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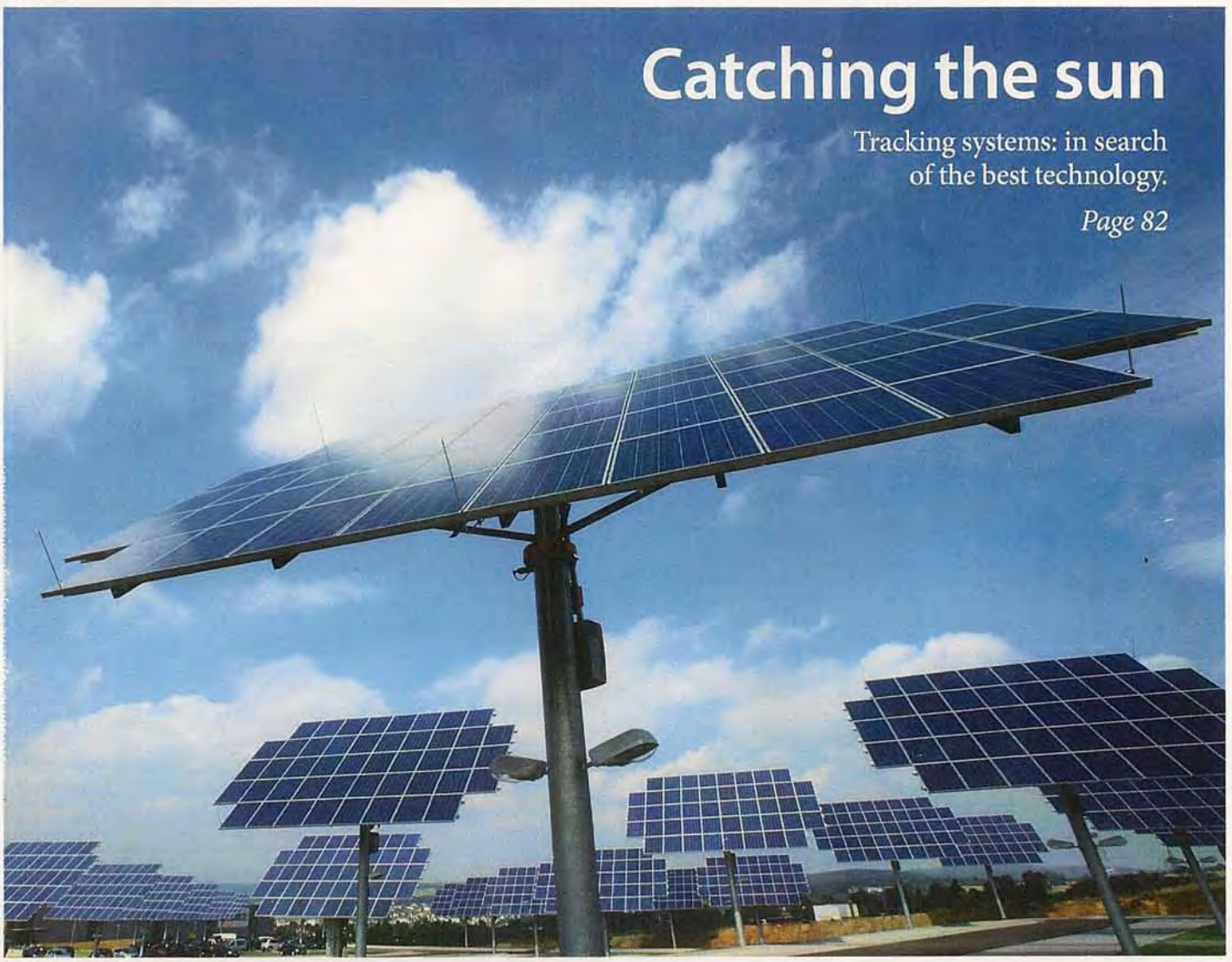

Catching the sun

Tracking systems: in search of the best technology.

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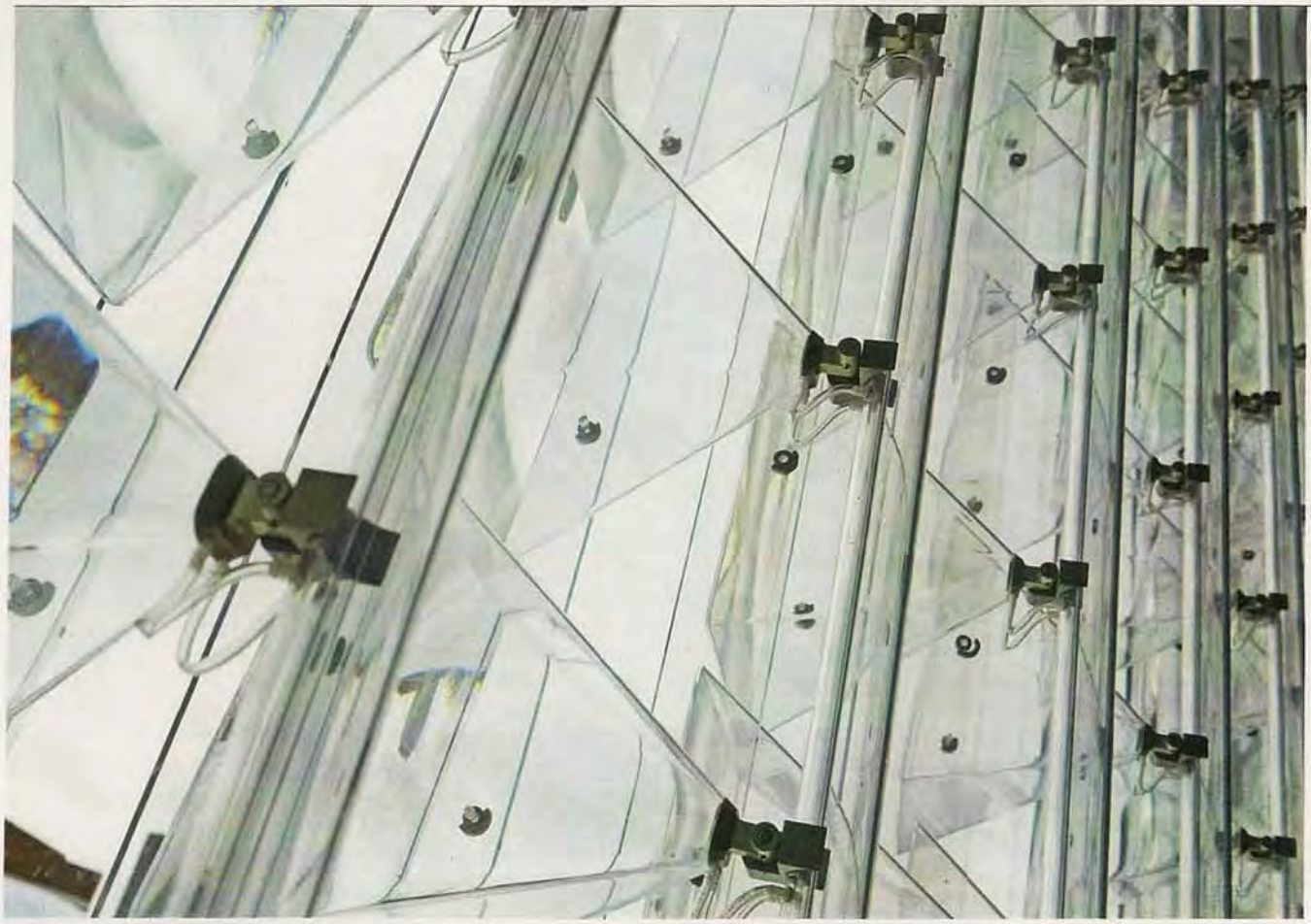


Photos: Center for Architecture Science and Ecology

The concentrating solar facade system at the Center of Excellence of Syracuse University, State of New York.

Pretty and efficient

Concentrating PV: As the photovoltaics market gets more competitive, new systems that combine solar electricity generation with solar hot water and heating could help reduce cost payback periods. The Center for Architecture Science and Ecology is developing a concentrating PV technology integrated into a glass facade, which also hopes to gain a competitive edge with its "gem-like" design.

Look at an installation of large solar concentrators on trackers and one of the first things you're likely to notice is their enormity. Consider the dimensions of Amonix Inc. systems, for example, in which seven concentrating PV modules, together forming a 22-by-15-meter (72-by-49 foot) rectangle, are mounted on a single tracker. When associate professor Anna Dyson read about the large solar concentrators which Amonix and others were developing back in 2000, using Fresnel lenses and trackers to follow the sun, she immediately saw the potential to make them smaller.

Dyson, who was teaching product design and innovation in both engineering and architecture at Rensselaer Polytechnic Institute in New York, was struck by the possibility of miniaturizing the technology to integrate it into building architecture. "I looked at the giant trackers and said we need to try and see if we can get a tracking system for a building envelope," she says, referring to the part of a building – including walls, roof and windows – that separates the inside from the outside. "I saw that they were working with a technology that was much more efficient, and I saw that as an architectural solution." She thought that such a technology could bring more day lighting into buildings, an important feature given recent studies finding that people need far more daylight for optimal health, and could potentially fulfill a whole range of the building's energy requirements, including electricity, hot water, heating and cooling. It could integrate those isolated systems into a single system on the building facade. She drew up concept sketches and set to work on making her invention a reality with partners at Rensselaer.

The idea has led to a decade of interdisciplinary research, funded in part by grants from the U.S. Department of Energy and the New York State Energy Research and Development Authority, and has so far yielded six generations of prototypes.

The technology, currently called the Integrated Concentrating Solar Facade System (the name will likely change later on), is now being developed for commercialization at the Center for Architecture Science and Ecology (CASE), a research-and-development collaboration between Rensselaer Polytechnic Institute, architecture firm Skidmore, Owings & Merrill (SOM), and other unnamed engineering and architectural companies. Furthermore the technology is being installed in a series of pilot projects, starting with the first full-scale demonstration project – consisting of 64 concentrators in a 8-by-10-foot piece of glass curtain wall – at the Syracuse Center of Excellence in Environmental and Energy Systems, scheduled to open in March.

The solar facade consists of a glass wall in which rows of transparent, pyramid-shaped concentrators are configured in a honeycomb pattern and hung on wires that both move up and down and twist side to side in accordance with the sun's movement. Each concentrator incorporates a Fresnel lens that magnifies light nearly 500 times and directs it to a postage stamp-size Spectrolab solar cell made of highly efficient gallium arsenide. The Spectrolab cells have reached a lab efficiency of 38.2 percent, and could reach a production efficiency of 30 percent. The system, encased between two pieces of glass, provides both heat and electricity. Heat sinks placed behind the solar cells absorb the sun's warmth, which heats the fluid that runs behind the system to cool it. The result is a symbiotic relationship in which solar cells are kept cool – photovoltaic cells lose performance when they heat up, and at 500 times concentration, they can get very hot – while the cooling system also captures the waste heat. This is then used by the heating system. As Jenny Chase, lead solar analyst for Bloomberg's New Energy Finance, puts it: "Heat and CPV work quite well together, because generally speaking you have something that wants heat and something that wants to get rid of heat."

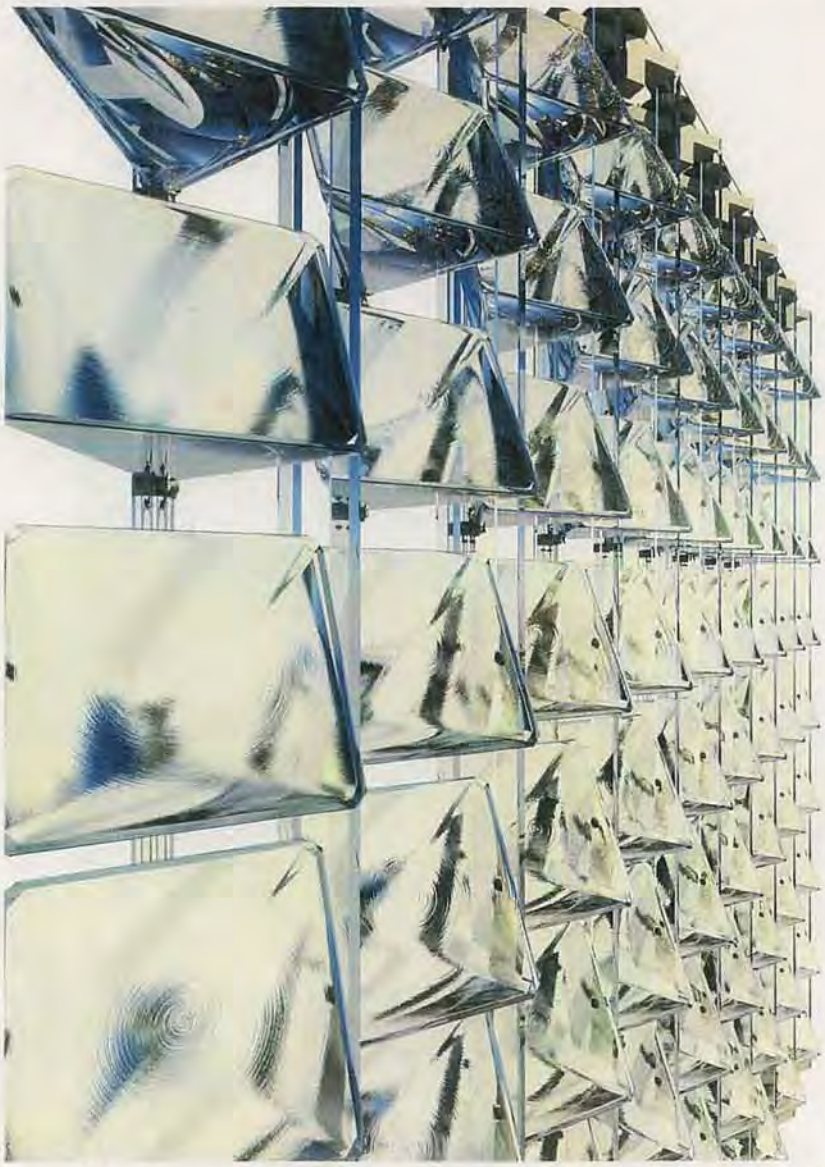
The solar facade: concentrators hung on wires that move up and down and twist side to side.

All together, CASE expects the system will use in the form of either electricity or usable building heat 60 to 80 percent of the sun's energy – including light and heat – reaching. This high efficiency, combined with the ability to provide multiple benefits including electricity, hot water, heat, day lighting features like skylights and potentially even cooling, leads CASE

to believe the facade's cost and energy payback periods will be a fraction of existing solar building projects'. The initial costs may be higher, Dyson says, but adding heat and day lighting features to the solar-electricity system means the cost payback period will be "substantially lower."

Calculating payback periods is notoriously tricky, however. The weather, the project capacity, the heating requirements of the building and customer choices about how to use the heat generated by the system all play into the equation, as well as the value of the systems that the facade might be replacing. For example, some customers also might not be able to use all the heating or hot water capabilities that a system could produce, reducing savings. "It's quite cheap using solar to heat hot water, but not that many places need enormous amounts of water," Chase says, adding that unused capacity "is not worth it."

The allure of the Dynamic Solar facade includes aesthetic appeal, not just economic calculations and environmental benefits. The concentrators have a modern design, bringing daylight into the building while deflecting heat and glare, reducing the need for artificial light during the day, Dyson explains. Like partially open Venetian blinds, people will be able to see past the concentrators throughout the day, except right at noon when they will be completely "closed," says Michael Jensen, a professor of mechanical engineering at Rensselaer. But unlike stationary blinds or drapes, the concentrators will automatically move throughout the day to block glare. The removal of much of the heat that comes with the light could make the building more pleasant for occupants, as buildings with many windows can suffer from stifling temperatures. It also might mean that buildings in hot climates would need less air conditioning in the summer, reducing electricity demand and cost.



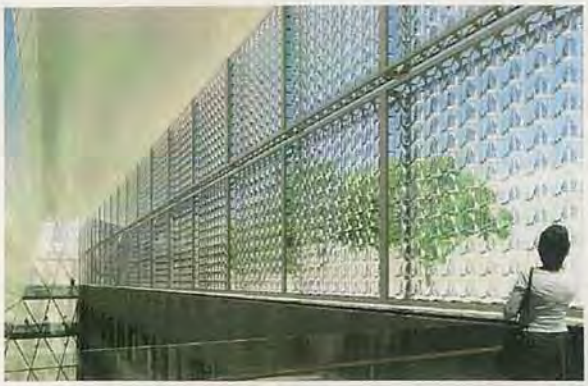
The concentrating solar facade system can provide electricity, hot water, heat, day lighting, and cooling.

Those architectural features could be useful and attractive to building developers, Chase says. She points out that people put all sorts of uneconomic features on skyscrapers, especially in periods of prosperity, to attract attention, such as bright lights that stay on all night. To that end, a big part of the success of the facade will depend on how good the team is at marketing it, Chase says.

Others also see the aesthetic appeal. The Fashion Institute of Technology in New York plans within a few years to install the solar facade in its student center, where it will provide hot water for the cafeteria and electricity to run LED task lights. And Nicholas Holt of Skidmore, Owings & Merrill calls the facade "a wonderful potential development." "You have something that is more efficient than competing technologies and is also stunningly beautiful – we architects like that," he comments. In a skylight-type application, Holt says the facade would look like "a gem-like thing floating over you in a cloud."

Still, CASE has a long way to go to bring the Dynamic Solar Facade to the market. First of all, manufacturing a new technology is hardly a simple task. Many thin-film companies, for example, have found it has taken longer than expected to reach commercial production. Innovative startups also often face a chicken-and-egg problem: they need lower costs to get customers, but initial manufacturing costs are high until volumes grow enough to lower said costs through the economies of scale.

Also, the higher up-front costs Dyson mentioned are no small obstacle in today's financial climate. Investors are risk-averse, favoring conventional technologies and making projects with higher upfront costs a harder sell, even if those projects are expected to cost less over time. Even when financing is available for new tech-



The Fashion Institute of Technology in New York plans to install the solar concentrator facade in its student center.

nologies, it tends to be more costly, and those higher rates can end up significantly boosting the total cost of a project. Jensen says the team is working to further cut costs.

Any reliability or maintenance concerns could make financing even more difficult. Think how annoying it can be when blinds get stuck in place, for example. Developers may be concerned that owners will spend more on maintenance and repair if anything goes wrong with the system. While Dyson says the maintenance would piggyback on the window-washing schedule, Holt warns that potential operations issues of new technologies can be tremendous due to the need to train staff to take care of new systems. Concentrating systems have also had reliability issues in the past.

But one major difference is that other CPV systems generally reside outdoors. They have to deal with wind, rain, snow and hail, and tend to corrode, degrade or shift slightly off-kilter. Small shifts can result in huge performance losses in concentrating systems, which need to be very accurately focused to reflect light on the tiny cells. As the facade is part of the building, enclosed in glass, it isn't exposed to the elements, which CASE believes will result in higher stability and reliability. And even though the facade is encased in glass, the system is accessible through a door in the window in the event that anything should go wrong, Dyson adds.

Meanwhile, the CPV technologies face increased competition as the cost of conventional photovoltaic panels has been sinking. "PV's getting so cheap that it might just be cheaper to shove a PV system on the roof and run a conventional heating and air conditioning system from it," Chase says. And even though thin-film photovoltaics are less efficient – in most cases, you'd need to cover practically the whole building to defray a significant amount of the cost of power and heat, according to Dyson, who calls that unrealistic for most buildings – they are potentially cheaper. They remove the risk of water oozing out of the window, for example, if the cooling system leaked, says Chase.

All together, the technology could be ready for the market in less than five years, Dyson says. He cautions that many variables could change the timeline. Nicholas Holt and Michael Jensen also confirm that commercialization within five years seems reasonable. Anna Dyson says CASE expects to receive more interest from the commercial market at first, in part because of the modern, high-tech appearance of the facade. Yet ultimately it would like to target residential markets as well. ◆ Jennifer Kho