Energy diversity brings stability

When I pull up to a gas-station pump, I have three choices: regular, premium, or something in between. I make the obvious choice and fill up with the cheapest option (while I wonder who uses those even more expensive fuels). It is the same scenario whether I’m in State College, Pa., or Los Angeles. All across the U.S., we have a transportation infrastructure based almost entirely on one fuel and one source: gasoline and oil. Our energy portfolio for electricity production is only slightly more diverse, with coal and oil providing most of our energy needs.

Despite our brush with a national oil crisis in the late 1970s, we still have not gotten serious about alternative and renewable energy. Rather than facing serious energy shortages in the U.S. by developing other options, we simply extended our pull of energy to substantial reserves outside the country and postponed the inevitable decision to face our “addiction to oil”. Current plans to increase drilling in environmentally sensitive areas or exploit new types of fuels, such as coal gasification or mining methane hydrates, miss a more critical point: We must solve our energy needs while addressing climate change. Our situation is not as simple as it was 30 years ago when we exploited additional sources of carbon-based fuels: We must now solve the energy issue and reduce emissions of CO₂ and other greenhouse gases.

There seems to be an underlying need in our energy planning for “the answer”—some sort of techno-magical solution that can solve all our energy needs. Such a technology doesn’t exist and, barring a miraculous breakthrough in fusion, isn’t likely to be developed soon enough. Instead of searching for a single solution, we need to pursue all the little solutions that, when taken together, add up to something more powerful. We need energy diversity. We could stretch our own national reserves of oil, using it as a fuel of choice in remote areas, while building a new infrastructure based on different fuels that match our potential for energy production in other areas. For transportation, I can imagine biodiesel- and bioethanol-powered cars in the Midwest; hybrid vehicles augmented by solar energy and hydropower on the West Coast; and clean, hydrogen-gas vehicles in our cities. For housing, I envision strict building codes for eco-minded, energy-efficient housing and government-financed energy-conservation fixes.

We must also start making plans for an energy- and carbon-neutral water infrastructure. In the U.S., we use 1.5% of our electricity on wastewater treatment and 5% of our electricity on the whole water infrastructure. This energy requirement is not sustainable, especially as we move toward more stringent, energy-intensive treatment levels for drinking-water and wastewater treatment.

In this issue of ES&T, we highlight one new “green engineering” technology that may bring us closer to a truly energy-sustainable technology: wastewater treatment coupled to electricity production with technologies based on microbial fuel cells (MFCs). Modern wastewater treatments have accomplished more to protect human health and our environment than perhaps any single technology, but they have energy costs. MFCs offer not only a path for sustaining energy for wastewater treatment but also the promise of a net electricity gain by producing more energy than is needed for treatment. Understanding how to improve energy production in these systems and make cost-effective, scalable bioreactors is an exciting challenge.

Electricity generation from wastewater will not by itself solve the need for power in the U.S. The energy in human, animal, and food-processing wastewater alone can provide at most only 5% of our current electricity needs and thus a small percentage of our total energy use. MFCs are just one part of a needed transition to a more diverse and stable energy portfolio.

Our energy and transportation system is currently a type of ecosystem based essentially on one “top competitor”—one that continues to eliminate almost all others because of low costs. We know from studying natural ecosystems that a diversity of organisms brings stability to the ecosystem. When a system is dominated by a single crop, organism, or species, the whole structure becomes vulnerable to complete collapse (think about elm trees). Such scenarios can be avoided if we pursue multiple approaches to alternative and renewable energy. In the future, we can hope that when we pull up to a refueling station, our choices are as vast as the coffee menu at Starbucks, ranging from gas and biodiesel to hydrogen, natural gas, or just an “electric top-off” for our hybrid vehicles. I have to believe that such a diverse and wide-ranging approach to power will bring greater economic security and stability to our environmental and energy future than our current, one-size-fits-all approach.

Bruce E. Logan
Pennsylvania State University

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