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Back to the Future: A Smart Energy District

Posted by Euan Mearns on August 1, 2011 - 11:10am
Topic: Alternative energy
Tags: alternative water supplies, cool district, district heating and cooling, energy efficient buildings, historic green village, smart energy district, smart network [list all tags]

This is a guest post by Raymond Kaiser, LEED AP, Director of Green Building Services for Stewart Engineering Consultants. Mr. Kaiser has considerable experience in renewable and sustainable energy strategies and technologies. He has provided energy and environmental consulting to State and local agencies, private developers and engineering firms for over 10 years.

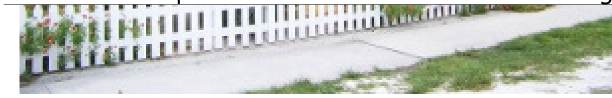
The Historic Green Village at Anna Maria

Background

Today's power industry is built around centralized generation, transmission and distribution of *electricity* utilizing primarily coal, natural gas and uranium as fuel sources. For several years, a new model for more distributed generation and delivery of energy services has been evolving, and a product of this evolution is the *Smart Energy District*. A *Smart Energy District* includes a range of alternative energy sources, energy efficiency measures, intelligent energy management of distributed resources and loads, and internet-based monitoring that provides real-time feedback on energy consumption. Implementing a new energy architecture across several buildings (i.e. a district) can reduce capital and operating costs, increase energy efficiency, and accelerate the transition to a renewable energy economy.

Surprisingly, the setting for this new distributed energy model is Anna Maria Island, a barrier island on the Gulf of Mexico that has retained the look and feel of Old Florida. It is a pedestrian and bicycle friendly community, with miles of sugar white sand and a relaxed, easygoing atmosphere.

Several years ago, a vacationing British couple, Lizzie and Mike Thrasher, were captivated by the natural beauty and slow pace of the island and decided to put down roots in the sandy soil. Amidst significant development pressures, they saw the opportunity to simultaneously preserve the historic charm of Anna Maria Island while demonstrating the feasibility of setting a new benchmark for environmental sustainability. They bought five lots on Pine Avenue, the modest commercial center of the City of Anna



Maria, on which two neglected historic buildings sat. The Thrashers then purchased two other historic buildings designated for demolition and moved them to the site as well. The result: the Anna Maria Island Historic Green Village.

The Village preserves the historic charm and scale of Old Florida while providing a portfolio of technologies that demonstrate the state-of-the-art in sustainable design and development. The Village generates more energy than it consumes, harvests rainwater and storm-water, and encourages a range of sustainable transportation choices. There is a free public charger for electric cars and golf carts. The City also offers free trolley service – 7 days a week, 16 hours a day-- that arrives every 20 minutes. Beach Bums, the store next door to the Village, rents bicycles, electric golf carts and Go Pets, a Segway-type personal transporter. All of the buildings are designed to meet LEED Platinum level - the highest level of certification from the US Green Building Council (USGBC). From the beginning, the owners have been committed to creating the first Net Zero Energy campus in the US, and with the opening of the Rosedale Café and Sears Cottage they have succeeded. The Smart Energy District was the means to achieve this objective.

Figure 1: *Artist's Rendering of Historic Green Village site*

The Smart Energy District

The Smart Energy District is not a single technology, but three distinct and still evolving design elements: Solar Technology, A Cool District and a Smart Network.

Solar Technology

The Historic Green Village has Solar PV panels on each building and on (planned) solar car ports, with a single point of common coupling to the utility. This micro-grid allows extra electricity being generated at one building to flow to its neighbor. When more electricity is generated across the entire site than is being consumed by the campus, the extra electricity is exported to the utility to supply adjacent properties on the Island. In addition to solar PV, the Café and (planned) residences have solar thermal panels that generate hot water. Currently, there are 233 solar PV panels with an installed nameplate capacity of 48 kilowatts to power the campus. We anticipate doubling the existing capacity to achieve Net Zero Energy as the next phase of the project is completed. During the first full month of operation (Phase 1), the PV system generated 6,972 kWh of electricity.

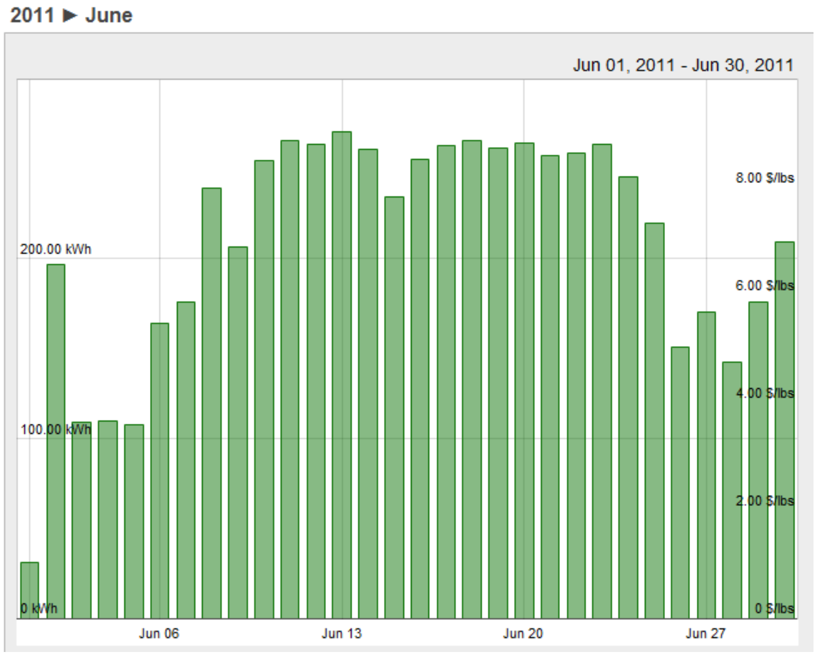


Figure 2: *PV Production – 30 days*

Technical Details

	Product	# of panels	PV Array kW	Estimated Annual PV Production kWh
Sears Cottage	[Suntech 190] watt panels	40	7.60	9,500
Rosedale Café	Suntech 190 watt panels	88	16.72	20,900
Warehouse	SolarWorld 230 watt panels	105	24.15	30,188
Sub Total Phase 1			48.47	60,588

Phase 2				
Thelma's By the Sea	Suntech 190 watt panels	35	6.65	8,978
Bldg F	Suntech 190 watt panels	68	12.92	17,442
Pillsbury House	Suntech 190 watt panels	68	12.92	17,442
Car Port	Suntech 190 watt panels	136	25.84	37,468
Sub Total Phase 2			58.33	81,330
Total Buildout			106.80	141,917

Note: All of the inverters are SMA Sunny Boy grid tie inverters.

A Cool District

At least half of a buildings' energy use is to ensure thermal comfort, i.e. for heating and cooling. The Historic Green Village has a geothermal heating and cooling system that takes advantage of the relatively constant temperature of the earth to maintain indoor thermal comfort. Geothermal heat pumps extract heat from the earth during the winter and use the earth as a heat sink when cooling is required. Strictly speaking, the heat does not originate from the earth's core, rather, the heat pumps harvest heat absorbed at the Earth's surface from the Sun. Engineers and scientists prefer to use the term "ground source heat pumps" (GSHPs) to avoid confusion with geothermal power which taps into the heat generated by the radioactive decay of the earth's core.

The EPA has stated that geothermal systems are the most energy-efficient and environmentally safe systems available. District heating and cooling is more economical since the costs – the wells, pump and heat exchanger – can be spread across several buildings.

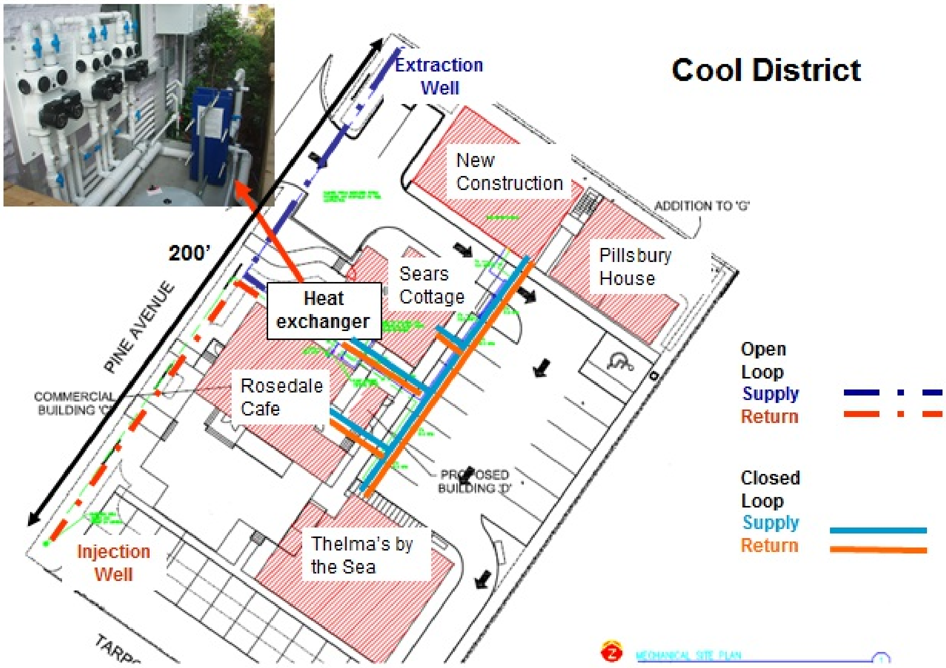


Figure 3: *Diagram of Historic Green Village Cool District*

Technical Details

Typically the ground temperature at 6 meters (20 feet) is equal to the mean annual average temperature at that latitude at the surface. At Anna Maria's 27° latitude the average year round temperature is 74° F. Given the anticipated mix of uses – retail, restaurant, office and residential – the thermal load for the HVAC system was sized for 250 square foot (sf) per ton. The Cool District at the HGV employs a vertical open loop between an extraction and injection well spaced far enough apart to allow thermal recharge (i.e. the rejected heat or cold dissipates in the aquifer without affecting the water temperature at the extraction well). There is a horizontal closed loop that provides the supply and return water from each building's GSHPs. The full buildout for the project is 10,000 sf or 40 tons of capacity. At 3 gallons per minute (gpm) per ton the wells need to supply 120 gpm. This required 400' wells. At that depth the water temperature was 80° F. We have added thermometers, flow meters and data loggers to measure the actual energy performance i.e. the Coefficient of Performance (COP) and the Energy Efficiency Ratio (EER). The well pump is a 5 hp variable frequency drive and the GSHPs are Bosch AP Series Water2Air Extreme Efficiency 4 ton, two-stage units (Rosedale has two). For more details on the geothermal cooling system please contact Tom Stockebrand at stocky(at)alumni (dot)Caltech(dot)edu.

A Smart Network

Each building has an e-Monitor from Powerhouse Dynamics that monitors and transmits real-time building energy use for lighting, heating and cooling, refrigeration, and various other "plug" loads, as well as the amount of renewable energy generated on-site. This data has been an invaluable tool in targeting how to effectively reduce energy demand. It highlights when equipment is unnecessarily left on after hours, or when a thermostat is improperly programmed.

Technical Details

To accumulate circuit level data there are currently four e-Monitors. One for each building, one measuring campus loads (the well and irrigation pumps, electric charging stations and landscape lighting) and one measuring all of the PV arrays. The data is remotely monitored by the equipment supplier Powerhouse Dynamics. We are working with the Center for Advanced Power

Systems (CAPS) to simulate the performance of the micro-grid and to develop an open systems application framework for dynamically managing diverse generating assets and loads. CAPS is a multi-disciplinary research center at Florida State University in Tallahassee Florida. With support from the U.S. Navy, Office of Naval Research (ONR) and the U.S. Department of Energy, CAPS has established a unique test and demonstration facility with one of the largest real-time digital power systems simulators along with 5 MW AC and DC test beds for hardware in the loop simulation. The center is supported by a research team comprised of dedicated and highly skilled researchers, scientists, faculty, engineers, and students, recruited from across the globe, with strong representation from both the academic/research community and industry. The March 2011 issue of the American Society of Naval Engineers Journal recognized CAPS as "The Only Facility of its Kind in the World." For more detailed inquiries of the modeling of the micro-grid please contact Rick Meeker at meeker(at)caps(dot)fsu(dot)edu.

Energy Efficient Buildings

The most cost-effective means to creating a Net Zero Energy campus is to ensure that the buildings and equipment meet the highest energy efficiency standards. In a typical office, heating, cooling, and lighting comprise about 90% of the energy usage. In Florida's hot, humid climate, an energy-saving strategy seeks to maximize natural daylight while minimizing excessive solar heat gain. The existing street and building layouts follow the natural topography of the Island, so aside from generous landscaping to provide shade, we had little opportunity to incorporate passive solar design elements and orientation into the project.

Figure 4: *Historic Green Village Net Zero Energy Campus*

High Performance Envelope

Our initial design focus for energy savings was to create a well-insulated building envelope: the roof, walls and windows, which rejects heat and lets in natural light. Each building has an EPA Cool Roof: a roof that reflects sunlight and emits heat. The insulation for the roof and walls exceed State code (R-30 vs. R-19 for the roof; and R-19 vs. R13 for the walls). More than half the energy (heat) in sunlight is in the infrared portion of the solar spectrum. Spectrally selective windows, specifically developed for hot climates, reflect the invisible infrared radiation. The result is a major reduction of the solar heat gain through the window without significant loss of visible light transmitted through the glass. Cooling represents 40% of commercial energy use in Florida. As previously mentioned, the heating and cooling is provided by geothermal water source heat pumps. Such systems are generally 30-50% more efficient than conventional HVAC equipment. As previously mentioned, we will be measuring the actual COP and the EER over time.

Lighting

Lighting generally accounts for 20% of energy use in commercial buildings. In retail establishments it's often almost twice as high, since lighting allows merchandise to stand out. All of the lighting fixtures at the Historic Green Village use LED lamps. These lamps use 80% less energy than the typical MR16 halogen lamp that is typically used in a retail environment. In the Café, lighting accounts for less than 4% of electricity consumed.

Other Plug Loads

Electrical devices such as TVs, computers, printers, copiers and refrigerators not only use energy but also generate heat, thus increasing cooling costs. These "plug" loads represent about 6% of the electrical use in a typical office setting. The Café has a much higher density of electrical devices energy, including espresso and coffee machines, as well as a freezer, display refrigerator and ice maker. The eMonitor has provided insight into the demand profile of these devices. We learned that the espresso machine would heat up at 3 a.m. in the morning, so we added an automatic shut-off timer. The display refrigerator was the second largest energy consumer to the HVAC equipment, so we ordered a thermal blanket to keep in the cold (and reduce the heat generated) on off-hours. This reduced the refrigerator's electricity demand by 15 to 20%.

During the first full month of operation, the total load (electric demand) was 7,812 kWh. FPL delivered 3780 kWh and the Village exported 2,940 kWh. So in June we are 840 kWh short for our first full month of operations. On an on-going basis we will make operational adjustments (e.g. changing set points) and add additional PV capacity as needed to attain our objective of Net Zero Energy.

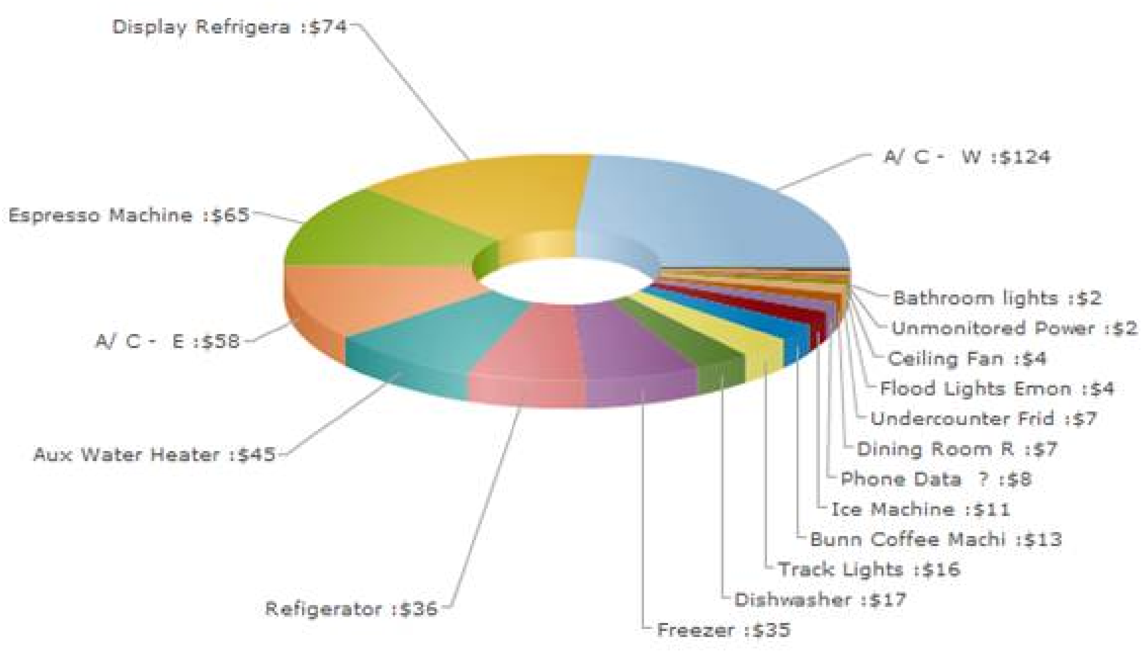


Figure 5: *Rosedale Café – 30 days demand by circuit*

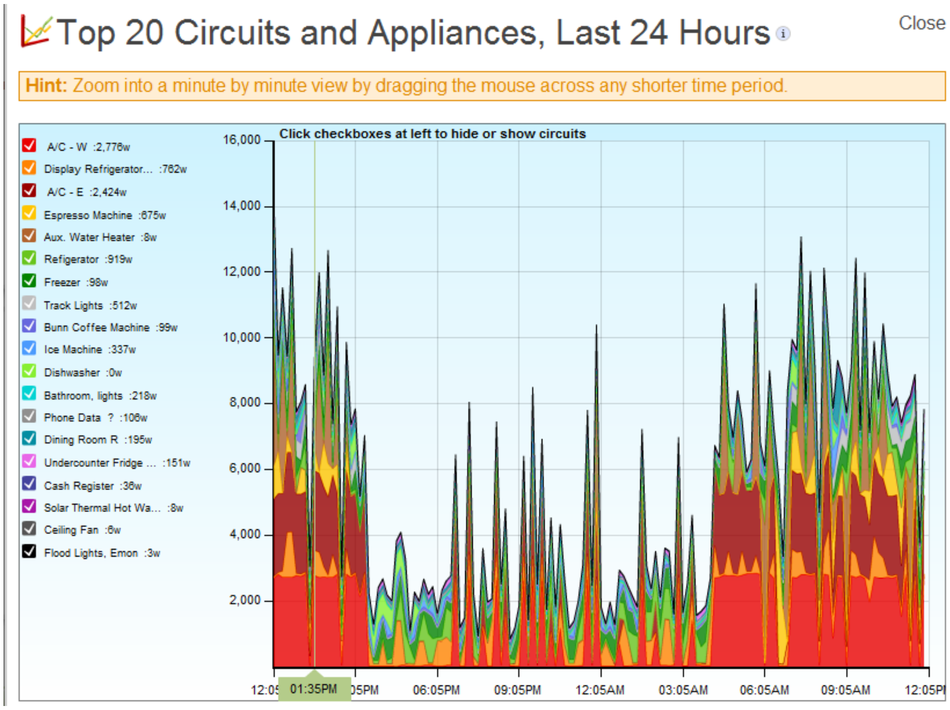


Figure 6: *Rosedale Café – Minute by minute demand by circuit*

Integrated Water Management

Florida is blessed with an abundance of rain – over 54” per year. But Florida’s population growth combined with the seasonality (rainy and dry seasons) and periodicity (wet and dry years) means that we are most often pumping out groundwater faster than our aquifers can be replenished. The Historic Green Village has an integrated water management approach based on demand management i.e. use less water; and developing alternative non-potable supplies, rainwater, storm-water and greywater.

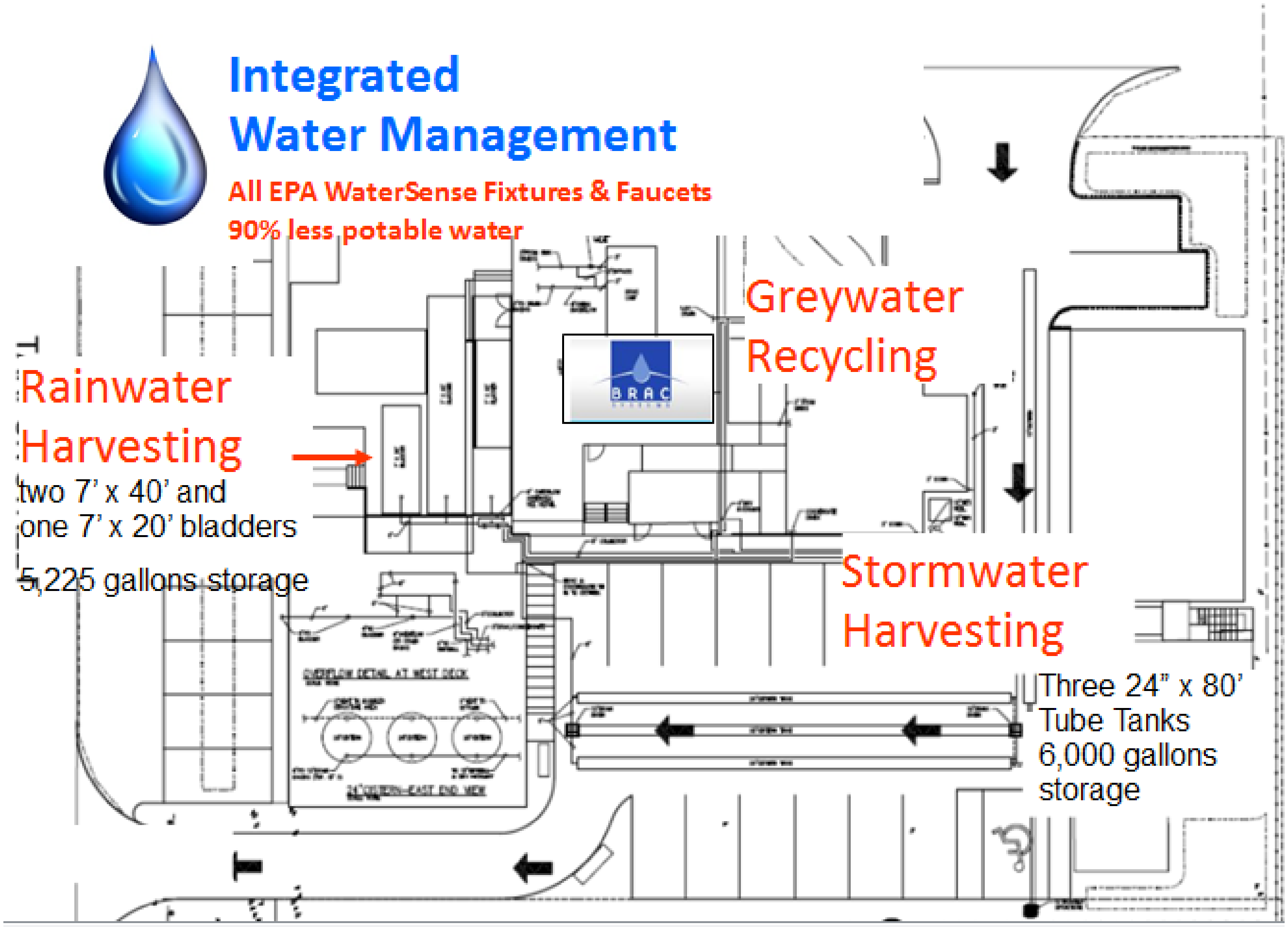


Figure 7: *Historic Green Village Integrated Water Management system*

WaterSense Appliances

All water fixtures-- toilets, urinals, showerheads and faucets-- are EPA WaterSense-compliant, meaning they use at least 20% less water than a standard fixture. The urinals do not require any water. Total overall water demand is 35% less than standard fixtures.

Florida-friendly Landscaping

The lush native maritime landscaping at the Village is naturally adapted to the sandy soils, and will produce a root system capable of reaching the ground water table year-round. A representative sample of the native trees, shrubs, wildflowers and ground cover selected and installed include Railroad Vine, Muhly Grass, Knotgrass, Sea Purslane and Coontie. Once established, these native plants will not require irrigation.

Alternative Water Supplies

There are three separate and interconnected alternative water supplies at the Village: Rainwater Harvesting, Storm-water Harvesting and Greywater Recycling.

Historically, barrier island residents relied on rainwater and cisterns to supply their potable water needs. Rainwater is one of the purest sources of water available. It almost always exceeds the quality of groundwater and surface waters, since it does not contain dissolved salts, minerals and other groundwater contaminants. The Rainwater Harvesting system collects water from roof gutters and funnels the water to underground bladders. It is used to supply the toilets. Excess water is directed to the storm-water cisterns. The Stormwater Harvesting system collects water from site runoff and is stored in underground plastic tubes. The system provides water storage for the local fire department (a dry hydrant) and is used for irrigation. The Greywater System pipes water from the showers and sinks to the underground cisterns once it is filtered and chlorinated. This range of technologies has reduced potable water demand for the campus by over 90%.

Technical Details

The rainwater collected from roof gutters and the condensate from the WSHPs is collected in three bladders (two 7' x 40' and one 7' x 20') under the patio deck outside the café. The total storage volume is 5,225 gallons (7.48 gallons per cubic foot). Overflow from the bladders is routed via a 6" pipe to the stormwater harvesting storage tanks. The stormwater tanks are three 24" 80' cistern storage tanks that collect site run-off from 18" drain basins. The Greywater Harvesting system is a Brac RGW-350 that treats sink and shower water and then is routed to the cisterns. For more detailed inquiries of the system please contact Skip VerMilyea at skip(at)stormwaterreuse(dot)com.

Costs

The renovation costs for the Sears Cottage was $211,000, or $193 per square foot; and for the Café, excluding furniture and fixtures, the cost was $285,000, or $158 per square foot. The Energy District budget is separate because the costs will be allocated to all five buildings on the HGV campus.The geothermal system (wells, pumps, and piping) costs $153,000. The power distribution and PV panels cost $250,000. The PV panels were $6 per watt installed (an existing 25 kw PV array was tied into the Village). Is it all worth it? Traditional return-on-investment metrics suggest not. Yet we undervalue so much – natural beauty, historic charm, walkable streets, the costs of mountaintop removal, altering the chemical composition of the atmosphere, and finally, the rich abundance and diversity of life itself.

As John F Kennedy, echoing an old proverb, said: *We are not here to curse the darkness, but to light... (a) candle that can guide us through that darkness to a safe and sane future."*