7.0 SUSTAINABLE DESIGN / LEED

7.1 OVERVIEW

The Cornell NYC Tech First Academic Building (FAB) is envisioned to be a sustainable building. Integrated design was been used throughout the process to create an exemplary green building. The Leadership in Energy and Environmental Design (LEED) New Construction (NC) 2009 rating system will be used to provide a recognized benchmark for sustainable achievement. Sustainability goals for the building include meeting the functional requirements of advanced technology while creating a building that has a low carbon footprint, is net zero energy, and is healthy and pleasant to be in.

7.2 SUSTAINABLE DESIGN GOALS AND STRATEGIES

In the pursuit of a green campus on Roosevelt Island, Cornell has set many sustainability goals for the design of the First Academic Building. As overall operational energy use is one of the main metrics of sustainable design, the building will aggressively target energy reduction and work toward zero net energy use. Decreased water use through demand optimization and on-site water capture and reuse is also of prime importance in an urban environment. The building will also target **LEED Platinum** certification, as LEED has become the most widely recognized green building certification system. Although pursuing low energy design will synergistically work towards the LEED Platinum goal, LEED encompasses much more than simply energy use. Meeting one goal does not guarantee the other.

Cornell is also considering additional certification through the International Living Future Institute, which administers the **Living Building Challenge**. Although pursuing the full challenge is not being considered at this time, the design team will pursue the **Net Zero Energy Certification** scheme or the **Petal Recognition** program.

The following table shows a list developed during DD, and updated in CD, of First Academic Building design measures that exceed typical practice:

Table 1 – FAB Exceptional Design Measures

Item	Description	Benchmark
Site energy consumption	Modeled site building electric energy consumption rate of 29.3 kBTU/GSF/year (35.5% reduction in DD)	ASHRAE 90.1 baseline model – 45.4 kBTU/GSF/year (DD)
LEED Platinum	Current LEED checklist shows 86 expected points and 10 additional possible points	LEED Platinum – 80 points; Gold – 60 points; Silver – 50 points; Certification – 40 points
On-site solar energy	Canopy-mounted PV cells are designed to generate energy greater than 50% of building consumption	Typical buildings rely on grid power which is partially derived from fossil fuels; renewable energy is operationally carbon neutral
Ground source heat	Heat pumps generate 2.8 units of heating energy	ASHRAE 90.1 compliant gas-fired boilers are 83% efficient, generating 0.83 units of heating energy for

Item	Description	Benchmark
pumps – heating	for every unit of input energy	every unit of input energy
Energy recovery wheels	Recovery wheel transfers 75% of energy from exhaust airstream to precondition outside air	Without recovery wheels, peak HVAC loads increase by up to 30% depending on ventilation
Plug loads	Workspace users will rely on laptops only with some monitor usage, resulting in typical plug loads of 0.5 Watts per ft²	Assigning desktops and monitors to each user results in plug loads of 1.0 Watts per ft²
Lighting controls	Lighting control system programming includes aggressive time schedules and wallstation functions in meeting rooms, main public corridors, and in open plan work zones. In some areas outside of normal building hours, lighting energy will be limited to 50% of the full design target, responding to human circadian rhythm and acceptance of lesser illumination. In meeting rooms, lights will default to 50% of the full design target to encourage reduced levels.	Multi-level control only required in enclosed rooms without vacancy detection
Lighting power density	Open work zones will be designed for power density of 0.7 Watts per ft²	LEED referenced energy code permits up to 1.1 Watts per ft² for open office space
Potable water use reduction	Potable water use will be 67% less than that of a baseline building via efficient fixtures and rainwater reuse	Typical buildings have standard water fixtures based on the Energy Policy Act of 1992, which set maximum flow standards
Rainwater harvesting	Rainwater harvested from the FAB roof and canopy will be reused to meet at least 70% of the FAB's flushing and campus lawn irrigation needs	Typical buildings do not collect rainwater for reuse

7.2.1 NET ZERO ENERGY DESIGN WITH RENEWABLES

The building is designed to minimize energy use, so that enough energy can be produced on-site to offset all of the annual building energy consumption. The best way to achieve a low energy building is through a stepped approach where the first priority is reducing energy demand as much as possible through load reductions and passive and energy efficient design, and then using renewable energy to power much of the building systems. The building is designed to achieve site *operational net zero energy*, so that enough energy will be produced on-site to meet the designed annual building energy consumption at full-occupancy.

It is important to properly define the term “net zero energy” for the purpose of this report. According to a report published in 2010 from the National Renewable Energy Laboratory, since the building will use solar energy *on-site*, but not entirely within the building *footprint*, it will achieve a Net Zero Energy Building (NZEB) classification of B.[1]

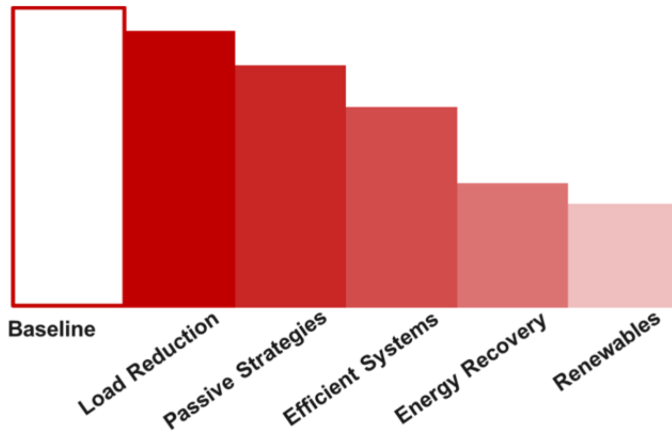


Figure 1 - Getting to Net Zero Energy

Energy Demand Reductions

The recommended approaches to achieving energy demand reductions in this climate include internal load reductions, energy recovery, and design to reduce solar heat gains. Internal load reductions both eliminate energy use at the source, and also indirectly reduce cooling load by producing less heat within the building. Energy recovery systems, such as enthalpy wheels, recover warm or cool air from exhaust streams to pre-heat or pre-cool incoming air to the building. Reducing solar heat gains can be accomplished by limiting glazing on the south, east, and west faces of the building and providing vertical and horizontal overhangs to block the strong summer sun (see Figure 2). The building is designed to limit the glazing percentage to 40%.

South, east and west-facing glass is shaded via the overhanging solar canopy. The building rooftop is also shaded with the canopy, keeping it cooler, and lowering energy needed for cooling. Throughout the design, Arup worked with Morphosis and Cornell to evaluate opportunities for energy demand reduction through internal load reductions such as low energy workstations and lighting, energy recovery systems, and design to reduce solar heat gain.

As the net zero energy goal is an aggressive target, energy efficiency will be of prime importance. The project goal is to reduce the total modeled building energy use by at least 50%, as measured by annual energy cost, through a combination of energy efficiency measures and renewable energy generation. Based on the Schematic Design energy model, the energy load reduction contributed 42% of the total energy reduction. The Detailed Design energy model resulted in a 35.5% total energy reduction. This decrease in the reduction was caused by a decrease in the modeled baseline building energy usage rather than an increase

[1] http://www.nrel.gov/sustainable_nrel/pdfs/44586.pdf

in the modeled proposed building energy usage. The updated energy model for the 100% Construction Document will be submitted under a separate report.

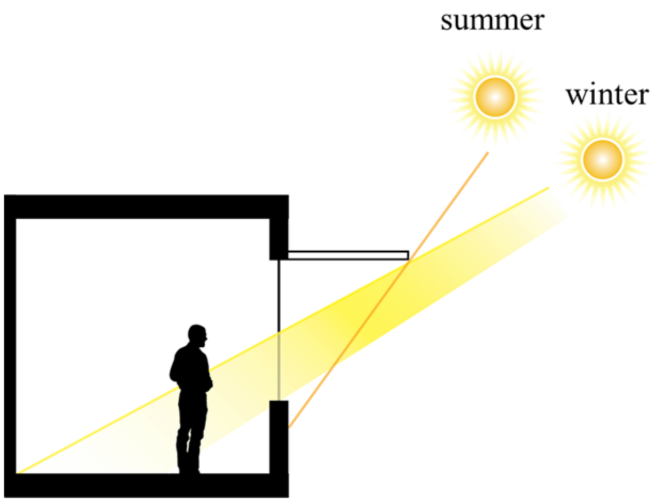


Figure 2: Schematic Showing Passive Solar Design Strategies

Renewable Energy

An on-site array of solar panels on the building roof will produce renewable energy to offset approximately half of the project's electricity demands. The building will be connected to the campus central utility plant and electricity grid, since the daily renewable energy supply profile will not sync with the building demand profile. The campus microgrid can be used as an energy storage system by exporting electricity to other buildings when solar generation exceeds FAB demand.

The goal is to supply enough solar energy to meet the designed building energy demand in an average year. Although this may differ from the actual energy performance of the building, the intent is to achieve net zero energy status in operation. During DD, three options were analyzed for the solar canopy. These options are summarized in Figure 3. Between 40 - 47% of building energy was projected to be met by the FAB PV Canopy. After DD, due to a reduction in the building energy use from the energy model, 48% of building energy can be met by the canopy (Option 3). The neighboring CoLo building will also have rooftop solar panels which will contribute, and possibly a ground-mount PV array will be installed on the site south of the FAB. All three energy sources are expected to combine to meet the expected energy demand of the FAB (see Figure 4 - Figure 7). The PV production numbers are estimates, and final PV energy production numbers will be developed by the PPA provider selected to install the PV systems.

The options for the modules selected for the various portions of the solar canopy are shown in the tables below. Further details of the solar canopy are provided in the next section.

Option 1 - Baseline

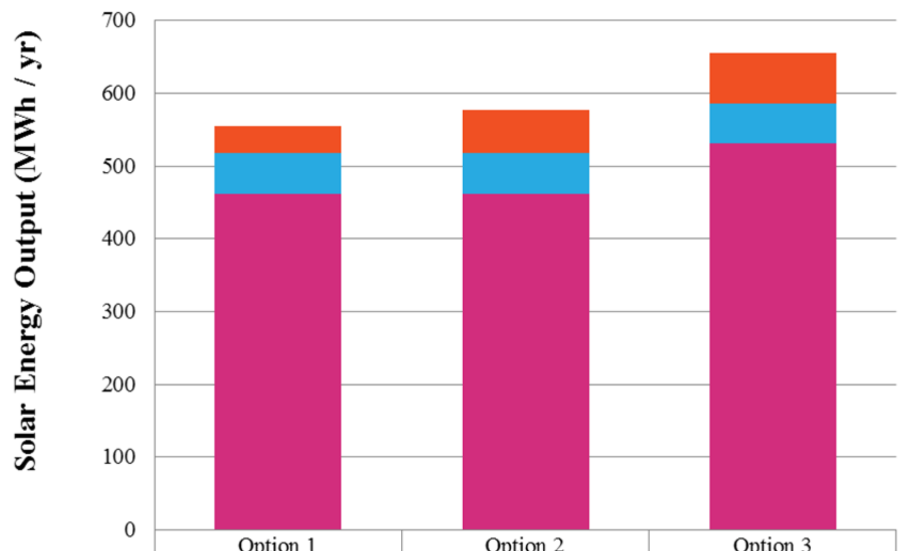
Panel Type	Panel Quantity	Panel Tilt	Panel Location
LG Mono	1290	Low-Tilt (5 degree)	Main Roof
DelSolar Light-thru	247	Low-Tilt (5 degree)	Above Skylights
DelSolar Light-thru	154	High-Tilt (30 degree)	Above Tech Plaza

Option 2 – Opaque Panels at High Tilt

Panel Type	Panel Quantity	Panel Tilt	Panel Location
LG Mono	1290	Low-Tilt (5 degree)	Main Roof
DelSolar Light-thru	247	Low-Tilt (5 degree)	Above Skylights
LG Mono	154	High-Tilt (30 degree)	Above Tech Plaza

Option 3 – Sunpower Modules for all Opaque Panels

Panel Type	Panel Quantity	Panel Tilt	Panel Location
Sunpower X	1290	Low-Tilt (5 degree)	Main Roof
DelSolar Light-thru	247	Low-Tilt (5 degree)	Above Skylights
Sunpower X	154	High-Tilt (30 degree)	Above Tech Plaza



	Option 1	Option 2	Option 3
High tilt transparent	38	59	68
5° transparent	56	56	56
5° standard	461	461	530

Figure 3: Modeled PV Options Outputs

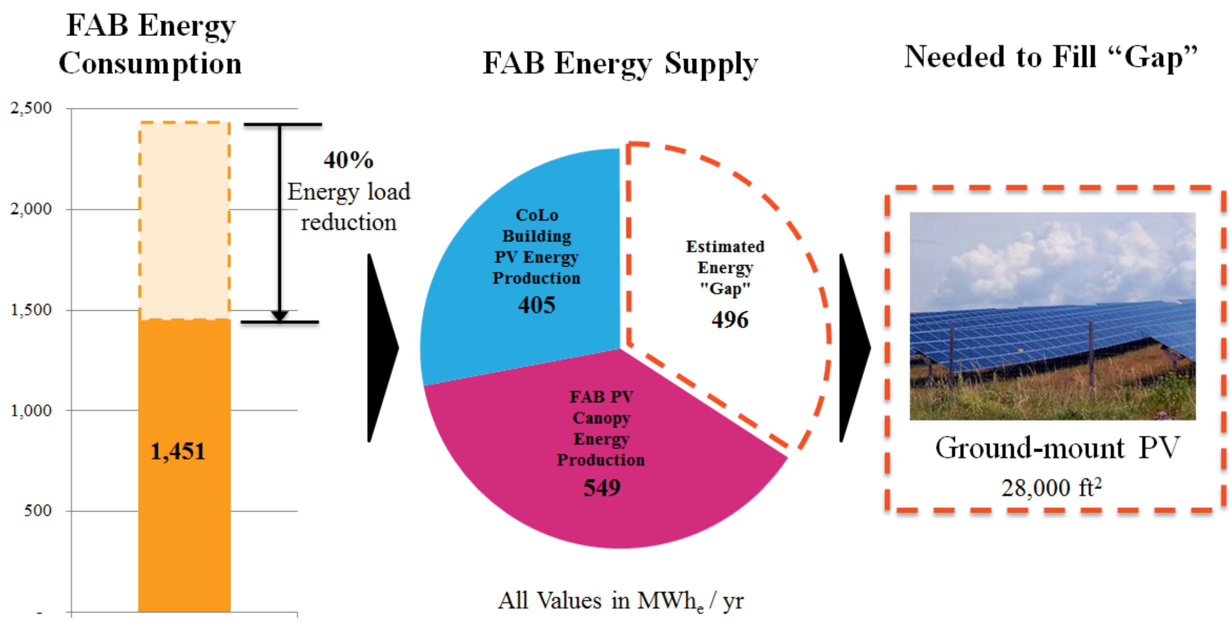


Figure 4: Net Zero Energy and PV at **SD**

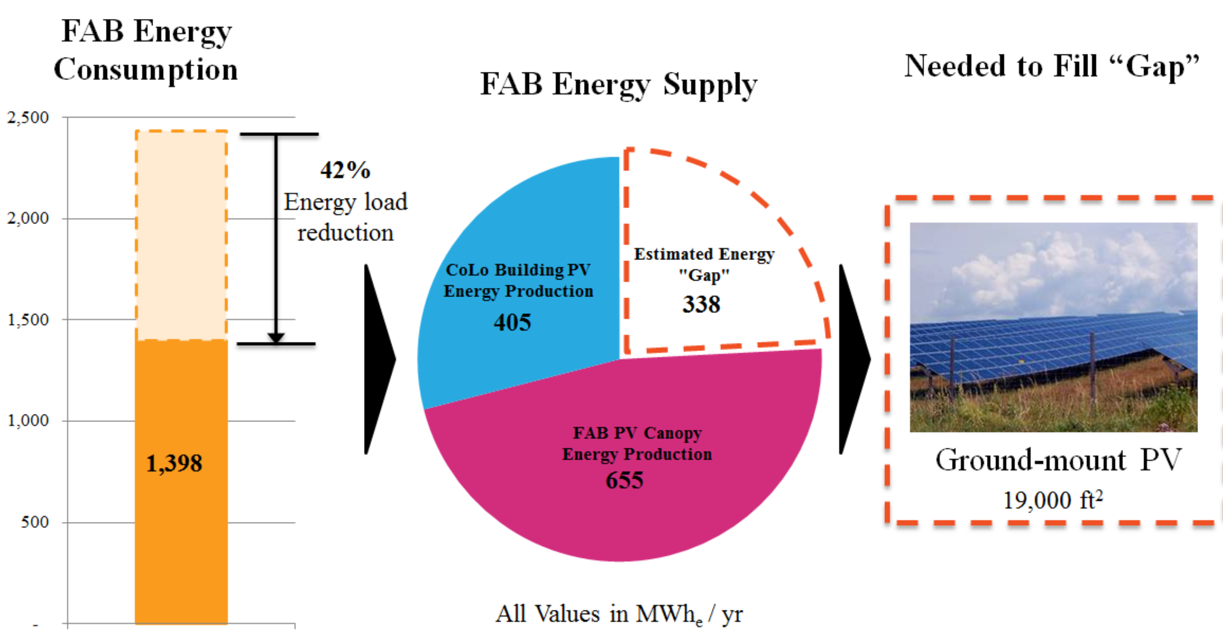


Figure 5: Net Zero Energy and PV at **DD** (Option 3)

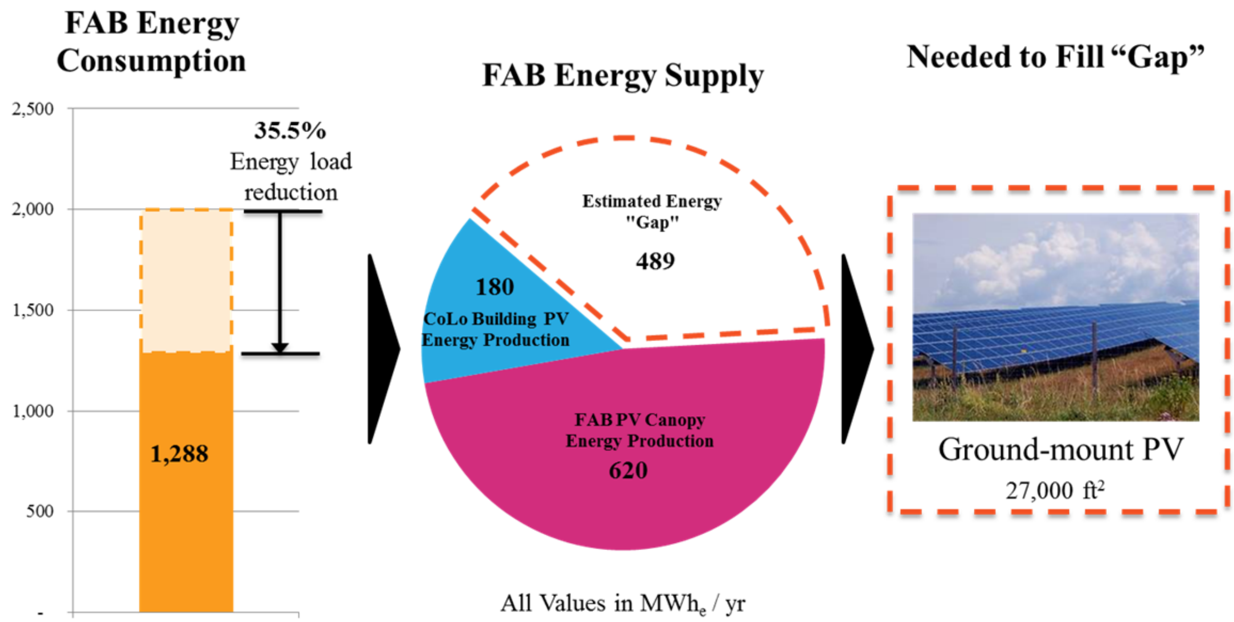


Figure 6: Net Zero Energy and PV at **50% CD** (Option 3)

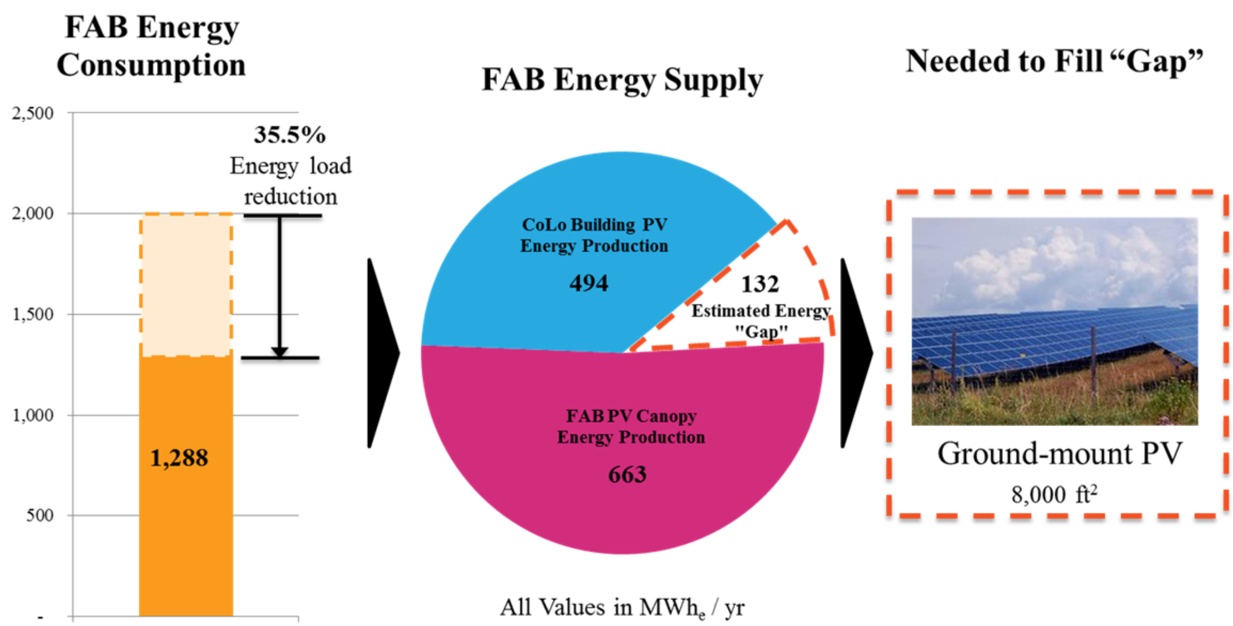


Figure 7: Net Zero Energy and PV at **100% CD**. Note that this is a best-case scenario using 23% efficient modules expected to be available at the end of 2015 (see next section) and the DD energy model results.

Solar Canopy

The photovoltaic canopy over the FAB provides on-site renewable energy generation as well as optimized shading to reduce building cooling loads in summer, and a pleasant environment for the plaza spaces (see Figure 8). A power-purchase agreement (PPA) structure will be used to reduce the up-front cost to Cornell University and allow the full benefit of tax credits for photovoltaic systems to be realized. Under a PPA, ownership of the solar panels is held by a third-party, and the building owner purchases electricity produced by the solar array, usually at similar or reduced rates compared to utility rates.

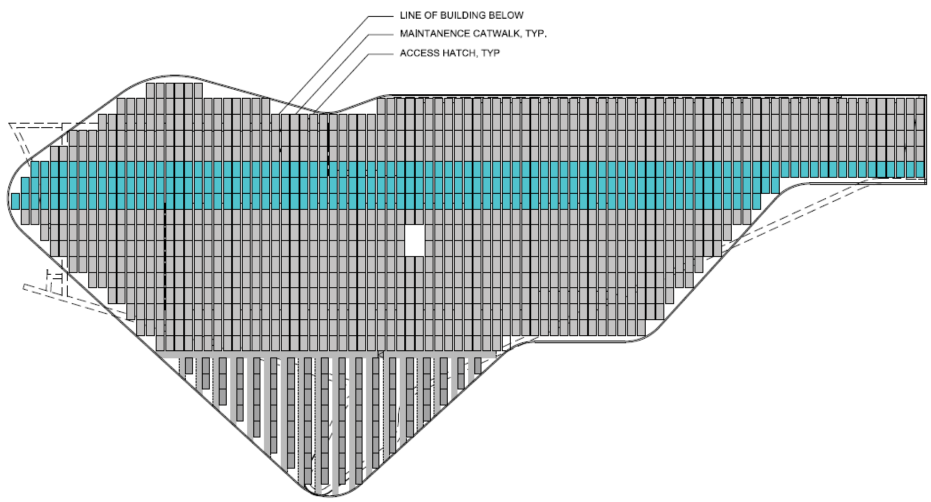


Figure 8: Plan View of Proposed Solar Canopy above Roof of FAB

The solar canopy will be located at an elevation high enough to clear most obstructions on the roof. During SD, the mechanical room roof was designed as a surface to place solar panels, however during DD the decision was made to elevate the PVs above the mechanical roof as part of the PV canopy. Although more steel is added, this circumvents thermal break issues with the conditioned mechanical penthouse.

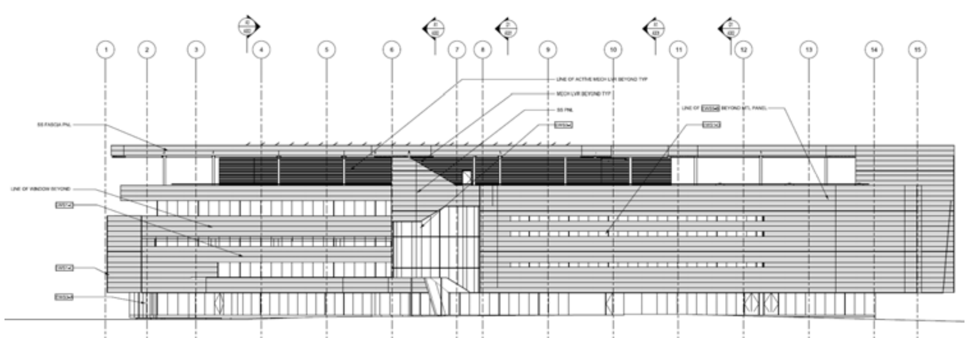


Figure 9: Section of FAB with Mechanical Room and Canopy

Solar panels will not be located above any equipment or structures likely to continuously produce large amounts of heat such as generator exhaust and kitchen exhaust because of potential damage to the photovoltaic material. The design team has determined that solar panels can be placed above the cooling tower, since the humid condition of the air is similar to that of a foggy day, and temperatures should be at or below the ambient dry bulb temperature. However, the PV consultant should analyze the impact of localized effects on the performance of the panels, and whether these panels should be isolated on a separate inverter to increase the efficiency of the array.

There will be two types of panels with differing tilt angles. The panels in the canopy above the roof will be tilted at a low-angle of approximately 5° in order to maximize the energy production per unit area of the roof (Figure 10).

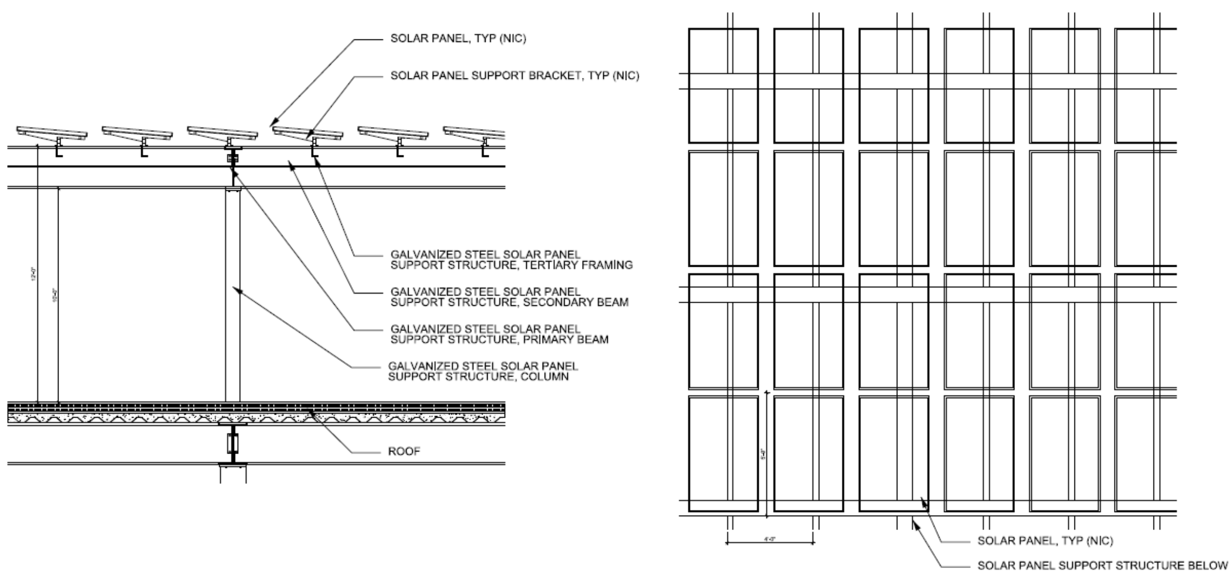


Figure 10: PV Canopy Detail, Low-Tilt Solar Panels

The panels in the canopy above the plaza will be tilted higher at an angle of approximately 35° in order to maximize energy production per panel, and to allow more light penetration into the plaza area below (Figure 11).

All panels will be oriented in a direction to align with the building grid, which will simplify the structure. It is estimated that this orientation will reduce the energy generated 0.7% for the low- tilt panels, and 3.2% for the high- tilt panels, as compared to an array facing due-South. The relatively more western orientation will optimize electricity production for the afternoon, which is beneficial, since the summer peak electricity load occurs in the afternoon on hot days when the air conditioning load is the greatest. During this period, time-of-use electric rates are highest.

The standard PV modules will use monocrystalline silicon technology, as these provide the highest output per area. The Sunpower X21 panel is currently the highest efficiency commercially available panel on the market, and will produce the most energy per area. With a 21.5% efficiency, the panel would produce at least 15% more energy than a comparable monocrystalline silicon module (LG

Mono X). Panels with an efficiency of 23% are expected to be produced by Sunpower by the end of 2015.[2] Glass-backed modules will be included in the design for the areas above the roof skylights to allow for more light penetration. These panel types have a maximum efficiency of approximately 12%, but allow for some daylight to pass through to the skylights below. These panels were also considered for the area above the plaza, but were changed to standard opaque panels during CD to increase energy production and reduce costs.

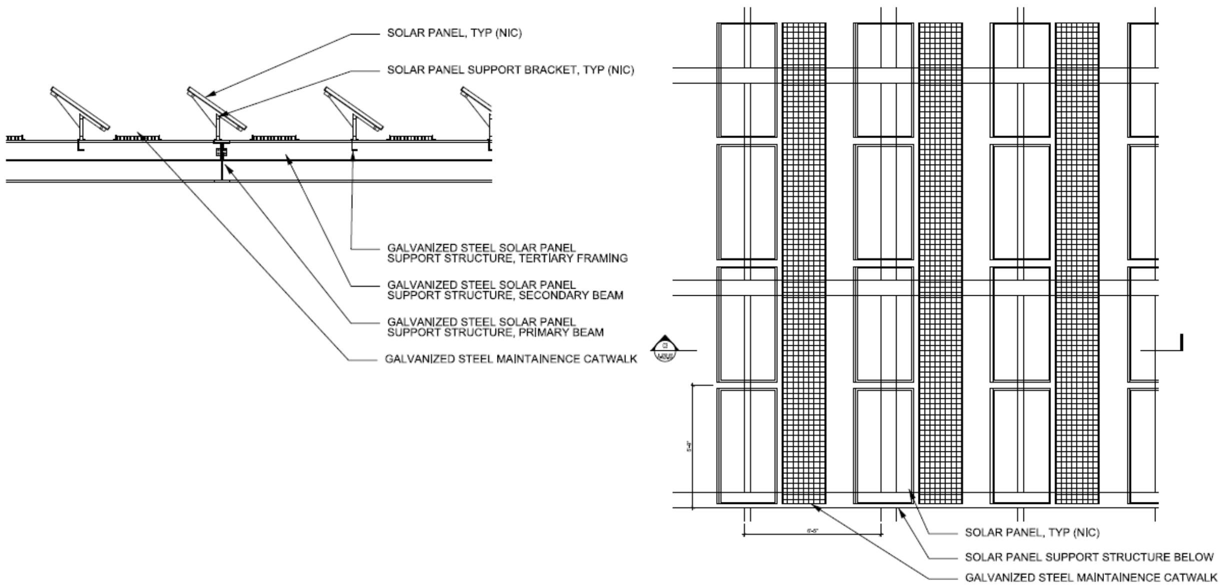


Figure 11: PV Canopy Detail, High-Tilt Solar Panels

Solar Costs

It is recommended that the highest efficiency commercially available solar modules be used on this building. Despite a cost per Watt of approximately twice that of conventional silicon panels, the overall cost of installation of the entire solar canopy would likely be *lower* with higher efficiency panels. This occurs because the relatively high fixed cost of the PV structure can be offset by the higher output of the more efficient panels. The fixed cost of labor can also be further spread with the higher output system. Table 2 demonstrates the approximate cost comparison between Sunpower X modules and conventional modules for the FAB. Panel costs were obtained from approximate quotes from local PV suppliers.

Table 2 – Cost comparison of Sunpower and Conventional PV Installations

	Sunpower PV ($/W) 498 kWp	**Conventional PV ($/W) 433 kWp**
Panels	1.40	0.75
Structure*	4.62	5.31

[2] http://www.pv-magazine.com/news/details/beitrag/solid-partnerships-and-full-fab-capacity-mark-strong-fiscal-year-for-sunpower_100014226/#axzz2wEM1FleJ

Other BOS	1.00	1.20
Inverter	*0.20*	*0.20*
Labor	*0.40*	*0.60*
Other	*0.40*	*0.40*
Total	**$7.02**	**$7.26**

*Structure is based on canopy structure cost of $2.3M (cost estimate from Dharam, Lally & Smith, 3/7/2014). Example: $2,300,000 / 498,000 W = $4.62 / W

Alternative: Rooftop Solar Panels

During SD, a less–costly alternative to a solar canopy strategy was examined. During DD, this strategy was determined not to provide enough energy to meet the goals of the building. Although the solar canopy continues to be pursued in the design, the alternative rooftop PV strategy is described below.

The rooftop strategy would be to locate solar panels directly on the roof via a ballasted (self-weighted) system. There are many drawbacks to this strategy, including a large decrease in energy production due to competition for roof space with other systems.

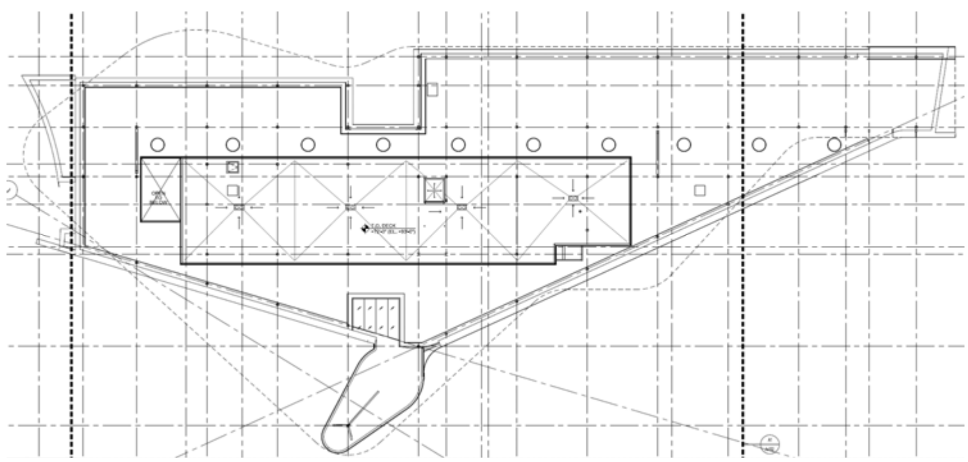


Figure 12: Roof layout showing mechanical equipment and skylights

The integration of skylights with the roof solar panels will also present a design challenge. If solar panels are not placed within the skylight areas, then total solar energy production is not maximized. However, if standard solar modules are placed over the skylight areas, then they will likely block most of the useable light to provide daylight to the building. Glass-backed solar panels are one option. Technology also exists to incorporate photovoltaic cells into skylights while allowing visible light to pass through (see Figure 13). Although the cost of these PVGU products is about ten times the price of a normal skylight, if both the skylight and PV cells can be eliminated, tax credits can redeemed through a third-party, and energy is produced, the lifecycle cost may be comparable to the alternatives. If desired, this technology can be explored further.

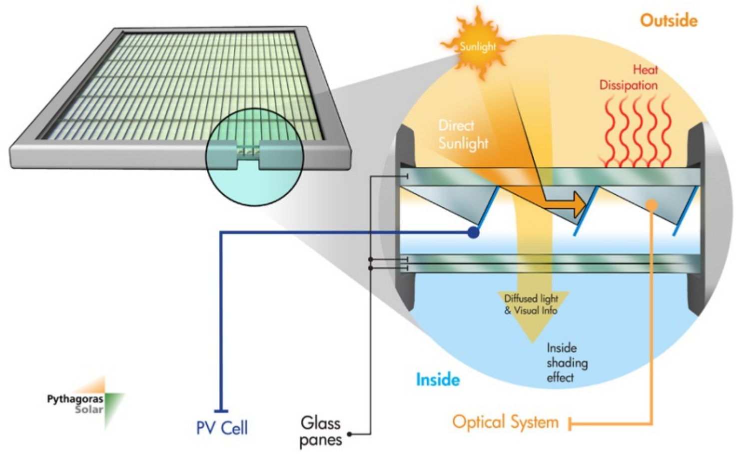


Figure 13: PVGU Photovoltaic Skylights[3]

7.2.2 DECREASED WATER USE

As a first step, efficiency measures planned into the building fixtures and operations can reduce water demands and subsequent wastewater discharges by 28%. The design incorporates a rainwater harvesting system, which further reduces combined sewer discharge and potable water usage in the building. By capturing precipitation that falls on the roof, the building can become more self-sufficient, supplying nearly all of its non-potable water demand with rainwater. During SD a greywater reuse system was evaluated, but it was eliminated from the design during DD since the water goals can be met without such a system, and the system adds little value but significant cost. For more information, see Section 7.5.

7.2.3 DESIGNING FOR FLEXIBILITY – ALL-ELECTRIC BUILDING

Another important characteristic of the building is the goal that it be an all-electric building. During the normal operation, it is envisioned that no fossil fuels will be used for heating, cooling, or electricity generation. This enables the building to have the flexibility to continue to become greener in the future as the electric grid decarbonizes. New York City has the stated goal of reducing greenhouse gas emissions 30% by 2030. New York State has committed to reducing greenhouse gas emissions to 80% below the 1990 baseline by the year 2050, and much of these carbon emissions reductions will stem from reduced power plant emissions. Coal and oil, the dirtiest fuels for generating electricity, will continue to be phased-out for electricity generation in the state, decreasing the emissions intensity of the grid in the future. As the grid becomes cleaner to achieve the 2050 target, an all-electric building will become cleaner with the grid.

Today, many buildings are still being designed with natural gas boilers for heating and hot water. While this may be an efficient option, it doesn't consider the long-term outlook, as the studies indicate that the burning fossil fuels must be almost completely eliminated by the year 2050 in order to achieve target

[3] http://www.pythagoras-solar.com/technology-solutions/pvgu-for-skylights/

carbon emissions rates. Heating and cooling will be provided to the building primarily using electrically-powered ground-source heat pumps.

7.3 LEED APPROACH

The project's LEED submission will use the LEED online system (www.leedonline.com). The LEED credits will be submitted in two stages: design review ("D" on the checklist) and construction review ("C" on the checklist). Design credits are usually submitted immediately after Construction Documentation so that the Green Building Certification Institute (GBCI) has the final design documents and so that certification can begin. Construction credits are submitted after construction is completed.

Cornell will be pursuing certain LEED credits through the "master site credits" approach. This approach can simplify documentation, since campus credits allow eligible LEED credits and prerequisites to be documented once for an entire campus. These campus credits are pre-approved through a separate review of the master site. Once pre-approved, campus credits are available to individual LEED projects associated with the same master site and located within that same LEED campus boundary. Individual buildings may also opt to pursue the same credits independently (i.e. with an alternative compliance). Cornell has indicated that the following credits will be pursued as campus credits: SSp1, SSc1, SSc3, SSc4.1 (with exemplary performance), SSc6.1, SSc6.2, SSc7.1, and WEc1.

7.3.1 FULL-TIME EQUIVALENT

LEED requires the calculation of a value representing full-time equivalent (FTE) occupants in the building. The projected building capacity is shown in Table 3 below:

Table 3 – FAB Projected Building Capacity for Fiscal Year 2027

PhDs	225
Tenure-track Faculty	61
Non-tenure track Faculty: research/post docs/lecturers/corporate	82
Administrative staff: general & senior	61
Masters students	500
Total	**929**

Since, the Masters students are considered transients and not full-time occupants, the FTE is **429**. The FTE value is used to determine information required in the following credits:

- SS Credit 4.2 Alternative Transportation, Bicycle Storage & Changing Rooms
- WE Prerequisite 1 and Credit 3 Water Use Reduction

Based on this calculation at least **47** secure bicycle spaces and **three** showers are needed in the facility (SSc4.2). The SD design had two showers in the cellar, and a third shower was added during DD.

7.3.2 LEED-DEFINED SITE

The First Academic Building will be located on the southern portion of Roosevelt Island in New York City. The LEED project boundary will not be identical to the site as defined by the architect-owner contract, but it must be logical and be used consistently across all LEED documentation and credits. The boundary for the work done by Morphosis will be immediately at the boundary of the building. The recommended LEED project boundary is shown below.

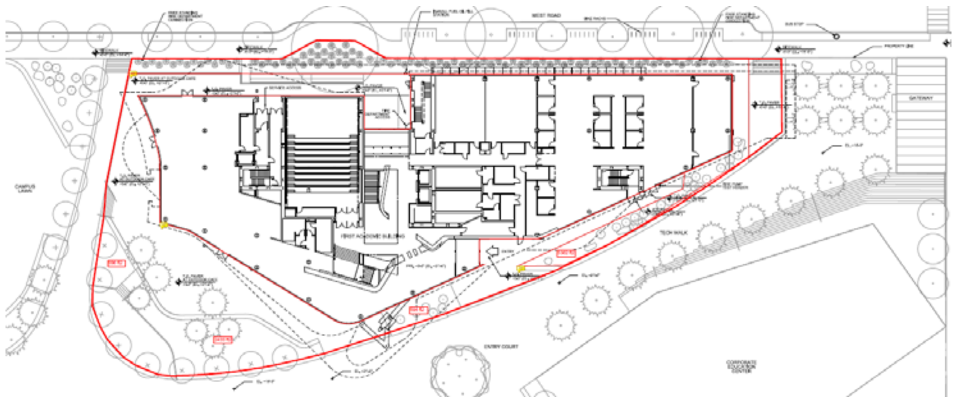


Figure 14: LEED site boundary (in red)

It is important that the context of the campus be considered when defining the LEED boundary. Since other buildings on campus will seek LEED certification, the LEED boundaries from other buildings must not overlap the LEED boundary of the FAB.

The LEED boundary above is logical since it follows the curve of the seatwall which creates a perimeter around the building, and excludes the lawn area. It is advised that the campus lawn be excluded from the site since it requires a permanent irrigation system, which would need to be 100% irrigated from rainwater in order to achieve 4 points under WEc1. Also, since the lawn is a monoculture planting, it cannot contribute to SSc5.1. Under the boundary configuration above, SSc5.1 is not met, since an additional ~1,100 ft^2 of vegetated space within the boundary is needed. SSc5.2 is met, since pedestrian-oriented hardscape counts as open space as long as greater than 25% of it is vegetated.

7.3.3 SUSTAINABLE SITES

The First Academic Building will be a new building on a new university campus. The previously-developed site is not considered prime farmland, not near threatened or endangered species habitats, not within 100 feet of any wetlands, and not on public parkland (SSc1). The project site is also within a dense community on Roosevelt Island and within a half mile of many basic services, including restaurants, convenience stores, and beauty salons (SSc2). Also, future development of the campus can count toward the site density given that an existing urban fabric is in place to support transportation and mixed use requirements[4] Parks and water bodies may also be omitted from the calculation, which means that the very dense areas of Midtown East in Manhattan would also be counted toward the credit if needed[5]. SSc1 and SSc2 have been documented by Cornell in DD.

Figure 15: Aerial View of Roosevelt Island in the Context of New York City (looking north)

There is evidence that the site contains environmental contaminants including contaminated soil from oil spills, and asbestos in the existing on-site buildings. Cornell plans to document the contamination as a campus credit (SSc3). If asbestos is found in accordance with EPA Reg. 40 CFR Part 763, it will need to be removed safely.

[4] LEED CIRS# 3131, 3132, and 6012
[5] LEED CIR #6003

Figure 16: Roosevelt Island Tramway in Operation

The project is within a half-mile of the F subway line, and the Roosevelt Island Tram (**Error! Reference source not found.**Figure 16). It is within a quarter-mile of at least one existing city bus route and one local circulator bus route (Figure 17) (SSc4.1 and IDc1.5). These routes have frequency of service of at least 200 transit rides per day. The Roosevelt Island tram runs with a frequency of 104 trips per day in each direction.[6] Arup suggests that the team pursue an Exemplary Performance point for this credit. Bike racks and showers will be included in the design to promote cycling around the island (SSc4.2, see "Full-Time Equivalent" above).

[6] http://rioc.ny.gov/pdf/TramBusSched.pdf

Figure 17: Roosevelt Island Circulator Bus

There is currently no vehicular parking in the FAB plans. Cornell will evaluate parking in the site masterplan and Co-Lo building. There will likely be no net new parking on the site (SSc4.4). If the project is eliminating existing surface parking on the previously developed site, as long as it is not creating more parking than the existing site, the credit will be met[7]. The submittal documentation for this credit should clearly identify the pre-development and post-development parking scenarios and numbers, demonstrating no net increase in parking as a result of this new project. Cornell's standards may allow for the use of preferred parking for alternative fueled vehicles (SSc4.3). Existing sustainability strategies at the Ithaca campus indicate that this is the case.[8]

However, in order to obtain the *Site Development – Protect or Restore Habitat* and *Site Development – Maximize Open Space credits* (SSc5.1 and SSc5.2), at least **10,700 ft^2** of vegetated open space must exist within the site, and **11,200 ft^2** must be vegetated with native/adapted species (given the boundary above). Any intensive gardens on the building should be able to count towards this requirement.

Due to an estimated shortage of ~1,100 ft^2 of vegetated space, it is estimated that SSc5.1 will not be met, even if the site landscape architect plants entirely native or adapted plant species to add biodiversity to the project site. However, these plantings will reduce the need for extensive irrigation which reduces potable water use (WEc1).

Ample pedestrian-oriented campus plaza space will provide open space greater than 20% of the LEED boundary area (SSc5.2). At least 25% of this open space will be vegetated in order to meet the credit. The 50% CD drawings show 22,477

[7] LEED CIR #2126
[8] http://www.sustainablecampus.cornell.edu/initiatives/commuting--2

ft^2 of open space within the LEED boundary, of which 9,325 ft^2 (41%) is vegetated. Therefore, the design at this stage meets the credit. See the "LEED Defined Site" section above for more information on the site development credits and integration with the site.

Local construction standards require an Erosion and Sedimentation Control Plan to reduce negative impacts of construction activities on water and air quality (SSp1). Cornell will work with the site team to implement a stormwater management plan that results in a 25% decrease in the volume of stormwater runoff from the existing mostly impervious condition (SSc6.1). A rooftop rainwater collection system will help to achieve this credit by collecting rainwater for use in the building, thereby reducing runoff. The proposed rainwater collection system should help treat 90% of the annual rainfall and remove 80% Total Suspended Solids (SSc6.2). As a project located in New York City, stormwater management will be a high priority. Though the roofing material will not have an SRI over 78, the entire roof is covered with the PV canopy and mechanical equipment. High SRI roofing materials are designed to reduce the heat island effect, and help reduce cooling loads during the summer (SSc7.2). The canopy is designed to absorb as much of the incoming sunlight as possible (even though there are small gaps between modules). This meets the intent of the credit, and therefore the credit will be documented with this strategy. The site designers will attempt to use mostly bonded aggregate paving for hard walking surfaces with an SRI > 29 to reduce the heat island effect surrounding the building, though there are indications that these materials may be too bright to incorporate into the site (SSc7.1).

The Design Team has minimized light pollution from interior building lighting (SSc8). The exterior lighting portion of the light pollution reduction credit will be documented through the campus masterplan process.

7.3.4 WATER EFFICIENCY

It is proposed that native and adaptive species will be planted on the site to provide a vegetated amenity, enhance biodiversity and reduce landscape irrigation (WEc1). The plantings will require no permanent irrigation, and therefore four LEED points are expected to be earned. However, rainwater water will be collected in a tank located outside the LEED boundary to provide some additional irrigation water for the great lawn, also located outside of the LEED boundary. Harvested rainwater will reduce both the amount of stormwater discharged from the building, and potable water drawn from the utility connection.

An intelligent irrigation controller will be used that reduce irrigation needs for the lawn by measuring soil moisture, and also using rainfall predictions to alter the watering schedule to water only when needed – for instance, if a storm is predicted tomorrow, the irrigation will not turn on that day.

Low-flow plumbing fixtures will reduce the potable water use in the building. The design will at least include electronic flush toilets (1.28 gpf), 1 pint urinals, metering lavatory faucets (0.17 gallons per 10 second cycle) and low-flow showers (1.8 gpm) (WEp1 and WEc3).

Although a greywater system was evaluated in SD, it was determined that the system could be eliminated for cost savings in DD without compromising the LEED water credits.

More details on the water efficiency credits are provided below in the water management section (Section 7.5).

7.3.5 ENERGY AND ATMOSPHERE

Cornell University has engaged with a commissioning agent for verified installation, calibration and performance in accordance with the Owners Project Requirements (OPR), Basis of Design (BOD) and construction documents (EAp1). EAc3 requires a third party commissioning agent independent of the design and construction team (Facility Dynamics). The commissioning agent has provided design review comments on the 50% Construction Documentation. The BOD was created early in the design process and has been continually updated as the design changes.

Through good, energy efficient design and the production of renewable energy, the building should require a much smaller amount of grid-delivered energy to operate compared to a typical building (at least 50% reduction). During SD, it was predicted that 26-34% of the energy reduction could be attributed to building energy efficiency, and the remainder to the solar canopy. During DD, the building energy model demonstrated a reduction from baseline of 42%. At the end of DD, the model was updated again to reflect a 35.5% reduction. This decrease in the reduction was caused by a decrease in the modeled baseline building energy usage rather than an increase in the modeled proposed building energy usage. The updated energy model for the 100% Construction Document will be submitted under a separate report.

The structure of the PPA for the solar canopy will influence the number of LEED energy points that Cornell can achieve. The PPA structure directly influences three credits: EAc1, EAc2 and EAc6. Arup has reviewed all relevant LEED credit interpretation rulings (CIRs) and has determined that under the right conditions up to 20 additional LEED points can be achieved using solar panels provided under a PPA. Cornell has confirmed that the solar PPA will require that the provider not sell the associated RECs or obtain incentives which contribute to an RPS. Therefore, full EAc1/EAc2 points should be obtained. See Table 5 for more details.

One revenue stream from a solar installation can originate from the sale of the green aspects of the system, often called “Solar Renewable Energy Credits” (SRECs). If these credits are sold, then the right to claim the energy produced as renewable is passed from the owner to the buyer of the SRECs. Under LEED, no points will be awarded under EAc2 and EAc6 if SRECs are sold. However, if Renewable Energy Credits (RECs) on the national market, which are much cheaper than solar RECs, are re-purchased, then the energy produced is once again considered renewable, and the USGBC will allow energy points for EAc2. To obtain points for EAc6, additional RECs may still need to be purchased.

Table 4 – PV PPA Economics

The third party PPA provider…

…Buys	…Sells to Market	…Buys from Market	…Sells to CornellNYC
Entire Solar Installation	-	-	Power ConEd Rates + Green Premium
Entire Solar Installation	SRECS	-	Power Below Standard ConEd Rates
Entire Solar Installation	SRECs	National RECs	Power Standard ConEd Rates

The building is targeting a 50% or greater energy cost reduction from the baseline building performance rating per ASHRAE/IESNA Standard 90.1-2007 by a whole building project simulation using the Building Performance Rating Method in Appendix G (which maximizes the points for EAc1).

Although EAc1 is a cost reduction calculation, the energy tariff will not affect the calculation if the building is all-electric, since the baseline utility rates and proposed utility rates must be kept the same.

Energy utility rates consist of two parts – an energy charge and a peak demand charge. The peak demand must be measured on the utility side of the solar connection to minimize the demand charge. The solar array will reduce the peak electrical demand of the building. Figure 18 shows a simplified schematic of the arrangement between the solar array, building, and electric grid and metering under a PPA.

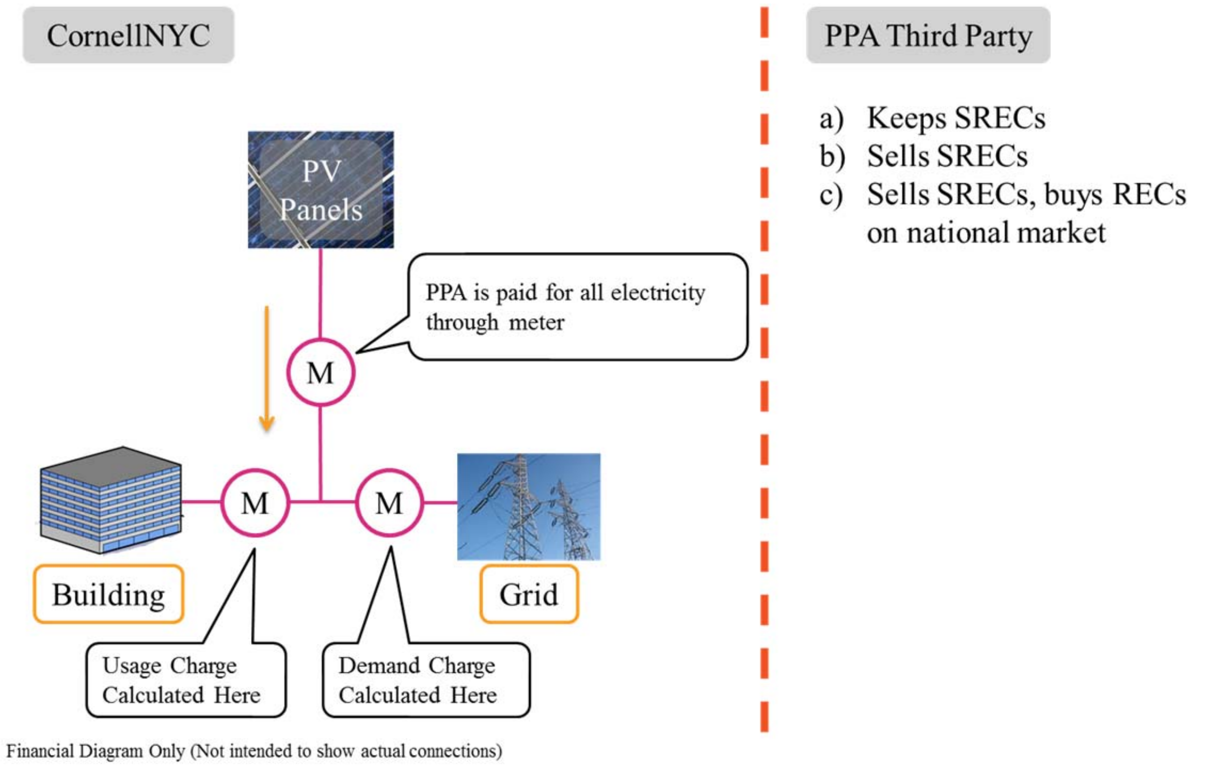


Figure 18: PPA Structure and the Metering of Electricity

The table below summarizes the options for selling RECs, how the resulting arrangement affects total energy costs and how these options would be treated for LEED EAc1, EAc2, and EAc6.

Table 5: Financial and LEED Impacts from Selling Renewable Energy Credits

Renewable Energy Credits (RECs)	Kept 	Sold 	Sold and Re-Bought* 
Financial Impact	–	$	$
EAc1† – Energy Performance	5 - 9 Additional Points	5 - 9 Additional Points	5 – 9 Additional Points
EAc2† – Renewable Energy	8 Points	0 Points	8 Points
EAc6 – Green Power	3 Points	0 Points	0 or 2-3 Points (Additional REC Purchase)
Total Energy Points	**16 - 20 Additional**	**5 - 9 Additional**	**13 – 20 Additional**

*RECs Purchased Back on National Market (100% purchased for 10 years)
†Clarification needs to be made with USGBC on how PPAs are treated under EAc1. Based on 32-40% energy cost reduction through energy efficiency.

Although SRECs are currently not available in the New York State market, the state provides Renewable Portfolio Standard incentives through the New York State Energy Research & Development Authority (NYSERDA). This program is funded through the Renewable Portfolio Standard (RPS) surcharge collected on the electricity bills of customers of the state's major investor-owned utilities (IOUs). If the PPA provider pursues funds through this program to assist in construction, then the state has the right to claim any renewable credit for the energy production. This agreement is similar to selling RECs, since the PPA receives money for the right to the “green credit”.

HVAC systems will not use CFC-based refrigerants (EAp3). Refrigerants with low ozone depletion potentials and global warming potentials will be used for the HVAC system, and no CFCs, HCFCs, or halons will be used in fire systems (EAc4).

As a 21st century classroom building focused on energy and technology, submetering of electricity will be provided on the main incoming service, at lighting panels, at the food service area, on the ground-source heat pumps and on the incoming solar power. The building management system will also provide real-time energy use of the mechanical equipment, and a plug-load monitoring solution will be implemented. A whole-building water meter will be provided. A measurement and verification plan will be used to optimize performance and minimize economic and environmental impacts associated with energy systems (EAc5). Cornell or the Commissioning Authority would need to develop a specific plan for carrying out the metering, and provide feedback to the design team to ensure the monitoring equipment planned is suitable.

If desired, Cornell University could purchase a minimum of 35% of the building's electricity from a 100% renewable energy source for at least two years (EAc6). If the "green credits" surrounding the solar canopy are not sold, the project may be able to meet the intent of this LEED credit without the need to purchase additional renewable energy by using on-site renewable energy to meet the intent of this credit.

Although CIR 10219 allows for a renewable energy system to count for EAc6 if 100% of the energy produced is from an on-site renewable source, CIR 10161 states that if RECs are sold and then re-purchased, these RECs cannot contribute toward EAc6. Therefore, if NYSERDA funding is obtained for the solar installation, the current CIRs indicate that EAc6 cannot be met through the solar installation.

7.3.6 MATERIALS AND RESOURCES

Recycling of paper, cardboard, plastics, metals and glass will be achieved by collection containers throughout the building (MRp1). Cornell's existing recycling policies will meet requirements[9]

The Contractor will be required to divert a minimum of 75% of construction waste from landfills and incinerators (MRc2). As a project in New York City, there are many waste management contractors that are familiar with proper construction waste recycling procedures, and 90%+ construction waste diversion may be achievable. Procuring reused materials will likely be difficult and cost-prohibitive (MRc3). Given the large amount and high cost of steel in the project, and because steel typically has a high recycled content, it should contribute a large amount to the recycled materials cost percentage. Building materials will be specified to have an aggregated total of a minimum of 10% by cost of recycled content and will attempt to have a minimum of 20% (MRc4). The project intends to use materials with low embodied energy and will attempt a minimum of 10% (and possibly 20%) by cost of local materials (within 500 miles of project site shown in Figure 19**Error! Reference source not found.**) (MRc5). The local materials must be extracted, processed and manufactured regionally.

[9] http://r5.fs.cornell.edu/about/howTo.cfm

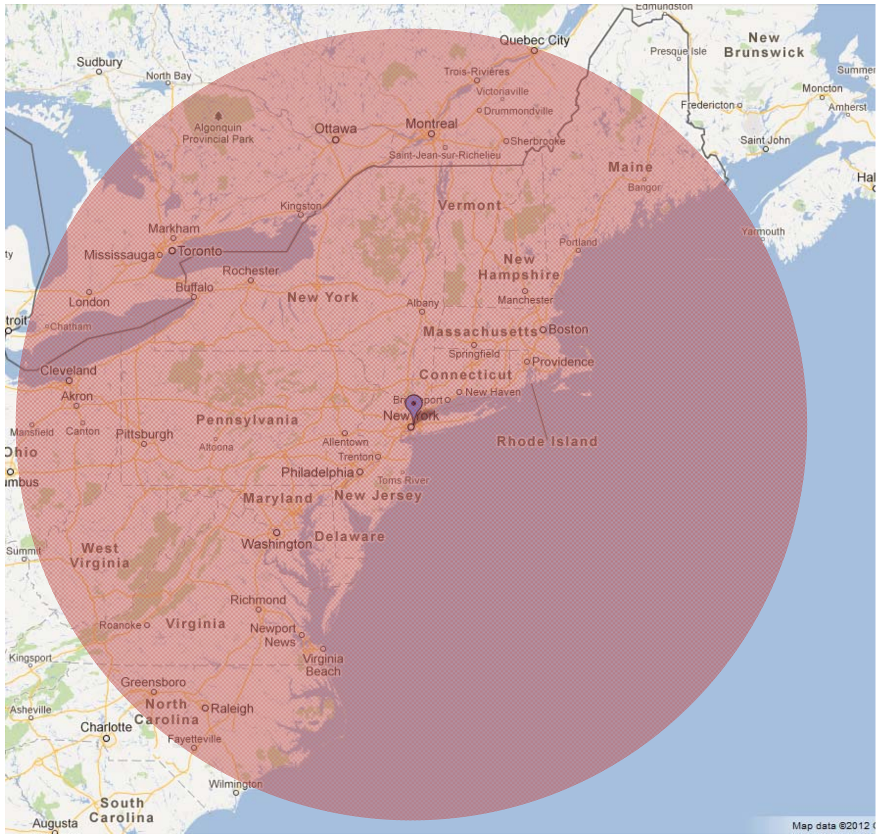


Figure 19: 500 Mile Radius

Rapidly renewable materials such as bamboo are unlikely to cover 2.5% of the total cost of building materials (MRc6). At least 50% of the cost of all wood-based materials should be Forest Stewardship Council (FSC) certified wood (MRc7). Construction waste diversion rates, recycled materials, local materials, rapidly renewable materials and certified wood will be tracked during the construction process.

7.3.7 INDOOR ENVIRONMENTAL QUALITY

The mechanical ventilation system will comply with ASHRAE 62.1-2007 (IEQp1). No spaces within the building will permit smoking and smoking areas will be designated a minimum of 25 feet from the entrance of the building, outdoor air intakes, and operable windows (IEQp2).

CO_2 sensors are installed in all densely occupied areas providing outdoor air delivery monitoring (IEQc1).

Increased outdoor air ventilation rates above ASHRAE 62.1-2007 were not designed into the building, since doing so would hamper the energy performance of the building.

During SD, the provision of entryway walk-off mats or grills/grates at the building entrance to minimize particulate pollutants were examined (IEQc5). Permanent entryway system locations were further explored during DD. Although the main entrance vestibule can accommodate a permanent grate in order to control particulate pollutants, there are other entrances in the building which do not have the space to accommodate a ten foot mat or grate. These entry spaces include the service entrance and café entrances. Although the service entrance is likely excluded from this requirement, the café entrance will be deemed frequently used. The USGBC only allows entrances to be excluded from this requirement if they are “infrequently used” or for egress only. Frequency of use is defined as “any door that is intended to be used regularly and frequently by building occupants”[10]. Therefore, the credit was not pursued further in CD, since entryway systems will not be installed in these areas. However, the other items in the credit will be achieved as part of good design. Ventilation systems require a Minimum Efficiency Reporting Value (MERV) of 13 or better. In addition, chemical storage rooms and janitor closets will be exhausted at a minimum rate of 0.50 cfm / ft^2 (IEQc5).

During construction the contractor will develop an Indoor Air Quality (IAQ) Management Plan to meet the Sheet Metal and Air Conditioning Contractors National Association (SMACNA) IAQ Guidelines for Occupied Buildings under Construction (IEQc3.1). During construction, either all grilles will be covered during construction, the AHU will be left off and an alternative ventilation system will be provided while the site is dusty, or all air handling units will be protected with MERV 8 filters at each return grille (not recommended due to high energy use). Baseline IAQ testing will be performed after construction and before occupancy using testing protocols consistent with the EPA Compendium of Methods for the Determination of Air Pollutants in Indoor Air (IEQc3.2). As long as maximum concentrations of certain contaminants are not exceeded, a building flush-out will not need to be performed.

The building envelope and all HVAC systems will meet ASHRAE Standard 55-2004 for thermal comfort (IEQc7.1).

Morphosis will specify building materials with minimal or no VOCs. All adhesives and sealants (IEQc4.1) must comply with the South Coast Rule #1168, paints and coatings (IEQc4.2) must comply with the Green Seal Standard GS-11, Green Seal Standard GC-03, and South Coast Air Quality Management District (SCAQMD) Rule 1113, and carpeting and flooring (IEQc4.3) must comply with the Carpet and Rug Institute Green Label Plus Testing Program standards, and the FloorScore standard respectively. The carpeting adhesive must have VOC content less than 50 g/L.

During CD, Cornell indicated that the design should not include individual task lighting (desk lams). Therefore, IEQc6.1 will not be achieved since lighting controls cannot be provided for at least 90% of building occupants. Open office areas, classrooms and meeting places will have controllable overhead lighting. Thermostats will be installed in densely-occupied spaces, however the thermal control credit will not be achieved since each huddle room cannot be individually controlled, and workstations in the open office areas will also not have individual comfort controls (IEQc6.2).

[10] CIR 5735, http://www.usgbc.org/leed-interpretations?keys=5735

The building will be designed to maximize natural daylight and views. The DD design resulted in 52% of regularly occupied spaces meeting daylighting requirements and 59% meeting views requirements, but thresholds of 75% and 90% are needed respectively to achieve these credits (IEQc8). The CD design resulted in 54% of spaces meeting daylighting requirements. Both credits are not achievable, mainly due to underground classrooms. Nevertheless, the building has maximized energy performance given the programming by using daylight instead of artificial lighting when possible. The building is also designed to maximize views of the Manhattan and Queens skylines and East River through its long, slender shape and the placement of offices and classrooms near the

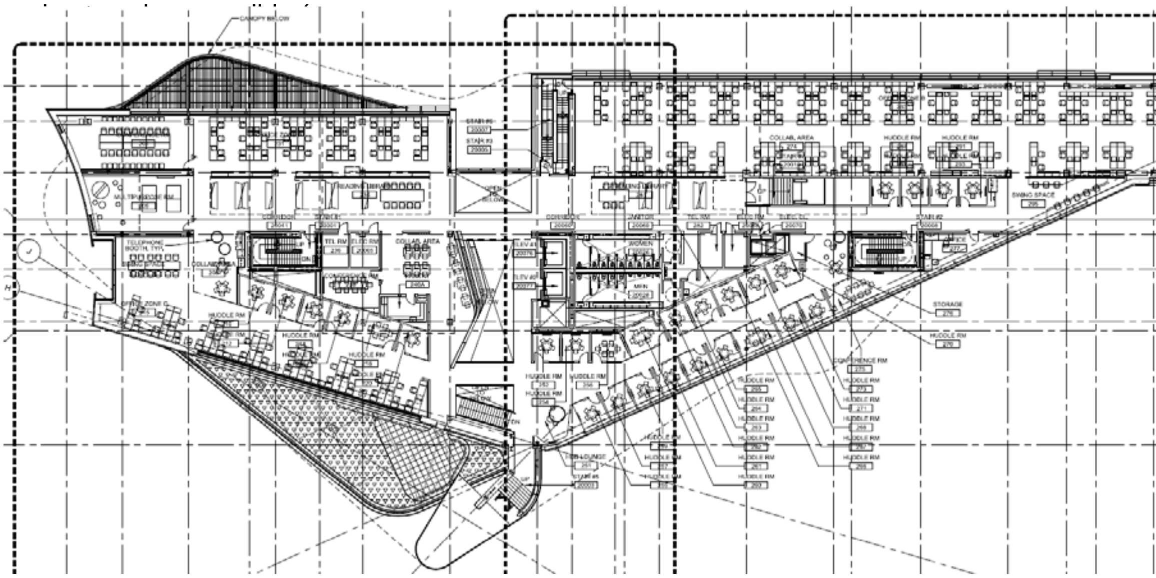


Figure 20). Care has been taken so that glare is controlled and building occupants do not consistently use blinds, which obstruct views.

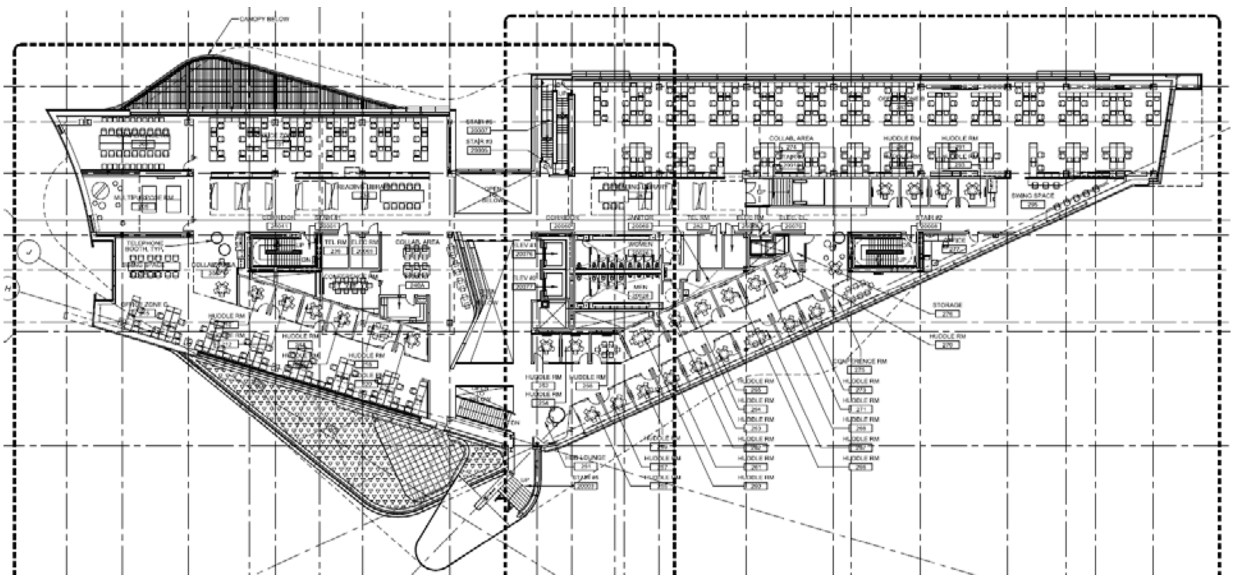


Figure 20: Proposed Floorplate with Offices near Perimeter of Building to Maximize Daylight and Views

7.3.8 INNOVATION IN DESIGN

Innovation in building design requires exemplary and/or innovative performance in Green Building design and operation. A green cleaning program using environmentally-preferable cleaning methods and chemicals can be implemented for the building (IDc1.1).

As a state-of-the-art example of a green academic building in the heart of New York City, the building will be useful as an interactive learning tool. An education and outreach program can be planned for the building, including tours, visualization of energy and water usage, and placards indicating green design features of the building (IDc1.2).

Since the building is targeting a 50% energy cost reduction under EAc1, achieving this reduction will qualify for an exemplary performance credit (IDc1.3). With a 15% or more energy cost reduction from the solar canopy production, exemplary performance under EAc2 should be achieved (IDc1.4). The proximity of the site to subway lines, the Roosevelt Island Tram, and numerous bus stops will help it achieve exemplary performance of Alternative Transportation, Public Transportation Access (IDc1.5).

A LEED Accredited Professional (LEED AP) will be part of the project team (IDc2). Other innovation points can be investigated in the case that any of the above points are not achieved. It must be ensured that the innovation strategy be replicable and measureable by LEED standards.

7.3.9 REGIONAL PRIORITY CREDITS

Regional priority credits were created to address geographically-specific environmental issues. For New York City this includes, Optimize Energy Performance (EAc1), On-Site Renewable Energy (EAc2), Stormwater Design – Quantity Control (SSc6.1) and Innovate Wastewater Technologies (WEc2). An additional LEED point will be obtained for each of these four credits (if achieved).

7.3.10 LEED CHECKLIST

The LEED checklist in Figure 21 below shows the credits which are required to achieve the project goal of LEED Platinum. The project is currently projected to receive LEED Platinum, with 86 points expected and an additional 10 points possible.

Y	?	N			
19	6	1	**Sustainable Sites**	Possible Points:	**26**
Y			Prereq 1	Construction Activity Pollution Prevention	
1			Credit 1	Site Selection	1
5			Credit 2	Development Density and Community Connectivity	5
1			Credit 3	Brownfield Redevelopment	1
6			Credit 4.1	Alternative Transportation—Public Transportation Access	6
1			Credit 4.2	Alternative Transportation—Bicycle Storage and Changing Rooms	1
	3		Credit 4.3	Alternative Transportation—Low-Emitting and Fuel-Efficient Vehicle	3
2			Credit 4.4	Alternative Transportation—Parking Capacity	2
		1	Credit 5.1	Site Development—Protect or Restore Habitat	1
1			Credit 5.2	Site Development—Maximize Open Space	1
1			Credit 6.1	Stormwater Design—Quantity Control	1
1			Credit 6.2	Stormwater Design—Quality Control	1
	1		Credit 7.1	Heat Island Effect—Non-roof	1
	1		Credit 7.2	Heat Island Effect—Roof	1
	1		Credit 8	Light Pollution Reduction	1

10	0	0	**Water Efficiency**	Possible Points:	**10**
Y			Prereq 1	Water Use Reduction—20% Reduction	
4			Credit 1	Water Efficient Landscaping	2 to 4
2			Credit 2	Innovative Wastewater Technologies	2
4			Credit 3	Water Use Reduction	2 to 4

33	2	0	**Energy and Atmosphere**	Possible Points:	**35**
Y			Prereq 1	Fundamental Commissioning of Building Energy Systems	
Y			Prereq 2	Minimum Energy Performance	
Y			Prereq 3	Fundamental Refrigerant Management	
19			Credit 1	Optimize Energy Performance	1 to 19
7			Credit 2	On-Site Renewable Energy	1 to 7
2			Credit 3	Enhanced Commissioning	2
2			Credit 4	Enhanced Refrigerant Management	2
3			Credit 5	Measurement and Verification	3
	2		Credit 6	Green Power	2

5	2	7	**Materials and Resources**	Possible Points:	**14**
Y			Prereq 1	Storage and Collection of Recyclables	**0**
		3	Credit 11	Building Reuse—Maintain Existing Walls, Floors, and Roof	1 to 3
		1	Credit 12	Building Reuse—Maintain 50% of Interior Non-Structural Elements	1
2			Credit 2	Construction Waste Management	1 to 2
		2	Credit 3	Materials Reuse	1 to 2
1	1		Credit 4	Recycled Content	1 to 2
1	1		Credit 5	Regional Materials	1 to 2
		1	Credit 6	Rapidly Renewable Materials	1
1			Credit 7	Certified Wood	1

9	0	6	**Indoor Environmental Quality**	Possible Points:	**15**
Y			Prereq 1	Minimum Indoor Air Quality Performance	
Y			Prereq 2	Environmental Tobacco Smoke (ETS) Control	
1			Credit 1	Outdoor Air Delivery Monitoring	1
		1	Credit 2	Increased Ventilation	1
1			Credit 3.1	Construction IAQ Management Plan—During Construction	1
1			Credit 3.2	Construction IAQ Management Plan—Before Occupancy	1
1			Credit 4.1	Low-Emitting Materials—Adhesives and Sealants	1
1			Credit 4.2	Low-Emitting Materials—Paints and Coatings	1
1			Credit 4.3	Low-Emitting Materials—Flooring Systems	1
1			Credit 4.4	Low-Emitting Materials—Composite Wood and Agrifiber Product	1
		1	Credit 5	Indoor Chemical and Pollutant Source Control	1
		1	Credit 6.1	Controllability of Systems—Lighting	1
		1	Credit 6.2	Controllability of Systems—Thermal Comfort	1
1			Credit 7.1	Thermal Comfort—Design	1
1			Credit 7.2	Thermal Comfort—Verification	1
		1	Credit 8.1	Daylight and Views—Daylight	1
		1	Credit 8.2	Daylight and Views—Views	1
6	0	0	**Innovation and Design Process**	Possible Points:	**6**
1			Credit 11	Innovation in Design: Green Cleaning Program	1
1			Credit 12	Innovation in Design: Education and Outreach	1
1			Credit 13	Innovation in Design: Exemplary Performance, EAc1	1
1			Credit 14	Innovation in Design: Exemplary Performance, EAc2	1
1			Credit 15	Innovation in Design: Exemplary Performance, SSc4.1	1
1			Credit 2	LEED Accredited Professional	1
4	0	0	**Regional Priority Credits**	Possible Points:	**4**
1			Credit 11	Regional Priority: EAc1	1
1			Credit 12	Regional Priority: EAc2	1
1			Credit 13	Regional Priority: SSc6.1	1
1			Credit 14	Regional Priority: WEc2	1
86	10	14	**Total**	Possible Points:	**110**

Certified 40 to 49 points Silver 50 to 59 points Gold 60 to 79 points Platinum 80 to 110

Figure 21: LEED Scorecard

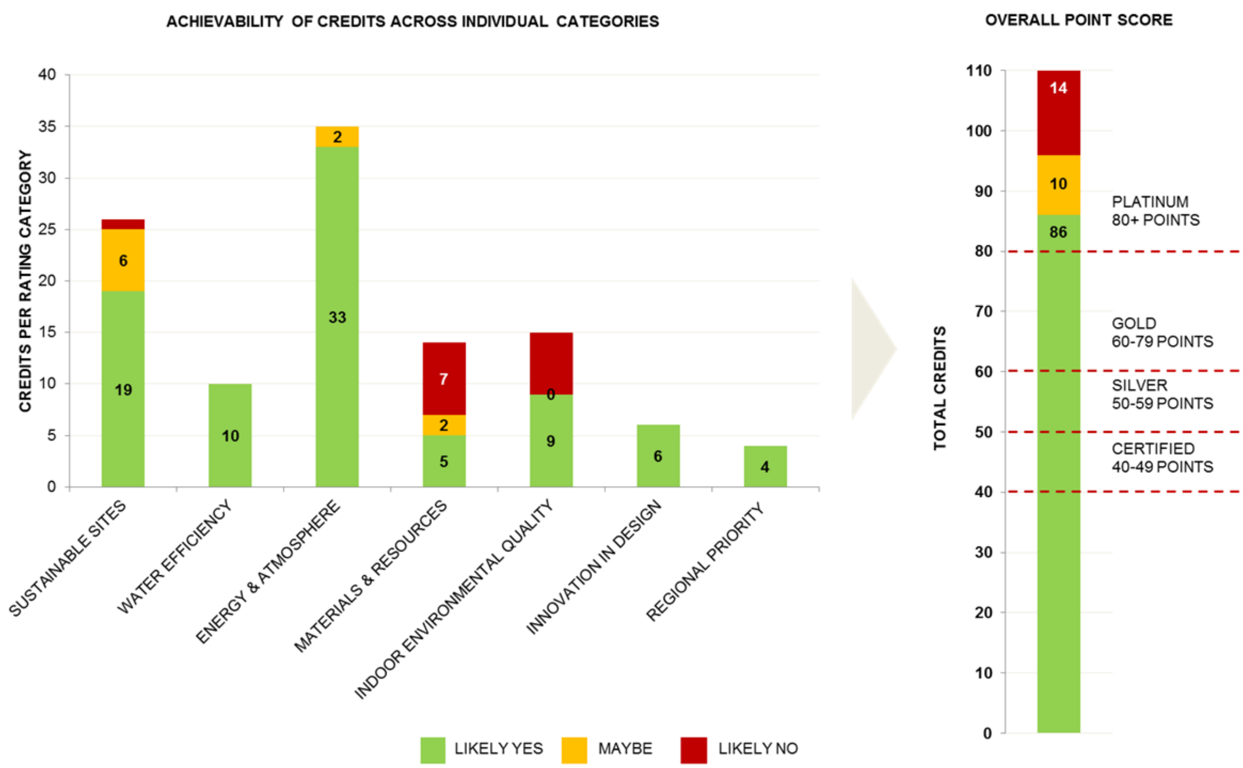


Figure 22: LEED Credits and Likelihood Graph

Since SD, the number of net expected points has decreased by three – SSc7.1 Heat Island Effect - Non-Roof, IEQc5 Indoor Chemical and Pollutant Source Control, IEQc6.1 Controllability of Systems – Lighting, and IEQc6.2 Controllability of Systems—Thermal Comfort, and IEQc8 Daylight and Views were moved from “expected” to either “maybe” or “no”.

7.4 LIVING BUILDING CHALLENGE

The International Living Future Institute administers the Living Building Challenge, which is a green building rating system complementary to LEED. It is recognized internationally as one of the most challenging and progressive green building rating systems. There are seven ‘petals’ that are required to achieve for the challenge, as shown in Figure 23.

Figure 23: Living Building Challenge Petals

7.4.1 THE CHALLENGE V2.1

There are 20 imperatives within all seven petals that must be achieved to meet the challenge. More information about the specific requirements regarding each imperative can be viewed at http://living-future.org/lbc. Figure 24 shows a summary of the petal and imperative requirements to meet the challenge.

Petals	**Imperatives**	**Living Building Challenge v2.1** (Plus 10 more imperatives)	**Petal Recognition** (Recommended)	**Net Zero Energy**
Site	Limits to Growth	✓	✓	✓
	Urban Agriculture	✓		
	Habitat Exchange	✓		
	Car Free Living	✓		
Energy	Net Zero Energy	✓	✓	✓
Equity	Human Scale + Humane Places	✓	✓	
	Democracy + Social Justice	✓	✓	
	Rights to Nature	✓	✓	✓
Beauty	Beauty + Spirit	✓	✓	✓
	Inspiration + Education	✓	✓	✓

Figure 24: Summary Matrix of Petals and Imperatives

This certification would be very difficult, if not impossible to achieve at this stage. There are certain requirements such as a closed-loop water system (100% from rainwater), all occupants having operable windows, red list of materials (no PVC, etc), buying and setting aside an equal portion of land as habitat and 100% FSC wood that would be very difficult to meet with the current design. The estimated cost to the project would be $20,000.

7.4.2 PETAL RECOGNITION

The petal approach offers an alternative for projects to receive a certification without seeking the full Living Buildings Challenge. Three petals are required for recognition, instead of seven through the full challenge. Of the three, at least one must be water, energy, or materials.

It is recommended that Cornell pursue the Energy, Equity and Beauty + Inspiration petals if Petal Recognition is desired. Because there are so many extra imperatives to the Net Zero Energy Certification, the increase from this certification to Petal Recognition only requires two extra imperatives - Human Scale + Humane Places and Democracy + Social Justice (within the Equity petal). Since both imperatives only require 1-page narratives each, and the project likely meets these requirements already, the added effort is minor to obtain petal recognition. The estimated cost to the project would be $12,000.

7.4.3 NET ZERO ENERGY CERTIFICATION

It is recommended that Net Zero Energy Certification be pursued in order to certify the building as Net Zero Energy. One benefit to certification is that Cornell could possibly claim the FAB to be the largest certified net zero energy building in the world, country or northeast US (if another building does not surpass it before certification). Cornell could not claim to be the largest net zero energy building, however, since the 360,000 ft^2 Research Support Facility at NREL is larger, although has not been certified to date. Another benefit is having a 3rd party verification of net zero energy. Some buildings are beginning to make this claim in their marketing, however there is not technical rigor to ensure that they are truly net zero. Certification would be achieved after twelve months of normal operation of building shows on-site net zero energy has been achieved. The estimated cost for the certification would be $12,900.

7.4.4 SELECTED IMPERATIVES

Selected imperatives to meet each type of certification are summarized below:

<u>Limits to Growth</u> – Projects may only be on greyfields or brownfields – previously developed sites that are not on or adjacent to: sensitive ecological habitats (wetlands, primary dunes, old-growth forest, virgin prairie), prime farmland, within the 100-year flood plain

<u>Net Zero Energy</u> – 100% energy needs must be supplied by on-site renewable energy on a net annual basis

<u>Human Scale + Humane Places</u> – The project must be designed to create human-scaled rather than automobile-scaled places, so that the experience brings out the best in humanity and promotes culture and interaction

<u>Democracy + Social Justice</u> – All primary transportation, roads and non-building infrastructure that are externally focused must be equally accessible to all members of the public regardless of background, age and socioeconomic class, with reasonable steps taken to ensure that all people can benefit from the project’s creation. Access for those with physical disabilities must be safeguarded through designs meeting the ADA

<u>Rights to Nature</u> – The project may not block access to, nor diminish the quality of, fresh air, sunlight and natural waterways for any member of society or adjacent developments

<u>Beauty + Spirit</u> – The project must contain design features intended solely for human delight and the celebration of culture, spirit and place appropriate to its function

<u>Inspiration + Education</u> – Educational materials about the performance and operation of the project must be provided to the public to share successful solutions and to motivate others to make change.

7.5 WATER MANAGEMENT

7.5.1 EXISTING CONDITIONS

The project site is located on Roosevelt Island, which is owned by the city. In 1969 the island was leased to the state of New York's Urban Development Corporation for 99 years.[11]

The site receives an average of approximately 45 inches of rainfall/year with a fairly even distribution over the year as shown Figure 25 below, which makes rainwater harvesting a feasible option for further consideration.

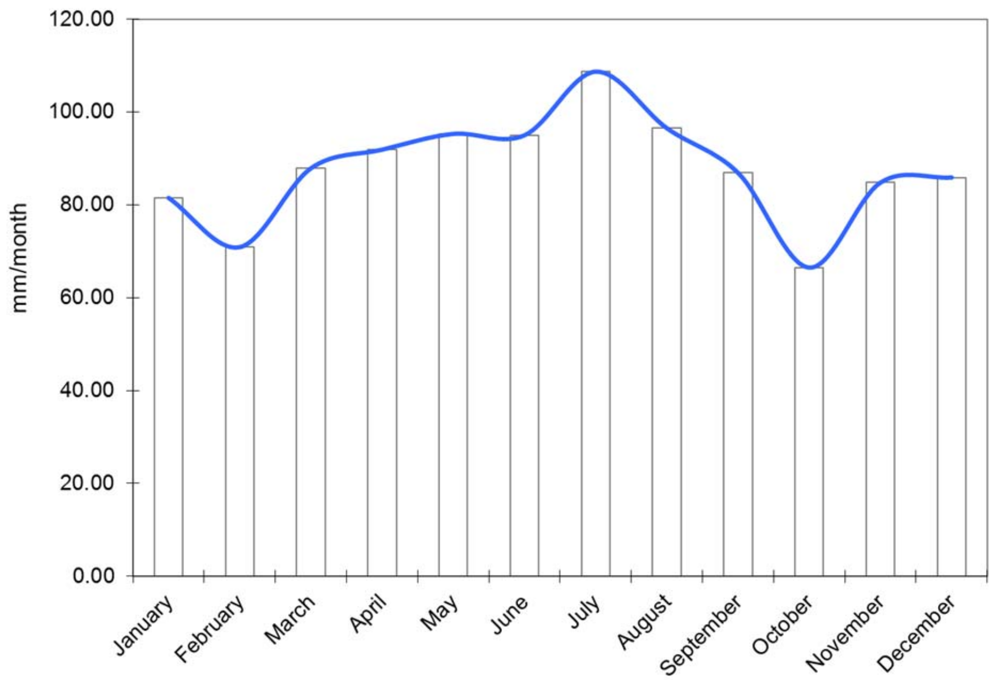


Figure 25: Average annual precipitation for Roosevelt Island (data from Flour, 2010).

[11] The Roosevelt Island Operation Corporation of the State of New York. (2008). Roosevelt Island, Manhattan's Other Island: A Brief Overview. Retrieved July 25, 2012, from http://www.rioc.com/devhist/Roosevelt-Island-Manhattan's-Other-Island-A-Brief-Overview.pdf

7.5.2 LEED CREDITS – WATER

The following list identifies the LEED credits that are related to water design, along with a likelihood of achievability for the FAB:

- SSc6.1 Stormwater Design – Quantity Control
- SSc6.2 Stormwater Design – Quality Control
- WEp1 Water Use Reduction
- WEc1 Water Efficient Landscaping
- WEc2 Innovative Wastewater Technologies
- WEc3 Water Use Reduction

7.5.3 SITE STORMWATER DESIGN AND WATER EFFICIENCY ANALYSIS

The goals for a sustainable water management strategy for the FAB and its surrounding landscape and hardscape include reducing potable water demand through water conservation, water efficient design, and rainwater harvesting.

During SD, a range of options were developed for the water design for the FAB, as outlined in Table 6. Each option initially excluded landscape irrigation, and a modified calculation was provided in the event that irrigation was integrated in the FAB design scope ("+i"). Although Option 2 (incorporating both greywater and rainwater harvesting systems) was considered for the schematic design, the analysis during DD showed that Option 1 (incorporating only rainwater harvesting and not greywater) met all water goals and resulted in reduced costs.

Table 6 – FAB Water Management Options

Option	**Stormwater** (roof and landscape / hardscape areas)	**Greywater** (lavatory faucets, showers)	**Blackwater** (toilets, urinals, kitchen sinks)
1	Rainwater Harvesting for *non-potable building demands*	Discharge to existing collection system to off-site treatment	Discharge to existing collection system to off-site treatment
2 (SD Option)	Rainwater Harvesting for *non-potable building demands*	Onsite treatment and Reuse *for non-potable building uses*	Discharge to existing collection system to off-site treatment
1+i (DD Option)	Rainwater Harvesting for *landscape irrigation* and *non-potable building demands*	Discharge to existing collection system to off-site treatment	Discharge to existing collection system to off-site treatment
2+i	Rainwater Harvesting for *landscape irrigation*	Onsite treatment and Reuse for *non-potable building uses*	Discharge to existing collection system to off-site treatment

Each option was analyzed using the proposed LEED site boundary for the project, which covers 53,500sf (1.5 acres). Water demands were calculated for the 150,000 GSF FAB and provided by the irrigation consultant, Northern Designs LLC for the 21,600 SF Great Lawn area (not included in FAB project boundary). Cornell has indicated that no other areas of the campus will have permanent irrigation installed. The projected building capacity was given as 941 for FY2024. This includes 429 FTEs (faculty, staff, and PhD students) and 500 transients (Masters students).

Baseline water demands were calculated using the LEED WCp1 methodology. The following assumptions were included:

- 260-day/year building use
- 429 FTEs, 50% male and 50% female
    - 5 lavatory faucet uses per capita per day (upcd)
    - 0.1 shower upcd
    - Males: 4 urinal upcd, 1 toilet upcd
    - Females: 5 toilet upcd
- 500 transients, 50% male and 50% female
    - 2 lavatory faucet upcd
    - no shower usage
    - Males: 2 urinal upcd, 0.5 toilet upcd
    - Females: 2.5 toilet upcd

It is assumed that no irrigation will take place during the colder months of November through March, as is common for New York City.

Table 7 summarizes the water-related LEED points that would be reasonably achievable in each option.

Table 7 – LEED Credit summary analysis by Option

LEED Credit	**Possible Points**	**Possible Points per Option**			
Option	**ALL**	**1**	**1+i**	**2**	**2+i**
SSc6.1 Reduce Stormwater Runoff by 25% for 2-year storm	1	Campus Credit			
SSc6.2 Treat 90% of Average Annual Rainfall to remove 80% TSS	1	Campus Credit			
WEp1 Water Use Reduction	Pre-req.	-	-	-	-
WEc1 Limit potable water use for irrigation	2-4	4	4	4	4
WEc2 Reduce potable water use for building sewage conveyance by 50%	2	2	2	2	2
WEc3 Reduce building potable water use	2-4	4	4	4	4
Regional Credit SSc6.1 If SSc6.2 is met	1	Campus Credit			
Regional Credit WEc2	1	1	1	1	1

LEED Credit	Possible Points	Possible Points per Option			
If WEc2 is met					
Total possible points per Option		**11**	**11**	**11**	**11**

Since all options maximize LEED water points, they are all good options for the project. Option 1+i is the preferred option since it provides the same value to the project with lower cost than Option 2 or 2+i. Option 1+i also provides rainwater for the campus lawn, reducing overall campus potable water consumption.

In all options, it is proposed to use high efficiency fixtures to reduce the water demands for the building by 28%. This in turn will reduce the potable water used for building sewage conveyance; however, this reduction is not sufficient on its own to achieve WEc2 and WEc3.

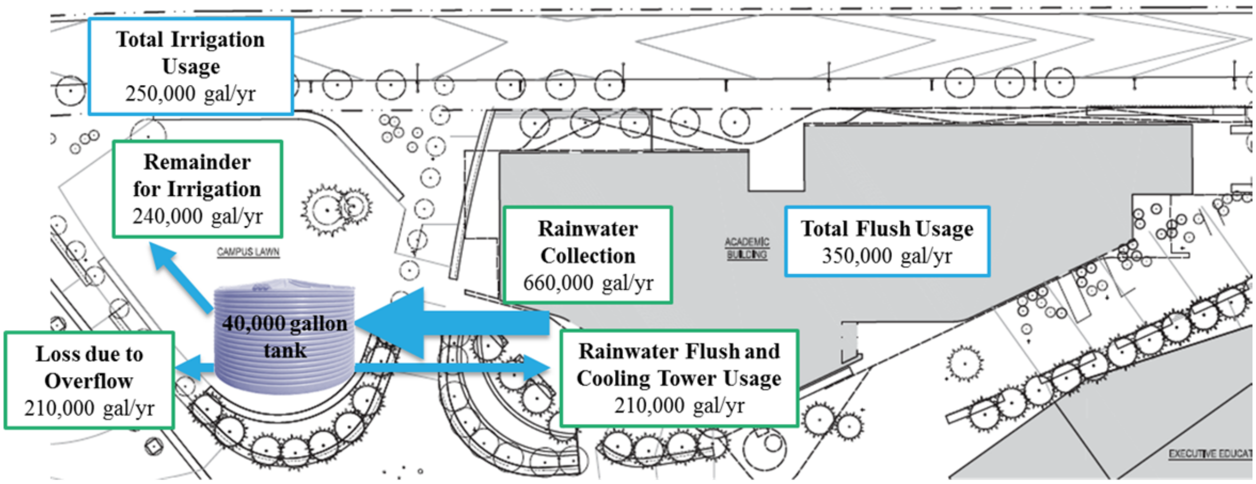
The following water-efficient fixtures are proposed for the FAB:
- Toilets: electronic flush 1.28gpf
- Urinals: low-flow 0.125gpf
- Lavatory faucets: low-flow 0.35gpm
- Showers: low-flow 1.8gpm

Water conservation strategies include public education campaigns and signage, and detailed sub-metering. While these strategies can be quite effective at reducing water usage, conservation-related reductions in water demand have been excluded from the calculations at this stage of design (to comply with LEED documentation requirements).

Rainwater Harvesting System

The building potable water usage is further reduced in all options through rainwater harvesting (RWH). A 40,000 gallon stormwater retention tank will be buried under the campus lawn close to the FAB. Water would be collected from the 30,000 GSF roof of the FAB. In discussions with the site team, the design team looked into collecting water from the nearby CoLo building and pathway trench drains. This has not been included in the design. After providing preliminary treatment to the collected rainwater, this non-potable water will be distributed to the building's non-potable fixtures (i.e., toilets and urinals), irrigation for the campus lawn, and cooling tower through dedicated non-potable plumbing (i.e., purple pipe). Reclaimed water information and warning signage is required at each fixture.

Irrigation will be included in the rainwater harvesting system. Since the campus lawn is outside of the LEED boundary for the project, it will not count as irrigation for LEED. The non-potable water sprinkler systems would be discharged subsurface to ensure no human contact with this water. Reclaimed water information and warning signage would be required in all irrigation areas. Figure 26 below shows the scenario where the maximum amount of water is supplied to the lawn and the remainder is used in the flush fixtures. Because of variations in supply and demand over the course of the year, some collected rainwater must be dumped to the sewer. If rainwater is also collected from the CoLo building or other portions of the site, it may be possible to provide 100% of the irrigation from rainwater over the course of the year.



60% of flushing usage met with rainwater
96% of lawn irrigation met with rainwater

Assumptions
Water is collected from Roof of FAB (30,000 ft^2)
Rainwater cannot be used at all times of year due to gaps in supply
Based on mean year rain data

Figure 26: Rainwater Harvesting Flows

With rainwater harvesting, the WEc2 requirement is exceeded, with at least 50% reduction in potable water used for wastewater conveyance, depending on how much water is diverted to non-potable fixtures. **It is estimated that at least 48,000 gallons (13.5% of non-potable use) of rainwater be used for non-potable fixtures on a yearly basis to meet the requirement.** These options allow the wastewater discharged from the building to be reduced, decreasing the load on existing wastewater conveyance and treatment infrastructure that is currently subject to combined sewer overflows (CSOs) during large storm events.

The FAB rainwater harvesting system will include the components listed in Table 8.

Table 8 – Rainwater Harvesting system elements

Element	**Description**
Drainage collection system	Roof drains, outlets, and downpipes to collect runoff from roof. This includes a first-flush diverter.
Coarse filtration	Either in-pipe or in-line filters (by site designers)

Element	Description
Storage	Cistern for treated non-potable water with cleaning access (detention tank located beneath lawn close to the café area, by site designers)
Overflow	Discharge to street storm sewer
Top-up connection	Potable water make up water to the non-potable water storage
Distribution system	Pressure piping leading to the distribution network to supply the design uses

The detention tank size was determined by analyzing the combined water demands of the irrigation and FAB flush fixtures. Figure 27 below shows the percentage of flush fixture demand *only* met by different tank sizes, depending on the precipitation amount for a given year. The tank for the building in SD was sized at 25,000 gallons based only on supplying non-potable water to building flush fixtures.

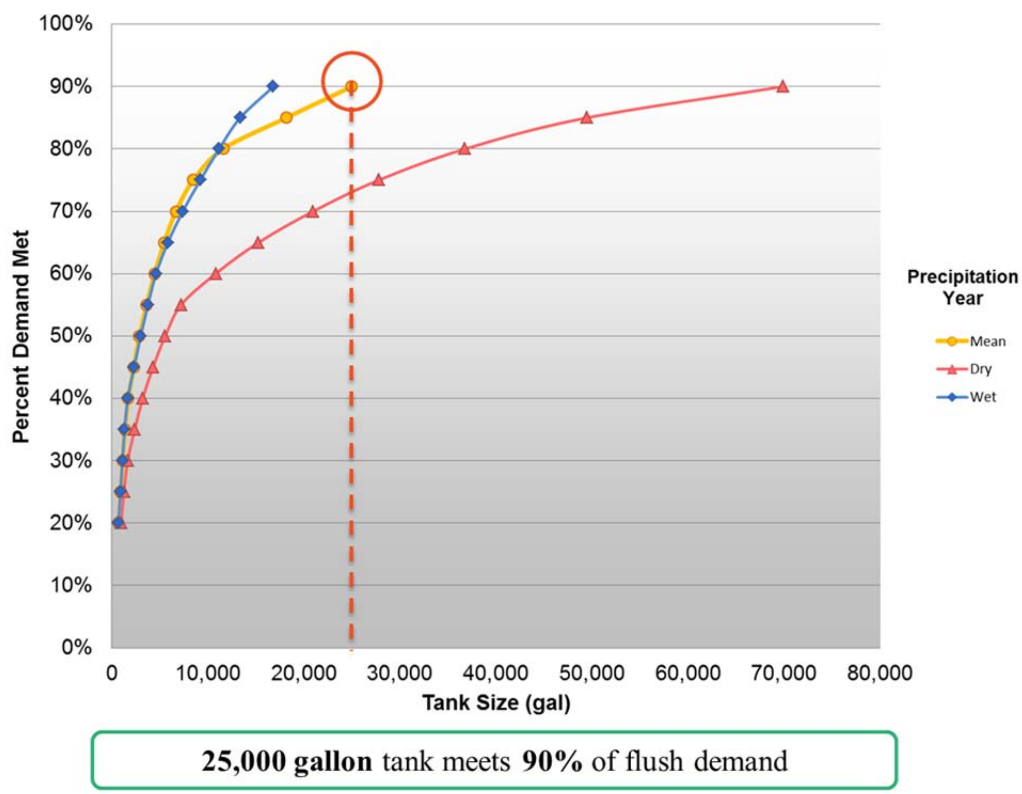


Figure 27: Percentage of Building Flushing Demand met with Various Detention Tank Sizes

Figure 28 below shows the percentage of flush fixture demand *and* irrigation demand met by different tank sizes, depending on the precipitation amount for a given year. The tank for the building in DD was sized at 40,000 gallons based on supplying non-potable water to building flush fixtures *and* irrigation.

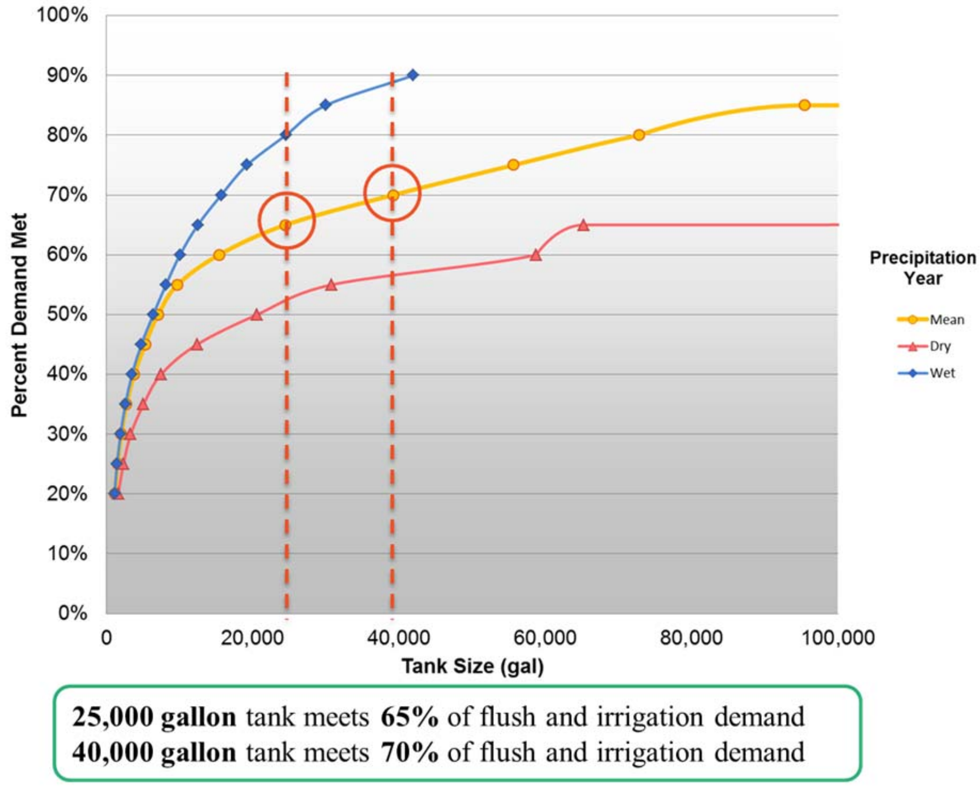


Figure 28: Percentage of Building Flushing and Irrigation Demand met with Various Detention Tank Sizes

Figure 29 and Figure 30 show the flows over the course of a typical year for flush fixtures, irrigation, and rainwater. The second diagram combines the non-potable demands together, and indicates the relative volume and time of year when potable make-up water is needed. The assumptions for these diagrams are collection from the FAB roof only, with a 40,000 gallon tank.

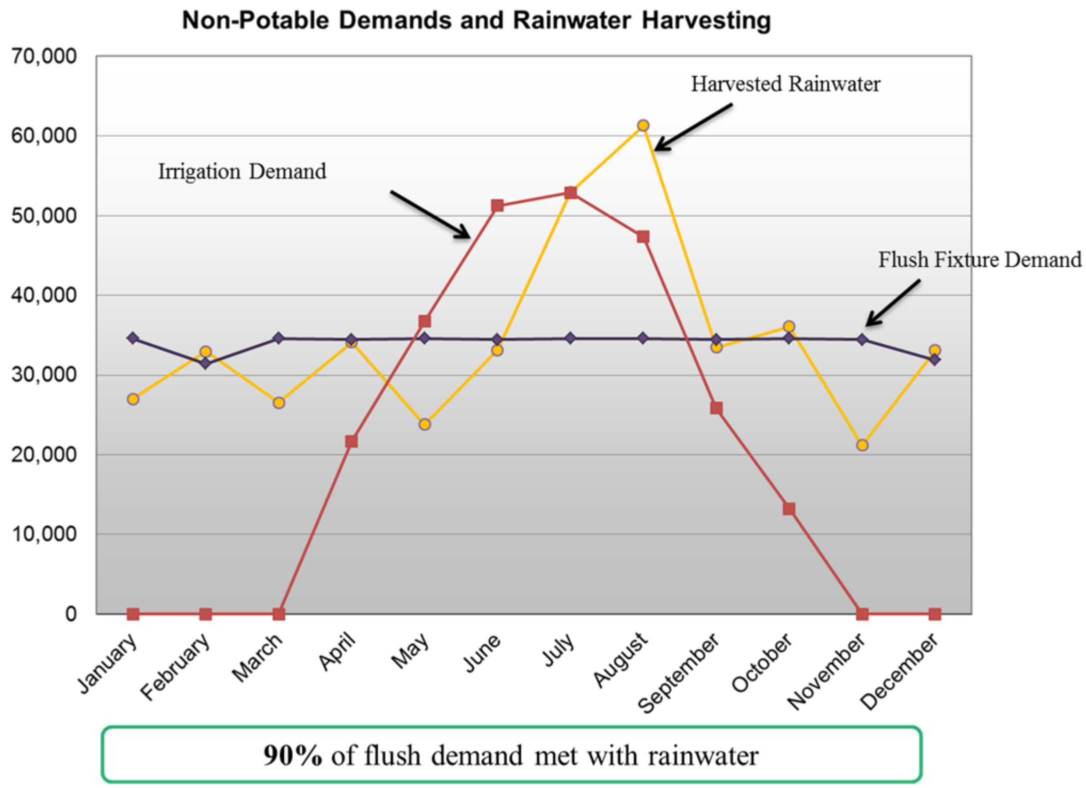


Figure 29: Flush Fixture and Irrigation Demands and Rainwater Harvesting Collection over an Average Year

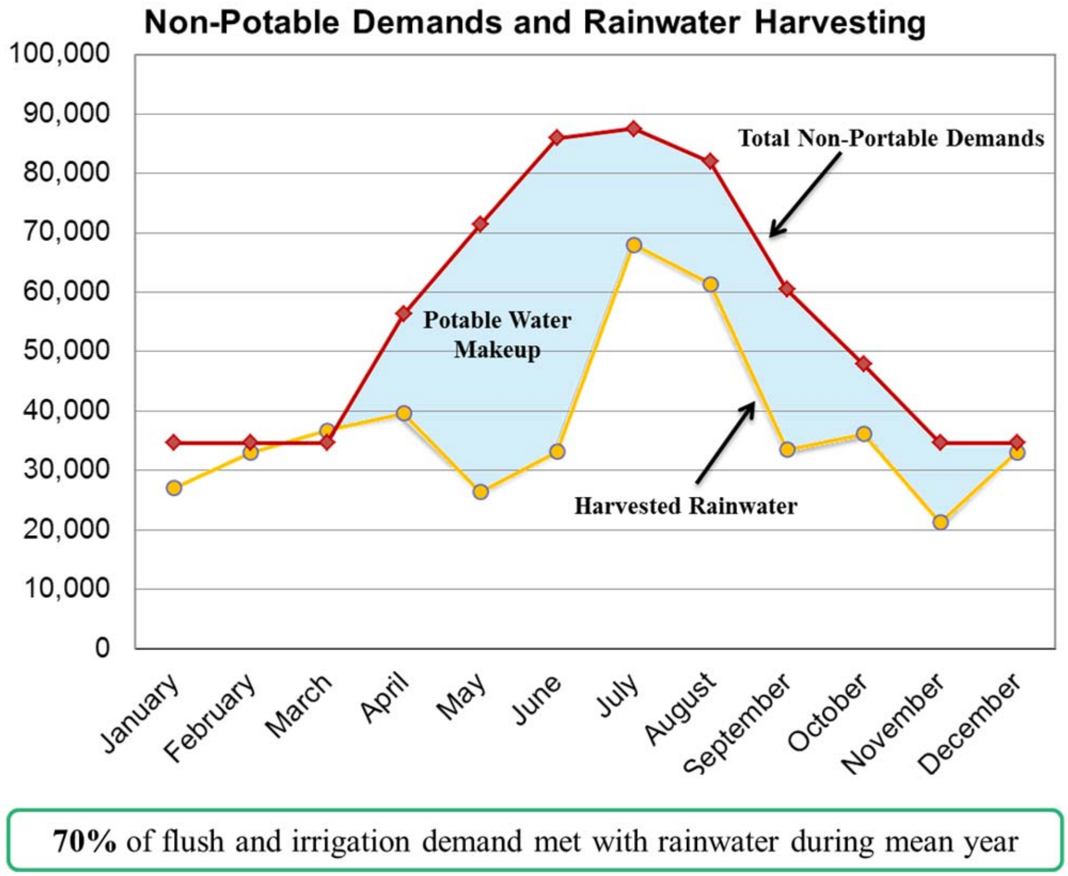


Figure 30: Non-Potable Water Demands and Rainwater Harvesting Collection over an Average Year

Stormwater Design credits SSc6.1 and SSc6.2 were not included in the analysis because they rely on coordination with the broader campus plan. These credits will be pursued under the LEED campus scheme.

According to the site 100% DD drawings, stormwater will be collected in trench drains running along the main pathways that discharge to bioswales located adjacent to the Loop Road. The bioswales will consist of approximately three feet of engineered soil underlain by a three foot layer of open-graded stone wrapped in geotextile. The bioswales will be planted with native plantings and include a stormwater inlet to collect excess stormwater and convey it to the storm sewer system. In areas which do not have sufficient size for a bioswale, a hydrodynamic separator, or other treatment measure will be installed to comply with NYCDEC requirements.

Stormwater best management practices (BMPs), and other strategies for consideration could include:

- Pervious pavements, porous asphalt, pervious pavers
- Bioswales, enhanced tree pits, stormwater planters
- Rain gardens
- Disconnected downspouts
- Hydrodynamic separators