Making with a Sustainable Purpose: An interview with Matthew L. Mauriello

This interview presents insights into Dr. Mauriello's research projects in user-centered design to promote energy literacy within residential households.

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Over the last two centuries, energy needs have skyrocketed dramatically, making energy literacy a center topic of sustainability research. Can we use low-cost tech that can be installed in homes to help raise energy literacy in smart and playful ways? This has been a practical and challenging question for researchers in computer science and other engineering fields. In our conversation with Dr. Mauriello we discuss what led him into research in sustainability, his work on the application of thermal cameras for insulation quality inspection and thermographic sensor systems that support residential energy audits, and his more recent work focusing on residential energy consumption, energy literacy, and sedentary lifestyles.

Dr. Mauriello is an assistant professor in the Department of Computer & Information Sciences at the University of Delaware where he directs the Sensify Lab (sensifylab.org). His work focuses on applying user-centered design and computer science techniques to societal challenges emphasizing those facing our health, education, environmental, and computing systems.

Jiayi Li: Nice meeting you, Matthew. We know you have done a lot of work in the intersection of human-computer interaction, design, and sustainability. Let me start by asking, what sparked your interest in sustainability and how did you start your career in this area?

Matthew Mauriello: As cheesy as this might sound, I have had a lifelong interest in sustainability. I've been trying to "save the planet" since I was a child. Picking up recycling and asking people to be better to the planet, selling candy to buy acres of the rainforest through programs at school, and stuff like that. I've always been very interested in promoting environmental sustainability and better stewardship of our local and global environments. I think that's a pretty big aspect of my life in general. So, now I try to use computing to help with that.

My dissertation work with Dr. Jon E. Froehlich (University of Washington) focused on the application of thermal cameras for insulation quality inspection in built environments which, as an application, always struck me as both challenging and practical at the same time. The idea, at least long term, was that if we could make these kinds of inspections more scalable and collect a large amount of data about the quality of building stock

then we might be able to get building owners to invest in retrofits. Down the line, we also wanted to get this data in the hands of policymakers through some sort of database that would help them create better policy around improvements lowering consumption over the long term. While I was mostly focused on residential homeowners during my dissertation work, I hope to return to making this kind of data easily accessible to policymakers in the future.

After completing my Ph.D., I joined Stanford University for a postdoc. In California, they are a bit further along in terms of smart grid research and implementation. There, I was looking at energy usage in residential homes, particularly involving families with young children as part of a project with Dr. Hilary Boudet (Oregon State University) and Dr. Ram Rajagopal (Stanford University). The background around the project was that there were a number of new pricing policies coming into effect that would negatively impact these users. These policies basically change energy pricing throughout the day. Particularly when everybody comes home at five o'clock, the energy pricing goes up and families with young children don't always have the flexibility to shift their activities to accommodate these changes in price. They don't get to say 'let's not do the laundry right now'. They have to do the laundry when the basket is full, or they have to have dinner at a certain time because children need enough time to do homework in the evening. A lot of their schedules are locked in. Part of the research I was involved in was about trying to promote energy literacy within families, so they know more about how it's produced and how pricing works, but also how they might be able to be more efficient in small ways that add up to big savings over time.

To a degree, my interest in this project has translated to the University of Delaware. We are a bit behind the changes that are happening on the West Coast, but we have the same problems with families who need to get better around energy pricing and usage. How might we do similar interventions in this new environment with very different infrastructure?

Can we use low-cost tech that can be installed in homes to help raise energy literacy in smart and playful ways? We could just give the data to the head of households via a bill with some improved visualizations, but there is still plenty to do in terms of adapting those visualizations to varying levels of information and environmental literacy as well as making them more accessible to the entire family unit. So going from rainforest and recycling activism as a child to building inspections and energy consumption, these are some of the areas I've been focused on.

In a perfect world, what we want to do is create a really attractive shared display that you can put in the home that is accessible to the entire family and all of the people living there.

JL: Can you elaborate more on the key technologies that are used in your projects?

MM: I'm most interested in developing better user experiences through low-cost, ubiquitous technologies. Or, at least with technologies that have this potential. I'm looking at using low-cost hardware, like Raspberry Pi and their HDMI displays as a platform for in-home energy visualizations. And of course, we also need to collect energy data. There are numerous technologies that will transmit energy usage data from homes to servers, technologies for automation, and in-home displays. All of these things are actually relatively low-cost individually, but it adds up quickly. A low-cost plug-and-play kit could provide real value here. Eventually, the idea is that we will deploy such a kit and begin to look at forecasting and interventions as well as answering questions users have about energy consumption. What people really want to know is: How much are my appliances using? What energy services are being used that generate my overall energy consumption pattern? Often these are disaggregation problems that are a lot harder to figure out from the overall energy usage alone. One solution is wiring up different components and sub-metering different devices around the home, but this increases the expense and burden of collecting the data as well as the kits that we want to deploy.

JL: Since you have worked both in California and in Delaware, how would you compare the different energy needs in these two states and how would that affect your research?

MM: Energy in Delaware is generally cheaper. We pay less per kilowatt-hour. Speaking for my household, this has a direct impact on how much we use. We can use more energy without too much concern about how much it's actually going to cost, which is a bit of change from my time in California, where we were a bit more aware of the costs. Natural gas and oil are also still quite common where I live now, so it is a different energy mix and these factors play a role in how we need to educate residents with regard to where their energy comes from, how it's used, and pricing. That being said, I am still learning and trying to build up collaborations with the local energy providers.

Karan Ahuja: **When you talk about increasing energy literacy, it sounds user-specific. Who do you think these insights are for? Is it targeted toward me as an individual who has a monthly bill to pay or is it geared toward civil engineers and energy producers who are looking to reduce carbon footprints?**

MM: Right, I would say we're more focused on residential energy customers but that doesn't mean that all parties can't benefit. Like the head of households, they're going to have access to the energy portals where they can pay the bill and look at the consumption graphs and they can, if they are so inclined, dig into the platforms that exist from energy providers. In a perfect world, what we want to do is create a really attractive shared display that you can put in the home that is accessible to the entire family and all of the people living there—putting out that information in such a way that you could actually engage a middle school child or someone who's not associated with paying the bills.

A lot of past research has focused on the bill payer or the head of household. We want to widen that audience. Certainly, there is this aggregation component. We want to be able to power these displays and do community comparisons. That is something that's common in energy visualizations and intervention research today. Ultimately, if we're aggregating more granular or annotated data then that has some value to the local utility company and perhaps builders. If we can say what kinds of interventions or messaging work best in terms of making consumption more predictable then that also has value. Can we get residents to lower their usage at certain times of the day or can we get them to be more predictable in their energy usage? That kind of information certainly has benefits to those who are designing the grids and the buildings on them.

If people have more knowledge and more reasons to engage with energy information, then we will create more of a shift in the right direction.

The other element to the project here at Delaware is we're also trying to look at sedentary lifestyles. While at home, you are probably using various energy-consuming devices and services. Instead of saying we want you to get off your computer for a little bit, can we take a more holistic or well-being approach to lowering energy consumption and suggest that you go for a walk instead? A lot of us are using fitness trackers and things of that nature today and that's an interesting source of data and feedback that might help with lowering energy demand in households while improving our physical activity, which has other well-being benefits. We are still in the early prototyping phase right now. We are setting up the infrastructure for aggregating the data but with COVID-19 it has been a bit harder to think about getting into people's homes. It is a slow roll but we're hoping that the summer or fall, when the campus opens, will be a bit more productive in terms of deploying some early prototypes and starting to aggregate pilot data on this topic.

JL: With COVID-19 and quarantine policies, have there been different trends in terms of energy consumption. Have you been able to observe that in your research?

MM: That is a great question. I have not yet looked deeply into this research myself, but I wouldn't be surprised if it did and I am sure people are. We're certainly all home more. My computing time has definitely increased. I am sure we have all noticed an increasing number of COVID-related studies coming out across disciplines with abstracts indicating that we're all spending much more time on our computers and with digital services. I would imagine that this has had some effect on energy demand as well.

KA: I have a broader question: where do you think the true motivation for a sustainable future comes from? For example, when you approach coal mining companies or other non-renewable energy companies, do you think they're intrinsically receptive to the idea of change or is it a matter of public perception for them?

MM: I've spoken to a number of people working in the energy industry in California, Arizona, and Michigan. Anecdotally, they seem to be forward-looking areas. However, I think this is going to vary state-by-state. How entrenched are local economies in less desirable energy sources? How much of your town is invested in that kind of production? Are the producers not just creating energy but also the primary source of employment? You can see this if you drive through some states, there are billboards every couple of miles that read "the wind stops blowing and the sun sets but coal is always reliable." There's obviously a campaign in certain areas that demonstrates resistance to change. In some areas, it's going to be a faster rollout and an easier campaign but in others, it's going to be a much harder sell.

KA: That's a very interesting point. It seems there is a policy and a technology pillar. Is it technology that influences policy, or do you think it's the policy that influences the technology in a particular area?

MM: Yeah, I think it's a bidirectional relationship but I'm going to focus on talking about policy. There's going to need to be some major investment in the production capacity of green energy in those areas. We need to have those industries start to try and work with policymakers and say, look, this is a real thing that we can do. We need *X* and *Y* things to make it happen, whether that's a subsidy for doing the initial construction, or we need some kind of assistance with training the workforce in the area, or even that we need help attracting the right people to do this kind of work. There are lots of different leverage points that are going to need to be used, including getting policymakers and industry working together on clean energy solutions. I don't think any of this can exist in vacuums. These pillars of technology, policy, and industry have to talk to each other.

I've always been very interested in promoting environmental sustainability and better stewardship of our local and global environments.

KA: Do you think that green technology would ever get to the point where you'll see traditional energy companies, such as British Petroleum and Chevron, not just be early-adopters but drivers of sustainable technology? Or, do you think that most of the innovation will come from startups, such as Tesla or Arcadia Power?

MM: Yeah, so energy producers can, I think, read the writing on the wall. They know that the future is increasingly about green energy solutions. I do think that many have plans in place for the integration of these energy sources and they are already in action. We need to make this shift. Certainly, the big companies are moving in that direction but perhaps smaller operations may not have the capacity to start heavily investing in, say, wind farms and other tech. However, I don't think the concept or need to be leaders and have mixed production profiles is lost on them.

KA: Since you started working in this domain, are you satisfied in terms of the progress we've made and the general direction of sustainability and computing?

MM: I would say that I have become more skeptical personally, but I am also an eternal optimist. That's why I continue to work in these spaces. If people have more knowledge and more reasons to engage with energy information, then we will create more of a shift in the right direction. If we can get that information to children and families who grow up in a different environment, a more conscientious one, then those attitudes and mindsets will go on to affect how they live and their lives 20-plus years from now when they are homeowners and have households of their own. I'm increasingly interested in how we create healthy and sustainable lifestyles and I think part of that is unioning energy information with other important information that people care about. That's why I'm thinking about things like a sedentary lifestyle and physical activity as being another piece of information that we tend to care about. Another piece of the puzzle. Hopefully, by uniting these two problems, we might come up with more creative and impactful solutions for both.

JL: Is there any advice you would give to someone who decides to pursue a career at the intersection of conservation, sustainability, and technology?

MM: I would say one of the mistakes that I made as a Ph.D. student was not engaging with local policymakers more. It's hard. I was very focused on making something for homes and getting feedback from residential users, but the further I have gotten away from that research the more I wonder if I should have tried to engage with those stakeholders a bit more and a bit earlier in the process. The information in many IoT systems is often so valuable. I think the sooner you can engage with policymakers, probably the better for the long-term health of these kinds of projects.

Biographies

Jiayi Li is a Ph.D. student in statistics at the University of California, Los Angeles. She has a B.Sc. in mathematics from Stony Brook University and the University of Hong Kong. Her research focuses on the fundamentals of machine learning, including generalization, non-convex optimization, and manifold learning.

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