

# Talking Energy with Dr. Laura Schaefer

## What kind of engineer are you?

I'm a mechanical engineer. I think when people think of mechanical engineers, they think car gears and stuff like that. But a big part is also looking at how fluids, like gases and liquids, flow. How air flows over the contour of an airplane wing. How fluids flows inside heat exchangers like in heating and air conditioning systems. I'm more focused on the fluid, flowy part of mechanical engineering.

## What made you decide to be an engineer?

When I was in high school I really enjoyed the math and science classes, like physics and chemistry. I wasn't as fond of biology. We had to dissect cats and things like that, and I was a little squeamish so I knew I was not going to be a doctor. I didn't really know what kind of engineer or scientist I wanted to be when I went off to college. I had some **AP** credits, so I was able to fool around a little bit, and I took some classes. I took just blew me away. And once I took that, I knew med



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[apstudent.collegeboard.org/exploreap](http://apstudent.collegeboard.org/exploreap)

**Thermodynamics** is a branch of physics that focuses on the transfer of heat and other types of energy.

**thermodynamics** class my freshmen year that  
mechanical engineering was the field for me.

## Why did thermodynamics “blow you away”?

It pulls the surface back on understanding so much of what's going on in our physical world. Thermodynamics deals a lot with energy. You suddenly learn how, for example, the heat transfer is working from my cup of tea. How I can quantify that. How weather patterns form. We can understand how the engine in a car works. All these different things are in thermodynamics. It's so great walking around and saying, "I know how that works and how that works." At least on some level, you know how it works. And it's really exciting to have a kind of double view. The Sherlock TV show, as he's walking around, he has all these little words and equations that form up in the air. And that's sort of what being an engineer is like.

## What did you have to do to become an engineer?

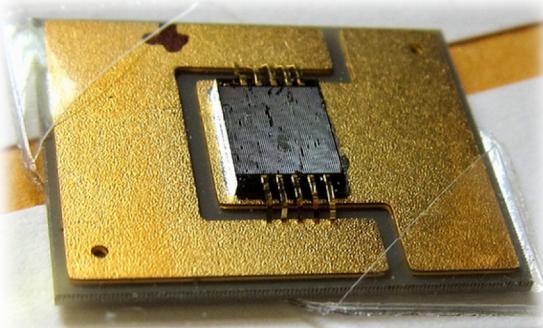
I took a lot of classes that were very challenging. But the challenging part of those classes was a lot of fun because you are surrounded by other people who have the same excitement for really digging into the physical world and understanding how it goes together. And not just the understanding, but then taking that and making it into something that can improve the world you see around you. But more than that we had design projects and summer internships where we actually got to put these principles into play. That's what made me want to be an engineer.

## What is an example of a problem you had to tackle? And what did you do to design a solution?

Historically, electricity has been produced through a big central power plant. A big power plant with big equipment producing electricity and sending that power out through power lines. The problem is that in these big central plants, what you are doing to make electricity is burning or chemically igniting something in some way. The burning produces heat, but you lose a lot of that heat. That is lost energy. As our natural resources are being eaten up, losing that energy is becoming a bigger and bigger problem.

There's this big push to make power locally, and then we can actually use the heat that comes from this electricity-producing system. So one problem is how to combine the energy production and the wasted heat in a useful way. One of the projects we have to address this that I think is pretty cool is combining solar **photovoltaic**, or **pv, cells** with water heating for a house. Most people think of solar cells as these big blue flat plate panels. And silicon cells have been the traditional kind of pv cells, but those things are really inefficient. We are talking 10-15% **efficiency** if you're lucky. So of the sun that shines on them, lots of it just turns into heat and only 10-15% actually become electricity from that process. Since the sun is free, that's not as big of a deal as it might otherwise be. But it costs money and energy to manufacture these cells. So what people have been trying to do is make the pv cells smaller and more efficient.

There is a type of cell called a multijunction cell that has multiple layers of the cell stacked on top of each other. So you can have a cell strip as wide as a cell phone but longer. This multifunction cell is smaller than the traditional pv cells and can produce the same amount of power as covering a rooftop with cells. These cells are like 40% efficient, which is a huge increase.



A power plant is a place where electrical energy is generated (or produced). This energy is then distributed to communities for businesses and homes. There are different kinds of power plants—nuclear, gas, and coal are a few examples. Want more info?

[science.howstuffworks.com/environmental/energy/power.htm](http://science.howstuffworks.com/environmental/energy/power.htm)

Photovoltaic cells convert solar or sun energy into electrical energy. Wondering how **photovoltaics** work?

[science.nasa.gov/science-news/science-at-nasa/2002/solarcells/](http://science.nasa.gov/science-news/science-at-nasa/2002/solarcells/)

**Efficiency** is the amount of functional energy available for use compared to the total amount of energy. So the more energy available the more efficient a system.

The problem is all that heat I mentioned before. As you are concentrating all this solar energy on to the cells, they are getting really hot at the same time they are producing all of this electricity. And the hotter they get, the less efficient they get.

So we are like, "How can we cool these cells?" But to cool these cells, we are going to have to use power in some way to put some kind of cooling fluid under the cells. But we

don't want to lose efficiency that way either. So we can take two strips, again about as wide as the phone and about 3 feet long. One of those strips has enough power to produce about 80% of the power you would need typically for two single-family homes. So you aren't taking up a lot of space to produce that power. You can run water from the city underneath the cells to cool them. Then run the heated water into a hot water storage tank and use that to produce 80%, maybe a little bit more, of the hot water you would need for these two homes as well. So you are no longer using energy for your hot water heater or burning natural gas for your water heater. And you are making electricity at the same time!



### **That sounds like a great solution. Are there issues connected to this solution?**

Yeah, there are lots of issues connected to this solution. Like how do you equitably share hot water between two different houses? Do you have two different storage tanks? How do you figure out the timing of this? Lots of people take hot showers first thing in the morning, but the sun hasn't been shining all night. So you have to come up with a way to store this heat so you aren't having a lot of losses. At the same time, the sun is shining all day, but no one is home. You don't want to recirculate the hot water under the cells because then you aren't cooling them anymore. So there are lots of time-based issues and control issues to work out to find the best potential solution. We think we have worked some things out to basically save each household about \$800 per year in electricity and gas hot water heating costs. It turns out a gas hot water heater, which is the most efficient kind of hot water heater, is actually one of the biggest uses of natural gas in your home.



### **So you really have to think about a lot of different parts.**

Absolutely. You have to look at all of this stuff together. This is the fun part! You can't just focus on one part or you are ignoring some of the bigger considerations. You have to think about the whole system. And a lot of these systems we look at, like a hot water tank, don't seem particularly exciting. But it's a huge energy hog! And if we can look at these systems we just take for granted, we can really make a lot of improvements.

All of my energy work is basically looking at either replacing or reducing the amount of **fossil fuels** we use for energy generation. People talk about electric cars, and that's great. But the problem is in most cars the **internal combustion engine** is actually super efficient. It's a fantastic technology. These hybrid cars, and I'm biased because I have one of these cars, but I have one because I know something about what's going on under the hood. The

Gas and coal are examples of **fossil fuels**. But how do fossil fuels form? Curious?

[energy.gov/sites/prod/files/2013/04/f0/H\\_S\\_FossilFuels\\_Studyguide\\_draft1.pdf](http://energy.gov/sites/prod/files/2013/04/f0/H_S_FossilFuels_Studyguide_draft1.pdf)

How does an **internal combustion engine** work? Interested?

[auto.howstuffworks.com/engine1.htm](http://auto.howstuffworks.com/engine1.htm)

When you push on the break pedal in a car, energy is released (or wasted) in the form of heat. When breaking in a car that has **regenerative breaking**, the car captures and stores some of the lost energy in the form of electrical energy. Want to know more?

[auto.howstuffworks.com/auto-parts brakes/brake-types/regenerative-braking5.htm](http://auto.howstuffworks.com/auto-parts brakes/brake-types/regenerative-braking5.htm)

hybrid systems are powered on gas, but they are high efficiency because they use **regenerative breaking** when you go down a hill the car stores energy in the battery. That's great because then you are able to use the electric power systems to power the parts of the car that work best with electricity. Where the basic bulk engine uses fossil fuels because burning fossil fuels is actually a really great way to move cars around. But for things in our house, our computers or cell phones or for our lights, we don't need to be burning things for those. So if we can move to more renewable energy and higher efficiency solutions for those, that will let us use a **dwindling resource** in the most effective way possible.



**Dwindling** refers to a gradual (slow) decrease, and in this case **resource** refers to materials. Materials like natural gas and oil are examples of dwindling resources on Earth.

### So how can someone who's not an engineer use this information to make everyday changes?

A lot of what I've talked about is how we produce the power. What's also equally important is how we use the power in our homes. Everyone at this point has drilled in turn off the lights when you leave a room, replace your light bulbs with compact fluorescent light bulbs and things like that. And those are very helpful, so I don't want to discourage people from doing that! But looking at the non-flashy parts of your home can help. Like looking at the type of insulation that you have in attic. Or looking at the type of sealing you have around your windows or doors. There are HUGE energy losses through openings, and if you can cut down the amount of electricity you are using, you can make a really big impact. Not just because we're using this fossil-fuel based power but even in places that have high-efficiency power generation.

### Thinking deeper about resources and efficiency

You really have to be a critical thinker about what efficiency means. When we talk about the efficiency of power generated from a natural gas-fired power plant, what we are looking for is what is the latent (untapped or potential) energy of the natural gas that comes into a power plant versus the energy in the form of electricity that comes out of the power plant. When we are talking about efficiency of the photovoltaic cells, it's how much latent energy from the sun comes on to the cells versus how much electricity comes out. And we can compare them in terms of how much useable energy comes out. But for one, we have a resource that we are depleting and has additional cost in the extraction and transportation of that resource. And with the sun, we are talking about a resource that is essentially free.



Most of power plants are sized for **baseload power**, or the type and amount of power a neighborhood or commercial district would use in everyday operation. When the temperatures spike up or down, more people use power.

When people are using greater amounts of power, that's when the less efficient older coal-fired power plants get fired back up again to meet the demands. If you are using a lot of power during those times, you are directly responsible for this lower efficiency, bad power generation. So taking care of the little things in a home is really important.

Also, the government would like us to be more efficient in our power generation. Efficiency is great from an economic, or money, point of view. And it's great from a security point of view, like if we are less reliant on foreign powers for our oil, for example. So the government has put in to place all sorts of different **incentives**. For example, incentives for putting a photovoltaic system in your home. Or, in Europe and Japan, wind power. And not just the wind turbines you see slicing through the air in a big field, but local turbines like small-scale wind turbines you can have on your house. There are financial incentives for that as well. The technology is well-established at this point. There are professionals who can do this. So it's not going to affect your day-to-day quality of life. It will just bring your costs down and be better for the Earth too!

**Baseload power** is the minimum amount of power a plant must have available for its customers at a given time. Baseload plants are plants used to produce the baseload power and usually produce only a part of the needed power. During times when additional energy is needed to meet high demands of customers, other power plants will begin to produce energy, often less efficiently than the baseload plants.



**Incentives** encourage people to take certain actions. Incentives often come in the form of money or tax breaks. Want to know about incentives for energy efficiency in your area?

[www.dsireusa.org](http://www.dsireusa.org)

### **What if you wanted to apply this information at a school level?**

A lot of schools keep their physical plant operation completely separate from the education part. But if students understand the cost and the environmental impact of the choices they make, it turns out that there is an incentive. For example, on the dashboard of my hybrid car, I have a thing that tells me the amount of miles per gallon I'm getting right now. And it's a big rush to be like, "Oh! I'm over 40 miles per gallon!" I give a high five to myself. Schools can do the same sort of things.

There are cheap metering technologies that you can put into place to measure the amount of water you are using. Or for the amount of power you are using. Or for the amount of hot water that you are using. There are simple things for outlets called a "kilo-a-watt" that when you plug something in, it shows you how much power you are using and what that is costing. There are some that also show how many tons of carbon emissions you are putting out from what you are using. And people look at that and record it. And over time, as a school project, you can look at how your power, water, hot water use, and natural gas use change over time and figure out ways to change your behavior to make that better.

