

# Visualizing a Living Building

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**ABSTRACT:** This paper will chronicle the design process of the Odum School of Ecology at the University of Georgia and its objective to accomplish Living Building™ certification. In order to accomplish this, the architect (BNIM) and project partners applied Triple Bottom Line thinking, an Integrated Design Process and Life Cycle Analysis. The author, a member of the design team, will focus on the variety of representation techniques used and their roles within this design process pursuing Living Building™ status.

**KEYWORDS:** Restorative Design, Triple Bottom Line, Living Building™, Integrated Design Process, Life Cycle Analysis

## INTRODUCTION

Currently used terms such as ‘sustainability’ and ‘green’ are evocative but ambiguous. Depending on the use these terms can have multiple meanings. As an example, for some ‘sustainable design’ is synonymous with energy efficiency. For others it also encompasses many other factors such as water use, landscape and social dimensions. The development of third party standards such as LEED, Green Globes, Energy Star and the IgCC help to provide specific metrics and objectives that can be shared by individuals and across disciplines. Arguably the most ambitious set of standards is represented by the Living Building Challenge™. The LBC intends to go beyond sustainable design and achieve what the LBC literature refers to as Restorative Design. The Odum School of Ecology (Fig. 1) design process illustrates how the requirements of the LBC standards affect this process in the pre-design, schematic and (elements of) the design development stages and define ‘sustainable design’ in a distinct way. Another project with similar sustainability objectives will be used to illustrate the steps that would be taken to complete the project. The Omega Center for Sustainable Living – also designed by BNIM with its partners – became certified under the Living Building Challenge™ shortly after work on the Odum project was put on hold. As a member of the design team for the Odum project, the author of this paper offers an insider’s view of this process as it applied the principles of restorative design as defined by the Living Building Challenge™.



Figure 1: Odum School of Ecology Illustration, View from Southwest: (BNIM, 2009)

## **1.0 PRINCIPLES OF RESTORATIVE DESIGN**

### **1.1. Living Building Challenge™**

The Living Building Challenge 2.1™ (ILFI, 2012) was developed by the International Living Building Institute™ (ILBI) as a set of “imperatives” - all of which are mandatory. In addition, unlike other such programs such as LEED, LBC certification is based on actual, rather than modeled performance. The LBC categories are: Site, Water (net-zero water use), Energy (net-zero energy use), Health, Materials, Equity and Beauty. Under each of these categories are organized the specific imperatives. These categories and imperatives have strong parallels to the LEED rating system. This should not be surprising as the local USGBC affiliate (the Cascadia Green Building Council) shares a common umbrella organization (the International Living Future Institute) with the LBC. But the LBC contains some obvious exceptions to LEED such as the inclusion of ‘Beauty’ as a category. It is through the meeting of the LBC imperatives that ‘Restorative Design’ is intended to be accomplished. As a way of defining ‘Restorative Design’, the ILBI uses the metaphor of a flower. A Living Building™, just as with a flower, must: be rooted in place, harvest all energy and water, be adapted to climate and site, operate pollution free, be comprised of integrated systems and be beautiful.

### **1.2. Triple Bottom Line**

The USGBC identifies Triple Bottom Line thinking as an important component of sustainable design. Restorative design must satisfy the Triple Bottom Line (TBL). Originally published in his book *Cannibals With Forks*, John Elkington (Elkington, 1998) defined the TBL as a way to measure corporate performance. TBL thinking has since been applied to design and become commonly described as ‘the three P’s’: People, Planet and Prosperity (or Profit). It is alternatively known as ‘the three E’s’: Equity, Ecology and Economy. When synergistic solutions equally incorporate all three ‘bottom lines’ into a design, sustainability is achieved. Applying TBL strategies can also contribute to meeting the LBC and the making of a Restorative Design. As the three categories become more synergistically integrated, there is an increase in sustainability.

### **1.3. Integrated Design Process**

According to the AIA’s, “Integrated Project Delivery: a Guide” (AIA, 2007), an Integrated Design Process is guided by the following principles: Mutual Respect and Trust, Mutual Benefit and Reward, Collaborative Innovation and Decision Making, Early Involvement of Key Participants, Early Goal Definition, Intensified Planning, Open Communication, Appropriate Technology and Organization and Leadership. In brief, as many stakeholders and participants in the design process are brought together at the beginning of the process in order to collaborate from concept to construction. This early collaborative process can control construction and life-cycle costs while improving performance. One illustration of how this process can work is in the case of an architect considering a high performing envelope with sun control and daylighting features. The more expensive glass and louvers would mean greater initial construction cost in a conventional design process. But if the engineers are involved in this decision, they could make recommendations about the envelope design and coordinate their systems with the enhanced performance characteristics of the envelope in mind. So compared to the design for a building with a standard envelope, the hvac system could be a smaller and less expensive one. And the lighting system could integrate lighting controls designed to take advantage of the daylighting, thus posing less operating costs. In addition, an environment with high degree of daylighting has been shown to have beneficial effects on user satisfaction, productivity, absenteeism, etc. (quantifiable human HSW benefits) Having the owner and a consultant with expertise in environmental effects on users involved in the design decisions early in the process would make the benefits, as well as the costs, apparent to everyone throughout the design process. In short, not only would everyone know why decisions were made as they were, they would have contributed to those decisions at the initial stages. This process also facilitates decision assessment on the basis of a Life Cycle Analysis.

### **1.4. Life Cycle Analysis**

As its name suggests, Life Cycle Analysis is a method of determining the value of a design’s projected performance and costs over its life. At the opposite extreme is the practice of evaluating a design based solely or primarily on initial construction cost. Employing the principles of restorative or sustainable design above leads the design team to evaluate the value of a design over time – suggested in the very word ‘sustainable’. So in order to evaluate the cost/value of a given design such factors as Energy, Pollution, External Cost to Society, Construction Cost, Furniture Fixtures and Equipment Costs, Management Fees and the total Cost (capital and operating) over the project’s life span need to be considered. BNIM completed such a study for one of their projects - the David and Lucille Packard Foundation Los Altos Project (BNIM, 2002). The study was documented in the form of a matrix that compares different solutions for the same program and site.

## 2.0 THE CONCEPT TEAM

The University of Georgia – including representatives from: central administration, facilities management, and other academic units that collaborate with the School.

The Odum School of Ecology – faculty, students and administrators from the first stand-alone college of ecology in the world with research and educational programs that include: infectious diseases, ecosystem ecology, watershed ecology, evolutionary ecology, sustainability, global climate change, conservation and invasive species.

BNIM – members from all parts of this interdisciplinary design firm consisting of architects, urban planners, landscape architects, interior designers, graphic designers and members of 'Elements', the in-house group devoted to sustainability research and analysis.

BIOHABITATS – a consultancy group devoted to ecological restoration, restorative design and water management.

SUPERSYMMETRY – an engineering consultant with expertise in energy efficiency and sustainable design.

VIVIAN LOFTNESS, FAIA - an internationally renowned researcher, author and educator in environmental design and sustainability, the integration of advanced building systems, climate and regionalism in architecture, as well as design for health and productivity.

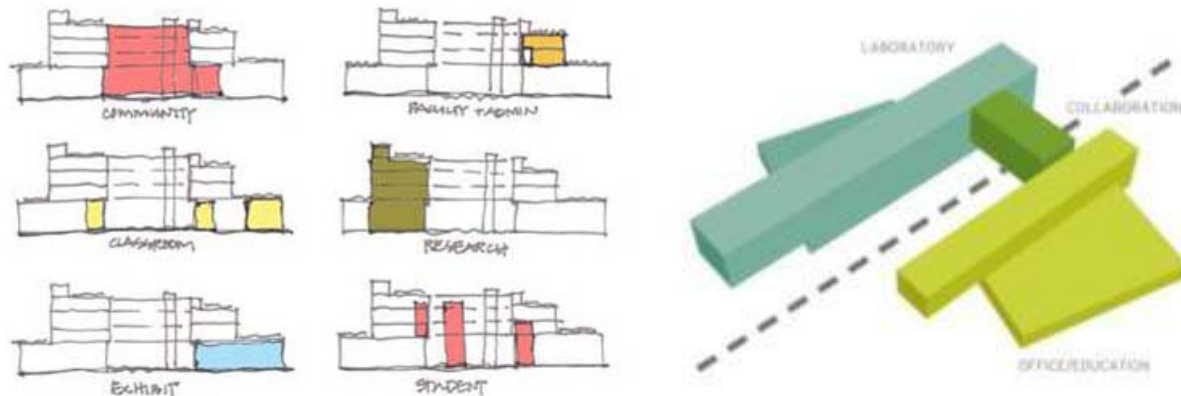
COSTING SERVICES GROUP – a consultant with expertise in construction cost analysis through all phases of a project's development.

## 3.0 THE PROJECT: THE BUILDING AS A SPECIES IN A HABITAT

One of the ways of maintaining the Concept Team's focus on Living Building objectives through the design process was to conceive of the project as a Species in a Habitat. This emphasized the interrelated systems of the building, the human activities served by the building, and the building's context as an organic whole. This conceptual framework facilitated finding ways by which the metaphor of the flower could be applied to design decisions. As with the flower, the project must: be rooted in place, harvest all energy and water, be adapted to climate and site, operate pollution free, be comprised of integrated systems and be beautiful.

### 3.1 The Building as a Species

The building is comprised of three general categories of activity/space: Laboratory (approx. 8,800 m<sup>2</sup>), Collaboration (approx. 1,350 m<sup>2</sup>) and Office/Education (approx. 4,850 m<sup>2</sup>). These general categories are further broken down into sub-categories of: Community, Faculty/Administration, Classroom, Research, Exhibit, and Student. This comprises approx. 15,000 m<sup>2</sup> (165,000 sf<sup>2</sup>) of enclosed activity/space. (Fig. 2)



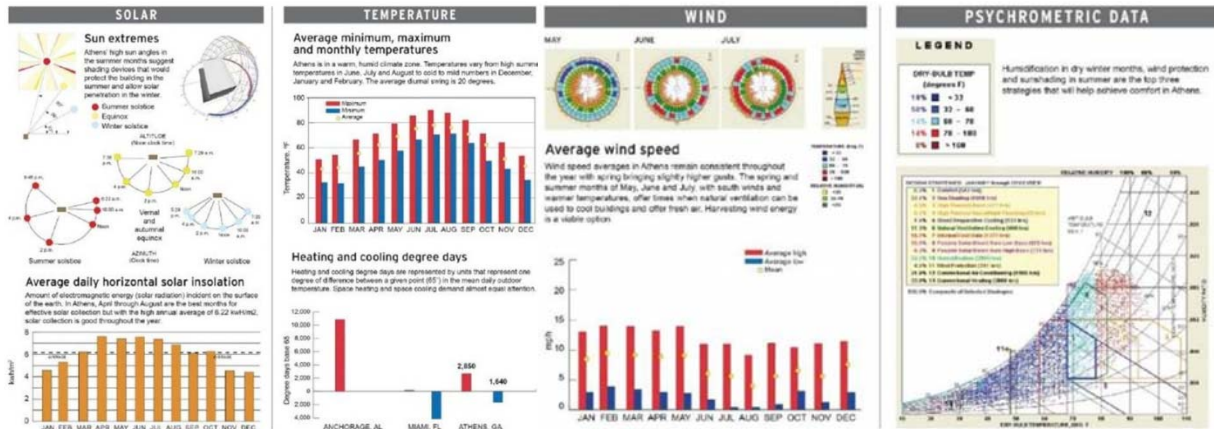
**Figure 2:** Odum space categories. Source: (Courtesy of BNIM, 2009)

For purposes of meeting the LBC, this set of activity/space categories poses several challenges and opportunities. For instance, laboratories require a large capacity of exhaust ventilation that has an impact on the entire hvac design for these spaces. In addition the lighting requirement in lab spaces is high. Both of these requirements typically result in a high energy requirement for lab space.

The purpose of the building – to facilitate the educational and research mission of the School – suggests a special relationship to the surrounding landscape. Consequently, visual and functional connections of interior and exterior functions and the project developed as a 'living laboratory' became important design strategies. In further support of the educational mission of the School, the project uses devices that mediate the natural elements (light, air and water). In order to demonstrate these mediating devices, they were to be visually expressed.

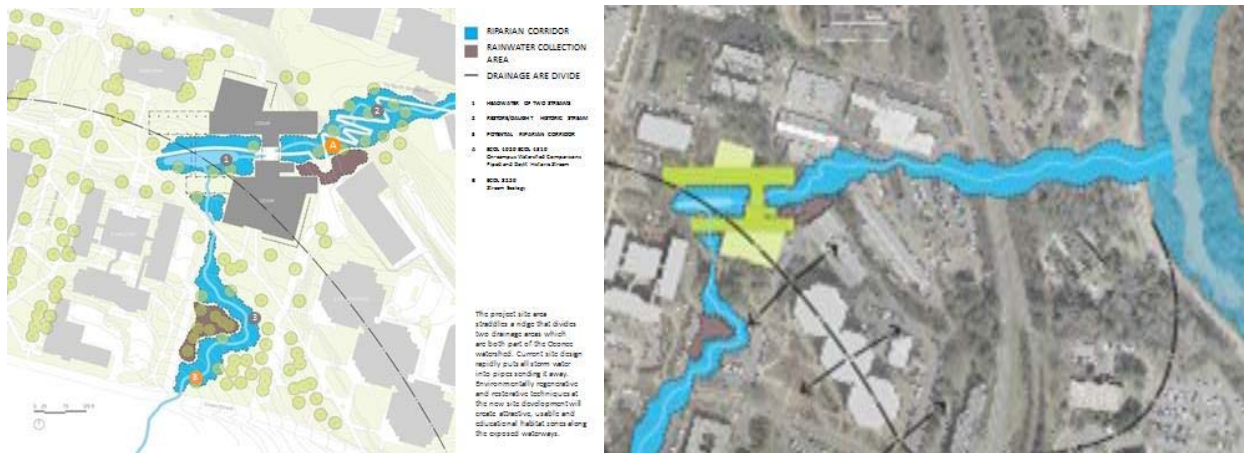
### 3.2 The Habitat

Prior to any design conceptualization, site and climate data was collected and documented. This documentation included: solar, temperature, moisture, wind, psychrometric and regional ecosystem data for the Athens, GA region (Fig. 3).



**Figure 3:** Odum Site and Climate Analysis. Source: (Courtesy of BNIM, 2009)

The site is on the main campus of the University of Georgia on a hill overlooking the North Oconee river valley. As an important strategy of restoration design, the restoration of the watershed in this area of the campus was integrated into the project. In order to accomplish this, the landscape immediately around the project collected rainwater and directed it to a new riparian corridor, diverting this rainwater from the storm water system. This riparian corridor slowed the rainwater and cleaned it on the way to the river beyond (Fig. 4). The restored watershed and riparian corridor also is to serve as a research and pedagogical purposes as it provides subject matter for data collection as well as a case study to illustrate water management techniques for the School's courses.

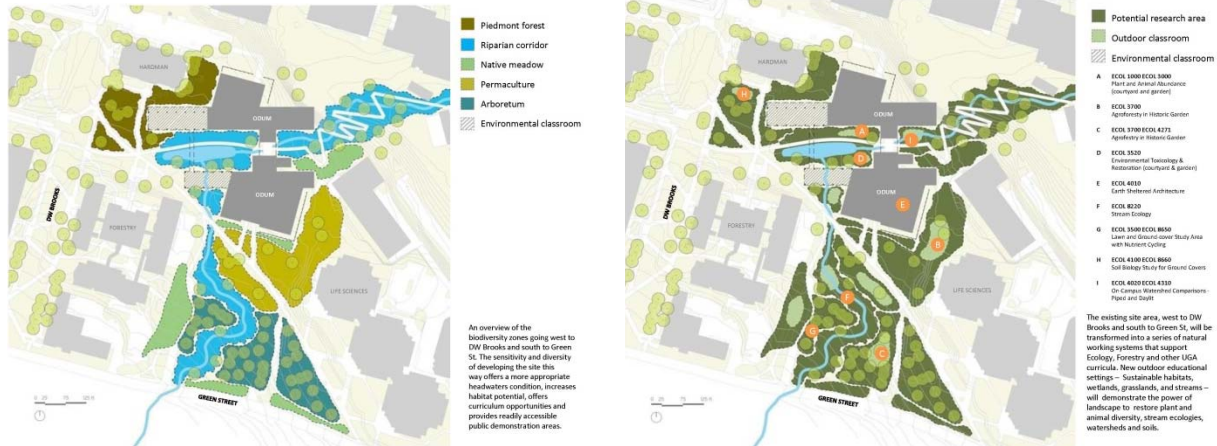


**Figure 4:** Odum Riparian Corridor. Source: (Courtesy of BNIM, 2009)

Another way in which the surrounding landscape served research and pedagogical purposes was in the development of five separate biodiversity zones. This is seen in an overview of the biodiversity zones going west to DW Brooks and south to Green St. The sensitivity and diversity of developing the site this way offers a more appropriate headwaters condition, increases habitat potential, offers curriculum opportunities and provides readily accessible public demonstration areas.

In addition to the riparian corridor, four other biodiversity zones were proposed to be established. They are to include: piedmont forest, native meadow, permaculture and an arboretum. Once the plantings appropriate to the zones are established, it is anticipated that the fauna associated with these zones will be attracted. The resultant landscape can then be enjoyed by everyone passing through the landscape, observed by the students of the School's courses and studied by the School's researchers.

(Fig. 5) shows the biodiversity zones and the courses associated with each.



**Figure 5:** Odum Biodiversity Zones and Pedagogical Areas: Source: (Courtesy of BNIM, 2009)

The connection between the biodiversity zones and the curriculum is an important aspect of the design. Just as important is the connection of the landscape and the building. As is the case with a species in its habitat, there is a co-dependent relationship. (Fig. 9) above helps to illustrate this point. Illustrated with the biodiversity zones are 'environmental classrooms' tucked under west ends of the elevated north and south laboratory and office wings. This indoor/outdoor space takes advantage of its ground level position and overhead protection to provide a place for presentations to be made within the environmental conditions being studied. In addition, the inclusion of green roofs and green walls in the built fabric will also provide for biodiversity. And finally, the building's (species) water management function is intended to be integrated with the environment's hydrological functions. Specifically, rain water is collected from the roof and used or stored for later use as grey water. In addition, all of the waste water from the building is to be processed through the 'eco-machine' and recycled through the building's grey water uses. What is not needed for these grey water uses is sent on to the stream running through the middle of the project and from there down the hill through the riparian corridor and on to the river beyond.

Many of the built features of the project that establish a co-dependent relationship between the building and its environment as conceived as a 'species within a habitat' can be seen in the Building Section (Fig. 6).



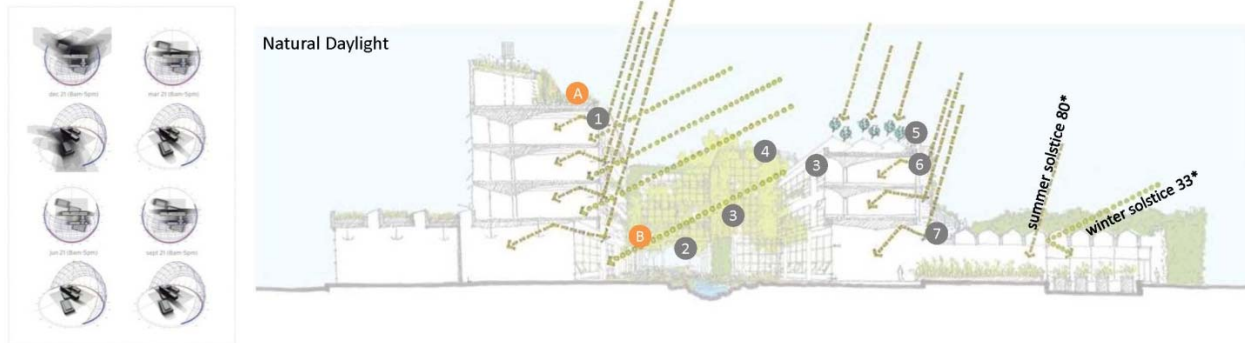
**Figure 6:** Odum – Building Section looking East: Source: (Courtesy of BNIM, 2009)

The features numbered in (Fig. 6) are: 1) Mechanical, Storage, Overflow, 2) Laboratories, 3) Courtyard (stream, trees, living laboratory), 4) Offices, Administration, Café, 5) Auditorium, Exhibit Space, Entry, Eco-Machine, 6) Green Roof, 7) Mechanical Room, 8) Green Wall/Green Roof, 9) Green House, 10) Living Wall, 11) Balconies, 12) Photovoltaics, 13) Access Between Upper Levels and Green Roof, 14) Double Skin Façade.

The building was laid out on an east/west axis. This facilitates day lighting, sun control and natural ventilation strategies. The depth of the major multi-story wings also facilitate these strategies. At approx. 20m in depth, day light can be reflected into the full depth of the space and air flow from the north to the south is relatively unimpeded. In addition, when in full natural ventilation mode, replacement air is brought in from the central courtyard where the stream and plantings condition the air by reducing particulates, oxygenizing and cooling.

## 4.0 LBC PERFORMANCE

### 4.1 Sun

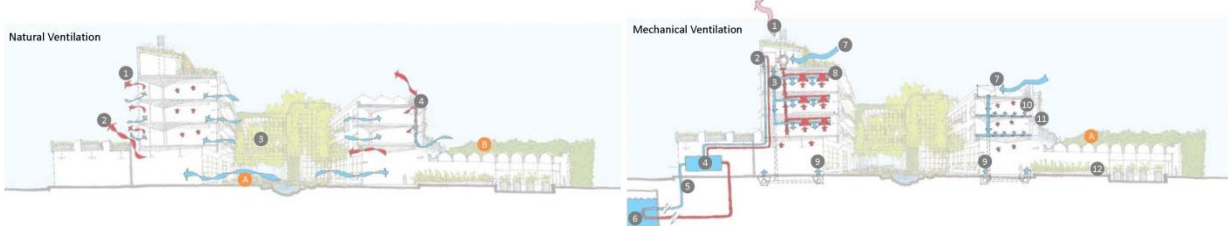


**Figure 7:** Odum Sunlight and Day Lighting Studies: Source: (Courtesy of BNIM, 2009)

(Fig. 7) Illustrates the initial sun studies done for the proposed massing and the Building Section showing the elements of the design intended to control the sun and maximize day lighting.

The numbered design elements in (Fig. 7) include: 1) All south exposure glazing is protected from the summer sun by overhangs and/or louvers. 2) Deciduous trees in the courtyard provide shade in the summer. 3) The building massing allows for sunlight to reach the courtyard and lower level of the north wing. 4) East and west walls have limited glazing and green walls for light modulation. 5) Rooftop photovoltaic array help off-set electrical use. 6) Light shelves maximize day lighting. 7) Clerestory and skylights illuminate public gathering spaces and the Eco-machine. The pedagogy of the School is also served by related elements. ECOL 3100 is served by a roof top green house and ECOL 4700 by a soil lab wall.

### 4.2 Air



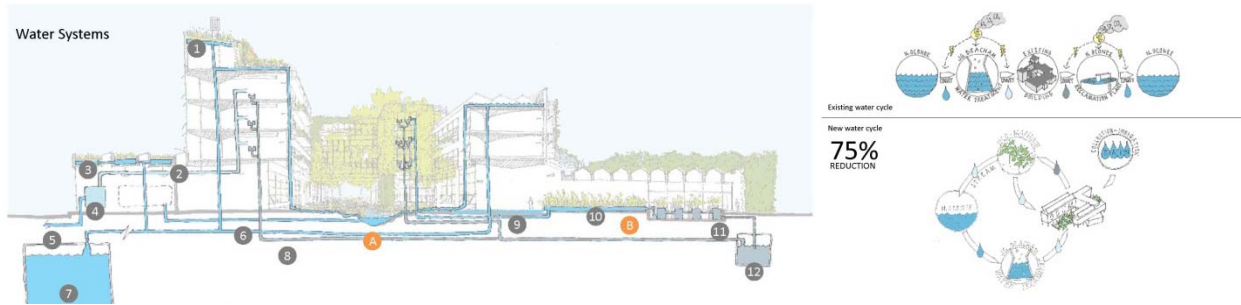
**Figure 8:** Odum Natural Ventilation and HVAC Systems: Source: (Courtesy of BNIM, 2009)

(Fig. 8) illustrates the natural ventilation and hvac design features.

The numbered design features in the building section labelled 'Natural Ventilation' include: 1) North corridors ventilated by natural convection. 2) Exhaust through operable skylights. 3) Vegetated courtyard with running stream cleans and tempers the air. 4) Double skin façade acts as a convection chimney providing a stack effect. The pedagogy of the School is served by related elements. ECOL 3520 is served by the courtyard. And ECOL 4100 and 8660 is served by the varieties of soils and ground covers on the south green roof.

The numbered design features in the building section labelled 'Mechanical Ventilation' include: 1) Exhaust from labs through heat exchanger. 2) Variable frequency air handler served by chiller or boiler. 3) Overhead air distribution to labs. 4) Chiller. 5) Pre-chilled water from re-purposed fuel oil tank. 6) Ground coupling system. 7) Fresh air in-take draws air over green roof and through green wall before going through heat exchanger. 8) Low flow fume hood exhaust system in labs. 9) Under-floor air supply. 10) Return air used for lab make-up air. 11) Under-floor air supply in offices. 12) Interior plants and moving water provide natural cooling. The pedagogy of the School is served by related elements. ECOL 4010 (Earth Sheltered Architecture) is served by the south green roof.

### 4.3 Water



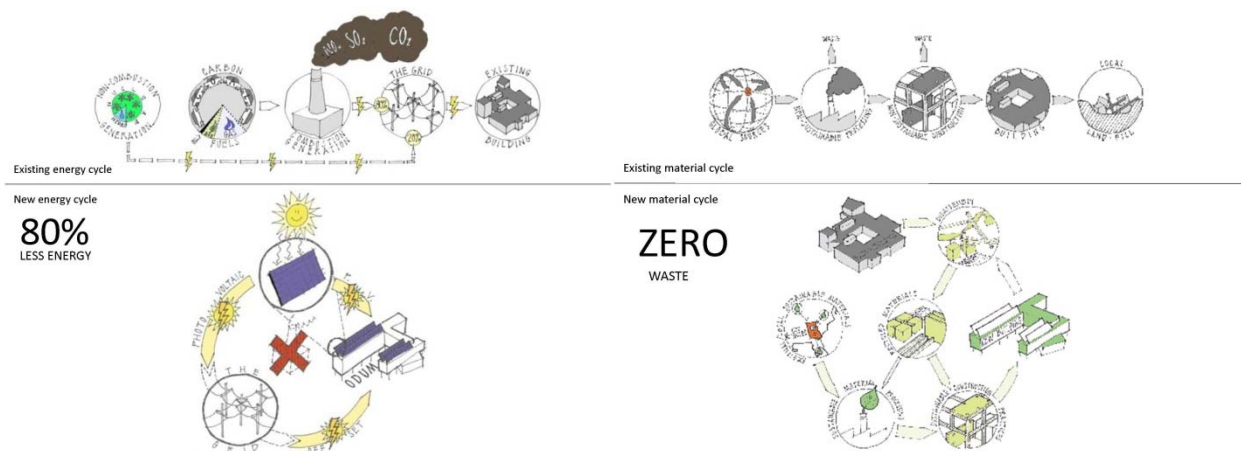
**Figure 9:** Odum Water Systems and Projected Use: Source: (Courtesy of BNIM, 2009)

(Fig. 9) illustrates the water systems and projected water cycle and water savings of the new design.

The numbered design features in the building section labelled ‘Water Systems’ include: 1) Green roofs drain rain water to water tank. 2) De-ionization water to labs. 3) Green roof. 4) De-ionizer. 5) City water. 6) Overflow from chiller to stream. 7) Water tank (re-purposed fuel tank) filled from roof drainage and condensation from chiller. 8) Wastewater from lavatories, sinks and toilets to Eco-machine. 9) Treated water from eco-machine to toilets. 10) Clarifying tanks/stream. 11) Eco-machine aerobic tanks. 12) Eco-machine anaerobic tanks. The pedagogy of the School is served by related elements. ECOL 8220 (Stream Ecology) and ECOL 8150 (Wetland Ecology) are both served by the Eco-machine.

The water cycle diagram shows both the existing water cycle and the proposed new water cycle. The new water cycle features a (preliminary and conservatively projected) 75% reduction in the use of city-treated water (and the associated energy/carbon footprint due to the conveyance and treatment of both supply and waste water). This is to be accomplished by the harvesting and storage of rainwater and process water, the use of low flow fixtures and systems, the in-house treatment of waste water by the eco-machine and the use of this treated and harvested water for grey water applications. With further development of the design and more exact performance analysis, it is expected that there will be a net 0% use of city supplied potable water.

### 4.3 Energy Use and Material Cycle



**Figure 10:** Odum Projected Energy Use and Material Cycle: Source: (Courtesy of BNIM, 2009)

(Fig. 10) illustrates the existing and projected cycles of energy use and material use

The new energy cycle diagram features a (preliminary and conservatively projected) 80% reduction in energy use over the existing energy cycle (with its associated pollution and carbon footprint). This is proposed to be accomplished through the use of more energy efficient systems throughout the project, the harvesting of daylight and the use of photovoltaic arrays (approx. 6,000 m<sup>2</sup>) to off-set the remaining energy used. With further development of the design and more exact performance analysis, it is expected that there will be a net-zero energy use.

The material cycle diagram in (Fig. 10) illustrates the differences in the existing material cycle (materials from global sources, non-sustainable and hazardous manufacturing processes, non-sustainable construction practices with a high degree of waste and full demolition of the structure – with the material to the land fill at the end of its life) with the projected new material cycle (regionally sourced materials processed in ways that produce minimal contaminants and a small carbon footprint, assembly practices that enhance the opportunity to disassemble and reuse/re-purpose the building materials at the end of the building's life.

## CONCLUSION

As was the case with so many projects in 2009, the Odum project was put on hold pending further funding. As discussed above, the level of preliminary analysis did not allow the team to claim that the requirements of the LBC had been met. In order to complete the Odum project a good deal more finite analysis and more refined design decisions would be needed to be made – particularly with regard to the use of BIM and digital analysis applications for energy modeling, air flow and daylighting/lighting for instance. But this was not due to a lack of confidence that they could be in the future with additional design refinements and analysis. This is at least in part due to the fact that BNIM had already met the Living Building Challenge™ with the 'Omega Institute for Sustainable Living' project, one of the first two projects to earn Living Building™ certification. In the Omega project, BNIM led the project team in a similar way, employing Triple Bottom Line thinking, an Integrated Design Process and Life Cycle Analysis. Similar design strategies were also employed. (Fig. 11) shows the results of the Omega project in the form of a photograph, and a presentation of data collected for the LBC process. If the Odum design process resumes, similar results are expected.



Figure 11: Omega Institute for Sustainable Living: Source: Photo (c) Assassi, Date Page: Source (Courtesy of BNIM, 2009)

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