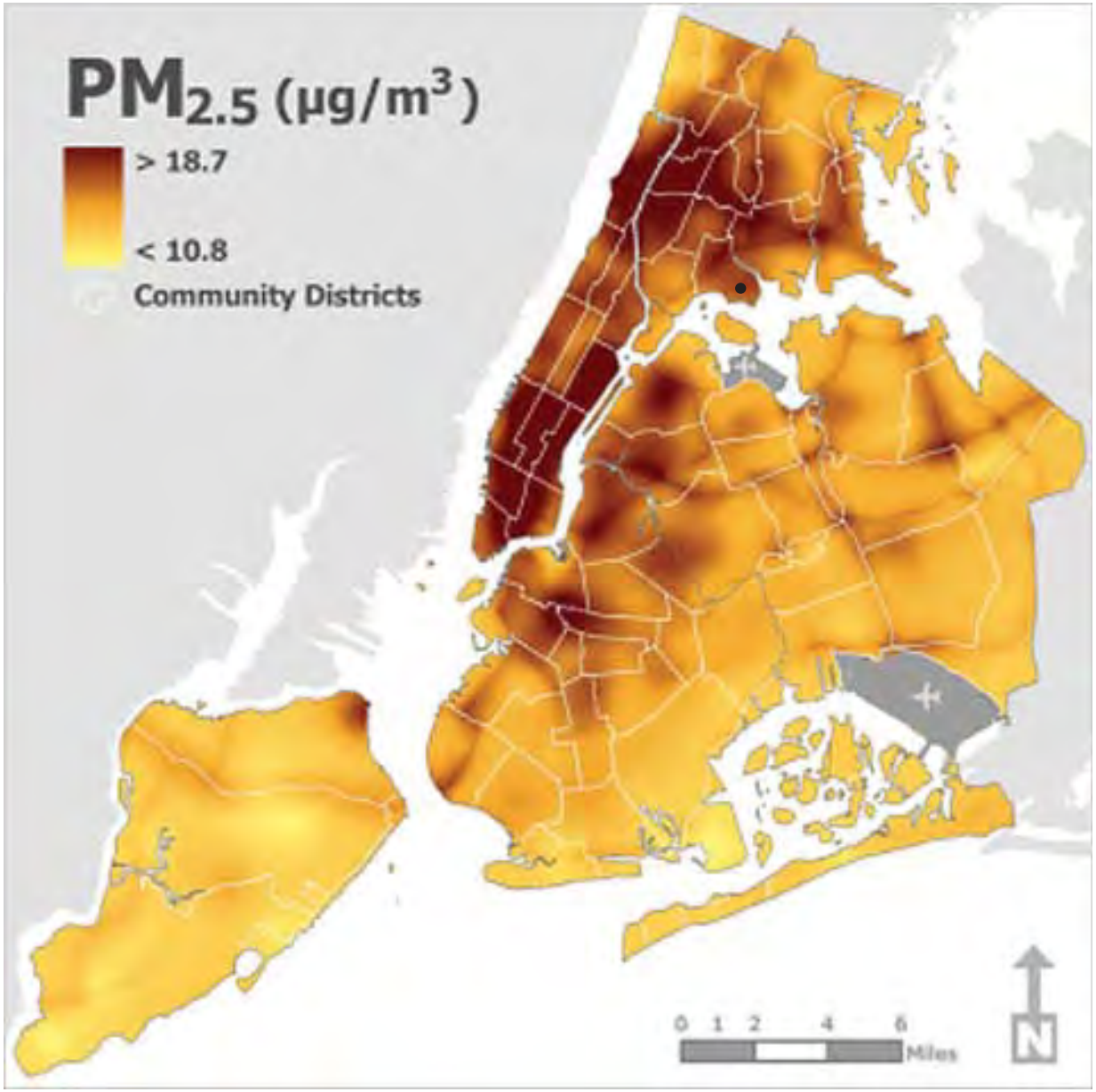
The FoodHub Site in the South Bronx sees a relatively high concentration of particulates in the air.

CONCLUSION

The FoodHub could potentially be a catalyst for sustainable development in the area by pushing design solutions that not only improve on-site air quality but also actively address the overall air pollution within the surrounding neighborhood.

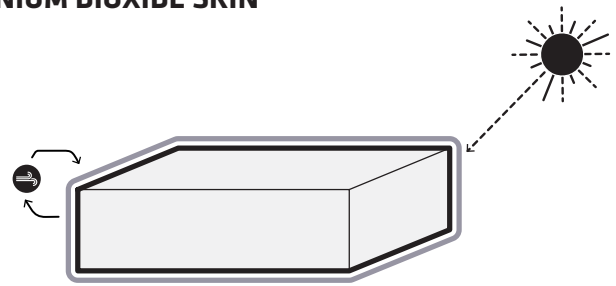
APPLICABLE STRATEGIES

- **Photocatalytic Air Purification**
- **Titanium Dioxide**
- **Increased Planting**
- **Green Walls**
- **Cross Ventilation**



DIAGRAMS

1 TITANIUM DIOXIDE SKIN

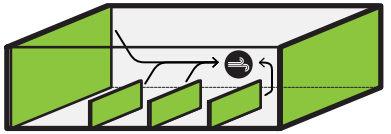


Photocatalytic effect: UV light releases electrons from TiO2 film which interacts with water molecules in the air to break down pollutants

PRO:
- Passive photocatalytic process that naturally purifies air, requires no energy usage.

CON:
- Long term efficacy is still being researched
- New technology that has not seen large scale employment yet

2 GREEN WALL



Green Walls convert CO2 into oxygen while also removing pollutants and toxins from ambient air to improve air quality both within the space and for the larger urban context as a whole.

PRO:
- More efficient use of energy towards space cooling

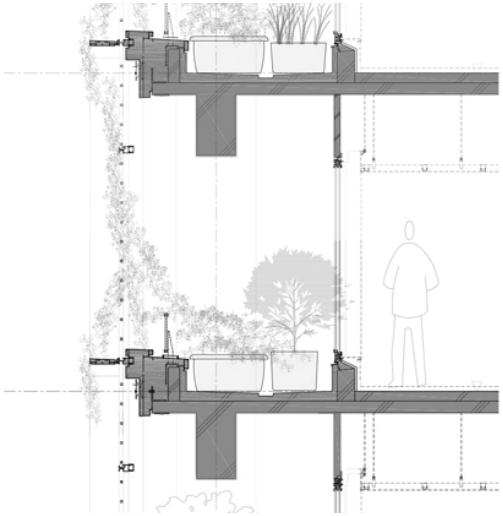
CON:
- Dependent on price differential between time of energy use.
- Susceptible to spikes in energy use and billing

PRECEDENT STUDY - LIVING GREEN WALL

URBAN FARM, TOKYO

Urban Farm at Pasona Tokyo Headquarters is a nine story high, 215,000 square foot corporate office building for a Japanese recruitment company, Pasona Group, located in downtown Tokyo. It is a major renovation project consisting of a double skinned green facade, offices, an auditorium, cafeterias, a rooftop garden and most notably, urban farming facilities integrated within the building. The green space totals over 43,000 square feet with 200 species including fruits, vegetables and rice that are harvested, prepared and served at the cafeterias within the building. It is the largest and most direct farm-to-table of its kind ever realized inside an office building in Japan.



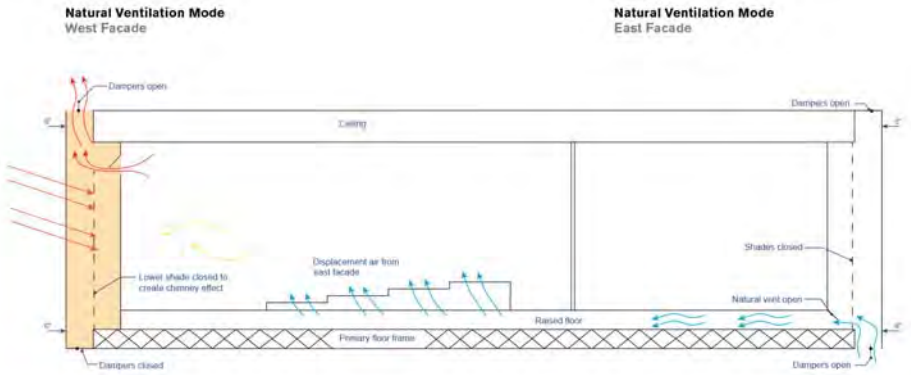


PRECEDENT STUDY - NATURAL VENTILATION

MARVIN HALL, UNIVERSITY OF KANSAS

The Forum is an addition to Marvin Hall, the historical School of Architecture building at the University of Kansas. It satisfies the school's acute need for a central commons space and an auditorium, neither of which were originally present in Marvin Hall. It was primarily designed and constructed by the post-graduate architecture students and participants of Studio 804, the Department of Architecture's Design/Build program, with support from various industry experts.





INTEGRATED DESIGN STRATEGIES

DOUBLE SKIN

- https://www.dezeen.com/2013/01/27/optical-glass-house-by-hiroshi-nakamura-nap/
- http://www.burckhardtpartner.ch/en/references/items/new-mfo-park.html
- https://www.commerzbank.com/en/hauptnavigation/presse/mediathek/bilddaten/buildings/buildings_1.html

ALGAE REACTOR WALL

- http://www.fao.org/docrep/003/w3732e/w3732e03.htm#2.%20MICROALGAE
- http://thecloudcollective.org/#/projects/culture-urbaine/
- http://inhabitat.com/overpass-algae-garden-turns-co2-emissions-into-combustible-biomass-in-switzerland/

BIOREACTOR

- https://energypedia.info/wiki/Portal:Biogas
- http://www.waterworld.com/articles/print/volume-24/issue-12/editorial-feature/microturbines-turn-digester-gas-into-power.html
- https://www.epa.gov/agstar
- https://www.epa.gov/anaerobic-digestion
- https://www.epa.gov/sites/production/files/2014-12/documents/lib-ben.pdf
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