A Global "Manhattan Project" for the Energy Crisis

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The original Manhattan Project was conceived in fear, and executed in haste. It accomplished stunning technical achievements in an astoundingly short time and unquestionably changed the world—for both good and evil. Many argue that the looming energy crisis calls for a global thrust of similar urgency, sacrifice, and innovation, and that our generation will ultimately be defined by how we live up to this challenge.

A number of scientists have recently highlighted the emerging energy gap that Richard E. Smalley called the Terawatt Challenge (www.mrs.org/publications/bulletin/2005/jun/). Nate Lewis provides an exceptionally erudite and clear exposition on his Web site (www.its.caltech.edu/~mmrc/nsl/energy.html), and the U.S. Department of Energy provides excellent references for energy usage (www.eia.doe.gov/emeu/aer/contents.html) as well as the report on "Basic Research Needs for Solar Energy Utilization" (www.sc.doe.gov/bes/reports/files/SEU_rpt.pdf). The gap arises from a convergence of an escalating demand for energy and a catastrophic accumulation of atmospheric carbon. We know that the Wests's senseless profligacy with energy has accumulated damaging levels of CO_2 that are causing global warming on a scale not seen in ice-core records. We know that if we stopped producing CO_2 today, it would take 150 years for atmospheric CO_2 to return to 1980s' levels. We expect (and hope) that over the next two decades 500 million people in India and China will emerge from poverty to become new consumers. And we know that it takes energy to make people rich and that rich people burn more energy. We know that the gap between our current energy supplies and the unmet needs of the next 20 years is in the region of 10–30 TW. But we do not know of a way to generate this kind of energy economically without making even more CO_2. This forms the basis of a global challenge that dwarfs that of the Manhattan Project, one which should be met by an integrated global technical collaboration on a scale never before seen.

The scale of the energy gap seems to dictate breakthroughs on both the supply and demand side. The demand side is where most opportunities have been squandered, not only, but especially, in the United States. (What will we tell our grandchildren when they ask us what in heaven's name we did with all that oil? You did *what*? You did *20 mpg?*?) Historically, the rate at which we burn energy to get richer has improved somewhat over time. This should be improved much faster and much more steeply. Technologically, there are huge gains to be made. Lighting alone represents 18% of U.S. electricity consumption, and improved materials such as InGaN offer every prospect of vastly reducing this number. Heating and cooling are another large component of overall energy use, and again, thermal and radiation management through materials offers enormous prospects for improvement. Transportation is perhaps especially galling in that the gains are there for the taking but have not been taken. Beyond the present generation of hybrids (60 mpg, 110 mpg with careful driving; see Web site hybridcars.about.com/od/news/a/100mpgrecord. htm), there seems to be no reason why 200 mpg is technically infeasible with improved batteries, lightweight composites, and better aerodynamics.

The supply side question is more vexed, but materials seem to be at the crux of all the key technologies. A quick review of the various documents suggests that wind efficiencies cannot improve much, but the cost per watt could be decreased through materials engineering; tides/waves offer a respectable amount of energy, but conversion requires system costs (limited by materials) that are currently prohibitive; nuclear energy is undergoing a renaissance, but it seems unlikely that a new generation of plants will be built unless we have materials that address the problem of low-level waste disposal. Solar energy offers the greatest hope—being by far the largest carbon-free energy resource—but depends on new materials for better photovoltaic efficiencies and (perhaps just as importantly) for low-cost ac/dc converters, better packaging, and improved efficiency in photochemical and solar thermal technologies. Carbon sequestration is constrained largely by engineering costs, but even here I believe materials will turn out to be a large part of the answer.

So while physicists led the original Manhattan Project, the Energy Manhattan looks (at least to this "unbiased" observer) to be a materials project. But it also differs in another important respect. The Manhattan Project required one device (or a few) that could be built as expense-is-no-object. Don't know of an efficient way to separate isotopes of uranium? Just go ahead and build enough accelerators to send a few kg of material round a mass spectrometer. Energy is different. We don't need *one* of anything. We need 100 billion m^2 of photovoltaic systems, 10 billion solid-state lights, and a billion high-efficiency cars. And, most importantly, we'll need it all cheap. This changes the nature of the project, because, as a rule, governments don't do lots, and they never do cheap. So the Energy Manhattan will require not only an unprecedented international collaboration; it will require unprecedented coupling of the public and private sectors. It will call for simple and pragmatic approaches as well as visionary leaps. Getting industry involved could be simple (carbon credits, incentive schemes) or very complicated (joint government/industry projects), but the scale of the challenge makes it essential that we learn how to do it.

So, how do we go about making this happen? This will not be quick or easy. Indeed, I suspect it will not be as quick or even as straightforward as the original Manhattan Project. Governments, universities, and corporations are all going to have to reach across divides (financial, organizational, geographic) that make them uncomfortable. The solutions will be complex and multifaceted, and the programs unwieldy. But I think we have to take this challenge on because the alternative is too terrible to contemplate. And we have to take it on with urgency and in fear because, as in the original Manhattan Project, many in the technical community are afraid that we may already be too late.

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