Environmental scientist discusses transformation of U.S. energy

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Headlines focus on international agreements, sea levels, melting ice, and superstorms, but climate change is most of all an energy problem. Burning fossil fuels to power our cars and heat our homes produces carbon dioxide that transforms the atmosphere into a greenhouse, trapping heat that otherwise would radiate into space.

While the fundamentals are solid, everything else about climate change is evolving. Climate science is advancing and economic pressures have dramatically altered the national fuel mix—for the better, most agree, though we still have miles to go. Even the political landscape that determines national climate action—or inaction—is in flux.

Michael McElroy, Gilbert Butler Professor of Environmental Studies, has long helped explain the complexities of climate to students, scholars, and government leaders. His most recent book, "Energy and Climate: Vision for the Future," published in August by Oxford University Press, is a continuation of that work. He discussed the book in a recent interview with the Gazette.

GAZETTE: In "Energy and Climate," you talk about the U.S. energy picture being transformed over the last five years in ways that may make needed changes regarding climate tougher to accomplish. How has the U.S. energy scene changed into the one we're in now?

McELROY: The big change is that we no longer have the previous driving concern about national energy security. What has made the difference was the shale revolution. Ten years ago we were projecting that the U.S. would not only be dependent on imports for oil but also for natural gas. We now have a surplus of both. The U.S. is presently a net exporter of petroleum products. Prices for both natural gas and oil have plummeted. I had a student who wrote a beautiful senior thesis four or five years ago, in which he tried to analyze the break-even price for production of natural gas from shale. His conclusion was it would be about $5 per million BTU at a time when natural gas prices—wholesale prices—were $7, $8, $9. Now they're below $3. So it's a different world. Oil prices were $168 a barrel in 2008 just before the economic crisis. They are now below $50.

The U.S. also has abundant sources of coal. Were it not for the climate issue, we could contemplate taking advantage of this resource also, doing so as efficiently as possible to eliminate conventional sources of pollution such as sulfur and nitrogen oxides and particulates. Emissions of CO2 could go through the roof under these scenarios. There is no cost-effective means to capture CO2. Concerning the potentially expanded emphasis [that] coal—not to mention oil and natural gas—could have on our energy system, this would be a disaster for climate. Bottom line is that we can no longer rely on policies that could be adopted to address concerns about energy security, looking to climate policy as a silent secondary beneficiary. We must now confront the climate issue directly. Clearly many in the body politic are reluctant to do so.

GAZETTE: And the electricity supply has gotten cleaner, hasn't it? But not because of climate change efforts?

McELROY: Not because of climate change, but for economic reasons, largely. If you're a utility and you're able to vary the mix of generation options you can tap to produce electricity, your primary choice is likely to be between coal and natural gas. Old coal-fired power plants are very inefficient compared to new gas-fired power plants. The efficiency to turn the energy of coal into electricity in some of the older plants is as low as 20 percent. If you're just worrying about efficiency, if you have the opportunity to turn off that inefficient coal plant and switch to a gas system and additionally save money [since gas is cheaper than coal], you're going to do it. The choice is economically driven and the consumers are actually benefiting.

GAZETTE: In your vision for the future, you emphasize that more electricity usage could be part of the solution. Clearly, electricity is already a big part of our energy picture; why should it be even larger?

McELROY: Dealing with CO_2 emissions from the transportation sector is extremely difficult if the transportation sector is fueled with liquid fossil fuels. You can't capture CO_2 from the tailpipe of every vehicle on the road—260 million cars in the U.S. At the same time, there's another a good reason to want to use electricity more in this application. If you drive your car with gasoline, the fraction of the energy in the gasoline that turns the wheels of your car may be as low as about 20 percent. If you drive your car with electricity, the fraction of electricity that turns the wheels could be as high as 95 percent. So, on an efficiency basis, electricity is better. As I discussed in the book, if I had to pay the retail price for electricity here in Cambridge, 19.8 cents a kilowatt hour when I was writing the relevant chapter, the equivalent gasoline price would be as low as $1.46 a gallon, as low as 67 cents a gallon in Washington state where electricity prices average about 9 cents per kilowatt-hour. So on a cost basis, it's a good thing to do. Then, in addition, air quality would improve if we switched to driving electrically, so long as the electricity was produced from a nonpolluting source. The climate issue would be the obvious beneficiary.

GAZETTE: You go chapter by chapter on possible fuels, and settle on wind and solar as the cleanest and most likely sources to power a future clean electricity grid. What are their drawbacks and can those be addressed?

McELROY: The economics of wind in the United States is actually quite favorable. You can produce electricity for about 5 cents a kilowatt-hour with wind at present. So it's competitive. The really serious drawback is that the wind is strongest in winter and our demand for electricity is highest in summer. The wind is also generally stronger at night than it is during the day and our big demand is during the day. And wind doesn't blow all the time. So we need to find some way to deal with that particular issue.

There are a number of possible strategies. You could integrate the electrical system over a large part of the country—so if wind is blowing in one place and not in another, by combining outputs you could reduce the net variability. If you had the opportunity to store electricity, that could minimize the problem also. So putting an emphasis on storage systems is a good thing to do. There's important work going on here at Harvard by Mike Aziz and Roy Gordon on the flow battery idea. It's something that might actually scale up as a utility scale opportunity to store electricity.

I am enthusiastic also about the idea of taking advantage of the distributed storage available potentially in the batteries of large numbers of electrically propelled vehicles. I discuss this idea at some length in the book. You could imagine charging your car at night when prices of electricity are low and then selling power back to the grid during the day when prices are high, assuming you don't need to drive at that time. This could represent a win-win strategy.

You would still have the issue of summer demand for electricity when wind conditions will be less favorable. That's where solar comes in. Solar, however, to this point, is still more expensive than wind. Despite this, solar is doing quite well in the U.S. We have a house on Cape Cod and five years ago or so we installed PV cells on the roof. We did this by making a deal with a particular company, Solar City, one in which they actually own the solar cells. They sized the solar cells to meet our projected historical annual demand for electricity. They gave us a deal where we have a fixed price for electricity for 20 years at half of what we were paying previously. How do they manage to do that? Turns out the retail cost for electricity on Cape Cod is very high. It's very high because the delivery cost is high. The retail price is about 26 cents a kilowatt-hour, more than half of which is for delivery. So they're giving us a deal at 13 cents per kilowatt-hour.

There are requirements in almost all of the states now that some fraction of the electricity has to be renewable. If the utilities are not able to meet that requirement from their own resources, which generally they're not, then they have to buy it. So the Solar Cities of the world are auctioning their renewable energy for incorporation in the grid. If New England Electric is looking for a certain amount of electricity from a renewable source, then Solar City can supply this by packaging sources from large numbers of houses under their control.

The other thing that's happening in the U.S. is that meters in many states are allowed to run in reverse. We're not typically present on Cape Cod in winter. The sun is still shining most of the time and the house continues to produce electricity. Solar City is selling this electricity to the grid at the retail price. Our meter is running in reverse. So, for a lot of reasons, solar has done very well.

GAZETTE: You say that one of the top priorities for this country should be upgrading the transmission grid. I think a lot of people, when thinking about climate change, think wind farm, solar farm, but not transmission grid. Why do we need that?

McELROY: Think of the role played more than 100 years ago by Thomas Alva Edison. Edison was an incredible inventor. He was also a very smart guy and he built the first electricity-generating system in Manhattan. Then Westinghouse came along and suddenly we began to see electricity generated in central facilities and distributed more widely to local customers. We've built our electrical system in a piecemeal way. We didn't say, "What's the best national electricity system?" If we had done that, we would have had an interconnected national electricity system.

The U.S. has three electricity systems: East Coast grid, West Coast grid, and Texas. It's very difficult to move electricity across those boundaries. At a minimum, we should invest to interconnect the boundaries. That's a no-brainer and it would not be very expensive. I like to think about being able to move electricity efficiently over several thousand miles, coast to coast, border to border. We have wonderful wind resources in the middle of the country. The key location to produce electricity from the sun is in the southwest, where we have great solar conditions. The ideal would be to bring both those sources to where the markets are, on the East Coast and West Coast and in major cities like Chicago. But if you're going to serve those markets you have to be able to deliver.

In addition, the demand for electricity peaks in the morning and peaks in the evening: when people get up and when they come back from work. If we had a system that was interconnected from California to Massachusetts, at a minimum we'd take advantage of the three-hour time shift to smooth out the peaks in demand.

What are the obstacles? The obstacles are largely political—the fact that you have to bring power across state boundaries, and you may have to go across individuals' property. The federal government has the authority to overrule objections if it's declared to be in the national interest or if it's in effect a matter of national security. That's largely why we have a reasonably efficient natural gas distribution system. It could be done for electricity also if we had the will to do it.

If you really make a commitment to developing this electrical infrastructure, you're going to have to employ lots of people. So this would be good for the economy. My vision would be one in which we invest in community colleges that train people for those jobs. These are going to be good-paying jobs that can't be exported.

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