Profitable climate solutions: Correcting the sign error

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Climate protection, like the Hubble Space Telescope's mirror, got spoilt by a sign error—a confusion between a plus sign and a minus sign. The error originates in misapplied economic theory. Markets are widely but wrongly assumed to be nearly perfect. If they were, everything profitable would already have been done, so any unbought energy efficiency must not be cost-effective unless energy prices were raised (often by simple taxes that depress GDP, not by rebated user fees that raise it.)[1] In theory, theory and practice are the same, but in practice they are not. If markets actually *were* nearly perfect, all juicy rents would already have been arbitraged out, all innovations invented, and business sucked dry of any fun.

Observed physical reality and market behavior are orthogonal to this uninviting picture. In general, climate solutions are *not costly but profitable*, because saving fuel costs less than buying fuel. Many leading companies are making billions of dollars' profit by cutting their carbon intensity or emissions at rates of ~5–15%/y.[2] Salient examples include reduction rates averaging:

- 6%/y for IBM's and STMicroelectronics' carbon emissions with ~2–3 y paybacks;
- 10%/y for DuPont's greenhouse gas emissions (totaling a 72% reduction in 1990–2003) at a $3 billion profit, and 16%/y for Interface's GHG emissions (down 82% in 1996–2007) at a ~$0.2 billion profit;
- 15%/y for United Technologies' energy intensity (down 45% in 2003–07).

More examples abound. Dow pocketed $3.3 billion by cutting its energy intensity 22% in 1994–2005; BP earned $2 billion by achieving its 2010 operational carbon-reduction goal eight years early. GE is boosting its energy productivity 30% in 2005–12 to create shareholder value. No wonder business, the most dynamic force in society, is leading climate protection, while gridlocked public policy plays catchup. Whilst politicians debate theoretical costs, smart companies are racing to pocket actual profits before their rivals do.

Even widely achieved societal energy savings seem invisible: thirty years of reductions in energy intensity now save the US more energy each year than Europe uses, or 2.3 times total US oil use, but few leaders notice. In 2006, equally unnoticed, US use of oil, gas, coal, and total energy *decreased* because energy intensity fell more than GDP rose. But whatever exists is possible. When politicians who lament climate protection's supposed costs, burdens, and sacrifices discover and enter the parallel universe of practitioners who routinely achieve profits, jobs, and competitive advantage by wasting less fuel, any remaining political obstacles to climate protection will dissolve faster than the glaciers, because even people unconcerned with climate will presumably have no objection to making money (and incidentally improving security).

This could happen faster if policy were less dominated by economic theorists. Even such a worthy analysis as Sir Nicholas Stern's,[3] whilst mentioning that a considerable amount of energy efficiency may be cost-effective, *i.e.*, profitable, prefers to rely on historic price elasticities rather than the carefully measured empirical costs and physical quantities of energy savings achieved and achievable in buildings, factories, and vehicles. The distinguished IPCC panel responsible for forming energy scenarios and policy options seems to prefer econometric to physical data—perhaps reflecting its dominant discipline's (economists') tendency to interpret behavior through price, to assume that only price importantly influences behavior, and to steer whilst looking in the rear-view mirror. As a practitioner, not a theorist, I think price is only one of many influences on complex human choices and can poorly predict them, so I work mainly with direct physical measurements of energy efficiency, but physical scientists and economists have different ideas of what constitutes evidence. I think historic price elasticities contain useful information, but reflect conditions that no longer exist and that policy aims to change as much as possible, so they cannot be validly used to define future potential.

Stabilizing the rate of fossil-fuel carbon emissions requires reducing energy intensity (GJ of primary energy consumption per real dollar of GDP) by raising the canonically assumed 1%/y rate by only one percentage point, to ~2%/y. Stabilizing climate needs only ~3%/y; even stabilizing climate very briskly to achieve atmospheric levels fitting the latest and most disquieting scientific findings (*i.e.*, on the order of 350 ppm CO_2) needs only ~4%/y. That is because these faster intensity reductions—plus

Physicist Amory Lovins is Chairman and Chief Scientist of Rocky Mountain Institute (www.rmi.org). Published in 29 books and hundreds of papers, his work has been recognized by the Blue Planet, Volvo, Onassis, Nissan, Shingo, and Mitchell Prizes, a MacArthur Fellowship, ten honorary doctorates, and the Heinz, Lindbergh, Right Livelihood, and World Technology Awards. An Hon. AIA, FRSA, and Swedish engineering academician, he advises governments and major firms worldwide on advanced efficiency, and has led the technical redesign of more than $30 billion worth of facilities in 29 sectors to achieve very large energy savings at typically lower capital cost.

gradual decarbonization of fuels, as coal and oil switch to gas and renewables—can offset or more than offset projected growth in population and per capita economic activity.[4] For example, even if, over the next half-century or so, world population nearly doubled and per capita GDP tripled or quadrupled, increasing Gross World Product ~6–8-fold, fossil carbon emissions could simultaneously be *reduced* by 3–4-fold. This could be achieved if the carbon intensity of energy fell by 2–4-fold (consistent with historic trends), conversion efficiency from primary to delivered energy rose just 1.5-fold (a modest goal because many power plants in developing countries are very inefficient, and little combined-heat-and-power is used in the United States), end-use efficiency rose 4–6-fold (*i.e.*, at an average compounded rate of ~2.7–3.6%/y, consistent with many historic US rates), and "hedonic efficiency"—human happiness or satisfaction gained per unit of energy services delivered—stayed flat or doubled, a reasonable range for this poorly understood variable. Clearly the strongest lever is not decarbonizing energy supply, which dominates most policy discussions, but rather reducing energy intensity—a term fourfold bigger historically, and with even greater potential for dramatic future gains.

Could global energy intensity actually be reduced by 3–4%/y? Yes: such rates are often observed today. The US has long achieved ~3%/y—*e.g.*, 3.4%/y in 1981–86, 2001, and 2006—despite inattention, generally anti-efficiency national policies, perverse incentives rewarding more energy sales by electric and gas utilities in 48 states, and more than two decades' stagnation in light-vehicle efficiencies. But efficiency's pace varies widely between US states that pay much or little attention to energy policy: California has generally saved energy about a percentage point faster than the US as a whole. China achieved a percentage point faster still for >20 y until 1997, then nearly 8%/y to 2001, then a temporary reversal in 2002–06.[5] Raising the global rate of energy intensity reduction to ~3–4%/y, still severalfold slower than attentive firms profitably achieve, is not so difficult if we pay careful attention to "barrier-busting"—turning the 60–80 known market failures in buying energy efficiency into business opportunities.[6] It is encouraging that Japanese energy intensity could be reduced by two-thirds[7] without exploiting much of the applicable efficiency potential identified by others. Since Japan has 2–3 times US and ~7 times Chinese energy productivity, this implies that, if composition of output converged in the long run, China could ultimately have ~20 times its current GDP, yet still use less energy than today.

Energy efficiency is the main but not the only tool for profitable climate protection. Many kinds of supply-side substitutions and reforms of farm and forest practices can also save carbon at collective, and even at individual, costs ranging from modest to negative. A useful, partial, and technically conservative McKinsey assessment found that 46% of projected global GHG emissions could be saved at an average net cost of just $3/TCO$_2$-equivalent.[8] But other experience and analysis suggest that profitable energy efficiency *alone* could suffice to achieve ambitious long-term climate-protection goals if pursued to its full modern potential. This typically uses integrative design to achieve expanding rather than diminishing returns (*i.e.*, radical savings at *lower* capital cost). This has been demonstrated in a couple of dozen sectors, but its wide adoption awaits a revolution in design pedagogy and practice.[9]

Detailed and uncontroverted assessments have shown how to save half of US oil and gas at respective average costs of $12/bbl and $0.9/GJ (2000 $)[10] and three-quarters of US electricity at ~$0.01/kWh[11]—all well below the short-run marginal cost of delivered supply. For example, tripled-efficiency but safer and uncompromised cars,[12] trucks, and planes using current technology would respectively repay their extra capital cost in 1, 0.5, and 2–3 years at current US fuel prices.[10]

Now add alternative supplies. Global fossil-fuel carbon emissions come about 2/5 from burning oil and 2/5 from making electricity (the remaining fifth, from directly burnt gas and coal, offers analogous opportunities). Redoubling US oil efficiency at an average cost of $12/bbl, then substituting saved natural gas and advanced biofuels (together averaging $18/bbl) for the other half of the oil, can eliminate US oil use by the 2040s.[10] Since the average cost of getting completely off oil is ~$15/bbl (2000 $)—~$100/bbl below the recent real price—and is falling, this transition will be led by business for profit. Innovative public policies that support, not distort, the business logic can accelerate this transition without needing new fuel taxes, subsidies, mandates, or national laws.[10] Early implementation progress is encouraging, thanks to "institutional acupuncture"—determining where the business logic is congested, then sticking needles in it to get it flowing.[13]

As for electricity, "micropower"—low-carbon combined-heat-and-power plus zero-carbon decentralized renewables—provided[14] 1/6 of the world's electricity and 1/3 of its new electricity in 2005, meeting from 1/6 to over 1/2 of all electrical needs in a dozen industrial countries. Micropower added four times the electricity and 8–11 times the capacity that nuclear power added globally in 2005 and now exceeds it in both respects. Micropower plus "negawatts" (saved electricity), which probably has a similar annual capacity effect, now provide upwards of half the world's new electrical services. Both options' 207 "distributed benefits," when counted, will widen their already clear economic advantage[15] by about another tenfold.[16]

These dramatic market shifts in technology and scale are largely unnoticed but well underway: "clean energy" got ~$63 billion of global investment in 2006, $56 billion of it for distributed renewable electricity. And the shift away from both fossil and nuclear fuels is accelerating. In 2006 worldwide, nuclear energy's added capacity was less than that of photovoltaic energy, one-tenth of windpower's, and one-thirtieth to one-fortieth of micropower's. China's renewables, excluding large-scale hydropower, reached seven times China's nuclear capacity and grew seven times faster. In 2007, the US, China, and Spain each added more windpower capacity than the world added nuclear capacity; US wind capacity additions exceeded the past five years' total US additions of coal capacity; and distributed renewable power worldwide received $71 billion of private investment while nuclear, as usual, got zero, since its only buyers are central planners with a draw on the public purse.[17]

There is no nuclear revival—new US subsidies, though ~100+% of new plants' cost, are not luring investors—but if there were, nuclear investment would buy 2 to 11 times less carbon reduction per dollar, and do so approximately 20 to 40 times slower, than investment in micropower or energy efficiency.[18] Those low- and no-carbon competitors, best for climate *and* security, are winning as exploding sales drive down costs even further, offering lower costs and lower financial risks than their outmoded central-station competitors. For example, even photovoltaics have *already* achieved cost crossover: in (say) New Jersey they cost less, and add more capacity sooner, than building new nuclear *or* fossil-fueled generation.[19] Thus it is not good enough for an energy technology to emit no carbon; it must also provide the most solution per dollar and per year. Buying anything else instead reduces and retards climate solutions. Oddly, this opportunity cost remains unknown to most policy-makers and unremarked by the IPCC.

In short, the climate problem is neither necessary nor economic, but is an artifact of not using energy in a way that saves money. Climate change can be prevented by taking markets seriously—letting all ways to save or supply energy compete fairly, at honest prices, no matter which kind they are, what technology they use, where they are, how big they are, or who owns them. Internalizing carbon and other environmental costs will be correct and helpful but not essential; not sufficient (because correct prices do not yield efficient choices without barrier-busting); and in the long run not very important (since efficient carbon markets will ultimately clear at low prices).

Fair competition can simultaneously solve many other problems. For example, saving electricity needs ~1000 times less capital, and repays it ~10 times faster, than supplying more electricity.[20] This ~10 000-fold capital leverage can turn the power sector (now gobbling about a quarter of global development capital) into a net funder of other development needs. Profitably eliminating oil use would certainly make the world fairer and safer. A more efficient, diverse, dispersed, renewable energy system can also make major supply failures, whether caused by accident or malice, impossible by design rather than (as now) inevitable by design.[21] Thus the policy objectives of affordable, reliable, resilient, secure, climate-safe, and benign energy all happen to be satisfied by the same set of technologies—and they are winning in the marketplace wherever they are allowed to compete.

The inevitable demise of nuclear power—already stricken by a fatal attack of market forces—can belatedly stem nuclear proliferation too,[22] by removing from ordinary commerce a vast flow of ingredients of do-it-yourself bomb kits and their innocent-looking civilian disguise. That would make those ingredients harder to get, more conspicuous to try to get, and politically far costlier to be caught trying to get, because for the first time, the motive for wanting them would be unmasked as unambiguously military. Focusing intelligence resources on needles, not haystacks, would also improve the odds of timely warning. All this would not make proliferation impossible, but would certainly make it far more difficult for both recipients and suppliers.

Had early analyses of these opportunities been adopted when first published,[23] we would not now all be worrying about climate change, oil dependence, or Iran and North Korea. But it is not quite too late. As the late Donella Meadows said, "We have exactly enough time—starting now."

So what are we waiting for? *We* are the people we have been waiting for. As Raymond Williams wrote, "To be truly radical is to make hope possible, not despair convincing." And if any of this article seems too good to be true, just recall Marshall McLuhan's remark that "Only puny secrets need protection. Big discoveries are protected by public incredulity."

Amory B. Lovins

Chairman and Chief Scientist, Rocky Mountain Institute (www.rmi.org), 1739 Snowmass Creek Road, Snowmass, CO 81654, USA. E-mail: ablovins@rmi.org

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