Green Design

From Theory to Practice

The Jerusalem Seminar in Architecture

Lecture: Steven Strong

Opening Remarks: Dr. Yoav Sarne

I met him only one hour ago. I read about him the last few days, and I found that we are going to listen in the next hour to one of the leading people in the design of solar and energy powered buildings. A few words about Steven. He is the president of Solar Design Associates, a group of architects and engineers dedicated to the design of environmentally responsive buildings, and the engineering and integration of renewable energy systems. Steven Strong has earned an international reputation for pioneering integration of renewal energy systems, especially solar electricity, with environmentally responsive building design. Over the last 25 years, he has designed thousands of homes and buildings powered by solar electricity. Steven Strong has recently completed the design and oversaw the installation of a new solar scheme for the U.S. Mission to the United Nations in Geneva, and is currently working on powering the U.S. Embassy in Athens with solar electricity and upgrading the U.N. Headquarters in New York City with building integrating photovoltaics. Steven, please.

Mr. Steven Strong: Thank you Dr. Sarne. And thank you all for coming. I bring you greetings from my wife, shalom. I travel more than I'd like these days, and I don't get to see her as often so I brought her along, I hope you don't mind. We're going to talk about renewable energy for buildings today, but we're also going to explore the policy environment, because after decades of work in this field, it is my clear conclusion that the technology is available. It's proven, it's reliable, it's off the shelf, and it's essentially ready to go. The major barriers that remain to us making the transition to the post-petroleum era are largely in the policy and the political arena, and that's why we will address those issues together with the technology.

We have, as many of you know, two 800 lb. gorillas, among us. These two 800 lb. gorillas are known as peak oil and climate change. Many of you are quite familiar with the phenomenon. And even though our national policy in Washington DC has done everything possible to ignore these phenomenon, they are indeed upon us, and the market is responding, and will continue to respond. And so when people ask, “Well, renewable energy is very desirable, but is it cost effective?” The answer is, it will never be more cost effective than it is now. And the reason for that is, as continuing escalation in conventional energy costs draws down our discretionary resources as a society, these resources will then not be able to be invested to propel this transition. Put another way, we don’t have time to waste. There is a fork in the road. It is as real as the concrete abutment in the highway or autobahn with the flashing yellow lights. We can continue as a society to cling to yesterday’s outmoded technologies, which of course accelerate resource depletion, environmental degradation, and bring about increasing geopolitical conflict—which, if of course you take that formula to its logical extension, brings about more strife and war and the very real possibility of the extinction of the human experiment. We can, on the other hand, choose the more desirable fork in the road which embraces sustainable technologies, which in turn engenders resource conservation, environmental preservation, and the opportunity for a much more equitable society. If you carry that formula to its logical extension, you can see the possibility for an era of new prosperity, and I say possibility, because there is no promise in any of this.

The transition to the post-petroleum economy is upon us. It is coming whether we are ready or not. The only question is how and when. And because these technologies, although proven and reliable, and essentially off the shelf, have a huge ramping to ever hope to meet the scale of needs that our society presently has. Timing is everything, and time is of the essence. These two 800 lb. gorillas, climate change, and peak oil, are creating what I call "the perfect storm" for renewable energy. If we didn’t have enough good reasons to employ renewables, climate change and peak oil are certainly reason enough. We must as a society begin to build the bridge to sustainability.

Interestingly enough, I began my career working for the oil companies. I had the opportunity coming out of engineering school to work on the Alaskan Pipeline Project, just happening to be in the right place at the right time with the right skill set. And during my tenure on the pipeline, there was a minor dust up here in the neighborhood, which is known as the Yom Kippur War. And within a matter of a day or two, the world was convulsed by what became known historically as the first world oil embargo. And within hours, there were gasoline lines around the block in every major Western city.

This event was somewhat of an epiphany for a young engineer, and I resigned a very well-paying and very challenging position, and in the spring of 1974, not knowing any better, founded Solar Design Associates to offer design services in the design and construction of environmentally responsive buildings and the engineering and integration of the renewable energy systems to power them. In the early 1970's, this was a solar house. It certainly wasn't going to win any awards—it won't be on the cover of any architectural journals. But you had to admire the early pioneers, like the folks in the kibbutz looking to live autonomously, looking to take control of their own energy destiny, looking for a measure of self-reliance. And without any architects, without any engineers, without any building codes or standards, these early pioneers demonstrated that indeed you could have a lighter environmental footprint.

We were privileged to be retained on a competitive basis by the MIT solar program—this was one of the last initiatives that the MIT folks did before they went on to other things—to design and construct the world's first completely solar powered residence that was interfaced with a utility grid to share a surplus of its harvested energy with the community. This was designed in 1979, and we built it in central Massachusetts in 1980. We then went on to field the first solar neighborhood, taking an existing community of post-World War II ranch homes and converting them all to solar electricity. While we were in town, we also did the Burger King. We had things, "Our Way." And in the old days, when we started out, heavy steel wide flange was the design of the day, with lots of roof penetrations and a lightweight secondary support structure to field solar rays on existing rooftops.

Since then, we have pushed on the industry to innovate and make these solar components more like architectural building materials, taking the same solar cells and laminate them inside architectural glazing elements to create building integrated photovoltaics, where now almost every surface of the building can at least in theory become a solar generator: overhead glazings, atriums, curtain walls, skylights, vision glass. I want to show you several different options, the most popular options for fielding solar on buildings, and then we'll explore a number of examples.

Flat roofs, of course, are a very attractive piece of real estate. There are thousands of square kilometers of sun-drenched roof real estate baked in solar energy every day, waiting to be harvested, and of course, many different variations on how one might do that. Sloped roofs of course are also very attractive. Not much else happens on the roof other than keeping the weather out. There's a lot of roof real estate, and with a little cooperation from the architects it could be optimized to power the buildings beneath it. Solar sunshades are becoming a very popular design strategy with energy-conscious green designers, especially in Europe and Japan and now also in the U.S. The sunshade of course can reduce cooling load demand, shrink the size of the cooling investment in chillers, in compressors and cooling towers, while also of course increasing productivity, reducing glare, and unwanted thermal gain. Façades and curtain walls: one might argue that glass defines modern architecture, and any glass surface on a building, can now be a solar powered generator. Skylights and overhead glazing are perhaps the most popular strategy architects and engineers are used to, slope glazings for atriums and overhead glazing systems. And it's not that big of a design change to make those solar power plants.

I'd like to show you a variety of different applications now, using mainly U.S. examples—I don't yet have any here in Israel - I'd like to. But this is in California, it is a science center. Some folks might call it a museum, but a museum looks backwards and a these folks always look forward. They asked their architects, Architectonica, to design something that would be an icon, so that when you came to Santa Ana in California, you'd know where the discovery center was and what it was about. We arrived on the scene when the designers had finished the proverbial cocktail-napkin sketch and had created this giant solar cube about 50 meters above grade, and it was going to be built just as a metal sculpture. We gave it a purpose in life by cladding it with what was at the time the largest thin film array in the US, facing true south. And we ended up actually taking on the project as a design built effort because the contractors were busy at they time. There was a building boom in California; no one wanted to tackle these logistics.

A project we did for Tiger Woods—the Tiger Woods Learning Center in California—there is plenty of roof-top solar capacity, but you can't often see those arrays and the client wanted to have the technology shown off. The curtain wall is a solar power plant. It employs laser-etched thin film photovoltaics as the vision glass. This technology has evolved progressively such that the designers can now selectively specify the desired level of light transmission and translucidity. And we varied the density of the material much like the tinted band on your car windshield, starting with a high degree of shading at the top rows and then fading to clear at the floor level.

A project that we recently finished with the Polshek Partnership, powering the new public television complex, in Boston with rooftop solar: we covered every square meter of available roof surface, including the upper decks and then the solar ray was surrounded by a green roof and a roof garden. A fully-integrated sloped-roof array for a Museum of the History of the Adirondacks region in upstate New York. The museum has a campus of historically-significant all-stone buildings, structural stone walls and heavy stone slate roofs. We removed the slate and installed an integral solar electric skin which powers this wing of the museum and also provides energy for a display on renewable energy and climate change, with a special focus on how the by-products from the combustion of coal for a utility power in the mid-west are killing the lakes in the Adirondacks region with acid rain, which has become a real concern for this part of the U.S.

An environmental center in northern New Hampshire: a very cold and challenging winter climate with about 87 hundred-degree days. We cut a dove-tailed shape from the forested site to create a solar access window, because the client wanted to make a building that was completely energy autonomous. This is an integral solar thermal system for heating and domestic water. These two roof surfaces are solar-electric arrays. The solar electricity provides all the power the building needs on an annual basis with a surplus. The solar thermal system provides about 80 -85% of the thermal energy required. They do have a wood boiler which they power from trees that fall on their property. They purchase no energy, and they have a carbon neutral building in a very severe winter climate.

And I'd like to suggest to all of you who live in a more forgiving climate, that is, a warmer one with more sunlight, that if we can do buildings like this in a severe winter climate, they can be done anywhere, and I will take anyone on to debate that point because we have a severe demand in a severe climate, which is coincident with the lowest amount of sunlight available. Yes, it's hot in the warmer regions. Yes, it's humid. Yes, air conditioning is required. But as we have seen in the presentations thus far in this meeting, good design can dramatically reduce those loads. And satisfying the remainder, comes at a time when the site is blessed with an abundance of sunlight, whereas these buildings have their greatest needs during the time of minimal amount of sunlight on an annual basis. Higher education is a very attractive area for solar innovation because schools and colleges of course keep their buildings into perpetuity. They are often looking at them as a symbol for identifying their school and creating a distinction between their college or university and their perceived competitors, and of course they have the educational mission and the students, the world around, are looking toward the future and want renewable energy on campus.

This is a project we did in Washington DC in the early 1980s. At the time, it was the largest rooftop system in the world. And the very first time that solar-electric elements became the finished weathering skin of a commercial scale building. We worked with the photovoltaic manufacturers and the curtain wall specialists to create a solar power plant which became the roof of the facility. There is no conventional roofing and no waterproofing. The good news is this project is still feeding large blocks of utility-quality power into the campus distribution network over two decades later.

Sunshades are a very attractive opportunity. Most engineers and many architects recognize the benefits of sunshades in terms of cooling-load mitigation and glare control. You can reduce the cost of your capital investment in the cooling system and actually save money by fielding sunshades, and they make an ideal platform to show off the solar technology.

We were privileged to work with the Olympic Village design team to do the first solar-powered Olympics. This was the summer games in Atlanta in 1996. We designed what was then the world’s largest rooftop system, powering the women’s and men’s swimming and diving venue. The black bands are thermal collectors to temper the competition pools. And the canopy, arched structure in the upper left corner is the entry portal to the Olympic venue. Shade in Atlanta, just like shade in Israel, is very desirable in the summertime, and there was a design for a conventional roof canopy where people would be queuing up to enter the Olympic venue. We were asked to convert that to electric glass, and this was the first application of large area architectural electric glazing in an overhead glass application in the U.S. The solar-electric modules are the structural skin of the building, and they are clear glass, glass lamination so that you can see the solar cells and also have a light pattern of sun and shadow filtering through. The idea was that the attendees at the event would not likely see the large solar array, because it was 50 meters above the street level, but as they are entering the Olympic venue through this portal, the technology is readily visible, just three meters overhead.

The new business school for the University of Oregon was a nice opportunity to showcase integral photovoltaics in this south-facing curtain wall. This looks like very expensive construction, and it is, but everything in that photograph was in the base building budget and the base design. What we did here was laminated the solar cells in a pattern, designed by the design team of course, into the architectural glazing that they were going to buy anyway which was installed in the curtain wall system that they were going to buy anyway, using the labor that they would have had to use anyway. In other words, placing the electric glass is essentially the same as installing conventional glazing. Yes, you have to wire it, but the wiring is a modest amount of work in the overall scheme of things.

We, as engineers, wanted a high packing density to keep the sunlight out of the atrium area, because we were concerned about unwanted thermal gain. The architects, on the other hand, wanted a very broad or open packing density, because they wanted a transparency in the building, at least at eye level. And so the design evolved to the point where we have a very high packing density at the crown of the building, which then varies to a very high transparency at the floor level.

More sunshades: this is a technology center at a college near Boston. These are conventional solar modules, off the shelf, mounted in a custom-mounting configuration to meet the architect's design intent without requiring the fabrication of custom components. We also covered every square meter of roof surface on that building to harvest the sunlight.

A building we did for Tufts University has both solar thermal and solar electricity. It is a residence hall. They use a fair amount of hot water. The solar thermal needs to be canted up at a higher altitude angle. As you well know, Israel has an abundance of domestic water heating with solar energy. The solar electric systems can be at a more gentle inclination, because of the utility policy which allows any surplus that may be generated in the summer, when demand is modest because the students are largely not on campus—that surplus can be fed into the utility and effectively available in the future, and so that has allowed designers to deploy solar arrays at a much gentler angle.

A project we did for Oberlin College in Ohio—Dr. David Orr was the chair at the time, of the Environmental Studies department, and he wanted an energy self-reliant building powered from current solar income. That was the primary design driver for the whole program brief.

We, of course, were asked about the solar, but we worked to encourage the design team at every step in the design decision process to consider the impact of each decision in terms of energy demand. It is very important to emphasize the need to balance both sides of this equation. You can't just put solar panels on the roof and call it a green building. The opportunities are dramatic on the efficiency side. You must balance both sides of the equation, and that cannot be overemphasized. If you are an architect or an engineer, and you find your building in this ungainly position, and your first inclination is to wish you had a bigger ass, you should seek career counseling.

Proactive load management is essential for success. As engineers, we know how to do this stuff: it's not rocket science. The problem is that in most cases, we aren't rewarded for it. In many cases, we aren't encouraged to do it, and in certain cases, we aren't even allowed to do it. "Oh, there's no money in the fee for that kind of stuff. There's no time for energy modeling. We need to get these drawings done and get the building approved."

And so what happens? It happens everywhere, and we build more of these things. This of course is a coal plant. And I don't care how green you think your architecture is. If there's a cable that connects this thing to your building, don't tell me about the carbon footprint. It's just conveniently over the horizon and out of sight, and you can talk about how nice the carpeting is and what kind of light bulbs we're using, but we're still powering the building with coal. And coal is death: it just takes a little longer.

The people at Oberlin were not discouraged. That building used twice as much energy as the designers said it would. They came back and commissioned us to make up the difference, and achieve the original design goals of complete solar autonomy. We took advantage of an underutilized piece of campus real estate, namely, the surface parking area that served the academic facility, and fielded what they call their solar pavilion. And the harvest from the solar pavilion combined with the rooftop array is sufficient to create a surplus of energy, beyond the needs of the building, completely satisfying its requirements and providing an excess to the community. And as far as I know, this is the first academic center that is 100% solar powered with a verifiable surplus that's exported to the community around it.

And government solar, just like universities, have a long-term vision. They hold their buildings into perpetuity. They're not looking to flip them over for a quick profit, as a commercial developer might be. Government agencies are also stepping up and taking a leadership role. This was a local project that we did in Seattle with the Bohlin Cywinski Jackson firm: the Ballard Library, integrating thin film in the curtain wall, even though there's a deep overhang on the southwest corner of the building. The sun comes in at a low angle in the afternoon, and the idea was to keep the direct sunlight off the collection. We also integrated conventional crystalline photovoltaics on the green roof.

The U.S. mission to the U.N. in Geneva: we were asked by the U.S. State Department to create a new solar skin for the facility. The before picture is in the upper left corner. Can I see a show of hands of anybody who thinks the before picture was better? And I mention this because some architects are still concerned about what they consider the aesthetic impact of solar on their work. And the truth is, if you have a receptive client and a creative design team, solar can actually, in many cases, improve the aesthetics of a building. We fielded sunshades on the southwest façade because obviously you see the benefits of keeping the sun off the glazing. It reduces the air conditioning load saving electricity while also producing it. We have vertical façade applications. We have rooftop systems, and we have overhead glazing. This project was somewhat of a technical triumph for us. We'd done pretty much every one of these concepts in another manner, but most importantly, it was a policy triumph. I got to stand in the audience with the international press corps, when members of the U.S. administration—remember this is the previous administration—were standing in front with the renewable energy systems wrapped in ribbons and bows and talking about the benefits of environmental stewardship and living lightly on the planet. I asked the woman next to me to pinch me. She stepped aside and said, "I beg your pardon." And I said, "Oh, I'm sorry, I'm from the U.S.," and she said, "Yes, I know." And I said, "No, what I mean was that, I don't usually see these kinds of events in the U.S. with our previous administration." And she said, in the most wonderful French accent, "Well, I'm from Switzerland, and we see them all the time." And that was just another reminder that there are different ways of conducting public policy, and Switzerland of course took the lead along with the Netherlands and Germany and now Spain and France and Italy and the U.K. in moving renewable energy into the mainstream. And they have set a real standard for us to follow in the U.S. and of course good examples for Israel to consider as well.

A project we did for the Government Environmental Laboratory in my home town of Boston. We worked with the architectural aluminum company to create an industrial design whereby the photovoltaic elements are recessed into the sunshade movers. I remember this project very well because the sunshade was incorporated quite late in the development process, and it was about December, in the fall—very cold in Boston in December. They had this value engineering meeting—it was a freezing day—and we went. And the director of the laboratory was very excited about the solar, even though it was incorporated late. She introduced the meeting and brought it to order and said, "I know why you're here. This is a necessary process. Don't touch my solar." And so, those of you who are non-architects, this value engineering process is something that happens on certain projects where they're trying to see whether the design makes sense economically, and a bunch of people who know nothing about your project come in from out of town, take out red markers, and bleed all over your drawings for an hour or two, and then go away. But, anyway, the director said "Don't touch my solar," and so, of course, they had to do something to justify their involvement: they cut out all the energy efficiency measures. And that was the worst thing they could do.

I am a solar advocate, but I will be candid with anyone. Solar is the last thing I want to see you do. Why? Because there is so much waste, as we learned from Michael McDonough's presentation last evening: 60, 70, 80% of the primary energy is wasted. So much opportunity to save energy, to reduce demand, and these measures are less expensive, easier to implement, and most importantly in a new building, very difficult to implement later.

And so when I returned home that evening, my wife greeted me, "How was your day? Oh, you had that value engineering meeting, didn't you? Did they cut out the solar?" "No, no they kept the solar." "Great," she says. I said, "No, it's not great. They cut out all the efficiency measures." And every architect will acknowledge, it is extremely difficult to implement these things which are very easy to do when you are have a sheet of drawings on the table, extremely hard to do once the building is complete, closed in , and occupied. You can always put solar on the roof. And so my wife says, "Oh, that's nice. I want to show you the new coat I've just ordered." A winter coat—it's getting cold. She's ordered a new coat, and of course, I'm still thinking about this value engineering process. She says, "What do you think?" I said, "Well, dear, you know, if we look…that's an expensive coat. If we looked at that in terms of the value engineering process, the net present value of future dollars, the discounted rate, probably the conclusion would be that you should not buy the coat, wear your summer clothes and eat more food." Which, of course, describes the value engineering proposition very clearly—it completely ignores all of the important considerations: comfort, well-being, health, productivity, etc. The wife, of course, got the coat.

We were privileged to install or actually to return solar energy to the White House during this previous administration. It was my career goal to do this. I was on the roof with President Carter when he dedicated the first solar system on our White House, and the next administration of course came in and removed it and consigned a recently-installed and fully functional system to the dumpster. And so we brought solar back to the White House and in fact the President's office is now powered in part by solar electricity, and I hope this ingoing President will appreciate it more than the outgoing one did.

As was mentioned, our current government project is to power the United Nations World Headquarters with solar energy. We will be re-glazing the secretariat tower with building integrated photovoltaics. We will be covering the rooftop of the general assembly hall with photovoltaics. The mission or project brief is to power this with as much solar energy as possible. They've even told us to cover the crown of the tower. And this comes right from the secretariat down, and we do hope that it will be as significant as they envision.

I'll show you just a couple of quick schemes. This is the main diplomats' entrance, and existing, and new, and one of the assembly conference chambers looking out over the East River. The façade now has solar glazing proposed. And I think it is fitting that the U.N. be powered by renewable energy, because it is as close to a world peace organization as we have, and without sustainability, we cannot have world peace.

The architect has a lot to do with a lot of this stuff, and as an engineer I can criticize the profession. I am trained as an architect too, so the architects can't complain too much. This slide originally said, "The architect is G-d," but some architects came back and said, "That's a little bit too forceful." So, I said "creator." But basically, a lot of architects have very large egos. Yes, too large, and in fact, I look at that as a measure of inverse talent. In other words, there's a progression in an architect's career were they basically overdrive their native talent and then they make up for it with ego. And of course, it's very difficult to work with these folks because they have some grandiose ideas as to what needs to been done. And the reason I mention this at all is that the most often quoted reason for not doing the right thing in terms of environmental integrity, in terms of renewable energy, in terms of a lighter environmental or carbon footprint, is, "Well, it's not cost effective." So I'd like to show you a few examples of contemporary architecture—most of these are from the U.S., but we see these buildings all the time. I've spoken with some folks about a project that was proposed here in Israel, but was not built. Anyway, I want you to look at these buildings, and tell me, not if it is good architecture—because I know that that's subjective—if it is cost effective, in other words, if this building is the most cost effective solution for the client's requirements.

Here's the new library in Seattle. Is that the most cost effective way to build a library? I don't think so. And the new Transportation Agency Headquarters in California. How cost effective is an eight story house number? It gets better: the Denver Art Museum. Is this the most cost effective way to build a museum? This is a Klingon warship from Star Trek. It's captain Kirk's worst nightmare. And then the designers put this collection of scrap metal in the front courtyard and surrounded it with a giant circle of benches, as if people are going gather in masse and stare at this for a long period of time. What is this fellow thinking?

It gets better, and I know our session chair received his doctorate from MIT, and so I hope I am not treading on anything…The Stata Center at MIT is a shameful example in today's environment with the crisis facing our society in terms of energy and climate change. MIT which prides itself on its own assessment as being the most prestigious technical institute on the planet, opted for "funhouse architecture." This is the funkiest building east of Las Vegas. MIT spent a factor of 2 ½ times the cost of a normal academic center. They could have spent less money and had a 100% renewable-powered, zero carbon environmental showcase that could serve as a model and a motivator for the whole educational field, and in fact the world. Instead, MIT opted for frivolity. Now, don't get me wrong, I'm not against frivolity per se—its an important aspect of life—but when it becomes your primary objective against the backdrop of severe crisis in the world, I'd say you're off the mark.

Look what the designers did to the front entrance of this building. No wonder they have "crime scene" tape around it. And in fact, the Institute has since started a law suit with the architectural firm that designed the building. The students have revolted. They hate the building. They call it the "Richter Center" because it looks like it's just survived an earthquake. The Institute has in measure of some atonement to the student's demands fielded a large solar system on the building across the street, to sort of make up for what they could have done over here. Shame on MIT.

It gets better. This is the Ontario College of Art and Design in Canada. Last I checked, the Canadian climate is severely cold in the winter. And so the designers decided to expose every surface of this building to the cold winter climate. They actually built this thing! Is that the most cost effective way to add classroom space to this college?

I keep after this, because almost every time the architect says, "Well we can't use renewable energy. We can't have more environmental features, because they're not cost effective. Instead, this is what you get. This is not architecture, but it's a philosophical embodiment of what gets you the architecture we just saw. Looking at the lens from the U.S. perspective. It's the U.S. national bird, the American Eagle, pumped up on steroids, wrapped in patriotic garb, presiding over a despoiled and deflated planet with its talons outstretched and a hunk of the earth's biosphere in its beak, at the Hummer dealership. I did not do this in Photoshop. This is a real sculpture and someone is downright proud of it, which gives you an idea of why we have a red and a blue country. The blue of course for those of you who haven't been watching in detail are the good guys. The red guys are just off in the weeds. And it brings up the question as to whether unbridled petroleum consumption is patriotic, because at least in the U.S. when you go to the petrol station it's like the 4th of July. It's like Independence Day. It's like the flag day—you're enveloped in a procession of flags. Even the tankers that deliver this stuff to the addicted customer base are wrapped in the flag, and where are all of our resources going?

I gave a presentation to a government conference last year which was keynoted by James Woolsey. James Woolsey was the U.S. former director of the Central Intelligence Agency, and 2000 government officials were in the room. And he said to them, "Next time you go to the gas station before you get out of your car, reach over and adjust your rearview mirror so that you can look yourself in the eye, because you are about to finance terrorism." That's what our former CIA director told our government officials. Yes.

This is probably the most important image that I am going to share with you today. My wife came running into our office last winter and said, "Stephen, you've got to come out and bring the digital camera. Someone's parked a big old Hummer next to one of our electric hybrids. This is a perfect side-by-side comparison to two distinctly different worldviews. You can have a 6500 lb grocery-getter that's capable of paramilitary maneuvers on the way home from soccer practice, that gets in the single digits of miles per gallon, or you can have a 65 mile per gallon, ultra-efficient, intelligent, integrated-design, the lowest coefficient drag of any production automobile, electric hybrid. Not to put too fine a point on it, but for a U.S. audience, this is significant. This philosophy is embodied by Detroit, especially by General Motors. And if you've been looking at the international press, they're toast. It's just that nobody has pulled the sheet up over them yet. The electric hybrids—I'm pleased to see many here in Israel—are the province of the Japanese automakers and need I point out that they're having the best years of their business history. And so I would ask—architects, engineers, developers, academics, government officials—which world view do you want to embrace going forward from here? The future belongs to the efficient. This is a dead-end philosophy.

It’s very important to underscore this, because the choices that we make each day as individuals and as a society will determine how and how well we make the transition to the post-petroleum world. We’ve developed a fleet of ultra-efficient electric hybrids and solar design—it’s grown. We even have some of our engineers commuting by bicycle. We want everyone to be traveling in the most energy efficient transportation possible as we guide them to making the most energy efficient buildings possible. If you go to Europe, you’ll see solar energy kilometer after kilometer after kilometer along the autobahns and highways in Austria, Switzerland, Germany, the Netherlands. Why? Because its there. Now think about it? How cost effective is a sound barrier? What’s the payback? I don’t know either, but we’re building a lot of them and they make an ideal platform to field large amounts of solar electricity, right in or near the urban core, on land that’s already in the public domain, as guaranteed solar access—thank you for the serenade—guaranteed solar access. Nothing will be built here. You just field a lightweight secondary support structure, and you can deploy megawatts of solar energy. The utility frequently crosses the highway. You just plug in. This could be done in a modular fashion. No new land taking. No land clearing.

Land is probably one of our most, if not the most, precious resource, and of course, we don’t have any more of it. And so as designers, engineers, planners we need to be much more creative about using and fully utilizing every resource, including land. And so the solution, the formula, is to look for multiple design benefits from a single strategy or option. This is just a simple illustration of that.

Multi-family solar: we were privileged to be involved with the first high-rise tower in New York City. This is the Lower West Side, overlooking the Hudson River. Working with César Pelli’s office, we fielded an electric skin in the building’s vertical wall—this custom structural glass canopy at the street grade. Another building on the Upper West Side, we crowned with solar electricity. There were lots of shadows from buildings adjacent, so we couldn’t put any in the façade. On the East Side of New York—this is the East River. The U.N. is just out of the picture here. Roosevelt Island: a medium rise residential complex. We covered every square meter with a very tightly packed solar array.

Adaptive reuse of 135 year old mill complex in New England--we had many of these. Lots of them had fallen into disrepair. This was a complete refurbishment: one of the largest solar electric systems in the Northeast: 350,000 square foot or about 35,000 square meter complex now has a mixed use residential, retail, commercial, a charter high school and a technical incubator, and it's all powered by sunlight.

This is a pop quiz, especially for architecture students and their professors. What's wrong with this picture? That's a building; that's a solar array. This is not the heart. It's not a trick question. Did I hear shading? Yes, of course. Now, the architect usually is the coordinator of the entire project and design process. The architect and the landscape architect were obviously not communicating very well on this project. And it is important to point out that a solar electric array has a much higher [THERE IS SOME VOICE OVER ON THE TAPE AND A FEW SECONDS OF WORDS ARE MISSING HERE] in series much like the old Christmas tree lights, and when you shade a solar module, you dramatically reduce its output, and it becomes a resistor to the flow of electrons from the remainder of the array that is fully illuminated, and so it will drag down the whole array. What bothers me most is that this building received all sorts of design awards: a Gold-Green Award from the USGBC, the committee on the environment, an honor award, and it shows you how little, at least, the design jury understood the applications of solar. This is horrible. It's horrible for the building owner because they're not going to get an investment return. It's also horrible for the entire profession of rising designers, because when this is published, everybody thinks, "Oh, well it won all these awards, so it must be just perfect." And of course, it's not.

Residential solar: it may come as a surprise to most people and many architects, but the majority—it's very easy to do LEED Platinum buildings. In fact, the majority of residences on the planet are already LEED Platinum. We're trying to go towards zero energy. This is a, by the way, an engineer's version of building integration. I'm not being pejorative—it's an engineer's house, and he felt in northern New England, with the very deep snow that we used to get in the winter, that if they put their solar trackers up on the ridge, the steep snow slope would shed the snow, and if they were on the ground as they normally are, of course, you'd need a much taller pole to clear the deep snow, and that would look ungainly during the summer when the snow was gone. And so the owner decided for a solution that's ungainly all year. The interesting part is that this part of the house shades this tracker in the winter when you need the energy most, but you can't get everything right.

Here's an architect's version of building integration. This is a house I designed about 15 years ago on the main coast in northern New England. The portion of the roof array on your left is solar thermal. The portion of the roof array on the right is solar electricity. The two technologies combined to form a single uniform glass plane that makes up the entire south roof. There's no conventional roofing and no waterproofing. The array has a ventilated soffit with an air chimney and a tall louver on the north side of the ridge, to encourage passive air flow which cools the modules. Solar electricity is produced in greater quantities when you keep the solar cells cool. We also pulled the make up air for the heat recovery air to air heat exchanger from underneath the array in the wintertime. We get about a 20 degree temperature boost over ambient, which is very welcome in a location, as Michael McDonough said last night, can go well below zero Fahrenheit. Design requirements here are 25 below zero, and it is frequently 15 below zero, so it is a harsh environment. This house has made more electricity every year since the owners took occupancy in 1994. It is a delightfully sun-filled, day-lit, radiantly-heated house, and if you look closely, you'll actually see the windows open. This is in the dead of winter, because the owners like fresh air. And they also take great pride when the neighbors come over and are complaining about their $700 energy bills per month, and the hostess says, "You don't mind if we open the window, do you? It's getting around 74 Fahrenheit in here and we like to keep it around 72, and so we'll bring some fresh air in." And they think, "Oh, my goodness, it's January. You can't do that." They say, "No, we live in a solar house. The heating is free." "Oh."

We also worked closely on the site integration, because as I mentioned earlier, and I will continue to emphasize, in a northern climate, you have to do everything you can to eek out harvest from a very meager resource during the point of the year when you have your greatest demands, and so the siting, this knoll, is southeast-facing. The sun comes up in the sky in the morning. It's very low on the horizon. It bounces off the snow, and we get about a 1.6 augmentation or enhancement which warms the house up very quickly in the morning, and that's a delight to have. And then, of course, they open their windows in the afternoon occasionally, and they like that too. The roof system is made up of the solar elements. There's no conventional roofing and no waterproofing. The solar elements are the roof.

This is a similar residence we did in the Carolinas. This is a cooling-dominated climate, but they still have a winter and they still have snow. A larger array because we're driving a Ground-Coupled Heat Pump. There's no fossil fuel on site. This house creates a surplus of energy beyond its needs.

We're trying to get beyond zero energy. This is a house again in northern New England, in the Mount Washington valley: severe winter climate. The owners wanted a traditional New

England farmhouse. They did not want a contemporary design. And of course, the climate's prerogatives prevail. It makes our job a little bit more of a challenge, because with the last residences as you saw we had a good amount of south-facing passive solar gain. Here, we were restricted to the conventional farmhouse geometry. We did have some flexibility on the animal barn which was built first. It has a full-integrated solar-electric skin. The details are historically correct in terms of proportion and detail. The barn was built first. The solar electric system powered all of the construction. They were net positive on day one in terms of their electricity, in other words, they had a surplus. The main barn has the solar thermal system which provides domestic hot water and storage for radiant heat distribution. We always end up designing them in the summer and building them in the winter. You've got to shovel the snow off the staging and get the integrated array into the roof. There is the solar thermal system. And the two technologies combined to provide all the energy required for the house with a verifiable surplus. These are the solar thermal tanks for storage. There is an energy surplus which was purposely planned with the solar electric array, such that the owners' local transportation requirements will be fully met by their current solar harvest when plug-in hybrids become available. Why on gasoline, when you can plug your car into your solar system. This is available today. It's perfect for Israel. Israel is blessed with an abundant endowment of sunlight, and as I look out over your city, I think, "My goodness, if we could take just a little bit of that back to New England, that would be wonderful."

I pointed out before that almost the majority of residences are already LEED Platinum. They're indigenously built. They're made with local materials. They're powered by renewable energy. And this has been that way for the history of civilization, except for the last 200 years. Those 200 years, believe it or not are an aberration, and if we do not get this right in the near term, we may very well be calling on these skills again: the American Indian, the native American tepee, the native Inuit igloo, the early north settlers in Iceland with their crude sawed living cave, if you will, and a jungle village in Papua, New Guinea—all assembled by local craftsman with local materials, LEED Platinum, without the checklist. So, it's not that hard to do a zero net energy building, if we are willing to get our expectations in line with the natural environment.

The success formula is—I said before—efficiency, efficiency, more efficiency, conservation, and then renewables. You can't just throw solar panels on a conventional design and expect to get there. I liken the design process for a zero net energy building to the design process for an America's Cup yacht. Most of you are familiar with this sailing competition. It happens to be named The America's Cup, but it is an international world sailing competition. All countries are invited to participate, and it's a very prestigious event. The relevance of course is the naval architects that design these sailing craft have one single design determinant that overrides and impacts, influences every decision in the process. And what is that? Winning—single over-arching design criteria. And these craft are engineered, every single part of the entire design assemblage, is analyzed, assessed, engineered with computer analysis, amazing amounts of engineering go into these craft, with one thing in mind: winning.

I was delighted to see Dr. Lam's presentation last evening, and his encouragement of architects to begin to again embrace the technical features of the buildings they design. They have, by and large, the profession has enjoyed maybe a 50 or 75 year vacation from dealing with the technology. Many designers preferred to pass that down to the engineers that served beneath them on bended knee, because those are just pedestrian issues that need not concern the lofty focus of the designer. But in fact all of those pedestrian issues combine to decide whether your building is a success or not, especially moving into the future that is before us. And so, what we are going to find is that, just as Dr. Lam had so eloquently described last evening, we need to engineer our buildings to win.

The interior was delightfully understated: natural materials, locally harvested. Fortunately there was an outbuilding on the property that just by serendipity had a south-facing roof at exactly the angle we would have chosen—true south. We skinned that with today's solar technology and planted a wind turbine into the rocky coastline. The two technologies combine to provide more energy than she can use.

Commercial scale wind turbine right on the Boston waterfront: this is a Regional Training Center for the electrical workers. These are where the future electrical workers come for their apprenticeship, and now they have 40 hours of solar-specific coursework in solar and wind before they enter the workforce. You need to have a ribbon cutting, because the local leaders and politicians need to understand how important this technology is and for better or for worse, this is how you most often best get their attention.

We were privileged to field the first utility-scale turbine on the northeast coast. This is at the western mouth of the Cape Cod Canal, powering the Massachusetts Maritime Academy's campus: 18 buildings right on the waterfront. Every day you see the flag is out stiff. This is an ideal wind site, and where wind resources are compelling, wind can be very attractive economically. This was a very significant investment. It will pay for itself within five to seven years, at today's utility rates without any estimation for future escalation. We've since fielded solar on the campus. We have a complete walkway and path lighting solar stand alone system. We fielded solar on the rooftops. You get an idea—that's the open ocean—so this is a very good wind site. The chancellor of the campus has committed to a completely carbon neutral campus by 2020, and they may well be the first ones to get there.

Wind and solar make very good partners when the wind resources are committing. And of course, you have a very significant distribution of wind resources, unlike solar which is reasonably uniformly distributed. Wind is concentrated along the coast and in certain area of topology, mainly mountain ridges, and if an architect or a client is looking to assess a site for wind potential, you really need to take monitored data, unless there's historical data from right in the immediate area.

It's not a question of whether we like wind turbines or not, and if we cannot—at least in my country there's been a lot of opposition to wind turbines, because people don't think they are attractive. I think they are very elegant, but then of course I'm not objective about any of this. We have a choice. I always ask an audience if they would give a show of hands of anybody who's willing to give up electricity, and it's probably not worth looking too hard because I doubt anyone's going to put their hand up. And so electricity demand continues to go up and we have a choice. It's not, "Well, don't build wind turbines because they aren't pretty," you then end up building more of these. By the way, that's the coal plant we visited earlier. And so the question is: Which kind of future do you want. I don't know if anybody has seen a coal plant, but this is a coal plant. And you have a train that's often half a mile or a kilometer in length. They come at least once a day and they pour these chunks of carbon into this belching behemoth that creates a great deal of heat, a small amount of electricity, and a huge stream of pollution.

Now, during my time here in Jerusalem, I've met some very smart people. People who have been educated at prestigious universities all around the world, including our session chairman from MIT, many MIT students. The engineering challenge of our future, very simply put, is to simply reverse this conversion process, where somehow, and the MIT engineers are smart enough to do this, I know, we could create a reverse process where we're pulling the pollution out of the environment, out of the air mass, down the stack, somehow recombining it into solid chunks of carbon, putting it in the trains, and burying it in these giant holes that we have in the middle of our country. That's called carbon sequestration. It's going to be a challenge, but the MIT folks are smart enough to do that. While they're working on it, we need to have the good sense to leave this stuff in the ground where the good Lord put it in the first place. That is carbon sequestration.

I'd like to point out to those who are still skeptical about renewable energy making a significant contribution, that Denmark gets 30% of their country's entire electricity requirements from wind power. And that was a result of a very ambitious, focused, 10-year program, onshore and offshore. If you fly into northern Europe from London, for example, as you make landfall on the North Sea coast, as far as you can see in both directions are wind turbines—onshore and offshore. They're taking advantage of a resource which is very compelling. Sunlight and wind are free. There's no embargos. There's no war. There's no strife. You're not going to run out. What's not to like about that.

I was privileged to be invited to speak at Oxford University a while ago, and it was a humbling experience, not just because it's a very prestigious technical institute, but being trained as an engineer and an architect, I'm drawn to things that regular folks might not be. And I was just amazed by the architecture on campus: amazing, amazing, amazing buildings. Look at the detail, the loving care, the preservation. And the persons that were my host on campus were walking around and I noticed these little brass plaques tucked away inconspicuously in an alcove, and I said, "Is that the address of the building?" They said, "No, no, that's the year it was finished." 1473, 1527. Now this is nothing new to Israel—your old city is thousands of years old—but being from the U.S., I've never been in a building that's older than 100 years, probably. So, I was just marveling at these buildings, and then it occurred to me all at once: these buildings were built without computers, without calculators, without electricity, without hydraulics, without shaft power, without any cranes or mechanism or any kind, without even any power tools. They were built by hand with master builders. And the woman who arranged my visit to campus came down the main stairs and saw me kneeling on the stair taking close-up photographs of the marble mosaic in the stair banisters—there were 18 different kinds of marble here. And she thought I'd fallen on the stairs. "Mr. Stong! Mr. Strong what's happened?" I said, "Don't worry, I'm just taking pictures of your banister." She looked at my like I was crazy. I said, "I'm from the U.S"—as if to explain, "Well that's why you're crazy." I said, "No, I've never been in a building that's 500 years old. This is awesome." And she still, you know—they're used to that. But in a moment, she got it, and she said, "You know, Mr. Strong, in all of those 500 years, this building has been occupied almost exclusively by male undergraduates," as if to underscore how much torture it has received through the centuries and its still standing as proud and as true and as plumb and as solid as it was the day it was built, and so I want to ask the architects in our audience today, if the world's most prestigious university came to your firm, and said, "We want to select you to design out next academic complex. The only thing, we have a few details in our design brief. You have to design it without computers, without calculators, without electricity, without hydraulics, without shaft power, without cranes or power tools, and build it that way and guarantee with your firm's integrity that it will provide our university at least 500 years of uninterrupted service. Could you do that?" By the way, it needs to be LEED Platinum but that's LEED Platinum, and it was LEED Platinum before LEED was ever LEED. We knew how to do this before, and so it begs the question: what is sustainability anyway, and what have we lost and what have we gained over the last 500 years? This isn't steel studs and sheet rock. Could you do that? Show of hands: architects! 500 years of service—no electricity, no computers.

Corporate solar: we were privileged to be invited to do the solar on the Gentine (ph.) Facility that Stefan Behnisch showed the other evening. Quite a remarkable building—very difficult to put solar up there, but we managed. And the Midas (ph.) Center out on 128—the designers wanted an entry canopy along the entry promenade, and we did a custom solar glazing above. The idea was to show off the future-oriented, hi-tech nature of this R&D facility, and the designer got it immediately. She said, "I've got it. We're going to animate the transition between your arrival and entry into the building." And by that you see the varied shadow pattern. As you walk along the canopy, this pattern of sun and shadow envelopes you, draws you to the technology, and you're already sort of marketed to, in terms of "We're hi-tech," "We're forward thinking," "We're future oriented." It's great. The designers loved it. The owners loved it.

This is solar dream: kilometers and kilometers of open route space, megawatts and megawatts of solar. This is a project in a very un-sexy trucking distribution warehouse in Eastern New Jersey. It's main claim to fame or attribute is that it has acres and acres and acres of uninterrupted flat roof, begging to be harvested, just like all the thousands of kilometers, and that's the answer. That is the vision of the future. All of these roofs need to be harvested. They're begging to be harvested.

We were privileged to work with BP to field their solar powered gas station campaign across the U.S. Two flavors: the existing flat panel canopies got these low-angle retrofits. The new builds were a bit more interesting architecturally with these low-rise, barrel-vaulted canopies which were glazed with a laser-etched thin film to allow light to illuminate the service island below. We even fielded electric vehicle recharge ports, talking BP into welcoming electric vehicles into their petrol stations. Now how's that for beyond petroleum. It's a start as they say.

You're looking out through the Solar Power Plant, which looks like tinted glass to the untrained observer. And there was a "twofer" here that I have to admit we didn't even see coming. And that was the franchisees who run the petrol stations worked out on their own that there was enough sunlight coming through the overhead solar canopy, that they could turn out the high intensity lights during the day, which you often see running in full daylight. The savings from the lights about equaled the harvest from the solar array, and the two together were 200%. And that's an integrated design, and that's what we need to seek.

More integrated BIPV: this is recreational equipment. The mountaineering outfitter, Genzler's (ph.) firm wanted daylight in the central retail area, and so we helped design this lantern that has clear glass on the vertical façades, and a building–integrated component on the top. What you can't readily see is the solar electric glass. It has a slightly translucent inner layer, because the retail designers didn't want this hard shadow pattern on the merchandise, so as the shadow travels down to the merchandise from the roof level, that pattern is dispersed, so it's very gentle. And they loved it.

Solar parking canopies: we fielded in northern California with HOK San Francisco office. We also integrated electric vehicle and plug in hybrid recharge ports, along throughout the parking area with dedicated parking spaces. California, of course, is our most progressive state, and they are pushing for electric and plug-in hybrid vehicles. The parking lot is just a big black slab of asphalt. It creates an urban heat island. It's land that is grossly underutilized, and it's begging like the roost bases to be harvested.

More covered parking in Phoenix and Los Angeles, and a project in Germany which we were not involved with, but which I found extremely creative. This is an industrial facility, so obviously there's not a high aesthetic budget, but the owners Thyssen Steel in Dusseldorf wanted to do something that was highly visible, highly creative, and appropriate. And they took thin film flexible laminates and bonded them to their standard industrial metal siding. And it's just delightfully fun.

Our other speakers have mentioned the 2030 challenge that sets a very clear outline to the goal of getting to carbon neutral buildings by 2030, and many organizations including the Architects Professional society, the U.S. Green Building Council and others, the Engineers Society have signed off on these.

I want to close by looking at a rather weird phenomenon. It's surprising how people who have just until recently believed that climate change is just something conjured up by the environmentalists to slow down the economy. "It isn't really real. It doesn't have any scientific basis." We were recently hired by a very well-to-do conservative, red-state, Republican-leaning person to field renewables at their ocean side resort, their summer house, if you will. And we were told by the owner, just when you're on my property—they don't spend much time there, only a few weeks in the summer—when you're on my property just do the work you're supposed to do. Don't roam around. Don't look around. Just do the work. And the landscape crew laughed when we were there, and so of course the first thing we did was roamed around the property. Remember, this guy does not believe, at least publicly, that climate change is any reality. It's just hokum. That peak oil –there's going to be enough fossil fuels for the rest of the world forever. At least publicly, that's what he says. So, we were really amazed when at the far corner of the property, at the highest elevation, away from the water, behind a private gate, we discovered the most bizarre thing. This is his last resort, he's got a boat moored at the float, and when the water rises from the sea level rise, he's got completely outfitted. He's got solar panels, navigation equipment, provisions, and it's his last resort.

I sincerely hope we as a society don't wait that long. We need to figure out what kind of future we want, and it's time for us to choose. The problems are clear. We are the solutions. It's time to get working on this. Thank you very much.

Dr. Yoav Sarne: It was really a very great presentation. Thank you very much Steven. I have noticed some of your good engineering groups in your presentations, especially when you criticize some of the beautiful designs of the architects. I fully agree with you about the criticism about MIT, although I came from there. But I would add that any client—MIT is a client—that lets an architect do something like that, deserves it. So, I am sure that the entire audience will join me in thanking you for the great and impressive presentation. Thank you very much.