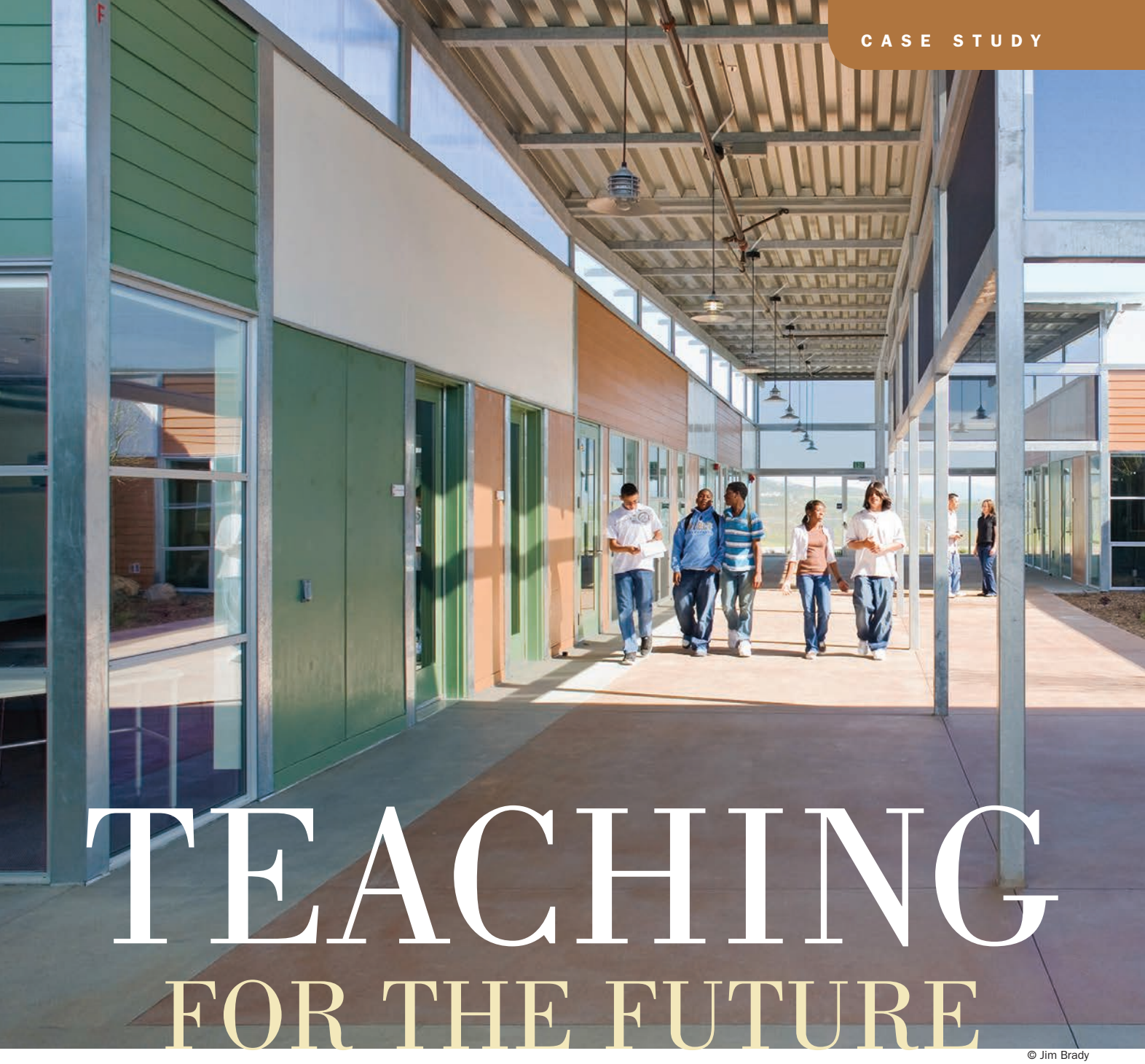


TEACHING FOR THE FUTURE

© Jim Brady

BY CHRISTOPHER GERBER, AIA AND ERIC NASLUND, FAIA

Located seven miles south of San Diego and seven miles north of Tijuana, Mexico, High Tech High Chula Vista serves one of the more culturally diverse zones in the U.S. The school is one of 11 High Tech High (HTH) public high, middle and elementary schools in San Diego County. All prepare students to work in high tech industries. The students for these schools are selected via a nonmeritocratic, ZIP-code based lottery.

© Jim Brady

Above **The school uses "exploratories" for specific teaching areas. These rooms are flexible and roll out onto outdoor work yards.**

Opposite **The modular portions of High Tech High Chula Vista are stitched together with site-built circulation and common spaces.**

Some 550 students in grades 9–12 attend High Tech High Chula Vista. The school is organized into neighborhoods that are linked to a gallery that spans the length of the school. The neighborhoods consist of adjacent seminar rooms, studio spaces and teachers' offices, designed to promote team teaching as well as a sense of ownership and place. Learning takes place in a variety of settings, including labs with yards for art and science instruction and a commons area for school meetings, instruction and presentations. The open-plan layout with movable walls supports a variety of room configurations and activities.

Students and faculty contribute to the school's ongoing sustainability by participating in carpooling, on-site recycling, composting and vermiculture. Extensive daylighting and a hybrid ventilation system contribute to an annual energy use of 23.8 kBtu/ft^2 and an ENERGY STAR rating of 94.

Energy-Efficient Design

The school's primary environmental goal involved reducing energy consumption while capturing energy available on site. Harvesting sunlight for daylighting and power, and shading walls and windows to reduce heat gain provides the most energy savings.

The project minimizes energy demand through compact planning, natural ventilation, daylighting and an efficient envelope and fixtures. In addition, the roof canopy acts as an umbrella and integrates a photovoltaic array, which exports electricity off site.

The compact plan has three interior courtyards, which break the building into smaller parts, providing fresh air and side lighting deep into the interior spaces, and adding instructional and work space. Large screened shade canopies allow for natural light and ventilation. Sunlight is the primary lighting source for all circulation and occupied areas. The building envelope includes diffuse clerestory lighting panels, exterior view glazing and skylights, which provide daylighting to 86% of the building.

Though all occupied areas have air conditioning for those extreme weather days, all classrooms have operable windows for natural ventilation. The school provides natural ventilation to 88% of spaces via operable windows and skylights.

Break-out spaces between classrooms and the hallways are passively conditioned. These areas are covered by the photovoltaic roof canopy and enclosed with an aluminum storefront system that has screen mesh

BUILDING AT A GLANCE

Building Name
High Tech High Chula Vista

Location Chula Vista, Calif.
(seven miles south of San Diego)

Owner High Tech High

Building Use Public Charter School
Includes grades 9–12

Employees/Occupants
36 Staff/550 students

Occupancy 100%

Gross Square Footage 44,370
Conditioned Space 32,284

Year construction started June 2008

Substantial Completion/Occupancy
January 2009

Total building cost $7,750,000
Cost per square foot $175

Distinctions/Awards
2010 LEED Gold

2010 Modular Building Institute Award of Distinction

2010 ENERGY STAR Rated (94)

2011 AIA Committee on the Environment Top Ten Green Projects Award

KEY SUSTAINABLE FEATURES

Water Conservation Reclaimed water supplied by the local water authority is used for 100% of outdoor irrigation. Both reclaimed and potable water are managed by the building management system to monitor and control use, which includes an active leak detection system to shut off affected areas and alert maintenance personnel. Low-water-use fixtures include waterless urinals, 0.5 gpm aerators on all faucets and dual-flush water closets.

Recycled Materials Recycled rubber flooring; bamboo/sorghum stalk wood paneling; recycled newsprint wall paneling; recycled rubber walk-off mats; recycled mineral fiber ceiling panels; and a comprehensive waste and recycling management plan for ongoing process improvement.

Daylighting Every classroom and 90% of all offices achieve a 2% daylight factor through optimal layout of skylights, translucent panel clerestories and vision glazing.

Individual Controls Robust building management system integrates individual thermostat controls in all occupied areas and lighting controls.

Passive Ventilation The core circulation areas (hallways/galleries/studios) are designed as passively ventilated spaces with high thermal mass floors, low thermal mass roofs, glass panels below 8 ft and screens above 8 ft. This moderates the temperature of these circulation areas, maintaining comfort on even the most extreme temperature days.

Transportation Mitigation On-site showers encourage staff to bicycle to work. A school-initiated carpool/rideshare program reduces vehicle pollution.

Construction Waste 83% was diverted from the landfill.

in the upper panels and glass in the lower panels. This allows heat to rise and escape and moderates the occupant-level temperatures.

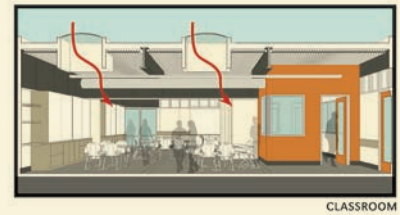
The building management system (BMS) integrates a weather station, which monitors and controls the lighting and mechanical systems and the irrigation and domestic water systems. This optimizes thermal comfort, indoor air quality, lighting levels and conserves energy and water.

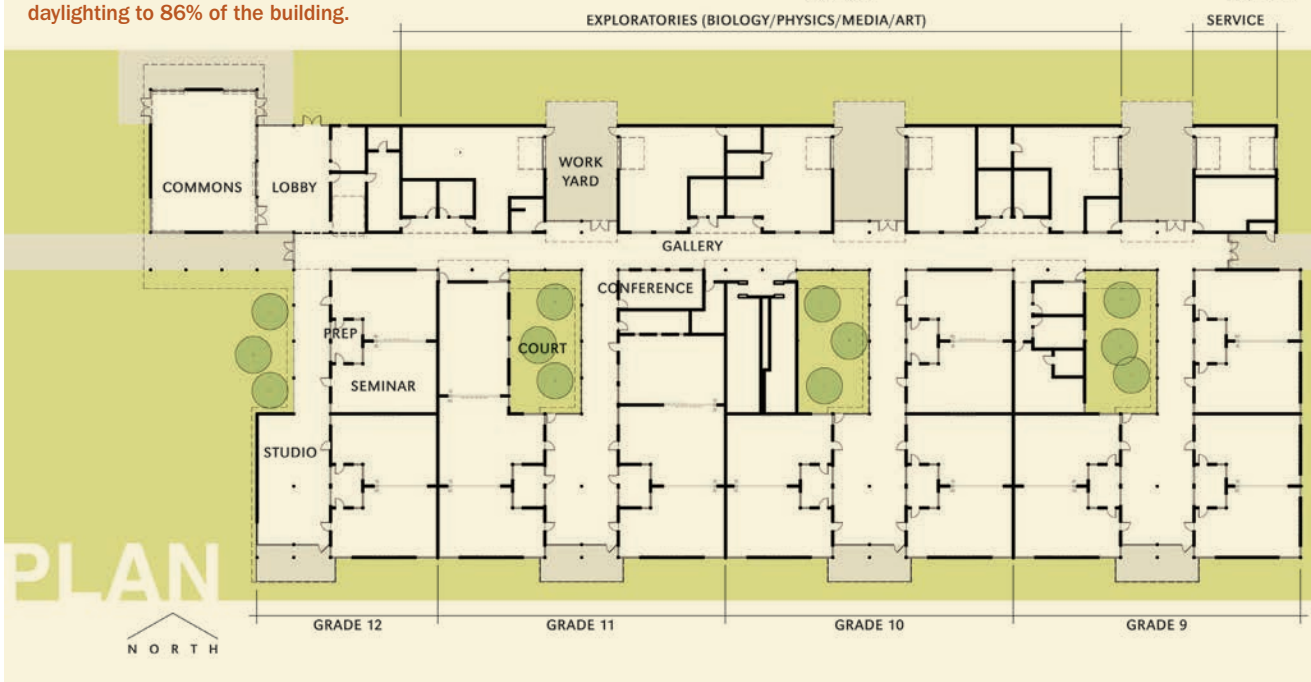
Bioclimatic Design

The site is 10 miles inland from the Pacific Ocean and has a semi-arid warm steppe climate. Temperatures can be 20 degrees cooler at night and 20 degrees warmer during the day than at the coast.

NATURAL VENTILATION AND DAYLIGHTING

While all occupied areas have air conditioning for extreme weather days, operable windows and venting skylights provide natural ventilation. A photovoltaic canopy prevents heat gain in the passively conditioned hallways and break-out areas. Diffuse clerestory lighting panels and exterior view glazing help provide daylighting to 86% of the building.





How is this city saving $60 million?

By partnering with Johnson Controls, the City of Baltimore is reducing energy and operational costs across 50 City buildings. Its City Hall, offices, courthouses and fire stations—even its wastewater treatment plant—are being upgraded to cut energy use and reduce CO_2 emissions.

Johnson Controls is installing high-efficiency HVAC equipment and lighting, low-flow plumbing systems and renewable energy sources. Even the wastewater plant is being upgraded to use residual product as fuel to generate electricity.

The result? The City of Baltimore is expecting $60 million in energy and operational savings over 15 years. Through performance contracts, Johnson Controls guarantees these savings, offsetting the project costs. City employees and the community are enjoying more comfortable facilities and Baltimore can reallocate vital funds to core services.

To find out how Johnson Controls can make your buildings work for you more efficiently, sustainably and profitably, visit MakeYourBuildingsWork.com or call 888-748-4404.

HPB.hotims.com/37999-15

Johnson Controls

© Jim Brady

© Jim Brady

Top **High Tech High operates based on a principle of open learning. Classrooms and exploratories open directly onto to the main circulation routes.**

Above **Classrooms are paired to allow team teaching and cross discipline projects. The modular units arrived with corrugated metal ceilings and cellulose-based fiber wallboard suitable for pinups and displays.**

Solar access is high and readily available. Prevailing breezes generally flow onshore, over the ocean from the west. A temperate climate such as this allows for year-round connections to the outdoors.

To help students and staff connect with nature, this design offers direct visual access to the outdoors from every learning space and direct physical access to the outdoors from all project workspaces.

The project climatic response involves breaking the building into discrete parts with internal courtyard spaces between them, a conditioned crawlspace below and a broad solar canopy above. The courtyard strategy allows for every space to access cross ventilation and abundant daylighting. Internal venting skylights fully balance the lighting.

The building's southeast-northwest orientation provides maximum solar access to all areas. The solar canopy acts as an umbrella, protecting the building's façade and passively-conditioned, screened circulation spaces from heat gain.

The conditioned crawlspace has air transfer grilles between it and the spaces. The air of the conditioned spaces above flows through the high-mass, insulated crawlspace, moderating the temperature—keeping the spaces warmer in the winter and cooler in the summer.

Water Cycle

Annual rainfall is less than 10 in. in this desert microclimate. When it does rain, it can rain heavily. The project includes vegetated swales and detention basins to regulate flows and reduce runoff rates below predevelopment conditions.

To ensure the basins are not breeding grounds for insects, they are designed to not allow standing water for more than 72 hours and to maximize infiltration within the site's technical limitations.

With such a scarcity of water in the region, water demand is minimized on site and within the building. The building management system (BMS) includes water management controls, which respond to changing weather

BUILDING TEAM

Building Owner/Representative
High Tech High

Architect Studio E Architects

General Contractor
Bycor General Contractors

Modular Contract Williams-Scotsman

Mechanical Engineer BTA Engineering

Electrical Engineer
Michael Wall Engineering

Energy Modeler
Brummitt Energy Associates

Structural Engineer R&S Tavares

Civil Engineer, Environmental Consultant
RBF Consulting

Landscape Architect
Ivy Landscape Architects

Lighting Design Michael Wall Engineering

Plumbing Designer
Oakley Construction Plumbing

Commissioning Agent MBO

LEED Consultant High Tech High Learning (a non-profit that develops High Tech High Schools)

ENERGY AT A GLANCE

Annual Energy Use Intensity (Site)
23.8 kBtu/ft^2
Natural Gas 6.8 kBtu/ft^2
Electricity 17 kBtu/ft^2

Annual Source Energy 64 kBtu/ft^2

Annual Energy Cost Index (ECI) $1.18/ft^2

Renewable Energy Exported Off Site
14.3 kBtu/ft^2 (PV)

Annual Load Factor 20.4%

Savings vs. Standard 90.1-2004 Design Building 54.6%

ENERGY STAR Rating 94

Heating Degree Days 718

Cooling Degree Days 2506

ASHRAE 90.1-2004 Energy Model Savings 50%*

*The base case was developed following the California Title 24-2005 Energy Code and using the Performance Rating Method, ASHRAE 90.1-2004 Appendix G. The software simulation program was EnergyPro v4.415, weather file CZ07RV2.WY2, with the California Title 24-2005 Energy Code and California Climate Zone 07.

LG
Life's Good

The LG MULTI V™ III VRF
Innovate Today for Tomorrow

High efficiency with AHRI certified ratings in a modern & compact design

For information on the latest breakthrough technology from LG, visit **www.lg-vrf.com**

Enhanced Energy Efficiency

New compressor design and optimized heat exchanger contribute to enhanced efficiency.

Modern & Compact Design

More indoor zones, less outdoor space. When space or access is at a premium, this equates to significant cost advantages for the owner on large projects.

Longer Piping Distances

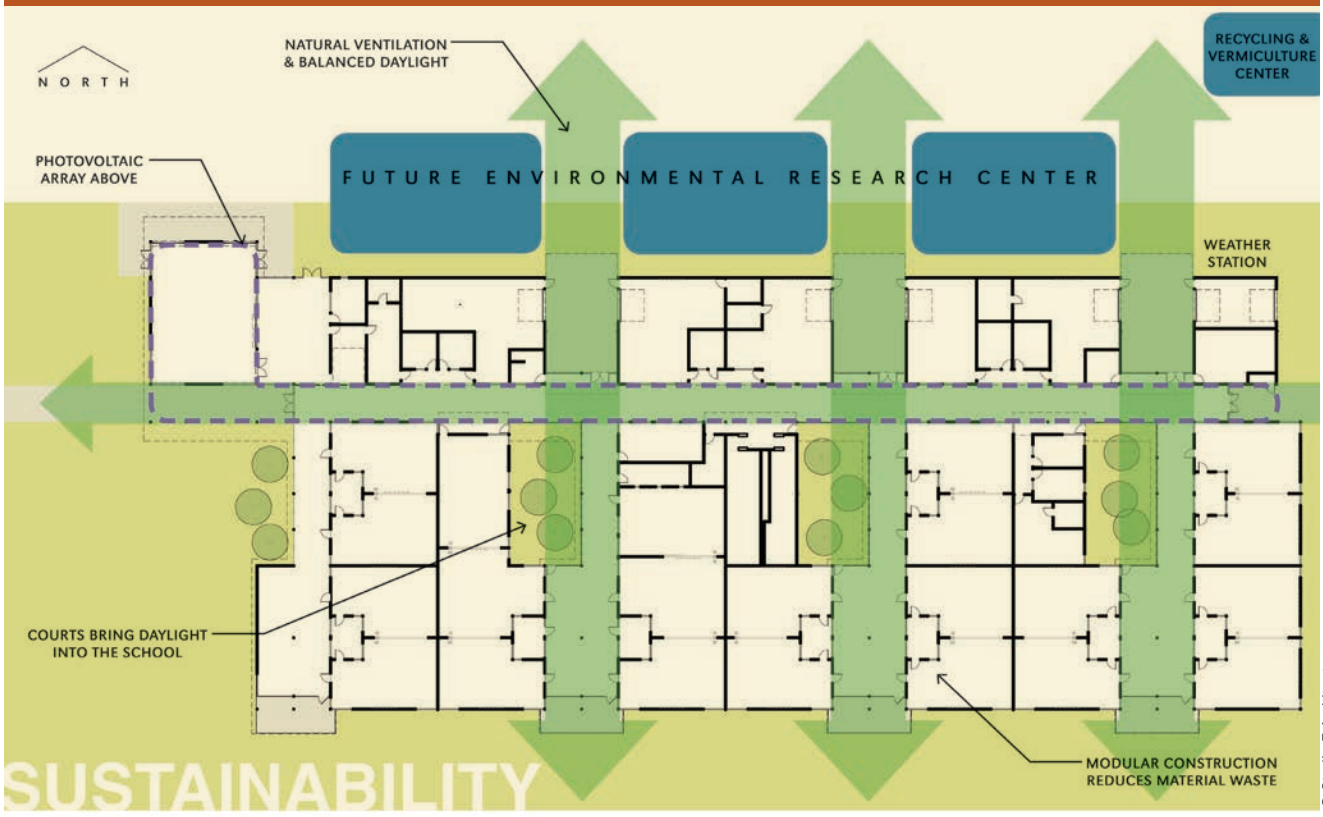
Owners can reach extra zones further off the same VRF units. This eliminates the need to invest in extra systems and saves on installation.

Rapid Start Cooling

The fast response cooling & heating feature drives heating or cooling faster than previous systems.

HPB.hotims.com/37999-20

PLANNING FOR SUSTAINABILITY



The building is planned around a series of courtyards and open walkways that introduce light and ventilation. The courtyards are outdoor learning and working spaces, and the central spine has become an "artifactorium" displaying student work.

BUILDING ENVELOPE

Roof
Type Polyurethane foam
Overall R-value R-30
Solar Reflectance Index 103

Walls
Type Gypsum wall board + 6 in. metal stud + fiberglass mat gypsum panel + fiber cement panel
Overall R-value R-19
Glazing Percentage 27.1%

Basement/Foundation
Slab Edge Insulation R-value 0
Basement Wall Insulation R-value
R-19 at crawlspace wall and sill plate
Under Slab Insulation R-value 0

Windows
U-value 0.69
Solar Heat Gain Coefficient (SHGC) 0.407
Visual Transmittance 0.7

Location
Latitude 32.62
Orientation 45°

conditions by adjusting the irrigation schedule in real time.

Flow sensors and motorized valves can turn off zones immediately in the event of a broken head or line. This also triggers the BMS to send an alert to groundskeepers, so they can address the issues at their next opportunity. Reclaimed water is used for 100% of the site's irrigation needs.

Every fixture in the building was scrutinized for water use, durability, and ability to ensure sanitary conditions. Due to the waterless urinals, faucet aerators, low-flow showerheads and low-flow water closets, the project demands 52% less water than the EPAct-1992 baseline. This equates to a savings of $5,000 per year in operating costs.

Materials and Construction

High Tech High is constructed with a mix of off-site custom modular, factory-built components and more traditional on-site components. Using repetitive parts based on industry standard sizing and assembly line production reduced construction waste and increased construction quality.

The assembly line technique allowed cost-effective and schedule-efficient integration of all building systems, which saved on construction labor hours and the cutting, fitting and patching

necessary with traditional site-built wood-framed construction.

The school layout was developed with factory-made modules and delivered to site ready to be assembled in a matter of days, which reduced on-site construction time, as well as air, noise and stormwater pollution associated with on-site construction activities. The modules can be easily disassembled, relocated, and reused in the future. The modular construction system also accommodates changes in technology and allows energy and HVAC systems to serve only currently occupied areas.

The project incorporates durable, low-toxicity, low-maintenance materials such as polished concrete floors, steel framing, steel roof and floor decking and fiber-cement siding. These core building materials ensure a building life cycle of more than 100 years.

All construction materials were selected for their overall environmental and health performance. Products with wood, lead, and mercury were banned from the project's structure. Pest and mold resistance were addressed through a monolithic foam over metal deck roof, steel moment-frame and metal stud infill structure, metal deck and exposed concrete floors over an insulated concrete crawlspace and fiber-cement siding.

Project Finance

With a $\$175/ft^2$ budget, it was clear that a large renewable energy system was not in the base budget because of the long payback period and minimal school culture benefits. High Tech High partnered with the local utility company to lease the rooftop for a photovoltaic array owned and operated by the local utility. The system feeds the community grid with renewable

© Jim Brady

Corridors, courtyards and common studio spaces become work spaces in support of this project-based-learning school.

2011 OPERATING COSTS, UTILITY CONSUMPTION/PRODUCTION

High Tech High operates 11 public charter schools in San Diego County, and the facilities team trends performance parameters, including water and energy use, to inform operations. HTH Chula Vista is the most cost-effective school to operate on both a cost per square foot and cost per student basis.

This is mostly attributed to the efficient four-pipe fan-coil mechanical system, efficient lighting, and ease of reliance on natural daylighting for spaces. The four-pipe system was chosen for its long-term cost payback and for its demonstrated record of energy and cost savings over time.

Custodial and maintenance costs are also tracked, and HTH Chula Vista's costs are less than all other schools in the HTH portfolio. This is attributed to the low-maintenance rubber and polished concrete floors, cleanability of the restrooms, and overall durability of materials from the fiber cement board walls and metal panel ceilings to the native and adaptive plants.

Potable Water (Includes Central Plant and Domestic Water Fixtures)	386,716 Gallons	$4,747
Reclaimed Water	1,371,832 Gallons	$6,442
Gas (Central Boiler)	3,634 Therms	$3,293
Electricity	321,000 kWh	$58,552
PV Array Production	190,551 kWh	
Percent of Building Electricity Consumption Represented by PV Array Production	59.4%	

2011 ENERGY USE, PRODUCTION

	Gas (therms)	Electricity (kWh)	Solar PV Production (kWh)
Jan.	746	4,037	11,186
Feb.	565	4,196	12,327
Mar.	539	4,590	16,505
Apr.	396	4,716	18,562
May.	208	6,184	21,037
Jun.	285	6,187	21,609*
Jul.	67	4,882	21,157
Aug.	62	4,398	19,508
Sep.	26	6,151	14,511*
Oct.	85	4,867	14,570
Nov.	233	4,113	9,880
Dec.	422	4,232	9,697
Total	**3,634**	**58,552**	**154,430**

Note: Electricity generated by PV panels is exported off site.
*Estimated based on same month from 2010 due to missing data.

© Studio E Architects


© Jim Brady

Above Left **The modular components were trucked in and placed in a few weeks.**

Above Right **The school, composed of modular and site-built components, is divided into grade "neighborhoods." Each grade is centered around commons areas that are located under the raised upswept roofs.**

energy and the school receives a lease payment as well as a lobby kiosk with interactive access to the array's data.

Though water, energy, and resource efficiency are important for the community, evidence has shown that indoor air quality, acoustics, and daylighting directly impact student performance. This is where the project team focused its efforts and these became the metrics with which to measure the project. The school uses the Collaborative for High Performance Schools (CHIPS) Operations Report Card to evaluate the facility on an ongoing basis.

The project team included an energy modeling consultant and acoustical engineer to analyze various project attributes and work collaboratively with the contractors and designers. Together the team efficiently reached consensus on how to cost-effectively approach indoor air quality, acoustics and daylighting.

The result is many low-tech details that perform exceptionally well. Examples include translucent polycarbonate window panels, which add light while controlling glare, and insulated perforated metal panel ceilings, which absorb sound and reduce reverberation time.

LESSONS LEARNED

Since this particular school opened, High Tech High has opened two more new schools based on similar planning and sustainability principles, and is continuing to grow with at least one new school per year. To accommodate this growth and ensure best practices are replicated, stakeholders constantly evaluate lessons learned from data and user feedback.

Modular Construction Systems. A traditional reason for using modular construction systems is to reduce the time between building design and building occupancy. Though the 18-month timeline was a constraint on this project, High Tech High would not allow it to trump other core project values such as planning flexibility, sustainability, transparency and architectural character. A modular construction systems manufacturer helped High Tech High understand that these systems embodied the core design values and reduced the project schedule to a minimum without increased risk to other parts of the project. With scopes of work occurring in parallel, rather than serially, management of communications and scope were critical for everyone to be on the same page. Every project has its own set of considerations, and High Tech High looks forward to leveraging the benefits of modular construction systems in an upcoming elementary school project.

Regulating Central Plant Water Use. A leak detector with an electronic shutoff valve at the building's domestic water entry point is connected to the BMS. If a faucet leak occurs, or a toilet keeps running, the water to the building shuts off, and alarm notification is sent to the facilities team. The central plant, however, was not designed with something similar. The project has had a pipe leak in the chilled water supply pipe of the four-pipe mechanical system. When a small amount of water leaked out of one of the pipes, a refill valve on the chiller simply added more. It wasn't until someone noticed a wet spot in a crawlspace that the issue was found. A flow sensor and electronic valve will be added to the refill valve to monitor how much water is being added to the system, so that abnormalities may be caught early.

Sizing the Server Room Mechanical System. The mechanical engineer worked closely with the High Tech High Information Technology team to properly design and size the mechanical system to be a three-ton ductless split system independent of the main four-pipe mechanical system. This allowed for the server room to be running 24/7, if necessary, even while the rest of the building was in holiday mode. The mechanical engineer sized the tonnage of the server room split system to include a 20% factor of safety. And, just before opening, the local telephone company changed the phone system to fiber-optic relays and added its own server to the room, along with an uninterruptable power supply (UPS). This addition causes the split system to run nearly constantly in the summer to keep up. High Tech High intends to replace the existing 13.5 SEER three-ton unit with a 15 SEER five-ton unit so the unit does not cycle on and off as frequently, and to ensure it can keep up with the heat load on even the most demanding hot summer days.

Don't Put the Safety and Security of Your Business at Risk!

Trust Your Emergency Cooling and Heating to Spot Coolers

- ***All portable cooling companies aren't alike...***
  As a member of a Fortune 50 company Spot Coolers holds the highest standards for business ethics, safety and security. We comply with OSHA and all federal and state regulations to ensure customer, employee, and community well-being.

- ***You can trust our reputation...it speaks for itself!***
  When you partner with Spot Coolers you enjoy peace of mind knowing that all of our people are experienced, knowledgeable and carefully screened. Our reputation is built on the consistency of our performance.

- ***Excellent equipment, excellent service...***
  Whether you rent or buy, Spot Coolers offers units from 1-12 tons available whenever you need them. We can service your facilities from one of our 38 locations nationwide. Our commitment is absolute.

We Take the Risk out of Renting or Buying...
Why Use Anybody Else?

spot coolers
RENTALS AND SALES
PORTABLE AIR CONDITIONING AND HEATING

MOVINCOOL®
PREFERRED DISTRIBUTOR

MovinCool, SpotCool and Office Pro are registered trademarks of Denso Corporation

HPB.hotims.com/37999-26

1.800.367.8675 • www.spot-coolers.com

HTH GETS RESULTS

Originally conceived by a group of San Diego civic and high tech business leaders concerned by the challenge of finding qualified individuals for the high tech work force, the original High Tech High opened in September 2000. Since then it has opened five high schools four middle schools and two elementary schools.

The design of the schools creates environments where teachers and students can teach and learn effectively. The proof of this concept is in the achievements of students and faculty.

100% of HTH's graduates have been admitted to college, 80% to four-year programs.

About 35% of HTH graduates are first-generation college students.

More than 30% of HTH alumni enter math or science fields (vs. 17% national rate)

HTH is the first California public school organization authorized to operate its own teacher credentialing program.

First charter management organization to operate its own Graduate School of Education.

Source: www.hightechhigh.org

Commissioning, Maintenance and Measurement

HTH stakeholders participated in enhanced commissioning to ensure the project functioned as intended. This commissioning process included traditional energy and thermal comfort systems, and other staff-related systems such as irrigation, audio/visual, security, transportation and storage.

The school participates in the Collaborative for High Performance Schools (CHPS) Operations Report Card (ORC) to benchmark systems that affect student performance including thermal comfort, lighting, acoustics and indoor air quality.

© Jim Brady

The school's central commons was site built and is a place for large gatherings and performances.

The CHPS ORC provides a report card of results and makes suggestions for improvement.

For example, user surveys showed that some teachers had complaints about how the daylighting was overpowering the digital projectors at certain times of the day. Through the CHPS ORC program, lighting was measured at different times of the day and subsequent analysis showed that the excessive light was coming through a series of clerestory windows. Simple blinds were added to the clerestory windows, alleviating the issue.

In addition to those factors affecting student performance indoors, High Tech High also surveys staff and students on transportation to/from school, lunch program food quality and custodial effectiveness to ensure the learning environment performs as well as possible.

Conclusion

High Tech High Chula Vista demonstrates that high performance, sustainable buildings don't have to be costly or complicated to achieve significant energy savings and to meet the goals of building users. Unconventional construction and design methods such as using modular systems and using a crawlspace and photovoltaic canopy to facilitate natural ventilation can reap significant benefits. The lessons learned from HTH Chula Vista will be incorporated in future HTH schools, which will provide unconventional school environments to challenge and inspire students. ●

ABOUT THE AUTHORS

Christopher Gerber, AIA, is the director of facilities for High Tech High, a nonprofit in San Diego dedicated to the development and operations of high performance schools.

Eric Naslund, FAIA, is a partner at Studio E Architects in San Diego.

Airtightness Testing

NOT JUST FOR HOMES ANYMORE

Airtightness testing of homes has been around for more than 20 years. Various energy programs and fluctuating energy bills have provided homeowners an incentive to improve the airtightness of their homes. Energy tax credits can also be received by the homeowner but only if the house airtightness has been verified that it is less leaky after remodeling than before.

Efforts to make commercial buildings more energy efficient in the US has only recently been incorporated into various "green" initiatives. Tests of commercial buildings show that they tend to be more leaky than the average house, based on air leakage per square foot of surface area. That means that commercial buildings are less energy efficient than the average house.

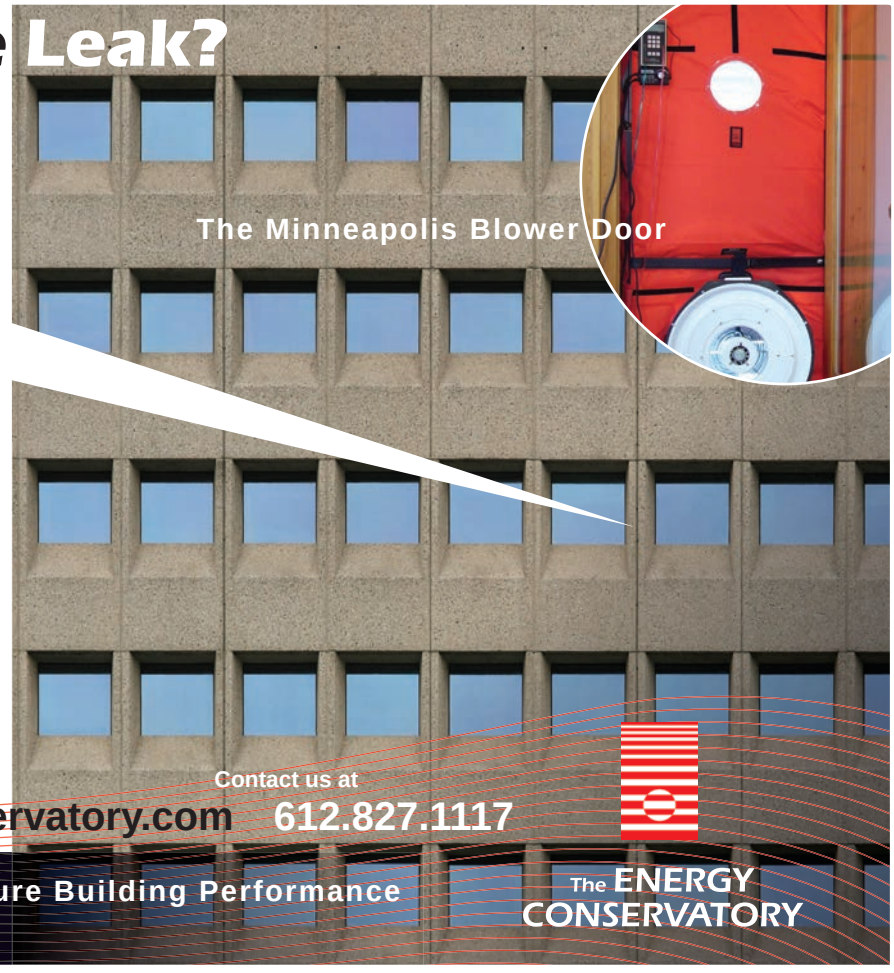
To measure the actual airtightness of a large building means more air is needed to maintain a reasonable test pressure. The Energy Conservatory, a leader in airtightness testing, has kits available to directly measure more than 18,000 cubic feet per minute of air leakage. Multiple kits and fans can be used simultaneously to generate more air for accurate and reliable measurements of air leakage for testing before and after retrofitting.

For more information on multi-fan systems, contact:
The Energy Conservatory
612-827-1117 or visit our website at
www.energyconservatory.com

Where's the Leak?

What's the best way to: measure the airtightness level of building envelopes; diagnose and demonstrate air leakage problems; estimate natural infiltration rates and efficiency losses from building air leakage; certify construction integrity?

For more than 20 years, the **Minneapolis Blower Door™** has been recognized as the best designed and supported airtightness testing system in the world. The **Minneapolis Blower Door** is the system of choice for utility programs, energy raters, HVAC contractors, builders, insulation contractors and weatherization professionals.



FEATURES:

- **Precision Engineered, Calibrated Fan**
- **Accurate, Powerful 2 Channel Digital Pressure and Flow Gauge**
- **Lightweight, Durable Aluminum Door Frame and Fabric Panel**

Download product pdfs at
www.energyconservatory.com

Contact us at
612.827.1117

Diagnostic Tools to Measure Building Performance

HPB.hotims.com/37999-12

The ENERGY CONSERVATORY