Making Waves at *The Atlantic*:
A Rebuttal to *The Atlantic* Magazine's Contention That "We're Going to Keep Burning Oil—and Lots of It"
By Amory B. Lovins, Co-founder and Chief Scientist, Rocky Mountain Institute

On April 24, 2013, The Atlantic *ran a cover feature by writer Charles C. Mann, "What If We Never Run Out of Oil?" The piece contained a number of inaccuracies, to which Rocky Mountain Institute co-founder and chief scientist Amory B. Lovins responded in a rebuttal the magazine posted on May 13, 2013. One day later, Mann offered a counter of his own, but perpetuated a range of errors. In this definitive reply, Lovins sets the record straight.*

Charles C. Mann's reply to my critique doesn't cure but augments the flaws in his article. There he featured game-changing innovations in supplying oil and gas but not also in *using* them, making efficient use (and its far lower relative price) not worth mentioning. Now his reply's sub-headline (which I acknowledge he might not have written) claims "the economics favor burning fossil fuels," but he doesn't show that: his efficiency discussion is only about automobiles (not other vehicles, industry, nor buildings), it still omits the economics, and it's still misinformed.

The Hypercar-class vehicles Mann thinks went nowhere are actually entering production this year from VW (the initially low-volume *XL1*, which I consider the world's first production Hypercar) and BMW (the midvolume *i*-series), and are strongly influencing some other automakers' strategies. Automaking's hottest strategic trends since 2010 have been lightweighting and electrification. Seventeen firms now offer technology for producing relevant carbon-fiber structures, some at automotive speed and cost. Simpler automaking and smaller powertrains can make such ultralighting roughly free. These modern developments are explained in Chapter 2 of the detailed and rigorous business book *Reinventing Fire*, which 60 RMI co-authors and I created over the course of a year and a half with much help from industry on both content and peer review.

Its readers know that *Reinventing Fire* didn't "neglect the initial costs" or obstacles as Mann claims. Rather, our analysis counted all the costs but found U.S. oil-free autos' benefits are \$3.8 trillion greater (or about \$12 trillion if we'd counted just oil's economic and military externalities). Automakers would gain higher profits and lower risks; buyers, better autos with three-year or shorter paybacks; society, a 14-percent internal rate of return and a ~\$25/barrel equivalent average cost for getting *all* mobility off oil if all externalities were worth zero. We also showed how temporary size- and revenue-neutral feebates could cover electrified vehicles' initially higher sticker prices, thereby advantaging buyers, dealers, and automakers.

Mann insists the peak-oil debate is about supply. I agree. But he ignores what I *did* claim: that such mainstream analysts as Exxon-Mobil forecasters, Daniel Yergin, Deutsche Bank, and Nick Butler of the *Financial Times* have begun to see "peak oil" emerge in demand *before* supply, because efficiency outcompetes oil. *Reinventing*

Fire documents this in detail for each significant use of oil in each sector, and demonstrates handsome financial returns to the required investments. Mann doesn't analyze the competition between oil and its efficient use for any use in any sector; he simply assumes that however much "petroleum" can be produced, at whatever price and external cost, will be burned.

Of course major energy price shocks rattle the economy, but that doesn't prove Mann's claim that energy use and GDP still march in lockstep. Oil intensity has plummeted in almost all industrialized countries, not just the U.S., thanks mainly to more-efficient use. Mann thinks developing countries will offset those OECD oil savings by growing very inefficiently. But will China and India build and buy hundreds of millions of gas-guzzling 20th-century cars while global automakers sell superefficient, oil-free models? More likely they'll leapfrog.

I acknowledged the recent German coal-burning uptick. But that coal displaced natural gas when gas's often-oil-linked price rose—not renewables, which as Mann says were increasing. He claims German CO_2 emissions* have risen "since 2009," but that's cherry-picking the data: 2009 was abnormally low, in the depths of the Great Recession. Mann's data source confirms that Germany's absolute CO_2 emissions were 4.5% lower in 2012 than in 2008, and that the 1990–2010 trend is down, falling further in 2011. I correctly stated that CO_2 emissions in 2012 from German power plants (which emit less CO_2 than do buildings and transport) and industry held steady, and that total CO_2 emissions rose slightly due to heating (not to electricity generation), but fell after the standard weather adjustment. If, as Mann claims, Germany were switching to coal because it's needed to replace nuclear power and is cheaper than renewables, the data for generation and emissions would show that, not the opposite.

Mann misdescribes Germany's coal-power plans, explained here and here. Actually, Germany has begun no new coal plants since Fukushima and will *lose* net coal capacity, coal-fired generation will decline, lignite has no future, and any of the coal plants planned long ago that are completed are likely to lose money, just as existing ones now do—requiring anti-renewables campaigners to explain how supposedly uncompetitive renewables are walloping their favorite technologies.

Mann ignores my specific renewables-cheaper-than-gas market data, calling for wider averages, but instead of offering data, he cites EIA forecasts for future wind and photovoltaic power costs—forecasts well above today's actual prices. EIA's expertise is not generally considered to be technology cost forecasting (especially for renewables), and the energy industries, like *Reinventing Fire*, don't use EIA's technology-cost forecasts for business planning. Rather, they prudently rely on observed market prices, such as the illuminating windpower contract prices published annually (see Fig. 34) and the kinds of power-auction results I cited, augmented by careful industry studies of observed trends and their underlying causes.

Mann's wider electricity claims add new errors to his previous ones. First, Germany's residential electricity price is high *because it's half taxes*, partly to finance payments for voluntarily added renewable power (though the solar feed-in tariff is falling monthly). Those payments are boosted several billion Euros a year by burdening households with tax exemptions for many industries. Big industries pay the highly competitive *wholesale* price, about the same in real terms as in 1978; that's why Germany is attracting energy-intensive industry and in 2012 booked record power exports. But *renewables are lowering those wholesale prices*, cutting coal and nuclear plants' operating hours, revenues, and profit.

Those discomfited operators and their allies sometimes spread disinformation blaming renewables, almost always falsely, for any power glitch. The president of Germany's network agency has confirmed that renewables aren't compromising grid reliability. Mann cites five references to bolster his claim that Germany's 23-percent-renewable supply is damaging power reliability, but his sources don't support his case.** One claims renewables are "causing havoc," the other four don't, and *none* of the five offers any evidence this is happening—because it's not.

To be sure, Germany's grid, built for central stations, got almost no expansion as renewable generation soared from 3 percent in the early 1990s to 23 percent 20 years later. Grid modernization and expansion are therefore needed and vigorously underway. But fear of what might happen if those grid improvements were *not* made doesn't justify claiming that blackouts and brownouts are rife today. In fact, German power, like 22-percent-solar-and-windpowered Spanish and 30-percent-windpowered Danish power (both for all of 2012), remains far more reliable than US power and is getting even more reliable. The grid operators may well be busier nowadays coping with variable renewables' more complex dispatch, but they're German engineers and they do their job very well. Likewise, as Spain's solar and windpower soared in the past few years, its reliability index rose too. Across Europe, renewable expansion correlates with *more* reliable power. Mann claims the standard EU-wide reliability metric doesn't capture fast power disturbances he ascribes to renewables, but he offers no evidence this issue exists—just rumor and anecdotal hearsay that evaporate on scrutiny. If he can document its existence and characteristics from a credible source, then that claim can be examined.

Mann cites Washington State's unusual issue with surplus Columbia Gorge windpower. It's due to currently limited transmission capacity, and storage is neither the only nor the cheapest answer. New Jersey, like many places with tight budgets, has reduced renewable incentives as costs have fallen and supplies burgeoned, but not due to reliability or grid issues; indeed, most of the state's billion watts of solar modules survived Superstorm Sandy and could have provided post-storm daytime power had they been wired resiliently as my comment proposed.

Mann's 1990s-vintage view of renewable limitations does not reflect modern theory or practice. NREL's REFS study and RMI's *Reinventing Fire*, both cited in my comment, provide detailed evidence. The latest such analysis, from eastern Australia's grid operator, confirms that 100% renewable power can be reliably provided without Mann's costly batteries.*** NREL's latest international review confirms: "Many countries—reflecting very different geographies, markets, and power systems—are successfully managing high levels of variable renewable energy on the electric grid, including that from wind and solar energy." Of my U.S. and international examples, six were short term as Mann says, but five were for a whole year, one for three months, and two for one month, all providing reliable power 'round the clock. This seems relevant to his claim of a 20–30-percent limit on variable renewables' share of production.

But more fundamentally, why his focus on electricity? As my comment said, there is virtually no U.S. connection between electricity and oil (except in Hawai'i, Puerto Rico, and island territories): less than one percent of U.S. oil (mostly otherwise useless tarry residual oil left at the bottom of the refiners' barrel) makes electricity, and less than one percent of our electricity is made of oil. There's more linkage with natural gas, which made 30 percent of U.S. electricity last year, but again, oil and natural gas are very different in all key respects, even though each is often a byproduct of extracting the other. Mann conflates these two highly disparate fuels as "petroleum" even though his own recommended source, Wikipedia, defines it as a liquid, and only in its fifth paragraph mentions a popular usage that includes natural gas.

Adding to the confusion, Mann then emphasizes electricity, but limits his discussion to variable renewable sources—not the most potent competitor to gas-fired power (which is efficient end-use)—and not dispatchable renewables, demand response, distributed storage, etc. This mishmash so confused even *Atlantic* editors that their own titles and illustrations mixed up oil, gas, and electricity. That didn't aid public understanding. Neither did Mann's article and response. But if he'll kindly read *Reinventing Fire*, he'll find most of it is devoted to explaining precisely the "real obstacles ahead" that he claims I refuse to see—and how business-led, policy-enabled innovations can profitably overcome them.

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* I appreciate Mann's correction that I misdescribed the 2011 and 2012 changes in Germany's greenhouse-gas emissions as CO_2. Fossil CO_2 emissions, according to Mann's data source, changed in 2011 by not –2.8 percent but –2.86 percent, and in 2012, preliminarily and before weather-adjustment, by not 1.6 percent but 2 percent (with the second significant figure not yet formally announced). My conclusions don't change; after all, energy-related German 2012 greenhouse gas emissions expressed as CO_2-equivalent, says Mann's source, were 97.8 percent CO_2.

** The first paper does not report actual problems; it's a theoretical treatment of problems that could arise if the grid weren't properly modernized and operated. The second paper capably identifies some well-known distribution-grid technical issues and describes their straightforward fixes, but it does not say, as Mann claims, that renewables are "already leading to…black- and brownouts"; that's his addition. (Reverse distribution power flows are not new and are not of particular concern if properly managed.) The third paper, by the Institute of Energy Research and its source, *Der Spiegel*—both frequent publishers of thinly sourced anti-renewable arguments—cite one example of voltage sags at a metal plant, but offer no evidence it has anything to do with renewables. Mann's fourth citation does say German industry in 2011 experienced 206,673 power disturbances (not necessarily blackouts) lasting at least three minutes, but doesn't link any of them to renewables, and only calls for keeping track of shorter disturbances too (a good idea…but without such data, it's unclear how Mann knows such transient disturbances are rising). The fifth paper, a highly theoretical analysis that Mann cites as finding that high renewable fractions will be blocked by bulk storage's prohibitive cost, actually concludes instead that "increasing grid flexibility as the penetration of renewable power generation increases will require employing several additional techniques [beyond bulk storage] including demand-side management, flexible generation from base-load facilities and natural gas firming." Those are three of the six options listed in my original comment; adding the other three would make bulk storage, the costliest option, even less necessary. Mann also cites a sixth paper that he interprets as showing that PVs can provide only 10–20 percent of electricity; it doesn't say that, and ends by stating that a follow-up paper will show how integrating the kinds of other options I described can raise the PV fraction to 50 percent or above. That sounds about right, since RMI's hourly simulations for the same Texas grid (the ERCOT power pool) already showed that it's possible to achieve 100 percent renewable supply reliably with no bulk storage and only 5 percent spill of leftover renewable electricity.

*** Windpower's impressive growth in the U.S. during 2004–12, when non-hydro renewable generation rose by 163 percent, coincided with a 45 percent *decrease* in use of the U.S. grid's main "batteries," pumped hydro. This can be ascribed both to more, wider, faster markets and to cheaper (since ~2009) flexible gas-fired generation, but dispatchable renewables, demand response, and smart charging and discharging of electric vehicles illustrate the similarly large flexible resources available in high-renewables scenarios.