Cool Earth Solar

GALCIT Alumni Are Diving into Muddy Problems and Coming out with Clear Solutions

Cool Earth Solar is a company founded and managed by Graduate Aerospace Laboratories of the California Institute of Technology (GALCIT) alumni Eric Cummings PhD '95 (Founder), Jacques Belanger PhD '93 (Vice President of Technology), and Aurelius Prochazka PhD '93 (Principal Scientist). The company has developed breakthrough concentrated photovoltaic solar technology that will dramatically reduce the cost and time needed to build large-scale power plants that can generate clean energy at prices competitive with fossil fuels. This new technology uses 8-foot-diameter inflated plastic balloons with a reflective lower surface that focuses sunlight onto a built-in photovoltaic cell.

We at ENGenious had the pleasure of sitting down with Eric, Jacques, and Aurelius to discuss their company, the global energy crisis, and the impact that Caltech and GALCIT had on their lives and careers.

ENGenious: What is the idea behind Cool Earth Solar?

Eric: We want to compete against coal without subsidies and without altruism. We want to be a great investment, the best and cheapest way to make electricity. We get to keep the coal in the ground. We get to use our oil for things that are better than putting smoke up a chimney. Renewable energies do not present a threat, and our view is that there is nothing but upside. We want to be responsible to future generations, and we really don't want to be hated by all of our descendants for having wasted and squandered resources. Also, I'm just not a big fan of going to war for energy, and I don't want to see a future where we have to defend our energy interests with violence.

ENGenious: What inspired you to become an engineer?

Eric: It really must have been my dad. When I was a kid growing up, he would spend the evenings on the recliner in our family room solving some design problem on a quadropad. He was a microwave engineer and a workaholic and I looked up to that. When I was in kindergarten, I used to do the same kind of thing, only I was designing airplanes made out of lawn mowers.

Jacques: When I was a kid I was always fascinated with new construction. It could be a bridge or a building and that interest slowly migrated into an interest for different modes of transportation. Creating something in your head and being able to go through the process of creating a product, like a plane or a bridge, was totally fascinating for me.

ENGenious: How has Caltech influenced you?

Jacques: Caltech had a very rigorous approach to problem

solving, which taught me to always go back to the principle and build the base for my solution. Caltech taught me how to solve problems; it is not the answer that is important, it is the process. This will always stay with me.

Eric: We all had Hans Hornung, the C. L. "Kelly" Johnson Professor of Aeronautics, as an advisor in some capacity. He is a remarkable person and a truly passionate problem solver. He was the director of GALCIT at the time and was trying to commission a new facility called the T-5 Hypervelocity Shock Tunnel. This was a very complicated and multidisciplinary process for which he formed a great team of grad students to solve the problems. I really enjoyed it because one day I might be machining threads in a piece of metal, and the next day designing a laser, and the day after that trying to figure out how to press grooves into a piece of stainless steel.

Jacques: The key thing that worked in T-5 was teamwork. We had a very tough facility to build and ran into a lot of trouble, but it was amazing. When you assemble a very good team, the amount of work that can be accomplished is unbelievable.

Eric: Some of my fondest memories of that time are sitting at the blackboard on a Friday afternoon and somebody posing a question to Hans. Hans would stand there and scribble away, doing calculations much faster than we could do on a calculator, and end up with an answer that was practically dead on and correct. That was a very important skill that he taught and it helped us when we were trying to start Cool Earth and had to figure out how we could possibly solve a problem as big as the global energy crisis.

The other person that I keep with me is Paul Dimotakis, the Northrop Professor of Aeronautics and Professor of Applied Physics, and JPL Chief Technologist, who is a really amazing researcher. One day in class, he posed a very difficult question and everybody gave a partial explanation that wasn't satisfactory. Finally, he said, "I detect a lot of muddy thinking here" and then he stood back, erased the board, and calmly gave a crystal clear explanation. It didn't seem that way at first, but while there was a lot of ambiguity and uncertainty, there was also a very clear and concise right answer to the question. That was just astonishing and kind of liberating.

I've been looking for those kinds of crisp, right answers since then. Whenever I spot myself in some muddy thinking, I try to get to the bottom of it until I have an absolute solid answer for something. When devising solutions to problems that are fairly out there, having that kind of mastery of the topic, embodied by this lack of muddy thinking, is pretty important.

ENGenious: What advice do you have for Caltech students?

Eric: You're much more likely to get wealthy doing something you're excited, ambitious, and motivated to do than something you're doing just from nine to five.

Aurelius: I want to expand on that a little bit. When you come into GALCIT, you should realize that you're entering a very interdisciplinary school and you have access to many different types of people. Eric's thesis work was a combination of chemistry, aerodynamics and fluids. I did computer science, applied math, and even minored in economics. Jacques did a minor in planetary science. This interdisciplinary world had a great impact on the companies that we have started, which have involved people from astrophysics, mechanical engineering, and computer science. So follow your heart and do not be stuck in any particular school or any type of work.

Eric: You know, we could be more practical: actually, what you need is to get some smart undergrads in your classes. They're smart enough to know to ask lots of questions that slow the professors down so you can actually write down what they've scrawled on the board. The undergraduates have it all figured out. Follow their lead.

Aurelius: Make every effort to meet and work with the undergraduates.

Eric: Undergraduates are really amazing at Caltech.

ENGenious: What are your thoughts on the global energy crisis?

Eric: I take it very seriously. It was 2005; I had three young children and a job that I loved at a national lab. I was pretty happy and comfortable in life. Then I went to a meeting in Washington, D.C., where Professor Nate Lewis, George L. Argyros Professor and Professor of Chemistry, gave an incredible 45-minute talk about "The Problem"—the energy

problem, the urgency of it, the size and how our concepts of possible solutions are really off by orders of magnitudes. It was an incredibly moving experience for me. When I left that meeting, I had resolved that I was going to dedicate my life to solving this problem. I didn't know exactly how that was going to play out, but there was no question about it after that.

I began to consider practical present-day solutions to the problem, with the right scaling characteristics and economics. I decided to quit my job to devote myself full time to finding a solution, and it took about a year to come up with something that actually penciled out in principle. You can imagine that starting a company with a product as unlikely as inflatable solar concentrators was a fairly high-risk, low-odds proposition. That was how Cool Earth started.

As a scientific community, we need more focus on basic practicalities such as scalability. There are some solutions that people are spending a lot of time on that use rare materials like indium, platinum, and palladium. But any solution that uses a significant amount of these rare materials to produce electricity doesn't end up penciling out; economically such approaches can't be viable. What will we do when we run out of indium or tellurium? Mine another planet?

Jacques Belanger (Vice President of Technology) and Eric Cummings (Founder)

ENGenious: What do you mean by scalability?

Eric: Caltech has been instrumental in getting the message of scalability out. A coal plant puts out about 500,000 watts and by 2050 humans will be consuming about 30 (10^{12} watts) terawatts. We need to have a viable alternative solution to fossil fuels by then. When Cool Earth Solar was funded, we were planning on producing 50 megawatts (10^{6} watts) per year. At this rate, it would take us ten years to replace one coal plant. Let's say we scale up by an order of magnitude. Then we're replacing a coal plant a year, where China, at least up until recently, was putting up a coal plant every two weeks.

So we take our business, scale it up by a factor of ten. Scale that up by a factor of ten. Scale that up by a factor of ten, and another factor of ten. What we need then is to roll out 500 gigawatts (10^{9} watts) of renewable power plants every year and sustain that for 20, 40 years. What is astonishing about Cool Earth Solar is that, at least in principle, we can do that 10,000 times scaling without any implausible use of resources and without hitting any limits.

The problem is daunting, but what's amazing is that with our technology today we have already produced enough plastic film (to make the balloons) to solve 100% of the problem. We don't need any kind of crazy scale-up of that resource. Cool Earth Solar is dedicated to finding the materials and the components that we can manufacture in sufficient quantity to scale and engineer our plants such that every time we need to do an order of magnitude scale up, there are no essential roadblocks.

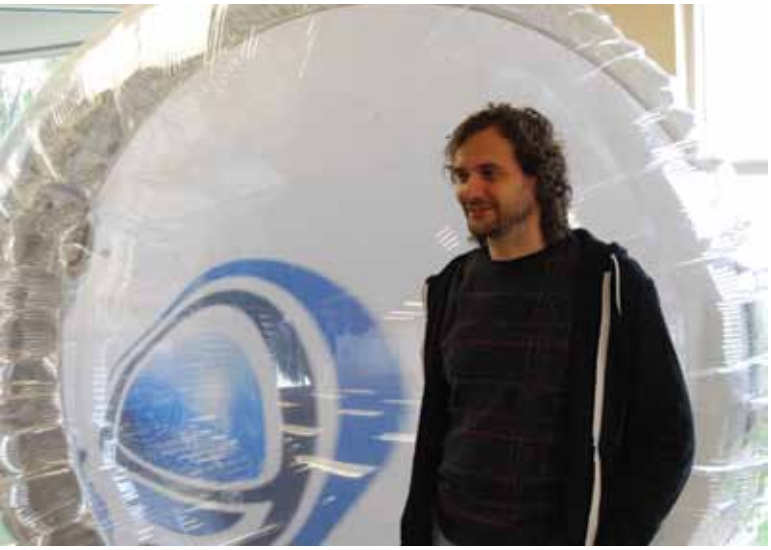
ENGenious: How has your work influenced your children?

Eric: As I mentioned before, I have inherited the workaholic gene from my dad. Consequently, I work at home all the time. So my kids really know what I'm doing. They understand it. They are excited about it. They can tell when we've made an advance and when we're struggling with a problem. I think it's very important for kids to see and experience that adults work hard and that they have problems that they struggle with—this is good for kids' education and their intellectual development.

Jacques: My two girls are starting to really be interested in science. They always ask me what's going on at work and when are we going to produce electricity. They are quite interested in what we're doing.

ENGenious: What is a typical day like for you?

Eric: The interesting thing about Cool Earth Solar is that we have so many different types of problems and challenges that every day is different. While this gets me going, it is also difficult to be interrupted several times a day with a wide variety of challenges, like a software or low-level firmware problem versus a fluid mechanics problem versus a materials problem. When I really want to dive into a particular problem, I try to carve out a few days. If I'm lucky, I can carve out a whole week and isolate myself to just work on that single problem. That's actually my favorite thing to do—take a deep dive and not come up until there's a real solution.



Aurelius Prochazka (Principal Scientist) stands in front of one of Cool Earth Solar's balloon-shaped solar concentrators.

Jacques: I complement Eric because I like to be at the company early and move things along, work with the engineers and try to help them out. I like the interaction with people on a daily basis.

Aurelius: There's not really a typical day in terms of what we're doing. I hope every day is different and better, and that the problems that we're solving lead to more interesting questions for the next day.

ENGenious: What do you find most satisfying?

Eric: Diving into muddy problems and coming out with a clear solution. What usually happens when you really tackle a tough problem and go at it remorselessly is that, at some point, something crystallizes in your brain and you realize there's actually a deeper principle; you learn a new rule and ,suddenly, you see your problem now not as a single problem, but as an entire class of problems and that the rule applies broadly to this much larger class. It's like breaking a log jam with a large technical advance in a short amount of time because you've got this new clarity, this new understanding of something. This is definitely the most sustaining thing. It's way too rare, but it's incredibly sustaining.

Jacques: For me it goes back to what inspired me to become an engineer—building things and solving problems along the way. When you have a problem you find a solution, design the remedy, and have it made. Once it is built and it does what you want, you are done. That is what it's all about. Solving problems and moving forward.

Aurelius: Progress is very important, not only progress in solving the problem, but boiling it down to a type of solution that you can use. I am pretty good at finding the principle.

ENGenious: Anything else you want to add?

Eric: We are looking for the brightest minds in the universe to solve the biggest problem facing mankind. Seriously, we really are looking for people who have the ability to reason their way through problems that don't have a precedent or that don't have tremendously relevant precedents. We want the kind of people who can take a particularly challenging problem, distill it, crystallize an understanding around it, and come up with a solution for all time. That's really the kind of engineer and scientist we're looking for, and there are many among your readership.

If you are looking for a mission, there is no better mission than solving the energy problem. So whether you join Cool Earth Solar or not, I really hope alumni try to follow the path that we have taken in some way. We all had very comfortable and successful lives and we've made abrupt changes in them to address this problem. I hope many more alumni make that shift. Caltech, with its intellectual leadership, can also become the technical leader in this transformation, because it is a transformation in need of technical leadership. E N G

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