AMORY LOVINS
MOVING TOWARD A NEW SYSTEM

"The energy problem is conceptually solved, but 50 years of details remain."
— Amory B. Lovins

Amory Lovins is the director of research at Rocky Mountain Institute. His paper "Supercars: The Coming Light Vehicle Revolution" focused on ultra-light hybrid-electric vehicles and spurred on a flurry of research and product development activities around the world. This transcript is from an interview held on March 24, 1994, and corrected September 2, 1994.

We are currently working with approximately 20 capable entities eager to bring Supercars to market, and there are more entities joining the list almost weekly. Several are automakers. The rest are non-automakers with impressive capabilities that they wish to apply to becoming automakers—in a new and different sense, obviously. They are chiefly manufacturing firms in other areas; some small, some very large. We're working with all of them on a non-exclusive, compartmentalized basis in order to maximize competition among them; *pour encourager les autres*.

The U.S. government has adopted many of your teachings in bringing about its Partnership for a New Generation of Vehicles program, also called the Clean Car Initiative. You speak of "maximizing competition," but one of the criticisms of the government's Partnership for a New Generation of Vehicles Program is that it isn't based on free-market, competitive forces.

Anything the federal government does is funded by Congress and therefore subject to a very unfortunate degree of direction by influential legislators who wish money to go to their own districts and who may allocate all of the money available, or more, to projects that may or may not merit them. That's a sort of central planning by several hundred people—well, actually the group involved is smaller—but by a small number of people who probably don't have any way of comparing the merits of their pet projects with other projects. That ends up making the program a lot less coherent than it ought to be.

The proposals that the Big Three put into the Clean Car Initiative were far short of what they can, and I think will, do. They will end up with a much more ambitious set of achievements than is currently on the table. But they will do so because of competitive forces, not government mandates or encouragement.

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The Pump is Primed

It seems to me the Clean Car Initiative has already had several very important and successful functions. The most important is to create a leapfrog mentality that brings the more imaginative engineers in Detroit out of the woodwork and validates their interest in going far beyond incrementalism. There is, additionally, some helpful technology transfer. The National Labs really do have useful things. There is a new opportunity for conversations that have never occurred before where, for example, aerospace composites experts who are used to making onesies and twosies, with cost no object, meet steel guys who want 100,000 a year at four dollars a pound. The most interesting discussions are now in the advanced materials manufacturing technique arena, where these two kinds of people have, apparently, never before talked to each other and are learning a lot from each other, even in this short time.

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That said, I think in the Clean Car Initiative, as in the Advanced Battery Consortium or any of the other joint efforts underway, the most interesting things cannot be discussed in such an inter-company forum because they're already too proprietary. I think the proprietary efforts are already moving far ahead of what is visible from the outside.

The automakers have compelling strategic reasons to go in the direction of Supercars even if such cars did not save fuel or pollution. These reasons have to do with radical shortening of production cycles, reduction in tooling costs, and hence reduction in financial risk. These competitive forces are, I think, even more powerful than presidential encouragement or regulatory mandate and will lead to the same result, only more so. The strategic logic of cheap, frequently renewed tooling, net-shape materials, and enormously simplified, highly integrated design has already occurred to all of the Big Three at high levels and is starting to receive the management attention it deserves.

*"Negawatts" is a term Amory Lovins uses to describe how societies can meet their energy needs not by building new 1000-megawatt power plants, but by producing "negawatts" of saved energy. This concept is now being practiced by utilities that teach their customers how to adopt smarter technologies that wring more work from each kilowatt-hour.

What is the role of Rocky Mountain Institute in this?

Historically, we've had three main skills to contribute to creating new efforts like, say, the "negawatts"* industry, which is now a $5-billion-a-year electric efficiency effort nationwide. First, we reconceive an old problem by looking at it in a new way. In the case of cars, rather than focusing on

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the incremental efficiency of the driveline, we started with the basic physics of the platform in order to achieve the huge leverage of saving power at the wheels, and then found this unexpectedly powerful synergy between ultralight construction and hybrid-electric drive; the 1-plus-2-equals-10 equation.

Second, we tend to be synthesists from a wide range of information in different disciplines. For example, one of the five *Technology Atlases* I've written on advanced electric efficiency* is on space cooling and air handling and how, in that application, one can save 80% or 90% of the energy in most buildings and make them cheaper and more comfortable. Exactly the same approach applies to cars and involves roughly two dozen technologies of which perhaps half are known in the car industry, but the rest are not. The notion of synergistically integrating them is quite novel.

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We're trying to do the same thing not just with cooling, so as to reduce accessory loads by up to an order of magnitude, but also with the design of the whole platform. This is, I think, the most important area of our collaboration with the entities we're working with. We can help them think in a more integrated fashion about how to put the pieces together, as well as help them find the people who have the best pieces, because of our international network from such a wide range of technical areas.

Third, we are in a peculiar and, I think, advantageous position of having been nonadversarial and transideological for so long that we can work with everybody. That is, we can have the trust and respect of a wide range of stakeholders and therefore may be better able to help them align their interests than somebody who is not so clearly a disinterested "honest broker." There are, of course, a lot of political as well as technical dimensions to introducing the Supercar, so this is an important area to which we are devoting a lot of attention. We're getting involved in issues like the California ZEV mandate, financing, and a lot of other things.

Grounded in Reality

I don't think we want, ourselves, to get into the car-building business, although we have people on staff who could do that. But I think we will be increasingly involved at a hands-on, prototype-building level with other entities and their shops and not simply talking about design.

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I'm originally an experimental physicist, accustomed to building things and making them work. The car guys we have on staff are, too. One is 26 and has been doing cars for 20 years. Another, at 29, had designed two good cars in a small team, two more by himself, and built one of these single-handedly from scratch, then sold, before he entered college. These innovators have what hackers would call the "hands-on imperative." I think we will stay grounded in the reality of car practice only to the extent that we have that degree of involvement. We can't be purely theoretical.

Is there international activity going on with Supercars?

Yes. There is a great deal of activity in Europe and some in Asia. We're involved in all of that.

I think it's all going to move much faster than we expect. Think about it this way, just by way of illustration using public information. It took about 50 people at General Motors about 100 days to build two copies of the Ultralite concept car in 1991. It took approximately a year, starting at a similar stage of concept car development, to productionize the Impact battery car. Both of those processes largely used the traditional model-building techniques with clay and other media, rather than, like a Stealth bomber, going straight from CAD screen to digital tooling instructions or, indeed, straight to stereolithography. It's always seemed to me that the logical development path for an ultralight hybrid starts with ultralights, both in order to achieve at the beginning the short cycle times and cheap tooling inherent in the net-shape materials, and because ultralight cars by themselves have roughly double the efficiency and are potentially a very attractive market product. One should then add the hybrid drive line that meanwhile would be developed in a parallel process drawing on experience from battery car development. There's a great deal of hardware and software work required to do a really good hybrid.

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The alternative, which many hybrid developers are pursuing, is to start with a heavy production platform and then hybridize it. We call those "tank conversions." They yield, typically, a 30-50% efficiency gain, but I don't think its advantages are compelling enough to make it that interesting a market product, and you're still in the Iron Age, dealing with all the ponderous nature of the steel technology.

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So given the choice between hybridizing an ultralight and lightening a heavy hybrid, I think the choice is quite clear. Its consequence is, of course, that the development and production time could be very much shorter than we've been accustomed to in the car business. My own guess, from public information, is that we will see prototypes dribbling out from a variety of established and new market actors just over the next few years and significant production volumes starting around 1998 or 1999. By roughly 2000, I think it will be clear that the era of the steel car is about to add its right parenthesis. Dr. Paul MacCready has said that by 2005 he thinks most, if not all, of the cars in the showroom will be electrically propelled. Probably most of those in turn will be hybrids. I think he's right.

The analogy to personal computers and how Apple bit into the mainframe business is often used when speaking of Supercars.

Well, it's a powerful analogy and indeed some of the entities we're working with have a great deal of experience in that field. The analogy is not exact, however. You don't, for example, put your family in a computer and wrap it around a tree at 60 miles per hour. But I think in terms of market development, the analogy is as good as any and better than most. It's easier culturally for, say, a computer-based company to become a Supercar maker than for an established car maker to do so. To change the existing car companies means you're going from steel to synthetics, stamping to molding, welding to adhesives or simply parts integration, actual to virtual prototyping, mechanicals to electricals, hydraulics to electronics, hardware to software, and mass to information. It's a profoundly different kind of product. For that matter, in particular skills as well, there's a similar transformation—for example, from die making to stereolith. It's such a big set of leapfrogs in so many areas that it's hard to imagine its being successful for most automakers unless they are thoroughly committed to a cultural transformation of such unprecedented dimensions that it's painful for them to think about it.

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A New Kind of Industry

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We're trying to bring this about with several automakers, and I think with some of them there is a good shot at it. But it takes an unconventional style and structure of project management to bring it about. I think it will only happen in the companies that pursue it not simply as a fringe activity or as an insurance policy, but as a whole-hearted commitment to the most fundamental kind of reinvention of what a car is, how you make it, how you sell it, and what business the company's in.

The pace of cultural change in some automakers is certainly impressive and gives me some hope that it may be possible to pull this off, but it's not guaranteed. I therefore suspect that the advantage, to an extent that's hitherto inconceivable in this field, may go to companies, both big and small, that learn as fast as computer companies do, that are not afraid of new stuff, and that are accustomed to very market-driven products, most of whose money is made in the first six months and where there are one or two new product generations in a year with extraordinary short cycle times.

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We're talking about rapidly speeding up the time to market. At the same time, we're talking about using materials that can be expected to last at least twice as long as steel lasts.

They can be an heirloom.

How does that affect the market?

I think the consequence of that, and also from a material flow management and recycling perspective, is that it may be highly desirable not to sell Supercars but to lease them. You wouldn't want them lasting so long that they clogged up the market 10 generations later like the DC-3 did in keeping out jets. Leasing would be like the new policy under which the German automakers own the car forever, because they have to take it back. This gives them a strong incentive for designing in what to do with the material afterwards. I think we can already recycle composites with methanolysis. It's brute force, but it works. We can develop much better methods, like resins that unlock with a chemical key. It's just that there hasn't been a demand for that until now.

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Back to the smaller companies' role: What I said a minute ago about fast learning and being unafraid of profound change tends to favor small companies. The obvious comeback is that small companies don't have the production capability.

Or the capital?

The capital is not necessarily a problem, because the amount required is an order of magnitude less than we're used to thinking about for cars, and you could start even much smaller than that. You can imagine something analogous to the Honda CRX, where they surged rapidly from bench scale to full production when they found there was a market there. The capital doesn't worry me so much. I think with the products and the kinds of capabilities behind them that we're now seeing enter the field, we'll find capital all right.

It's more a combination of capital, management, and other capabilities needed to produce large volumes of anything this big. I think a logical consequence could be an unusual degree of partnership between large and small companies, somewhat analogous to the joint ventures and strategic alliances we see all the time in the computer business. There will be important differences, but I think the similarities will be even more important.

Are the entities you are working with able to find win-win relationships with other entities?

A lot of that is already emerging. There's been an astonishing flurry of licensing and other partnering arrangements just in the last few months with many of the key enabling technologies.