Gilman Ordway Campus

Headquarters for Woods Hole Research Center

Demonstrating the Value of Sustainable Building Strategies

Photo by Charles C. Benton

A Case Study of Strategies, Challenges, Successes

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Commissioned by the Massachusetts Technology Collaborative

September 27, 2005

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Executive Summary

The Woods Hole Research Center's Gilman Ordway Campus is a high performance building designed to be a model for institutional buildings powered by renewable energy. Sustainable features include the reuse of a historical building, tight building envelope, photovoltaic panels, ground source heat pump, solar hot water, denitrifying septic system, storm water management, and green furnishings.

The facility consumes 80 percent less energy than the average newly constructed building that meets Massachusetts' energy conservation requirements.[1] Compared to national office building statistics, the building's energy intensity is approximately 20 percent of the national average and its atmospheric burden from SO_2, NOx, and CO_2 emissions is 80 percent lower than average.[2] Over 30 percent of its annual energy consumption is supplied from photovoltaic panels. Woods Hole Research Center plans to install a wind turbine in the future in order to make it a true "net zero" energy building – one that fulfills its energy demand with renewable energy systems onsite.

The purpose of this report is to provide insight to the successes and challenges experienced while building the Gilman Ordway Campus, review the sustainable design processes followed, and highlight the energy performance and efficiencies achieved.

1. Introduction

Woods Hole Research Center (WHRC) is a scientific, policy, and educational institution that was chartered in 1985 to address global warming and the destruction of forests and ecosystems. Part of their mission states:

> *We seek to conserve and sustain forests, soils, water, and energy by demonstrating their value to human health and economic prosperity. We work locally and regionally, assisting communities with resource management, and internationally to promote policies that stabilize climate and protect the integrity of the global environment.*[3]

For these reasons, WHRC actively shares information about the performance and green features of their sustainable building with the public.

The new headquarters, which was occupied in spring 2003, reflects the application of WHRC's mission. Several sustainable building practices that protect natural resources are incorporated in the property. The use of sustainably harvested or reused wood helped preserve the forest, a tight envelope and renewable energy technologies maximize energy efficiency, harvested rainwater and low flow fixtures minimize water consumption, and landscaping and wastewater management practices protect the area's soils and watershed. The community's interests were taken into consideration with the reuse of a historical structure and the treatment of wastewater onsite to avoid further burdening the town's system. One of the objectives with the new building was to be able to demonstrate attainable ways to minimize environmental impacts; therefore, local residents, students, and professionals are welcome to come to the facility to learn about sustainable building practices and the use of renewable energy technologies.

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[1] Woods Hole Research Center, Green Building–Building for the Future, www.whrc.org/building/index.htm
[2] Hackler, Joe, and Michael Ernst, (2005) "Toward a Zero Net Energy Office Facility in the Northeastern U.S."
[3] Woods Hole Research Center, About Us–Our Mission, www.whrc.org/about_us/mission.htm

1.1. Site at a Glance

Table 1: Sustainable Building Features of Gilman Ordway Campus

Category	Description
Site Selection	Minimal land disturbance, use of pre-existing house
Transportation	Near bike path, bike storage, showers for cyclists
Process	Systems approach with integrated building design
Material Selection	Natural materials, low VOCs, no carpeting, FSC wood, environmentally friendly furniture
Energy Conservation	R20 wall insulation, offset stud framing, double and triple paned argon filled glazed windows, optimized daylighting, occupancy sensors, reduced plug loads, valence heating units, variable frequency pump drive, building management system, monitoring system
Energy Production	Photovoltaic panels, ground source heating pump, energy recovery systems, solar thermal, wind turbine planned
Storm Water Management	Permeable pavers, gravel parking lot, reduced parking lot size, impermeable surfaces disconnected, bioswale, rainwater collection
Water Efficiency	Rainwater harvesting for irrigation, low flow fixtures, denitrifying septic system
Indoor Environment	Low VOCs, daylighting, operable windows, fans, thermostats in offices
Contractors	Architects: McDonough & Partners Construction: TR White, Inc. Energy Consultant: Energysmiths Photovoltaic Panels: Northern Power Systems Commissioner: Shooshanian Engineering (now Applied Energy Engineering & Commissioning)

2. Site

The Gilman Ordway Campus is located at 149 Woods Hole Road, Falmouth, MA, on an eight-acre site. Falmouth is situated in the southwest corner of Cape Cod; it covers 44.52 square miles and has 68 miles of coastline. According to the Chamber of Commerce's website, "Falmouth is the second-biggest town on Cape Cod and part of the fastest growing county in Massachusetts."[4] According to a narrative supplied by the community to the Massachusetts Department of Housing and Community Development, "Falmouth has a lot of agencies that are very attentive to the environmental demands of that coastline, whether it be the Planning Board, the Zoning Board of Appeals, the Conservation Commission, the Department of Natural Resources, Shellfish Warden, Harbormaster and the Board of Selectmen."[5] The town is especially proactive in their efforts to designate tracts of land as protected for public conservation and natural habitat for wildlife.

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[4] Falmouth Chamber of Commerce, Cape Cod, MA, About Falmouth, www.falmouthchamber.com
[5] Falmouth, Barnstable County, dhcd, Massachusetts, www.mass.gov/dhcd/iprofile/096.pdf

2.1. Zoning

The Massachusetts State Building Code states that nonprofit educational corporations are not required to meet all municipality zoning requirements, but the Center was not exempt from all of Falmouth's Zoning Bylaws. WHRC found that existing zoning codes can challenge the objectives of sustainable building practices. The use of new systems such as porous pavement and an overflow meadow required extensive conversations with local officials who needed to be assured that the approaches were compliant with the spirit of the town's laws and that the building would support their goals, including sustainable growth, open space protection, and maintaining quality of life for residents.

Because the facility is greater than 10,000 square feet, it qualified as a "Development of Regional Impact," and therefore required approval by the Cape Cod Commission, a regional planning and land use regulatory agency. The Commission gave the building a rare exemption from full review because of the sustainability goals associated with it. As part of their charter, the Commission urged WHRC to put a conservation easement on four acres of open space that would protect the land in perpetuity. WHRC took this action willingly, as it was in line with their values and they did not have any plans to use the land.

2.2. Transportation

The Woods Hole Research Center is not easily accessible by any forms of public transportation that are conducive for daily commuting practices. However, it is conveniently located next to a well-maintained bike path. Shining Sea Bikeway is currently 3.3 miles long; an extension was recently proposed to create an 11 mile bike path that will go from Woods Hole to North Falmouth.[6] Special accommodations for employees who use this alternative to get to work include bike storage areas and showers.

2.3. Landscaping

The majority of the front lawn is a wildflower meadow, which increases the storm water collection area and decreases the need for fertilizer that would pollute the nearby pond. Rain-water from the roof is collected into a 1,200 gallon rain barrel and used to irrigate the lawn court, which reduces fresh water consumption and further decreases runoff. The catchment collects more water than is needed for lawn care; the overflow is directed into the meadow. The parking lot is made of gravel and permeable pavement, which allows storm water to percolate.

1 Meadow Walks; 2 Field Parking;
3 Ellipse Garden; 4 Lawn Court;
5 Porch / Entry; 6 Rhododendron Garden
Source: www.whrc.org/building/landscape2.htm

[6] "Do you support the Bike Path extension to North Falmouth?" www.whoi.edu/science/B/people/sbeaulieu/bike/

3. Building

The Gilman Ordway Campus serves as the headquarters for the Woods Hole Research Center. The facility includes a 19th century refurbished summer home and an addition that is discreetly located behind the original structure. A common bleached cedar color palette blends the two buildings together to make them look more harmonious. The new four-floor structure, with 19,300 square feet of space, is used for offices, conference rooms, an auditorium, and a small laboratory. The building was commissioned on December 30, 2002. WHRC's goal was for the building to serve as a model for sustainable building practices that could be easily replicated.

The Gilman Ordway Campus includes a refurbished 19th century summer home.
Source: *Agents of Change* Project, http://aoc.uoregon.edu

3.1. Building Design

The LEED (Leadership in Energy and Environmental Design) framework and Energy-10 modeling predictions guided the design and construction of the building. The Woods Hole Research Center was committed to creating a "high performance building" that used renewable energy technologies efficiently and was a joy to be in, in order to demonstrate the viability of a green building and prove that there were no related shortcomings. The U.S. Department of Energy defines a high performance building as a building that is substantially better than the standard in terms of its energy, economic, and environmental performance.[7] The objective of the new campus was to have a building "that would be a model for 21st century construction in its use of energy, water, and environmentally friendly building materials."[8] The focus of the design was on maximizing performance through system integration, rather than evaluating technology options individually, in an effort to enable the building to meet its own energy demands. The experienced team working on the project was able to apply a "systems approach" very successfully. William McDonough and Partners, a firm that is recognized throughout the world for its green building accomplishments, was selected to design the building because its mission and goals are in alignment with the Center's. An integrated team concept was practiced throughout the design process. Team participants included members of WHRC, such as founder George Woodwell and Research Associate Joe Hackler, as well as contractors such as energy consultant Marc Rosenbaum. Joe Hackler, a Research Associate at WHRC who has a background in urban and regional planning, fulfilled the role of project manager for the new building. In this role he was involved in all the design and building development discussions, serving as the main contact between the client, design team and building contractor.

The group collaborated on a holistic, whole-building design approach, considering the building structure and systems as a whole and examining how systems would work best together to conserve energy and reduce environmental impact. The team found that involving all parties in the design discussions allowed for greater attention to be paid to details, which in turn minimized the number of change orders required for adjustments or replacements during the construction process.

[7] Office of Energy Efficiency and Renewable Energy–Design Approach, www.eere.energy.gov/buildings/highperformance/design_approach.html

[8] Woods Hole Research Center, Green Building–Building for the Future, www.whrc.org/building/index.htm

3.2. Construction

Construction took place from October 2001 through February 2003. Reusing and restoring an old building was not necessarily the most cost-effective approach, but it was important to the organization that the appearance of the original structure be maintained because it was a part of the community's cultural history. The summer home had a lot of structural decay and a gut rehab was required to make the building tight enough to meet the Center's energy goals, as well as to bring it up to current structural code. Lack of an accessible recycling market caused construction and demolition waste to go to the landfill.

3.3. Building Materials

Naturally-based materials were used throughout the building, including glass, stone, and wood. The paint and adhesives used had low volatile organic compound (VOC) content. The concrete was locally produced and the stone walls used in landscaping are made primarily from fieldstone available on site.

In line with the Woods Hole Research Center's dedication to forest conservation, the plan was for all of the wood to be sustainably harvested. However, the procurement and acquisition of Forest Stewardship Council (FSC) (www.fscus.org) certified wood was more time consuming than expected and the contractors were unable to have enough sustainable construction materials on site. Therefore, some of the dimensional construction lumber is not certified. Contractors were also unable to locate a source for certified plywood. The exterior finishes, including the cedar shingles and clapboard siding as well as the wood used for the entranceway porch, deck and stairway, are certified by the FSC. Certified wood was used for the interior trim as well. The maple used for the interior floor was sustainably harvested in Pingree, Maine; remilled ash and certified fir was used for the door frame and windows.

4. Energy

The Woods Hole team set an ambitious target of creating a facility that produced all its electricity on site and was carbon neutral. The Research Center's "High Performance Building" brochure explains that "aggressive conservation strategies are prerequisites for the practicable implementation of renewable energy in the operation of a building."[9] A tight envelope, optimized natural daylight and ventilation, energy efficient lighting and equipment, and properly-sized mechanical systems are critical components to this strategy.[10]

4.1. Strategy

With a net zero energy target, the strategy was to incorporate systems that would produce more energy than the building would require and avoid the need to burn fossil fuels that contribute to global warming. The goal was to meet 41 percent of the energy demand with power generated from photovoltaic panels and more than the remaining 59 percent from a wind turbine. Energy-10, a software tool that is used to measure the benefits of energy efficiency strategies, such as daylighting, passive solar heating, and envelope design in residential buildings and small commercial facilities, was used to facilitate the decisions of investing in different technologies. "Off the shelf" products that were readily available in the market were selected to ensure that Woods Hole's accomplishments could be easily replicated in other building projects.

Woods Hole found that having an energy advocate involved from the start with the design of building helped to ensure that the design supported the building's goals and that system performance was

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[9] Woods Hole Research Center–Steps to a High Performance Building, www.whrc.org/building/pdf/Building_Future_trifold.pdf

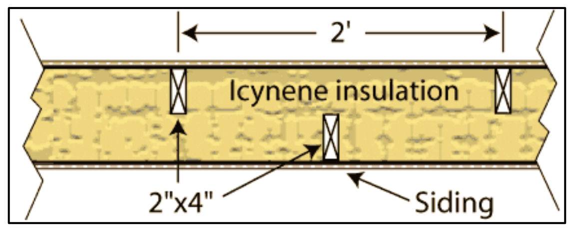
[10] Woods Hole Research Center–Green Building, Building for the Future, www.whrc.org/building/index.htm

optimized. Marc Rosenbaum, a well-established energy and integrated systems design consultant with Energysmiths, was hired to guide the design process, oversee the implementation of the energy systems, and purchase the energy-related systems. Rosenbaum was instrumental in determining what investments were necessary (window glaze, insulation, heat recovery, etc) in order to achieve the building's energy efficiency goals. When purchasing the energy systems, Rosenbaum applied the integrated systems approach and simultaneously considered energy use, resident comfort, durability, and resource use of the systems that were designed for the facility. Energy-10 calculations were also considered. Rosenbaum was routinely onsite to consult with the builders, electricians, mechanical engineers, and plumbers to make sure that technologies were installed properly and to ensure that WHRC achieved its energy goals.

Rosenbaum claims that the integration of the Campus's mechanical systems is complex, but he believes that the building's level of energy use is one of the lowest in North America. He contributes the success to the envelope retrofit, superb daylighting, and great material selection. He also believes that it is necessary to apply an integrated design approach and to have an understanding of the technical systems of the building in order to maximize its efficiency.

4.2. Building Envelope

A tight envelope with no air leakage is a top priority for a high performance building; any compromises in this area will reduce energy efficiency. Offset stud framing, also referred to as double-stud wall or double wall, was incorporated in the structure to eliminate thermal bridging. With this method, offset studs are positioned in a zigzag or staggered pattern and interior and exterior walls are attached to a different set of studs. The resulting wall cavity depth of 8-10" was filled with insulation to minimize air infiltration.



Cross-section of offset-stud construction
Source: www.whrc.org/building/conservation2.htm

Icynene spray foam, a low-density polyurethane that does not have ozone destroying compounds or formaldehyde and can fit into any sized area, was used to insulate the building. Although spray foam insulation is an expensive option, it is effective for tightly air-sealing a building. Insulation is rated by the R-value, which is a thermal resistance factor that measures the ability of the insulation to resist heat flow and keep heat inside in the winter and outside in the summer. The higher the R-value, the better insulator the material will be. The wall insulation is rated R-20; a combined insulation value of approximately R-45 was achieved in the ceiling when 4" of rigid polystyrene insulation board was installed above the roof deck. Polystyrene foam insulation has two to three times greater insulation than most other materials of the same thickness, thus it is good for areas that have space limitations or need high R-values. The insulation board was covered by rubber membrane roofing.

4.3. Lighting and Daylighting

Triple glazed windows (R-5.4) were used in the new addition where there is a large amount of window area, and double glazed windows (R-4.1) were installed in the original building where there is less window-area. All windows are Loewen's Heat Smart™ Plus models with argon-filled glazing and Low Emissive (Low-E) coatings that reduce radiative heat transfer. The window frames are wood on the inside and aluminum cladding on the outside.

4.4. Plug Loads

Steps were taken to minimize the energy demand of daily office activity. Fluorescent lighting and motion detectors were installed throughout the building. Energy Star appliances were purchased where possible, such as the refrigerator and dishwasher. Desktop computers and laser jet printers were replaced with more efficient laptops and ink jet printers and unnecessary redundant office equipment was eliminated.

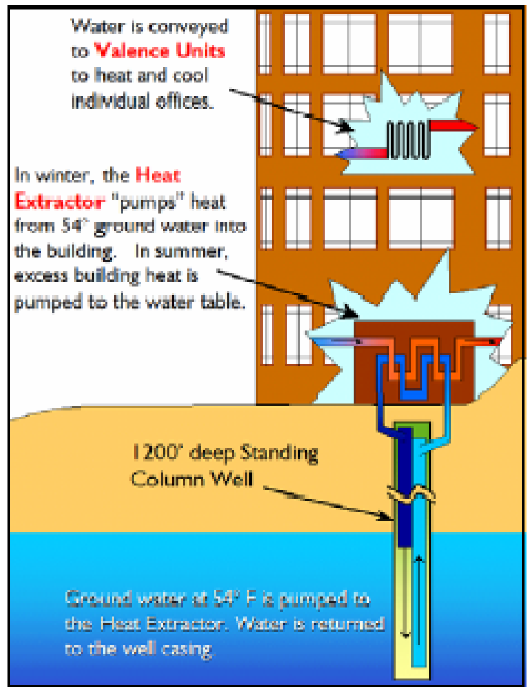
4.5. Mechanical Systems

The mechanical systems used in the WHRC facility center around heating, ventilating, and air conditioning (HVAC). The HVAC systems consist of a ground source heating and cooling system and an energy recovery system. The tight building envelope allows the HVAC systems to run efficiently, which extends the life of the systems, lowers utility costs, and decreases related emissions.

4.5.1. Ground Source Heating and Cooling

The geothermal heating and cooling system is cost-effective and efficient because it recycles renewable energy. A Water Energy Distributors ground source heating and cooling system was installed by Wilmington Pump. The underground machine uses the stable temperature of groundwater, which averages 50-54°F, to exchange heat.

Groundwater is pumped from and returned to a standing 1,200' deep column well to a heat extractor, which provides heat in the winter and extracts heat in the summer. The system is an "open loop," that returns the extracted water back to its source. The water from the well at WHRC only needs to be heated to about 80-120°, compared to 180° that is normally required for effective radiant heating. Electricity is required to operate the pump, transfer equipment, circulators, and fans. Woods Hole uses the energy generated by the photovoltaic panels for this purpose. This type of system is virtually maintenance free, as it does not require cleaning like traditional furnaces and boilers do, and has a life expectancy of approximately 30 years.



A geothermal heating and cooling system is used to maintain the building's temperature.
Source: www.whrc.org/building/pdf/Building_Future_trifold.pdf

The total installed heating capacity of the ground source pump is 180 million British thermal units (mBtus). The system is connected to Climatemaster water to air and water to water heat exchangers that can transfer 60,000 Btus/hour. Four water-to-air heat exchangers maintain the temperature of the large common areas via regular ducts and two water to water heat exchangers control thermal conditions of the office spaces via valence convectors mounted on the ceiling. Valance units, which use natural convection current to cool the air and radiation to heat the air, were determined to be the most efficient way to maintain thermal comfort in the offices. The ceiling-installed units use hot water to radiate heated air down into the room in the winter. In warmer months, cooled air is used to lower the temperature of the ceiling air and set up a convection current that cools the room. Because valance units take advantage of natural convection, they do not need to cool down the extra motor heat that is produced by fan coils, thereby increasing their efficiency. Valance units are more efficient than fan coils, which just move air around, and require more electricity and regular cleaning. Radiant floors were not installed because they can only be used for heating purposes.

The better insulated a building is the less energy it requires for heating and cooling. In energy-efficient structures smaller HVAC systems are sufficient and the "bigger is better" rule of thumb does not apply. Load calculations and system sizing measures must be conducted to account for efficiency features and avoid oversized HVAC systems that operate less efficiently.[11]

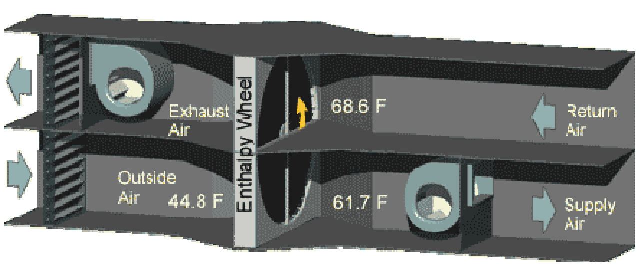
The ground source system used by Woods Hole is “right-sized” for the building. Because the system’s capacity is closely matched to the building’s needs, a consistent temperature is required for efficient regulating. To minimize the demand on the heat pump and maximize its efficiency, the thermostat is not lowered more than 1-2° at night or over the weekend, and decisions to use the heat or air conditioning are made a day in advance based on the predicted weather forecast. A variable frequency drive connected to the pump automatically adjusts the electric motor speed to the level required to manage the load demand, which significantly reduces energy waste.

The organization is satisfied with the performance of the ground source system, even with the New England winter weather. They have, however, discovered that the pumping requirements for this system are “higher than expected.”[12] WHRC is investigating the possibility of decreasing the present requirement to pump against the pressure of approximately 100’ of water to be more energy efficient.[13]

A related concern with ground source heating and cooling systems is that the return of colder or hotter water back into the well could cause inefficiencies because they require a constant water temperature. This can be addressed by installing a bleed feature on the return leg, which would divert 10 percent of the water from being returned to the aquifer. With less water returned than drawn out, the well draws in new water from the aquifer. WHRC has not installed a bleed feature because they have not noticed a change in the water temperature. It appears that the lateral flow of the area groundwater, equivalent to one foot of water through the area surface, sufficiently replenishes the well’s water and maintains the water temperature.

4.5.2. Energy Recovery

A Greenheck energy recovery system provides fresh outdoor air while recovering energy from the exhaust air stream. The system uses three “enthalpy” or “total energy recovery” wheels to recover (during winter) or reject (during summer) sensible (from temperature) and latent (from moisture) heat, which is normally lost. This improves indoor humidity levels, reduces energy costs, and lowers the need for air conditioning. The enthalpy wheels are 70-80 percent efficient in transferring both types of heat, as compared to 30-50 percent efficiencies for traditional flat plate exchanges.[14]



Enthalpy wheels warm or cool incoming air to help maintain a constant indoor temperature.
Source: www.whrc.org/building/conservation2.htm

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[11] EnergyStar, “Reduce System Costs by Right Sizing HVAC Equipment,” www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/BuilderGuide3A.pdf
[12] Woods Hole Research Center, (May 2, 2005), “From Photovoltaics to Solar Thermal Collectors: Evaluating and Improving Innovative Green Design,” www.whrc.org/pressroom/press_releases/PR-2005-05-02-building.htm
[13] Hackler, Joe, and Michael Ernst, (2005), “Toward a Zero Net Energy Office Facility in the Northeastern U.S.”
[14] Greenheck, (2005), www.greenheck.com/products/energy

4.6. Renewable Energy

Photovoltaic panels provide a significant portion of the energy for the facility and solar hot water panels are used as a primary source to heat water for domestic use. Woods Hole Research Center's strategy includes fulfilling their remaining energy requirement through wind power. The reliability of passive solar-powered heating and cooling techniques was explored during the design process, but it was not pursued. Several factors were considered in this decision, including the minimal "full sun" hours available in the Northeast, the amount of sun exposure blocked by the steepness of the site, and the related need to disrupt the building's façade in order to include more windows. Lastly, this energy source would require a back-up system, which would have been an additional expense.

4.6.1. Photovoltaic Panels

Solar photovoltaic (PV) technology takes advantage of the sunlight's energy; therefore it is one of the most environmentally friendly sources of power available. PV panels contain semiconductor cells covered with glass and an anti-reflective sheet, which are contained in a frame with panel packing. The semiconductors create an electrical charge when they are hit by sunlight; this electricity is then transferred through a circuit to the source of demand.[15]

Woods Hole Research Center's photovoltaic panels provide almost one-third of the building's annual energy needs, powering the ground-source heat pump system and providing electricity to support the building's plug loads. During the summer months the photovoltaic system met over half of the building's electricity needs (see Figure 1). The 26.4kW peak PV array produced 29,280kWh during the year March 2004 through February 2005.[16] During this time the system exported a total of 7,715kWh excess energy to the grid.[17] (See Energy Usage and Emissions for more detail.)

88 photovoltaic panels supply 30% of the energy needs
Source: *Agents of Change* Project, http://aoc.uoregon.edu

Northern Power Systems was responsible for the selection and installation of the photovoltaic panels. Lawrence Mott of Northern Power explains that when designing a solar system several aspects need to be taken into consideration, including: customer's need (e.g. peak demand, expected monthly kWh consumption, etc.) current market conditions, available incentives and rebates, technological attributes and efficiencies of different technologies, testing information, and alternative system costs.[18] Northern Power Systems uses NASA's Langley Space Center's Meteorological Database to acquire solar insulation data that aids the calculation of how much power the photovoltaic panels will be able to generate at a specific location.

[15] Massachusetts Technology Collaborative, Introducing Solar Photovoltaics, www.masstech.org/cleanenergy/solar/overview.htm
[16] Hackler, Joseph, and Michael Ernst, (2005), "Toward a Zero Net Energy Office Facility in the Northeastern U.S."
[17] Hackler, Joseph, personal communication, April 26, 2005
[18] Mott, Lawrence. Northern Power Systems. November 19, 2004, phone interview

A series of 88 4’ x 6’ photovoltaic panels are located on the south-facing areas of the building with nine 8-module strings on the roof of the new addition and two 8-module strings located on the summer home’s porch roof. Having some panels remote from the others presented a slight challenge and an additional cost, but it was considered a worthwhile investment because it contributed to the organization’s objective of generating renewable energy sufficient to meet their needs. The panels are mounted flush to the roof surface, which has an approximate angle of eight degrees (towards the south). The east-west axis of the new building optimizes the solar performance.

The ASE-300-DGF50 modules, with a rated power of 300 watts, were manufactured by ASE America (now Schott) in Massachusetts. Inverters convert the electricity into an alternating current that is compatible with appliances and computers. Each of the eleven photovoltaic strings is connected to its own SMA Sunny Boy 2500 inverter. This type of configuration preserves the renewable energy supply if one inverter fails. Nine of the inverters are housed outside the building shell to avoid heat gain in the summer months.

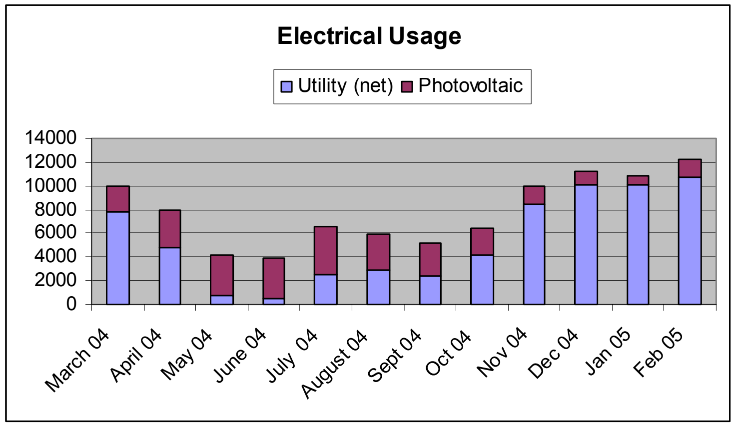


Figure 1: Energy Production of Photovoltaic Panels
Source: Joe Hackler, personal communication, April 25, 2005

Woods Hole’s PV array was funded in part through a Massachusetts Technology Collaborative (MTC) Renewable Energy Trust grant of $162,858 (75% of expected cost). The PV system was installed during the fall of 2002; independent metering data became available in October, 2003. There have not been any problems with the system and the organization is quite satisfied with its performance.

4.6.2. Solar Thermal

Solar panels heat the hot water.
Source*: Agents of Change* Project, http://aoc.uoregon.edu

The building’s hot water is initially heated by three 4’ x 8’ solar hot water panels located on the roof at a 45° pitch. The active solar water heating system is residential size because of the low hot water demand that stems from the showers and sinks. Water is stored in two tanks, one in the basement and one on an upper floor. A small “head tank” was put on the upper level to minimize the distance that the hot water has to travel. The tank in the basement acts as a buffer tank and preheats the water for the primary electric water heater. This conventional heater serves as a backup on cloudy days to ensure that the building always has hot water. During the period of May through November 2004 the solar hot water system provided 88 percent (1,684 kWh) of the total energy required for the building’s hot water.[19]

[19] Hackler, Joseph, and Michael Ernst, (2005). “Toward a Zero Net Energy Office Facility in the Northeastern U.S.”

4.6.3. Wind Turbine

A small wind turbine is part of WHRC's strategy to achieve a net-zero energy facility. The preferred 100kW wind turbine would be approximately 140 feet tall with a rotor diameter of 66 feet. However, for reasons explained below, the turbine has not yet been installed.

Soon after the environmental assessment was completed, Woods Hole was informed that the turbine they intended to purchase from Northern Power would not be produced. The new search resulted in a significant change in expected costs. The desired size turbine would be manufactured in Germany; due to an increase in the comparable value of the Euro and increased shipping charges, the estimated expense increased from $300,000 to $500,000, including installation, engineering and permitting.

A grant from MTC Renewable Energy Trust of $273,692 (75% of expected cost) was awarded to help defray the cost of the environmental assessment and the turbine. Although the organization is still fundraising for the turbine, it is unclear when WHRC will be able to move forward with this energy source.

NorthWind 100kW turbine
Source: www.northernpower.com

A 30-meter anemometry tower was erected to determine the average wind speed at the site and estimate how much electricity could be produced annually. The monitoring confirmed that wind, which averages 10.5 mph, is worth pursuing as part of WHRC's strategy to meet energy demands through renewable sources. It is believed that the turbine would be able to supply 60,000-127,000kWh/yr (67-141 percent) of the energy needs. ESS Group, Inc., an environmental consulting and engineering firm, was retained by Woods Hole to conduct an environmental assessment of the siting, installation and operation of the wind turbine. After investigating zoning requirements, sight views, noise levels, and avian activity, ESS concluded that there are no significant concerns associated with this endeavor.

The Falmouth Town Counsel confirmed that Woods Hole is exempt from the zoning bylaws and permitting requirements that pertain to windmills because of their standing as a nonprofit educational corporation.[20] WHRC would, however, be obligated to meet the height, lot area, and distance from the property line restrictions, per Falmouth Zoning Bylaws Section 240-166. When the Center erects the turbine, they will be required to file a Notice of Proposed Construction or Alteration form with the FAA Regional Air Traffic Division office (FAA Form 7460-1).

Initial tests conducted by the ESS Group confirmed that the noise from the turbine would not be audible above the 40 dBA threshold defined by the Town of Falmouth. WHRC will pay particular attention to noise impact and public opinion issues, as it is important that they avoid negative connotations associated with wind power in support of their goal to promote renewable energy technologies on a broad scale.

When evaluating a site for a wind turbine, birds that are known to breed, pass through, or migrate over the area require careful consideration. To determine the potential avian impacts, ESS Group reviewed literature, researched regulatory requirements, and corresponded with the United States Fish and Wildlife Service (USFWS), Massachusetts Division of Fish and Wildlife (MDFW), State Ornithologist, and the Natural Heritage & Endangered Species Program (NHESP). MDFW responded that they, in general, have concerns about the potential for tall wind turbines to cause avian mortality during night-time migrations; they also referenced songbirds that are known to migrate in the Falmouth area. After reviewing the information collected, ESS concluded that the proposed turbine "should have no significant

[20] ESS Group, Inc., May 8, 2003, correspondence from Frank K. Duffy, Jr., Falmouth Town Counsel

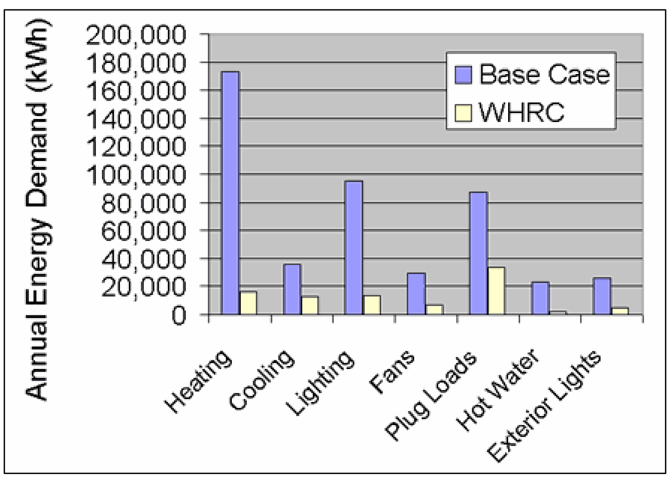
impact to avian species."[21] The proposed turbine's tubular shape will reduce the likelihood of birds perching there and its slow moving blades will be easier for them to take notice of. The height of the proposed turbine is 170 feet to the tip of the rotor, which is below the usual flight altitude of migratory species. The tower will also not have lights, which can attract birds, since it is under the 200 feet limit where lights are required by the FAA. Additionally, the potential threat of collision is reduced by the fact that guy wires will not be used.

4.7. Commissioning

Woods Hole hired Shooshanian (SEi Companies) to commission the mechanical and electrical systems. The commissioners were involved in the building design process to ensure that systems were designed, integrated, and implemented properly in a way that would maximize their performance. The company fulfilled their obligation following a process based upon ASHRAE Guideline 1-1996 "The HVAC Commissioning Process" and the "Model Commissioning Plan and Guide Specifications." Shooshanian's involvement included a review of the design goals, input on equipment location, and observation of the installation and startup of the heat pumps, chillers, pumping systems and PV array. Commissioners Art Adler and Mark Warren worked closely with the contractors and some of the manufacturers while they reviewed the design documents and developed test procedures for various systems. They also completed functional performance tests, reviewed the operation and maintenance manuals, and submitted a final commissioning report. Additionally, Shooshanian compiled documents on how to operate the building as a whole (including sequences of operations, descriptions, and set points) in a greater level of detail than what is provided in the systems' documentation. In this process, the commissioners become experts on the facility and the capacity of the building's systems and can serve as a valuable resource if something goes wrong in the future.

4.8. Energy Usage

Figure 2: Predicted Energy Use Compared to Average Building



Predicted energy demands are significantly less than the average demand of newly constructed buildings in Massachusetts. Source: www.whrc.org/building/renewables2.htm

A "Base Case Model" was created following Massachusetts' energy conservation requirements for new building construction, which was derived from ASHRAE/IES 90.1 – 1989 – *Energy Efficient Design of New Buildings Except Low-Rise Residential Building*. This comparable building would use an estimated 473,296kWH per year.[22] Energy-10 software V1.0 (Passive Solar Industries Council, 1996) was used to model energy scenarios to determine how usage and peak demand requirements would be affected with different energy strategies and systems. The model closest to the selected approach to efficiency estimated an annual demand of approximately 90,000kWh per year.

[21] ESS Group, Inc. (2003), Wind Turbine Installation Environmental Assessment, Woods Hole Research Center, Page 13.
[22] The Gilman Ordway Campus, Green Buildings Design and Construction Assistance, Solicitation No. 2002-GB-02. April, 2002. Page 4.

Figure 2 demonstrates the significant decreases expected to be accomplished with the sustainable building approaches incorporated in the design. Energy efficiencies to be gained in the areas of heating and lighting are especially impressive.

After occupying the building for nearly a year, the Woods Hole Research Center reported that "the facility fully meets our expectations."[23] Joe Hackler, the organization's building project manager, states that from a design perspective the building "functions wonderfully for the people here."[24] Hackler emphasized that the low energy use is impressive, and although it requires knowledge of how to run its systems, the building easily lends itself to manual and automated operation mode. For the most part, the building is run by an automated energy management system; a facilities person dedicates approximately one-third of his time managing the systems.

As highlighted in Table 2, actual energy usage was 80 percent lower than the ASHRAE/IE Base Case. For the year March 2004-February 2005, the Gilman Ordway Campus's energy demand was 94,280kWh.[25] Modeling predictions were calculated for a smaller building (16,000 square feet) with a different footprint and fewer windows. This would account for, in part, the difference in predicted and actual energy supplied by the grid and PV system. The photovoltaic panels provided 31 percent or 29,280kWh of the energy used; the remaining 65,000kWh consumed was supplied by the grid. The proposed wind turbine (100kW) is expected to be able to provide 60,000 to 127,000 kWh annually.[26] The addition of a wind turbine is likely to allow WHRC to meet their "zero net energy" goal.

Table 2: Gilman Ordway Campus's Energy Use, Actual Compared to Predicted

SOURCE	**Base Case** ASHRA/IES 90.1		**Modeling*** Energy-10		**March 04- Feb 05** Actual	
Grid	473,296	100%	53,000	59%	65,000	69%
Photovoltaics	0	0%	37,000	41%	29,280	31%
Total (kWh)	473,296	100%	90,000	100%	94,280	100%

*Median of Energy-10 V1.0 modeling predictions.
Subsequent design changes resulted in smaller footprint, increased floor area.

Source: Base Case and Modeling data: The Gilman Ordway Campus. Green Buildings Design and Construction Assistance, Solicitation No. 2002-GB-02. April, 2002. Page 4-5.

In addition to the low energy usage, the energy intensity (electrical usage/square meter) is also significantly lower than the national average. Energy intensity during this period was 51.7kWh/m2/yr, which is approximately 20 percent of the typical U.S. office building.[27]

[23] Woods Hole Research Center. "Construction Assistance Photovoltaic System and Energy Monitoring System" (2004), Page 1
[24] Hackler, Joe, Interview, February 2005
[25] Hackler, Joe, Personal communication, April 26, 2005
[26] The Gilman Ordway Campus. Green Buildings Design and Construction Assistance, Solicitation No. 2002-GB-02. March 12, 2003. Page 4
[27] Based on EIA, Commercial Building Energy Consumption and Expenditures 1999, August 2002, Table C8. Joe Hackler, Michael Ernst, Toward a Zero Net Energy Office Facility in the Northeastern U.S., Page 4

4.8.1.   Excess to the Grid

Excess energy generated by the photovoltaic panels is exported to the electric grid; this was equivalent to 7,715kWh for the eleven months April 2004-February 2005. Under a net metering arrangement with NSTAR and per 220 Code of Massachusetts Regulation, Section 11.04(7)(C), Woods Hole is able to receive a credit on their utility bill for net energy generated, which is calculated using the average monthly market rate ($0.14/kWhr). The net metering arrangement is limited to systems whose generating capacity does not exceed 60kW; therefore, Woods Hole will need to renegotiate the terms when the wind turbine is operational.

As part of Massachusetts' Renewable Portfolio Standard (RPS) that came into effect in 2002, utilities must secure a percentage of their energy from renewable sources. In turn, utility companies purchase this power from customers and small generators. Woods Hole will not participate in this market until they generate more than 100 percent of their power, as they want to first meet their own needs with the renewable energy.

4.9.   Emissions

As demonstrated in Figure 3, the Gilman Ordway Campus's atmospheric burden of pollutants is also a significant 79% lower than the national average for an office building of a similar size, as a result of maximizing their energy efficiency and not burning fossil fuels onsite.[28] This calculation is based on the ISO New England 2002 NEPOOL Marginal Emission Rate Analysis (www.iso-ne.com).

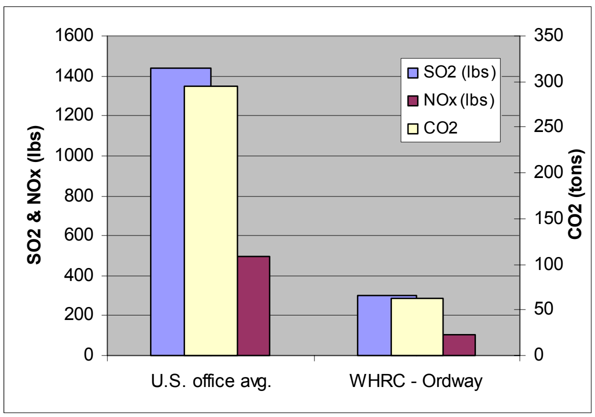


Figure 3: Gilman Ordway Campus's Emissions Levels

Emissions associated with the Gilman Ordway Campus are 21% of the national office average for a building of the same size.
Source: Joe Hackler, personal communication, April 26, 2005.

4.10.   Monitoring and Display System

"Because the Research Center's Ordway Campus incorporates so many different efficiency and renewable (clean) energy collection strategies, Center staff decided to display the energy flows through the building in a series of web pages designed to provide a full overview of the building's energy performance."[29] Northern Power's SmartView ™ application is used to collect, synthesize, and log data collected from 72 sensors attached to all of the major pieces of mechanical and electrical equipment and to outdoor environmental monitors. "Data are collected at one-second intervals, averaged to 1-minute intervals, and stored permanently in 5-minute intervals. Calculations for the display system and permanent database are performed at each of these intervals."[30] The tool provides real-time and cumulative data on the building's energy consumption, production, and conservation. Trend data is available from the time the web-based monitoring system went live in May 2004.

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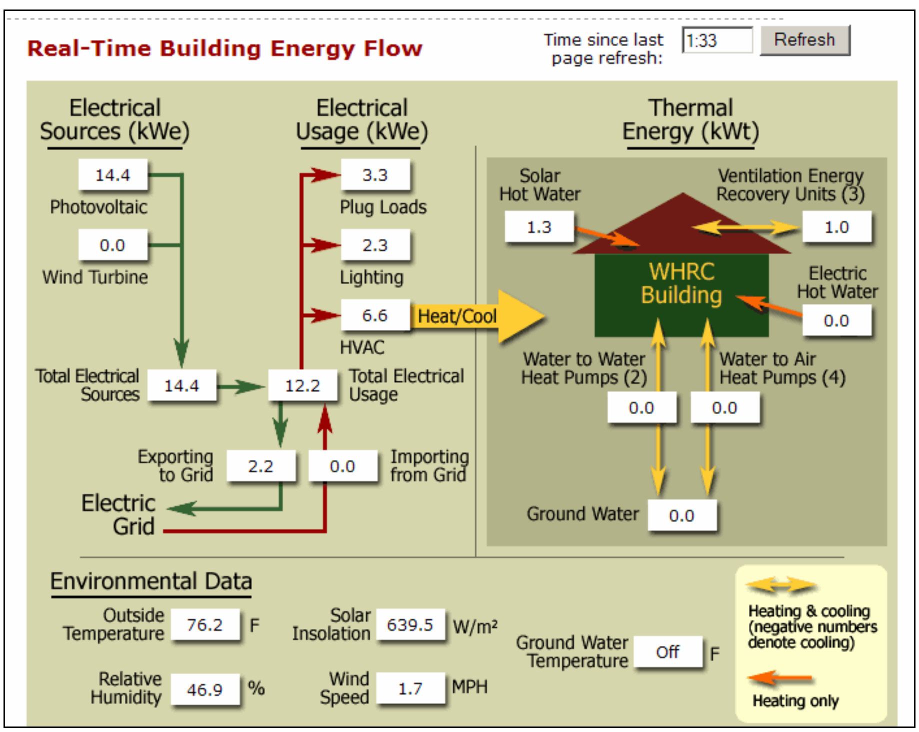
[28] Hackler, Joe, and Michael Ernst, (2005), "Toward a Zero Net Energy Office Facility in the Northeastern U.S.," Page 4
[29] From Photovoltaics to Solar Thermal Collectors: Evaluating and Improving Innovative Green Design, 2005
[30] Hackler, Joseph, and Michael Ernst, (2005), "Toward a Zero Net Energy Office Facility in the Northeastern U.S."

The monitoring application, which was partially funded by an MTC grant of $63,450 (75% of expected cost), has proved to be a valuable instrument for the Woods Hole Research Center. It acts as a diagnostic flag when an energy system is not performing as it usually does, thus it provides data that enables continuous commissioning and prompt response to possible problems. It also reveals areas where potential efficiencies are not maximized, or where demand is not being satisfied by renewable sources, which are opportunities for further savings. The tool may ultimately be used to calculate payback periods of the technologies used.

The system performance data are made available on a publicly accessible website for educational and research purposes (www.whrc.org/building/education/performance.htm). This data can be used by the public to assess the performance and efficiency of renewable energy sources and to demonstrate how renewable energies can meet a facility's power needs. The website offers two real-time snapshots and two interactive charts:

- "Energy Flow" provides details on the energy being provided from the PV panels compared to the load demands (plugs, lighting, and the HVAC systems), and the total energy imported from or exported to the grid. Energy provided by a future wind turbine will also be displayed here. Additionally, the webpage displays the thermal energy and current environmental conditions that influence the production of renewable energy.
- "System Details" demonstrates the real-time performance of the HVAC systems along with data on the outputs of the PV, wind (to come) and solar thermal energy sources.
- "Performance Trends" charts the cumulative outputs of energy sources and demands from usages along with environmental conditions for any range of time.
- "Meteorological Trends" generates reports on weather conditions to better understand the conditions under which the renewable technologies were performing.



The real-time energy flow – energy sources and electrical usage, along with environmental conditions – solar and temperature, are accessible over the Internet.

Source: www.whrc.org/building/education/performance.htm

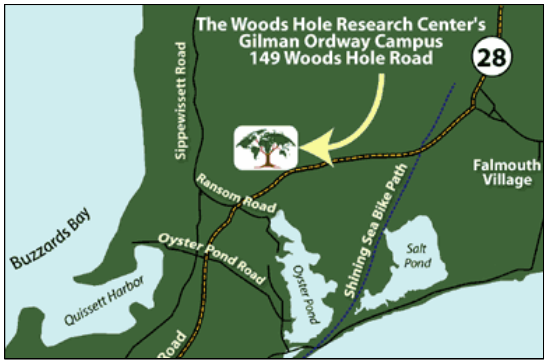
5. Water

Landscape and septic decisions were influenced by a commitment to protect nearby Oyster Pond and the local watershed.

5.1. *Water Protection*

The low flow dishwasher and showers help minimize water consumption and the generation of waste-water. WHRC did not explore alternatives to reuse their greywater because the organization does not use a significant amount of water with a typical occupancy of only 30-35 people who primary conduct research.

In addition to site grading and impervious surface disconnection, a bioswale filters storm water from the driveway and parking area and directs it into a wetland that was constructed to act as a basin to further treat the water.



WHRC strives to protect nearby Oyster Pond
Source: www.whrc.org/about_us/contact_info.htm

5.2. *Denitrifying Septic System*

WHRC uses a RUCK® sand filtration denitrifying septic system to manage the facility's sewage and avoid further burdening the town's wastewater system. Compared to the traditional septic system, this type of treatment provides an additional filtration to effluent and increases the amount of nitrogen removed to further protect local ground water.

A septic tank holds wastewater, where scum rises to the top, solids sink to the bottom, and the middle layer of water is allowed to flow out. This water contains bacteria, nitrogen, phosphorous and other chemicals.

With the denitrifying septic system, black water (from toilets and sinks) and gray water (all other sources) flow separately; effluent from the black water septic tank is sent through a sand filter, and then pumped into the gray water septic tank, where denitrification takes place in this anaerobic environment, and the effluent then passes through a leach field. This process minimizes nitrogen runoff from the wastewater. The effectiveness of this type of process is still being monitored and it may not be approved for use in all states. Some maintenance is required to ensure that sand filters do not become clogged and that sludge and solids do not accumulate in the septic tanks.

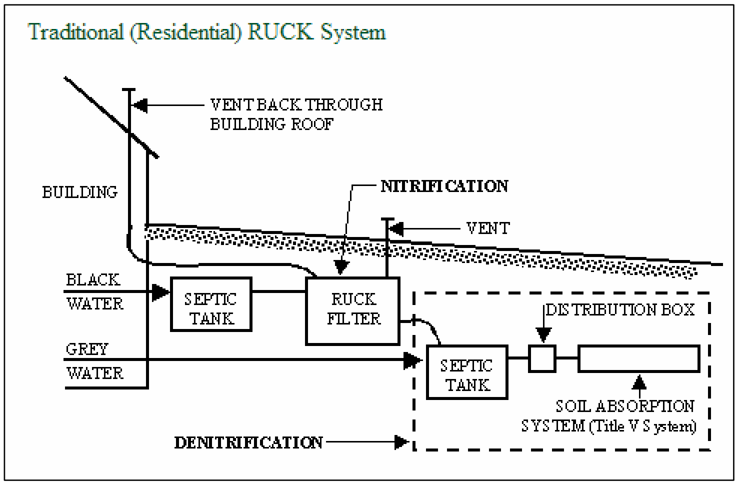


Figure 4: Traditional (Residential) RUCK System

Source: **www.irucks.com**

Zoning codes prevented WHRC from fully taking advantage of water conservation opportunities. The state's highly regulated septic system laws required the system to be sized to be able to continuously support the maximum capacity of the auditorium (100 people). However, the Gilman Ordway Campus averages fewer than 50 occupants per day (including visitors), and the auditorium is typically used once per month. Despite this explanation, the Massachusetts Department of Environmental Protection was not flexible on the requirement. Initially, the over-sizing of the septic system caused it to operate inefficiently; its performance has since been improved after some minor adjustments. Woods Hole soil scientists routinely test the organic carbon levels to confirm that the nitrification and denitrification processes are at expected levels and to document data that will help with the continued development of this system.

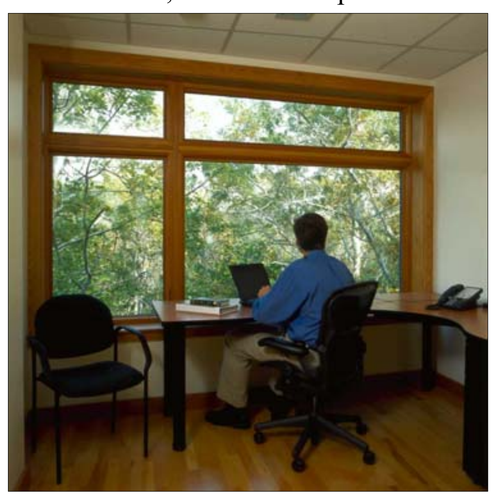
6. Build-out Materials

Continuing the focus on sustainable building practices, Woods Hole decided to reuse furniture from their previous office where possible and to obtain "green" furniture where additional pieces were needed.

6.1. Office Furnishings

Eco-friendly furniture was not easily located and was often more expensive. The Woods Hole employees that were organized to purchase furnishings were unable to locate green furniture standards and found that manufacturers were reluctant to clearly identify the sustainable features of their furniture. Maximum use of recycled materials, minimal use of toxic finishes and adhesives, and sustainably harvested wood were the criteria used to select green office furnishings. Additional green features of selected furniture include 100 percent recyclable steel, water-based stains and adhesives, powder coating for metal parts, and chair seat shells made from two-liter soda bottles and upholstered in Terratex fabric, which is 100 percent recycled polyester and is recyclable.

Watson Furniture Group's desk units offered the highest recycled content, the most benign finishes and adhesives, superior ergonomics, and minimized packaging. Herman Miller was a manufacturer of preference because of their "Design for the Environment" practices and Cradle to Cradle Design Protocol. Most of the furniture was obtained through Creative Office Pavilion of Boston; additional pieces were secured from Olive Designs and SitOnIt.



Typical office with Watson desking, Aeron task chair & SitOnIt sidechair.
Photo credit: Judith Watts Wilson

7. Occupant Comfort

"Research suggests that a well-designed workplace can increase employee productivity by 20 percent."[31] The wellbeing of the Center's staff was important to the organization, who wanted to prove that green buildings are also comfortable environments.

Agents of Change is a project hosted by the University of Oregon that brings faculty and teaching assistants from accredited architecture programs from around the country together to investigate buildings, conduct post-occupancy surveys, and develop exercises that they can use at their universities. In October 2004, *Agents of Change* students used the Woods Hole Gilman Ordway Campus as their laboratory and tested many aspects of the building, including noise, thermal comfort, indoor air quality, and lighting. Some of their findings are referenced below; additional details can be found at http://aoc.uoregon.edu/documents/1004teams.shtml.

7.1. Thermal

Tenants can control the temperature of their office with their own thermostats, operable fans, and windows. The building is set on a hill and receives a sufficient breeze to keep the building comfortable in the summer months, which minimizes the need to turn on the air conditioning. In the winter, additional warmth generated by the passive solar gain that is a result of the location of the building addition. An east-west axis, called passive solar orientation, is beneficial because it takes advantage of the sun's natural pattern in the northern hemisphere. Passive solar orientation maximizes the number and area of south-facing windows, which receive the most sunlight and warmth because the sun faces that area for the longest period of time. This is especially important in winter when days are shorter and additional heating is needed.

The *Agents of Change* team measured the temperature of the building and found that it was consistent from floor to floor and within a standardized comfort level. The students conducted a survey and found that over half of the building occupants were comfortable with the room temperatures during all types of weather.[32] (See Table 3 for results.)

Table 3: Survey of Occupant's Thermal Comfort

19 Occupants Surveyed	Cold	Just Right	Hot
Occupant thermal comfort during cold weather	7 (37%)	10 (53%)	2 (10%)
Occupant thermal comfort during warm weather	2 (11%)	13 (68%)	4 (21%)

Source: Agents for Change, http://aoc.uoregon.edu/documents/presentation_1004/whrcTeamB.pdf

After the facility was occupied, a few thermal-related concerns became apparent. The facility's computer server room, located on the ground floor, was not sufficiently cooled or ventilated and suffered from over-heating.[33] A fan has been added to circulate the air and protect the equipment from over-heating. A significant expansion of the institution's computing capability is currently underway, which

[31] Design Approach. Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy
[32] *Agents of Change* 2004, Groups A, B
[33] From Photovoltaics to Solar Thermal Collectors: Evaluating and Improving Innovative Green Design, (2005), www.whrc.org/pressroom/press_releases/PR-2005-05-02-building.htm.

will necessitate active cooling during the non-heating months. During the heating season the heat from the server room offset the buildings heat load. Additionally, there is now an awareness of the extra persistent energy that is required to support the 52 individual thermostats that are located in individual offices.

7.2. Indoor Air Quality

Indoor air quality at the facility is optimized by allowing for the input of fresh air through a ventilation system and operable windows. A temperature and humidity monitoring system and a zoned ventilation hood in the laboratory further enhance indoor air quality. Offices receive 20 cubic feet/minute of preconditioned 100 percent fresh air via roof dedicated ventilation; slightly less is delivered to the common areas. Additionally, fresh air is drawn into the bathrooms on a continuous basis during business hours.[34] Tests found that when windows are opened, fresh air enters through the basement and used air leaves through the upper level windows.[35] This flow enhances the air quality.

WHRC decided it was not necessary to install a CO_2 monitor since the office does not have a dense occupancy. However, the *Agents of Change* students found that the CO_2 levels drop overnight when no one is in the building, but become elevated to above the recommended 1,000 ppm when the building is occupied and windows are closed.[36]

7.3. Lighting

Natural daylighting was optimized in the new facility with skylights, large windows and the placement of offices on the periphery of the building. Translucent window shades reduce glare and allow occupants to enjoy the views. Lighting is user-controlled and task lighting is provided in the offices to give occupants individual control.

A survey of occupants determined that many do not use overhead lights due to the large amount of daylight they receive. It also confirmed that all occupants surveyed were satisfied with their office's lighting situation even though their light level was less than the regulated standard.[37]

8. Financial

The U.S. Department of Energy offers a guideline of a 10 percent increase in cost for a high-performance building.[38] The energy efficiencies gained are expected to offset the increased investment. The WHRC organization estimates that greening their headquarters and incorporating the sustainable features increased the building's total cost by 25 percent, but they believe the investment was worthwhile because of the decreased operational costs (e.g., energy, water) and the natural resources protected.[39]

8.1. Expenses

The total cost of the Woods Hole Research Center's Gilman Ordway Campus was $7.8 million.[40] Most of the significant expenses, excluding the cost of the land and summer home, are outlined in Table 4 (in some cases exact figures were not made available). The organization would like to begin using the

[34] *Agents of Change* 2004, Groups A, B
[35]ibid
[36] *Agents of Change*, Groups A, B.
[37] *Agents of Change* 2004, Group D
[38] Design Approach. Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy.
[39] Hackler, Joseph, and Michael Ernst, (2003), "Living a Sustainable Mission," *Environmental Design + Construction*
[40] ibid

monitoring system to calculate the performance/cost effectiveness of the technologies to calculate energy savings and payback periods of their systems.

Table 4: Expenses for Gilman Ordway Campus

Expense (*estimated)	**Source**
$6,000,000*	Construction[41]
$ 10,000*	Domestic solar hot water system[42]
$ 213,944	Photovoltaic panels[43]
$ 3,784	PV Commissioning[44]
$ 74,520	Monitoring system[45]
$ 60,000*	Ground source heat pump[46]
$ 9,000*	Denitrifying septic system[47]
$ 32,315	Building commissioning
$ 60,000*	Turbine environmental assessment, professional fees, electrical engineering study[48]
Unknown	Existing building, land, landscaping, green furniture, other
$7,976,491	**Total Project Cost[49] ($6,200,000 without land)[50]**
$ 500,000*	Planned wind turbine (site design, turbine, installation, permitting, connection, legal and professional fees)[51]

[41] Hackler, Joe, Interview, November 22, 2004.
[42] Hackler, Joe, Personal communication, September 1, 2005
[43] Melo, Beth E. Renewable Energy Trust. Communication to Robert Barry, attachment. May 27, 2004 Massachusetts Technology Collaborative Green Buildings Construction Budget Tracker
[44] Ibid
[45] Ibid
[46] Hackler, Joe, Interview, November 22, 2004.
[47] Montgomery, Tad, (1990), "On-Site Wastewater Treatment Systems: A Brief Description of Ecological, Economic and Regulatory Factors"
[48] The Gilman Ordway Campus. Green Buildings Design and Construction Assistance, Solicitation No. 2002-GB-02. March 12, 2003. Attachment B
[49] The Gilman Ordway Campus. Green Buildings Design and Construction Assistance, Solicitation No. 2002-GB-02. March 12, 2003. Applicant Information
[50] The American Institute of Architects (2004). *Gilman Ordway Building at the Woods Hole Research Center (Woods Hole Research Center)* Green Project Awards, Woods Hole Research Center, Finance & Cost, www.aiatopten.org/hpb/finance.cfm?ProjectID=257
[51] Woods Hole Research Center. Wind turbine design, permitting and interconnection. June, 2004. Page 2

8.2. *Fundraising and Grants*

Typically, over 50 percent of the Center's funding comes from government grants, and the rest is from foundations and private individuals. The Woods Hole Research Center conducted and "completed" a capital campaign with a goal to reach $10 million to help cover the cost of their new headquarters, energy systems, landscaping, green furniture, and laboratory equipment.[52] Known sources of funding, excluding individual donations, are listed in Table 5. Conservationist and WHRC board member Gilman Ordway contributed $1 million. The Kresge Foundation awarded a $500,000 challenge grant that required WHRC to broaden their normal donor base. The draw of McDonough and Partner's reputation and the significance of a sustainable building helped them collect more than $5,500,000 in campaign donations.

The Massachusetts Technology Collaborative Renewable Energy Trust, which promotes the adoption of clean energy technologies and the use of renewable energy sources (www.mtpc.org/renewableenergy/index.htm) awarded grants to Woods Hole to offset the expense of the photovoltaic panels, monitoring system, and wind turbine. Woods Hole also received two percent bond funding from Massachusetts Health and Educational Facilities Authority (HEFA).

Table 5: Funding Sources for Gilman Ordway Campus

Funds	Source
$1,000,000	Gilman Ordway Challenge Grant[53]
$ 500,000	Kresge Challenge Grant[54]
$ 162,858	MTC Grant for PV System, Commissioning[55]
$ 55,890	MTC Grant for Monitoring System[56]
$ 273,692	MTC Grant for Wind Turbine[57] (not fully allocated)
$5,500,000	Estimated Campaign Donations[58]
$10,000,000	**Capital Campaign Goal**[59]

[52] The Gilman Ordway Campus. Green Buildings Design and Construction Assistance, Solicitation No. 2002-GB-02. March 12, 2003. Page 2

[53] Environmental Writers (2003). *Woods Hole Research Center Lives Out Its Mission with New Headquarters*

[54] The Gilman Ordway Campus. Green Buildings Design and Construction Assistance, Solicitation No. 2002-GB-02. April, 2002. Page 3.

[55] Melo, Beth E., Renewable Energy Trust. Communication to Robert Barry, attachment. May 27, 2004. Massachusetts Technology Collaborative Green Buildings Construction Budget Tracker.

[56] Ibid

[57] The Gilman Ordway Campus. Green Buildings Design and Construction Assistance, Solicitation No. 2002-GB-02. March 12, 2003. Attachment B.

[58] Estimated based on information from The Gilman Ordway Campus. Green Buildings Design and Construction Assistance, Solicitation No. 2002-GB-02. March 12, 2003. Page 2

[59] The Gilman Ordway Campus. Green Buildings Design and Construction Assistance, Solicitation No. 2002-GB-02. March 12, 2003. Page 2.

9. LEED Certification

The LEED standard served as a reference tool during the design process; however, the Woods Hole Research Center decided not to pursue certification for the building. The design team was not comfortable with the U.S. Green Building Council's Leadership in Energy and Environmental Design's checklist approach and was disappointed that the standard would not properly measure or reflect the extent of their achievements or the quality of the investments made for energy efficiency, which was their primary focus. As an example, LEED awards points if up to fifteen percent of the energy used is from renewable sources, but no additional points are given for exceeding that threshold. The owners estimate that it would qualify for a Silver rating but believe that the building tells a strong enough story on its own. The amount of time the certification process requires and the related cost was another drawback to WHRC.

10. Education and Outreach

In keeping with their mission, Woods Hole sponsors many educational initiatives. On average, the Research Center conducts a building tour a week to interested groups. Tours are informal and are focused on the interests of the group. In 2004 they participated in the Northeast Sustainable Energy Association's Green Building Open House and hosted the *Agents of Change* conference in conjunction with the Society of Building Science Educators and the University of Oregon.

Press releases and news articles help to educate the public about the building itself and green buildings in general. A brochure about the building's major aspects is available at http://whrc.org/building/pdf/Building_Future_trifold.pdf. Additional articles include:

- "Green from the Ground Up," *Sierra Magazine,* January/February 2005 www.whrc.org/pressroom/news_items/Sites/SierraMagazine/ground.asp.htm;
- "The Earth Day 10," *Interiors and Sources,* July 2004 www.isdesignet.com/Magazine/2004/jul/earthday.html;
- "Living a Sustainable Mission," *Environmental Design + Construction,* November 1, 2003, www.edcmag.com/CDA/ArticleInformation/features/BNP__Features__Item/0,4120,111652,00.html;
- "Strategy of Hope on Cape," *The Providence Journal,* October 24, 2003 www.whrc.org/pressroom/news_items/2003-10-24-ProJo-Bldg-Will-Morgan.htm;
- "Sustainable Center for Woods Hole," *Architecture Week,* September 2003 www.architectureweek.com/2003/0910/environment_1-1.html;
- "Woods Hole Research Center Lives Out Its Mission with New Headquarters," *Environmental Writers*, July 24, 2003 press release www.ewire.com/display.cfm/Wire_ID/1690; and
- "PV System to Power Woods Hole Research Center," *Renewable Energy Access,* July 1, 2002 issue www.renewableenergyaccess.com/rea/news/story?id=6788.

The Woods Hole Research Center's Gilman Ordway Campus has earned the following awards and recognitions.

- AIA/COTE's 2004 Top Ten Green Projects (April 2004), www.aiatopten.org/hpb/overview.cfm?ProjectID=257
- First prize in the 2004 Northeast Green Building Award, "places of work (small buildings)" category (March 2004).

11. Key Contacts

Architect:		
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Commissioning Agent:		
Arthur Adler	Applied Energy Engineering & Commissioning - arthura@appliedenergy-ec.com	
Commissioner:		
Mark Warren	SEi Companies (Shooshanian)	www.seicompanies.com
Denitrifying Septic System:		
Michael McGrath	Innovative Ruck Systems	www.irucks.com/
Ground Source Heat Pump:		
Carl Orio, Carl Johnson	Water Energy Distributors	www.northeastgeo.com/who.html
Energy Consultant:		
Marc Rosenbaum PE	Energysmiths	www.Energysmiths.net
Renewable Energy Systems:		
Peter Matilla	Northern Power Systems	www.northernpower.com
Woods Hole Research Center:		
Joe Hackler	Gilman Ordway Campus	www.whrc.org

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