

ALISON G. KWOK
BRITNI L. JESSUP
NICHOLAS B. RAJKOVICH

Chartwell School Case Study

Project Description

“The vision for the Chartwell School was to create an exceptional, high-performance learning environment for children with learning differences, such as dyslexia. The result is a pleasing, durable campus that integrates daylight to improve learning rates, and uses its site overlooking Monterey Bay as a sustainability teaching tool. The design dramatically reduced environmental impacts, achieving zero net electricity use, and potable water reduction by 70%.”¹

Architect: EHDD Architecture, San Francisco, CA
Energy Engineer: Taylor Engineering, Alameda, CA
Structural Engineer: Tipping Mar + Associates, Berkeley, CA
Mechanical Engineer: Taylor Engineering, Alameda, CA;
Electrical Engineer: The Engineering Enterprise, Alameda, CA
General Contractor: Ausonio, Inc., Castroville, CA
Landscape Architect: GLS Landscape, San Francisco, CA
Green Consulting: EHDD Architecture, San Francisco, CA
Acoustics: Charles M. Salter Associates, San Francisco, CA
Lighting: Benya Lighting Design, West Linn, OR;
Daylighting: Loisos + Ubbelohde Associates, Alameda, CA

Project Awards

- 2009 American Institute of Architects Committee on the Environment Top Ten Green Projects Award
- 2008 LEED NC v 2.1 Platinum, U.S. Green Building Council
- 2007 Green Apple Award from the Collaborative for High Performance Schools
- 2007 Honor Award – Energy & Sustainability from the American Institute of Architects San Francisco Chapter
- 2007 Environmental Award from the U.S. Environmental Protection Agency

Project Data

Completion: October 2006
Cost: 9,000,000 U.S. Dollars (2006)
Area: 21,000 ft²

Location

City: Seaside, CA
Latitude: 36.38 North
Longitude: 121.48 West

*Climate*²

HDD65: 3125
CDD50: 2574
Annual Precipitation: 30.3"
Solar Radiation: 579 kBtu/sf/year

Energy Metrics

Energy Code: California Title 24
Predicted % Below Code: ~50%
Measured EUI:
30 kBtu/sf/year (2007)³
27.9 kBtu/sf/year (2008)³

¹ AIA San Francisco Chapter website at www.aiaasf.org

² National Oceanic and Atmospheric Administration website at www.noaa.gov

³ EUI: Energy Utilization Intensity onsite estimate. Based on electricity only from report by Pagliaga, Gwelen, *Chartwell School Electricity Use and PV Production*, Taylor Engineering March 26, 2008 and Allan Daly, Chartwell Presentation (ppt) to PG&E, May 13, 2009.

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Chartwell School Narrative: Architect Scott Shell

Getting the Project

We were invited to submit for the Chartwell School project, first a proposal phase, and then an interview phase. As I recall, it was our firm and two other firms. One of the other firms was Sim Van der Ryn's.¹

The school had been working with an architect and they had set an unrealistic budget. This happens all the time. You go to the interview and they tell you what the budget is. Do you tell them their budget doesn't match what they are asking for? Or, do you say, "Oh sure, we can do it for that." It's a real dilemma.

Although they had a number of developers and people who were knowledgeable about construction on the board, they didn't have experience with the quality of learning environment that Doug Atkins² had in mind. They also didn't have experience with sustainable design. The board's background was more in terms of building something quickly and inexpensively, in lower cost locations.

It's funny because Monterey, where the school is, is by Pebble Beach and Carmel, very pricey stuff. But, just a few miles away in the valley is Salinas. Chartwell spans both communities. Some people said, "People are building schools in the valley for so cheap!" But, that's not what you get when you build in Monterey, and that's not what you get when you hire our firm. There was definitely a disconnect. We still got the project and Doug was very astute about bringing his board along and helping them understand his vision.

Plus, it's their kids. Everybody loves their kids more than anything in the world. They want to make sure they get the best education. When you make the argument, "Kids learn better with daylighting," what are you going to say?



Scott Shell, AIA, LEED AP joined EHDD in 1996 and is the firm's Director of Sustainability. Scott has directed a number of EHDD's most successful high performance projects including two LEED Platinum certified buildings, an AIA/ COTE Top Ten Green award winning laboratory, a zero net energy/ zero net carbon office building, and the zero net energy Chartwell School.

¹ Sim van der Ryn is the former president of Van der Ryn Architects in Sausalito, California.

² Douglas Atkins is the Executive Director of the Chartwell School.

Selecting the Project Team

Selecting a design team is something I spend a lot of time on; finding the very best team because they can make us look brilliant or like a bunch of idiots. From our firm's perspective, we have to think about it a little more globally than just project by project. What are our longer firm goals and vision? We can't put all our eggs in one basket and go with a single firm or person for all of our projects. What if they got hit by a bus or went out of business? We try to keep our options open and keep a variety of top firms as consultants. Different firms have different strengths.

I think this was the first project where we used Tipping Mar³ for the structural engineering. I had followed their work because I had been very frustrated with some larger engineering firms not pushing sustainable design. In selecting our internal team, you really want one principal plus one strong person who does most of the day-to-day work for the duration of the project. This strong person is a project manager and a project architect, and they might work with a junior person to assist them.

Setting Goals for the Project

It's funny looking back at your own personal evolution. It was not that many years ago that I just thought PVs⁴ were not a realistic alternative. Something just switched at some point – you do a calculation and say, "OK, what would it cost to put PVs on this project?" If you're expecting a really big number and it comes in smaller the possibilities just open up. It's a whole new mental model.

On this project, our general strategy was to do daylighting; we wanted people to be able to operate this building without the lights on for

most of the school year. Sure, on a rainy day in the winter it's not going to be daylit all the time.

In our energy model at the very beginning of design, we saw that lighting was by far the biggest load, and with daylighting we can eliminate most of that.

Then what else do we have left? A little gas for heating, some plug loads, but we don't have much else. Then let's see how many PVs it takes to offset the remaining energy and it was 1.6 percent of the construction cost. I was shocked. If you would have asked me a few years ago I would have said that it would increase your construction costs by twenty or thirty percent or more. If you really go after the loads and get them down then you can do it. It became a personal goal that just evolved over the years, "Let's daylight it, the whole thing, every space." I talk about daylighting the toilets and janitor's rooms because then people get the point.

We're always looking for good people to work with. We work with George Loisos⁵ on daylighting a lot and we share these goals with them, and then they help make sure we get there. For example, on Chartwell that's why the windows wrap the corners. It's to get light back on the walls to reduce the contrast. It's not just a bright, punched opening in a dark wall. George did some Radiance⁶ studies about where the skylights should go to balance the light.

He always wants to do a bunch of Radiance models and I'm always saying, "This is a little project and it can't afford you doing Radiance models." I really trust his intuition on these smaller scale projects. But, he did some modeling of a typical classroom anyway with three different skylight options.

³ Tipping Mar + Associates are a structural engineering firm in Berkeley, California.

⁴ Photovoltaics (or PVs) are a technology that converts solar energy into electricity.

⁵ George Loisos is a principal at Loisos & Ubbelohde in Alameda, California.

⁶ Radiance is a suite of computer programs for the analysis and visualization of lighting developed by the Lawrence Berkeley National Laboratory in Berkeley, California.

Jim Benya⁷ was the electric lighting designer and he did a Lumen Micro⁸ model to analyze the electric lighting. I told him about our daylighting goals and that this is where we are trying to go with our practice. After the school opened, he went out to the site and measured the lighting. It was right around the winter solstice and it was something like thirty-five footcandles at the desk level. He said that teachers wanted it a little brighter, but the students were fine.

Selecting Technologies for the Project

I always ask the energy guys on my team what they think the energy pie is going to be. Allan ran an energy model for Chartwell and gave me what I call the “energy pie.” We then decided to go after the biggest slices most aggressively, and the other slices next.”

I know this is basic good design. A lot of times you have a pretty good idea of where the energy use is going to be just based on the occupancy type and the geography. On this project we didn’t have AC,⁹ but we had lighting, plug loads, and heat. There’s little hot water for hand washing. They have a kitchen that’s not used everyday. It’s just more for events or for teachers so it’s very light use. It’s really very simple

Eliminating AC was a major design goal and to do that and keep people comfortable, you have to watch out for heat gains, shade, your windows, use the right glass, get the orientation right, all the basics must be done well.

Project Tax Credits and Incentives

We used “Savings by Design.”¹⁰ Those rebate numbers are always small in the end. It was a fair

⁷ Jim Benya is a principal at Benya Lighting Design in West Linn, Oregon.

⁸ Lumen Micro is a computer program for the analysis and visualization of lighting developed by Lighting Technologies, Inc.

⁹ “AC” is an acronym for air-conditioning.

¹⁰ “Savings By Design” is a new construction incentive program offered in the State of California.

amount of work to go through that process for Taylor Engineering.

You know when people are giving money away they want to not give it away too loosely and so they want to see things in a certain format and be able to check things. There are all these rules that go with Title 24 then you’re always saying “Well, we don’t have air conditioning. Does that apply when we apply for the incentive?” It always takes some back and forth.

Methods and Tools Used on the Project

So you’ve got these different goals from the different energy models. When you ask a different question of the model you get a different answer.

If there’s one thing we’ve learned it’s to forget about the energy models, look at the real performance. Show me measured data, one with everything in, not just the predicted energy use. With Chartwell School we were way off.

I really try to trust my energy team. I used to try and do everything myself and I realized at some point that these guys know so much more than I do. It’s not just ten percent, more like five hundred and ten percent. I challenge them to do their best work, and they usually exceed my expectations.

Doug wanted the LEED¹¹ Platinum. But I’ve been focused on climate change, in part because of some clients we’ve had. I was less focused on indoor air quality, which I think are fairly simple and straightforward. So we really focused on daylighting and energy, striving for the net zero electrical goal.

I’ve found that if you really nail the energy issues, if you get all 17 of the energy credits – LEED is really not that hard. The indoor air quality points

¹¹ The Leadership in Energy and Environmental Design (LEED) Green Building Rating System, developed by the U.S. Green Building Council (USGBC), is a suite of voluntary standards for green buildings.

are easy—add the energy points, and you're already well into the gold.

Doug wanted to get LEED platinum.¹² I was terrified of falling one point short on some technicality, but we ended up with several extra points in the end. Whew!

The energy use, particularly the carbon component of that energy, was very important for me. On the Center for Global Ecology¹³ when we did our carbon calculations we learned that even though the natural gas was small from a cost point of view, from a carbon point of view it was significant. I just keep running into that over and over so we have to address natural gas and heating and strive for zero energy not just zero electrical. It just blows me away. Three years ago I didn't think it was feasible to do zero net electrical, and all of a sudden now we've got a handful of projects that are going for zero net energy.¹⁴

I remember looking at mechanical options with Gwelen and Alan.¹⁵ We sat in the conference room and did a matrix for all these different types of mechanical systems. We scored every system, and we weighted the scores and we ended up with a very conventional system. But the answer didn't seem correct. As we looked at it, we began to question our weightings—our fundamental priorities, really.

It's really hard to know how to weight things. Are tools like decision matrices a self-fulfilling prophecy or, do they really help clarify your

thinking? I think the latter, to make explicit your assumptions.

The students at Chartwell arrive there from conventional schools where they have had a very frustrating learning experience. Douglas's vision was just to get rid of every possible distraction for the students, so excellent indoor air quality, good acoustics and not a bunch of mechanical noise. So the radiant flooring was a key part of that, and was seen less as a sustainable strategy and more as a thermal comfort, acoustic and indoor air quality strategy. I had worked on a number of schools before, and I knew that you could have air quality problems in the winter when the windows are closed. We debated endlessly how to deal with that and ended up with CO₂ controlled fans that the teachers could also control.

I've asked Douglas, "How do the teachers use it, how do they like it, do they keep it running, is there a draft in the winter?" We finally got detailed CBE POE¹⁶ survey results in. We scored in the 99th percentile for air quality and the 98th percentile for thermal comfort.

I always have a lot of sympathy for anybody who has problems with a building. I know how easy it is to have a good design and then something changes or gets VE'd¹⁷ out. You can't just go back mentally and reconstruct all of the ricochet effects that is has on the project. Or the contractor submits something different, a subcontractor installs it does it a little bit different and so on...

Managing the Project

Doug is a visionary and that vision is always learning, growing, and evolving. Every time he gets a new idea it adjusts his vision. While I admire that greatly, from a business point of view it's challenging. You have to be careful you don't

¹² LEED Platinum is the highest rating in the LEED Green Building Rating System.

¹³ The Carnegie Institute for Global Ecology is a building designed by EHDD for Stanford University in Stanford, California.

¹⁴ The U.S. Department of Energy Building Technologies Multi-Year Program Plan defines a net zero energy building as "a residential or commercial building with greatly reduced needs for energy through efficiency gains (60 to 70 percent less than conventional practice), with the balance of energy needs supplied by renewable technologies."

¹⁵ Gwelen Paliaga and Alan Daly of Taylor Engineering in Alameda, California.

¹⁶ CBE is the Center for the Built Environment at the University of Cal, Berkeley, an industry/university collaborative research organization. The post occupancy evaluation (POE) refers to CBE's Occupant Indoor Environmental Quality (IEQ) Survey
¹⁷ "VE" is an acronym for "value engineering."

quash an idea. You can't say no too often to a powerful visionary – that's not our style. Our style is to get excited about it and keep changing the design. But at a certain point it's just really counterproductive to we have to get the project built and not lose our shirt.

Doug was wonderful to work with. He was a Naval officer on a nuclear sub. He was the disaster recovery specialist so he had to know how everything worked and how to get to every piece of equipment. He could understand all this; he could articulate it, he could tie it back to education, and that's the key point of the sustainability strategies in this project. When you're asking parents to donate big dollars for something, they don't want to hear about architecture, they don't want to hear about design, they don't want to hear about how pretty it's going to be, they want to know about how it's going to affect their kids. Doug can make that connection for them.

It was much more powerful of a message coming from the head of the school to hear how to inspire kids to learn, than an architect talking about design. It's coming from an educator rather than an architect; he was very adept at translating between those two worlds, and a very effective spokesman for sustainable design in learning environments.

For LEED you have to do a peer review. So I said we should get Charles Eley,¹⁸ the guy wrote CHPS¹⁹ and has a wonderful understanding of schools. What a privilege it is to have access to people like that. I was back at home in Pensacola, Florida would I have access to colleagues like this?

I've got Charles Eley over there who's looking for interesting projects to feature, I've got clients like Douglas, I've got an entire infrastructure of sustainable design expertise here in the Bay Area.

¹⁸ Charles Eley is the Executive Director of the Collaborative for High Performance Schools.

¹⁹ CHPS is an acronym for the Collaborative for High Performance Schools.

From Tipping Mar doing all this stuff on structures, to Eco Timber,²⁰ Hayward Lumber,²¹ great mechanical engineers like Allan and great daylighting people. It's just an incredible set of resources here in California. So we really learned from Charles' peer review and Charles got a case study for CHPS.

Lessons Learned

Certain things you know intellectually but it's completely different to experience them viscerally. When we turned on the rainwater pump in the winter and let it spill out into the sloughs – the kids just went wild! They were having so much fun. I see it now with my kids, you give them water and they're having so much fun. Conceptually you can talk about, "It's collecting water and flushing toilets and sometimes in winter you have more water than you need so you can use it for play or for learning about hydraulics, or water flow, or whatever. But when you see it happening and the kids' excitement, it is really something.

The Unisolar²² Peel & Stick PVs on that metal roof are so clean, beautiful really. I was really surprised by that.

I'm constantly reminded how hard it is to do daylighting well, especially to illuminate surfaces like the underside of the ceiling, so that spaces not only have adequate light, but feel bright and cheery.

The skylights – this is one of those million in and one ways things can go wrong. We had a two foot by two foot clear skylight well. We ended up with a two foot by two foot skylight less the curb. You take out three inches on four sides of a skylight

²⁰ EcoTimber sells sustainably-harvested and reclaimed wood products. They are headquartered in Richmond, California.

²¹ Hayward Lumber is an environmentally conscious lumber supply company. They are headquartered in Monterey, California.

²² Unisolar is a manufacturer of amorphous silicon photovoltaic (PV) solar panels.

and suddenly it's undersized by thirty or forty percent.

The contractor didn't have any experience with sustainable design and really had to stretch themselves on the project. In the end the workmanship looks pretty good but some things like the skylight were a problem.

We were constantly battling with cost issues and endless value engineering. Unfortunately this seems like it's just become part of our business.

A huge percentage of our time and energy goes into trying to meet a budget and a lot of times that budget wasn't set properly to start with. So, one of the games that gets played is you move things from the building budget to the furniture budget. The interior Mechoshades²³ were put into the FF&E²⁴ budget and they didn't get installed when they first moved into the building. And they were having terrible glare problems on the south side until they got the shades installed.

Another lesson learned is that when you take paving right up to building on the south side, heat really tends to build up there. You might start out with reflective concrete paving and think it's not a problem. By the time you get done with VE you've got a lot more asphalt than you expected. Then it's even hotter than you thought. Especially if breezes come from the northwest then the south side can get warm.

You read about these guys in the Alps that are growing grapes by putting south facing rocks in a vertical wall and growing something in front of that. "Well, that's kind of what we did with our building unintentionally!"

We actually have a school project in Salt Lake City where I'm really interested in creating different outdoor microclimates, especially for shoulder seasons when it's really cold but you want to be

²³ The MechoShade Corporation manufactures solar shading and interior shade cloth systems.

²⁴ Furniture, Fixtures, and Equipment.

outside. So we're making a kind of hot pocket, like what happened at Chartwell, and in other places you make cool pockets for summer when it's quite hot. The heat island on the south side of Chartwell was a little bit of a surprise for us.

I think one challenge for our profession is that people in the green building community say, "Look what I did!" but don't have any real data to back it up. Real energy use numbers, comfort surveys, things like that. We are trying to shift toward measureable benchmarks and trying to be honest about lessons learned.

I've been doing this for 20 years or so and how many buildings have I finished? Not that many. As architects, our product cycle is so long from start-to-finish is often, four years or more. You learn a lesson for a project you are working on that will take another four years to get completed. We've got to get better at sharing those things with our peers and learning those lessons.

You can't just layer in sustainable design later in the process. At some unpredictable point the design resonates with the team, they instantly like it, and get locked in. Once the client sees it and they like it, and the design team sees and they like it, at that point it's very hard to change. You don't know when that point's going to be, you could go along for months and then all of a sudden it happens. Or, sometimes you hit it in the interview.

Once that happens, if you don't have daylighting in there, then you're fighting an uphill battle. You're trying to sidelight²⁵ a distance that is unrealistic. For instance on the Packard Foundation building we said, "Hey, this is the building width that we can reasonably sidelight, and that's how we set our building width." That drives the whole parti.²⁶

²⁵ "Sidelight" is the daylight coming in from the side of a space, typically through a window. "Sidelighting" is a strategy to bring in more daylight from windows deeper into a space.

²⁶ "Parti" is an architectural term which means the basic scheme or concept of an architectural design.

Hiring New Staff

We have a big, diverse practice, and we need all kinds of talent. In general, a lot of people come to us because of their interest in our sustainable expertise. A lot of those people are really bright, really talented and we'll hire them because they have a great range of skills. We rarely hire somebody with just sustainability as a skill because it's just not broad-based enough.

Last summer we hired Janika McFeely²⁷ who was Ray Cole's²⁸ research assistant and she's been great. Even then, we don't want to pigeon-hole her just into doing LEED because she needs to also develop as an architect to understand integrated design. You can't do that in isolation without understanding how it fits into what we do.

So we get a lot of people interested in sustainability, and we have some really strong staff on that. But we also need people with fantastic graphic skills, or really strong technical skills, or somebody at an intermediate level who can really put together a sixty million dollar lab project.

Those people are really hard to find who have first the sustainability expertise, plus these other skills. They know what they are getting into when they come here; a serious effort to integrate great design, technical performance, and sustainability.

Among our principals there is broad and deep support for sustainability; it's a part of our firm culture and goes back to Joe Esherick and all of the original partners. The level of sustainability does vary among our projects, but we're always trying to raise the bar.

This narrative is based on an interview with architect Scott Shell at the EHDD Architecture office in San Francisco, California on March 25, 2008. University of Oregon graduate student, Britni Jessup, transcribed a digital audio recording of the interview. The interview was conducted by University of Oregon Professor Alison G. Kwok and Nicholas B. Rajkovich, Pacific Gas and Electric Company (PG&E).

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²⁷ Janika McFeely is a designer at EHDD.

²⁸ Dr. Raymond J. Cole is a Professor at the School of Architecture, University of British Columbia.

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Chartwell School Narrative: Engineer Allan Daly

Getting the Project

I had done some work with EHDD¹ at Arup² but we hadn't really done a lot of work with EHDD at Taylor Engineering.³ Scott Shell⁴ and I had crossed paths a number of times, doing things like natural ventilation seminars but we had never gotten a chance to work together. If I remember correctly, Scott just called up and said, "Let's try working together on this one."

Selecting the Project Team

I mainly was the one who worked on this project. Gwelen Paliaga⁵ was hired when the job was half to three quarters done. So, I did most of the preliminary work and the energy analysis and Gwelen came on near to the end of it, and helped finish it up and get it built.

Setting Goals for the Project

Right off the bat, the goal was to be zero net energy. I remember going to a LEED⁶ workshop down in Seaside or Monterey and there being a lot of discussion about trying to go to zero net energy⁷ on the project. So it was always meant to be very aggressive, it was



Allan Daly, PE is a registered mechanical engineer at Taylor Engineering where he specializes in energy efficient and environmentally responsible HVAC system designs that maximize occupant health and comfort. He is an expert in the use of computer programs to simulate buildings and systems to predict building energy consumption, thermal performance, natural ventilation, and occupant comfort.

¹ EHDD Architecture is an architecture firm in San Francisco, California, and was the architectural firm responsible for the Chartwell School.

² Arup is an international consulting engineering firm with an office in San Francisco, California.

³ Taylor Engineering is an engineering firm located in Alameda, California. They specialize in mechanical systems design and construction, energy conservation, indoor air quality, controls, and system commissioning.

⁴ Scott Shell was the principal at EHDD responsible for the Chartwell School.

⁵ Gwelen Paliaga is a senior mechanical designer at Taylor Engineering.

⁶ The Leadership in Energy and Environmental Design (LEED) Green Building Rating System, developed by the U.S. Green Building Council (USGBC), is a suite of voluntary standards for green buildings.

⁷ The U.S. Department of Energy Building Technologies Multi-Year Program Plan defines a net zero energy building as "a residential or commercial building with greatly reduced needs for energy through efficiency gains (60 to 70 percent less than conventional practice), with the balance of energy needs supplied by renewable technologies."

always LEED Platinum⁸ from day one. That's what the architect and client wanted.

There was certainly some discussion of goals back then, but it was scaled back from the energy independence, zero energy goals. I am not exactly sure if I remember all the reasons why, but it basically came down to a budget decision reacting to when we proposed, "Let's go and have it be a zero net energy building.

Tracking Progress on the Project

Just to give you a sense of history, as the design evolved we updated our energy models and tracked how we were doing. We were tracking a PV⁹ array as the way to make up for a good chunk of energy use of the building to get to zero net electricity. Sizing that array was part of the design process, "How big does it need to be to get to zero," we always had that design parameter in play. In our office we are mechanical engineers; we do the ducts and pipes and all that stuff. We're working with electrical engineers who are sizing the PV array, and specifying the PV array, so we were collaborating in that way. We weren't actually doing the PV design.

There was a LEED brainstorming charrette¹⁰ kick-off and there were some discussions, mostly with the architects. Scott was more in tune with the goals of the owner and brought those things to the project.

Selecting Technologies for the Project

We looked at energy recovery ventilators, we looked at a number of different insulation levels and glass types, and effective daylighting. The

effective daylighting controls and a whole series of options were under consideration.

We take a pretty analytical approach to these things, trying to figure out what makes sense and what doesn't make sense. The process was that we were generating ideas and then analyzing them and trying to figure out, "Is it logical, can we pay for it?"

Some jobs, it seems like the design team is much more interested in doing sustainable, low energy, interesting work than the client is. In those cases you're trying to persuade, not really fight with the client, but no natural connection occurs.

That was not the case at all on this job. They [Chartwell] were so into all these ideas but the biggest issue for them was just to figure out the budget. It's a school, it didn't have an unlimited budget, and anything they wanted to do they had to raise money for it. So they had some degree of having their desires tempered by that, but it was an easier discussion than usually occurs on a project.

Project Tax Credits and Incentives

I think that we were tracking and trying to get some money for the PV array, and we also were participating in the energy incentive program, "Savings by Design."¹¹

Methods and Tools Used on the Project

We primarily used eQuest¹² which is a DOE-2¹³ modeling tool. Early on in the project we also used a program from NIST¹⁴ that they were developing,

⁸ LEED Platinum is the highest rating in the LEED Green Building Rating System.

⁹ Photovoltaics (or PVs) are a technology that converts solar energy into electricity.

¹⁰ A charrette, often Anglicized to "charette", and sometimes called a design charrette, is defined as an intense period of design activity. Charrettes often range from one day to several days of meetings to kick off a design project.

¹¹ "Savings By Design" is a new construction incentive program offered in the State of California.

¹² eQuest is a building energy use analysis tool based on the DOE-2 algorithms provided free of charge by Energy Design Resources: <http://www.energydesignresources.com/>.

¹³ DOE-2 is a widely used freeware building energy analysis program sponsored by the U.S. Department of Energy (USCOE) that can predict the energy use and cost for many types of buildings.

¹⁴ "NIST" is an acronym for the National Institute of Standards and Technology.

and actually we got some money from them to use Chartwell as a case study.

It was called a very horrible name, LoopDA,¹⁵ and it was supposed to be a tool to help size natural ventilation openings. It was a little hard to use, but did provide some useful design guidance.

It was a professor on the East coast somewhere, who came up with an inverse method for looking at bulk air flows through buildings. They call it an inverse method because it's for design, you don't know what the building geometry is to plug into your analysis, you're trying to figure out what the building geometry should be. You're going backwards, what airflows do you want, so how big do your openings need to be?

So, for them, that was a huge breakthrough of to figure out that you need to go backwards. It seems silly, but they're all researchers. That's what we do every day. It was just one of these things that wasn't really connected to the real world particularly well.

One question is, do you do a CFD¹⁶ analysis? There's so many unknowns and it takes so much time. You try to use more simplified tools that have a rational basis and then use your judgment a lot; that's my preferred approach.

Project Challenges

There was always the desire to not have air conditioning, but that was always easy because Seaside is a very mild climate. I think that the only special challenge as far as the design went was when you do a naturally ventilated building, you don't really need any ducts or fans, it can just be naturally ventilated.

But partly because of the work Alison Kwok¹⁷ did with her dissertation,¹⁸ we knew there may be reasons that they would want to have windows closed, besides ventilation reasons or temperature reasons. So one challenge that we took on was how to provide, how to create a really high quality environment using a natural ventilation scheme even though we understood the dual motivation behind why people may open or close windows.

We ended up putting in these small little ventilation fans that were in some ways completely redundant with the windows to allow there to be situations when the windows are closed, but you are still getting fresh air in the room.

I actually think it's a very clever, very simple thing to do to put in little supply fans up high in each room, which don't have any air conditioning at all. They're not heated; they're not cooled. We're just dumping fresh air indirectly into the room, we just provided enough fresh air for each of the students plus the teacher, 15 CFM¹⁹ per occupant.

In heating mode, we dumped that air into the room up high, thinking that it would be warmed up already and would mix around and be tempered. In cooling mode, we only cared because we're not providing any air conditioning, we're just bringing in fresh air, and that was a way to guarantee that people would be getting fresh air in the room.

We put a CO₂²⁰ sensor in each room. Those are there to control the fans, so if it ever goes past a CO₂ high limit, then the fans come on to bring in some fresh air. There's a louver on the outside of the building and it's ducted up to the one of these fans, and we chose the kind of fans that are very

¹⁵ A computer program called LoopDA was developed by NIST to implement the Loop Equation Design Method to size the openings of naturally ventilated buildings.

¹⁶ "CFD" is an acronym for Computational Fluid Dynamics.

¹⁷ Alison G. Kwok is a professor of architecture at the University of Oregon.

¹⁸ "Thermal Comfort in Naturally-Ventilated and Air-Conditioned Classrooms in the Tropics," University of California, Berkeley, May 1997.

¹⁹ "CFM" is an acronym for Cubic Feet per Minute.

²⁰ CO₂ is the chemical symbol for carbon dioxide.

quiet, small, residential style. So they're pretty quiet in the rooms.

It was relatively inexpensive because it was just a fan and a couple of ducts with no heating or cooling, the controls are pretty simple. Plus, we did radiant heating which is really quiet and was certainly a premium over forced air. It makes for really nice spaces for the kids and for the teachers.

There weren't many design challenges, but construction-wise it was actually an incredible challenge to get this building built because they decided to go with a local contractor. This contractor totally unprepared to do a project that was so out of the ordinary.

Somewhere along the line the contractor had gotten another job that was going green, and there was a little shift at some point where he started to perk up about really understanding it more.

It was a fight; it was one of these jobs that was a fight. They didn't read any of the specs, they didn't want to follow any of the rules.

It was always a job where there were very minimal fees design-wise. This job was a design-assist job where we took it through DD²¹ and there's a lot of work for the contractors to do when they get the drawings. But, the general contractor didn't understand that, they thought it was a plan and spec job.²²

There was a disconnect between what our specs say called for and how to go forward with what we designed versus what they had priced.

I think it would be good to get the contractor to be a part of the design team. They weren't ready to be a part of the design team, they were just ready to build it, and they didn't understand that when

they read the specs that they needed be thinking, not just building. [Scott Shell: We worked with another contractor and their design build sub to to coordinate our efforts. But when their bid came in higher, Chartwell switched to a different contractor, losing some of this coordination.]

Lessons Learned

For small jobs, for green jobs, jobs that are aggressively green like this, I really feel like we need to be involved as much as possible and not hand it off and try to explain what needs to be done to someone else.

We just don't do a lot of school work, they're really small and they take tons of time, tons of passion and energy. As far as the business, just trying to keep our doors open and things, it's a small job so it wasn't like it was a huge black hole or anything. But, it's a job we didn't make any money on which is not sustainable from our standpoint. From our side of things, it certainly has affected our perception of what these jobs take to get complete.

Hiring New Staff

Taylor Engineering is an unusual organization. We pick our employees very carefully.

Gwelen was a new employee who came into our office and worked on Chartwell. He's not a mechanical engineer, he doesn't have a mechanical engineering degree. He's not really an architect, he doesn't have an architectural degree. But Gwelen understands building science -- all of the issues related to comfort and thinking about energy flows in buildings.

Being able to think critically about what might make sense and what might not make sense, and to think analytically about how to figure out those answers, those are the skills that are really useful and really valuable.

I think a lot of engineers, we do it too, when we look for a new hire we say, "Are they

²¹ "DD" is an acronym for Design Development, a phase of the architectural design process.

²² A "plan and spec" job is a delivery model where the design team develops detailed design drawings and specifications for the building systems.

experienced? Do they know our business today, can they do load calculations²³ and all these things?" Those are great skills to have when you are just trying to get work done and make a profit, but when you start doing green projects like this, you're constantly faced with all these new science challenges. You're doing something new for the first time and how do you determine when the technology or when the system approach is ready for prime time? When do you go with it?

One current example is that people are all excited about chilled beams²⁴ in the design world, the HVAC²⁵ world, because it's the new thing and they're cool and sexy and different. So how do you, as a professional, stand behind something and say yes to the owner, it's worth spending money on this? It really takes a lot of critical thinking, and a lot of analytical thinking to decide if the manufacturer's claims hold water.

It's much more about just having good critical thinking skills that are, in my mind, more in the liberal arts training. Engineers are trained to be able to solve problems in a linear fashion. They're not really trained in the way problems are formulated in this kind of design. How do you teach people to be good thinkers? That's the biggest question.

At the heart of it, it's someone with passion for what we do that's interested in low-energy buildings and broader environmental goals.

Closing Thoughts

I've done some teaching along the lines of zero net energy and carbon neutrality.²⁶ I'm an engineer; I come at these things very analytically. I like the whole energy modeling structure of thinking because it makes one analyze the components and then how they interact as a whole. The models also interact with the weather, and the building's climate, and the building's form.

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²³ Load calculations determine the maximum expected heating or cooling load for a building in a given climate.

²⁴ There are three types of chilled beam systems. They are chilled ceilings, passive chilled beams, and active chilled beams. Chilled beams are a water based system designed to remove heat from a space.

²⁵ "HVAC" is an acronym for Heating, Ventilation and Air-Conditioning.

²⁶ A carbon neutral building is a zero net energy building that uses emissions, especially carbon dioxide, as the accounting method.

Exhibit: Chartwell School



Fig. 1. The approach to Chartwell School in Seaside, CA



Fig. 2. The cafeteria and theater off the main courtyard

This exhibit, part of a larger case study describing the Chartwell School, was supported by a 2007 AIA Upjohn Research Initiative Grant. University of Oregon Professor Alison G. Kwok and Britni Jessup with Nicholas B. Rajkovich, Pacific Gas and Electric Company (PG&E), prepared the associated narrative. © 2009 University of Oregon. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means without the permission of the authors.



Fig. 3. Student entrance on the north side



Fig. 4. Covered walkways between buildings



Fig. 8. Integrated roof-mounted photovoltaic panels



Fig. 9. Southern shading system and recycled wine-cask siding



Fig. 10. Dew collection system



Fig. 11. Rainwater retention cistern with external display



Fig. 12. Student garden on the north side of the courtyard



Fig. 13. Interior of cafeteria, theater and entry



Fig. 14. Top lit circulation spaces of interior hallways



Fig.15. Top-lit entrance and student storage



Fig. 16. Daylit classroom