# From materials research to climate change: David Eaglesham assesses the solar energy industry

Interviewed by **Steve M. Yalisove** and **Arthur L. Robinson**

David Eaglesham is dedicated to using materials science to address energy problems. After earning a PhD degree in physics at the University of Bristol (UK), he spent many years at Bell Laboratories working on semiconductors and later took on management positions at Lawrence Livermore National Laboratory and Applied Materials. It was at Applied Materials that he began to connect with the solar industry, just as it was getting hot. When he joined First Solar in 2006 as Vice President of Technology, it had around 350 employees and about USD$50 million in revenue. The company now has grown to about USD$4 billion in revenue. With an extensive portfolio of achievements in scientific research and ever eager for new challenges, Eaglesham left First Solar this summer and has taken a new position with Mg-ion battery leader Pellion Technologies. We caught up with Eaglesham at a corner brewery in Ypsilanti, Mich., where we noticed that they were putting up photovoltaic panels on the roof combined with a solar thermal energy system—a hybrid system. This auspicious beginning led to an all-encompassing interview spanning the range from materials research to mitigating global warming.

***MRS BULLETIN*: Several years ago when you were president of the Materials Research Society, you called for a "Manhattan Project" for renewable energy. Is this still needed?**
DAVID EAGLESHAM: I think we need to make carefully targeted investments in basic research—that's actually something that the government does very well. And I think government investments in creating markets can help to build a marketplace in which all commercial sectors can then compete without further government involvement. And, I believe that as a planet, we will eventually put a price on carbon—a carbon tax. The countries that are first to implement such a tax will be the first to develop low-carbon technologies and will ultimately be the most competitive.

**Where are the biggest areas of opportunity for materials in improving photovoltaic (PV) efficiency and in reducing cost?**
With regard to materials, it's hard to come up with a truly new semiconductor because photovoltaic (PV) materials like cadmium telluride (CdTe) and copper indium selenide (CIS) are good by virtue of their defect properties. In particular, the recombination velocity at dislocations and grain boundaries is low. And that makes predicting good new materials difficult. As a result, a lot of people are working on the wrong problem. The big opportunities that I see lie in exploiting capabilities that the semiconductor and LED [light-emitting diodes] industries have developed to achieve higher efficiencies in silicon and other materials—technologies like heterojunctions, band engineering, heteroepitaxy, dopant engineering, barrier layers, and contact engineering. Figuring out how to adapt those tricks to photovoltaics in an affordable way while achieving high throughputs presents a huge opportunity. Other major PV challenges are around metrologies, control of the process, and manufacturability, and that's an area where the materials community excels.

**You said a lot of people are working on the wrong problem. What's the wrong problem?**
There's a big push to try to use earth-abundant elements in semiconductors, but it's hard to find something that's much rarer than tellurium, and in CdTe, only a tiny fraction of the total cost of the system is the tellurium. Similarly, the affordability of silver is not a problem in crystalline silicon. So we're trying to fix something that isn't a problem. What we really want is higher efficiency.

**Where can materials help promote sustainable, long-term significant PV power production?**

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I think there's going to be sustainable, long-term silicon power production without going beyond the existing materials technology. And ongoing improvement of the existing thin films, CdTe and CIS, will continue to make them successful. But there are things we could do to move the current technology landscape faster. Cadmium telluride is the technology that's farthest from its theoretical capability, so there's plenty of room for raising the efficiency. In other materials, producing a low-defect density III–V on glass either by heteroepitaxy or by liftoff techniques would result in a very high efficiency device, as would good defect passivation. Tandem devices are currently under- or unexploited and will be a major direction in the future. Organic devices are problematic because there's still a question whether someone can produce a reliable device at an efficiency that's high enough to make a difference.

**What about the vision of painting a solar cell on the side of a wall? Might organics be a part of that?**
The notion of spraying on PV is seductive but delusional: even if we could figure out encapsulation, there's still wiring, mounting, inverters. And I don't know how we'll test the device for reliability. Rolling out flexible devices onto a roof may be more practical, and the materials community will figure out how to make the installation cost-effective, which is the biggest cost of the system. The flexible device is not necessarily an organic device. Whatever it is, we'd still choose the materials system that provides the highest efficiency in order to lower the biggest cost.

**What challenges would we face if we wanted to get to even 1% of the global energy production with PV?**
I think the existing technologies and some of the emerging ones can take us most of the way. There's good reason to believe that a cost of electricity around 10 cents/kilowatt-hour is reachable, and that makes the economic impact of a carbon tax affordable. There's a lot of fear that a carbon tax will make the economy grind to a screaming halt. But the difference between fossil and PV electricity is only about 4 cents/kilowatt-hour, and that means that the tax is affordable.

Another area where we can make headway is in the "balance-of-systems" cost through higher efficiency [solar cells] and better construction practices. New materials for power electronics are likely to have a big impact, but lifetime is an issue.

**Many say that solar, as a significant energy provider, is a non-starter until storage solutions become either better or cheaper. Do you agree?**
I believe that renewables can and will play a large and successful role at the grid level without storage. Since demand in any industrial country peaks in the middle of the day, we can begin by adding solar to the grid basically as negative demand during peak hours. Second, as solar-energy production forecasting becomes better, we can use PV as a predictable component of our generating "mix," and ultimately, we can add wind, which primarily generates energy during the night. Studies show we can achieve very high penetration of renewables into the grid at the expense of fossil-fuel sources without storage. On the other hand, there's a clear pathway for hybrids to decrease the carbon footprint of transportation through improved storage solutions, and this direction is an extremely interesting path for materials innovation.

**The solar industry is in flux with IPOs and venture-capital cash infusions mixing with production scale-backs and business closings. What are the reasons for this shakeup? And how does it affect the prospects of a solution to climate change?**
This industry exists for regulatory reasons, and recently regulators have chosen to make the PV market smaller, resulting in lower capacity, lower prices, a collapse in stock prices, and bankruptcy for noncompetitive players. I think the regulators got pretty much the outcome they wanted: a much more competitive and less profitable solar sector that is serving a significantly smaller market. I think the underlying question is whether the shakeup means that the industry is closer to or farther from the long-term goal of making solar electricity competitive with fossil fuels, and clearly the industry is much closer to that goal than it was.

Regarding climate change, a competitive industry is not enough. People assume that all we need are renewable technologies that are competitive with fossil fuels, and the free market will do its work. That's delusional on three different levels. First, no energy market anywhere in the world is really competitive. Second, where renewables are now competitive with fossil fuels, as in India, fossils are subsidized. Last, if PVs were ultimately successful, people would just use more electricity, and we haven't solved anything. It's about choosing how we tax. Right now, most tax is income tax, so we're taxing labor as opposed to taxing more evenly across fossil-fuel consumption and labor. If we want to import energy and export jobs, we can keep 100% of the tax burden on labor. If we want to reduce the use of fossil fuels, we have to make them more expensive. We have to have a carbon tax. It's that simple. □



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