**How Many Barrels?**

In fall 2001, during the national discussion on oil dependence that flickered after 9/11, Amory B. Lovins began claiming that a modest (2.7 mile-per-gallon) improvement in the average gas mileage of U.S. cars and "light trucks" would save enough oil to eliminate U.S. imports from the Persian Gulf (some 2.5 million barrels per day, or "mbd").

My own calculations found that the savings would be only around 1.0 mbd, so I asked Amory, the renowned energy-policy guru who is also an old friend, how he came by his much larger number. Thus began the following dialogue, shown here.

-- C.K. January 30, 2002

**1. CK to ABL, Oct 30, 2001**

Amory --

Nice piece on the Tom Paine site.

But I don't get how a 2.7 mpg gain in the light vehicle fleet would eliminate Gulf imports.

Assuming a current base of 20 mpg (I think that's approx right), a boost to 22.7 would eliminate 12% (1 less 20/22.7) of gasoline use, which is around 8.5 mbd. So we save 1.0 mbd. But as you know, total P Gulf imports averaged 2.5 mbd during each of 1999 and 2000.

So the numbers don't seem to match. Are you perhaps leveraging gasoline savings against barrels of crude in a way I'm not grasping?

Best,

Charlie

**2. ABL to CK, Oct 31, 2001 [w/o CK passages included in ABL's reply]**

Date: Wed, 31 Oct 2001 15:42:02 -0700
To: Charles Komanoff <kea@igc.org>
From: Amory B Lovins <ablovins@rmi.org>
Subject: Re: your oil savings in Tom Paine piece

Yes, but 1 bbl of crude oil in 2000 yielded only 0.462 bbl of gasoline, and gasoline demand drives marginal crude-imports demand.

It's all laid out in the extensive annotations to our Foreign Affairs paper, all at www.rmi.org...where we also just reposted Brittle Power.

**3. CK to a list-serve of "energy advocates" administered by the Energy Foundation, Nov 28, 2001**

I winced at Robert F. Kennedy Jr.'s statement, in last Saturday's *New York Times* (Nov. 24 op-ed, "Better Gas Mileage, Greater Security"), that "An improvement [in automobile and light truck fuel efficiency] right now of 2.7 miles per gallon would eliminate our need for all Persian Gulf oil!" (exclamation point in original)

(Kennedy's op-ed is available, for several more days, at http://www.nytimes.com/2001/11/24/opinion/24KENN.html?searchpv=past7days )

Kennedy's claim understates the mpg improvement needed to eliminate Persian Gulf Oil by at least a factor of 3 in the long term, and probably as much as 2 in the short term.

Kennedy relied on a calculation by Amory Lovins. But this calculation rests on a fallacy: it credits each barrel of gasoline saved with saving more than 2 barrels of crude.

Yes, it's true that, on average, between 2.1 and 2.2 barrels of crude must be refined to make each barrel of gasoline. But in the long term — which is the time frame required for substantial mpg improvements — the ratio of crude in to gasoline out isn't fixed.

Refiners would adjust to lower gasoline demand by adjusting and, if necessary, re-engineering to a different output mix. These engineering changes could probably stay ahead of the market penetration curve of higher mpg vehicles, and at worst would trail it by very little. So each reduction in gasoline demand of one barrel would lead to little more than one barrel of crude's staying in the ground, invalidating the claim that a mere 2.7 mpg boost in efficiency would equal U.S. imports from the Gulf.

Even in the short term, refiners have considerable leeway to change their product yield by altering their runs and/or by switching from high- to low-gasoline-yield crude oil. Accordingly, even "overnight" reductions in gasoline demand would translate into far smaller crude savings than Amory calculated and Kennedy implicitly assumed.

As I show below, based on 2001 oil consumption and import data, it would take as much as a 9.2 mpg increase in U.S. cars and light trucks to eliminate oil use equivalent to Gulf imports. (Based on 2000 data, the needed increase is as much as 8.4 mpg.) While smaller increases would suffice in the short term, they would be far higher than the 2.7 mpg figure claimed.

Why should we care?

Obviously, it's important that we correctly state (and never overstate) our case.

But even more important: after Sept. 11, it's time to move far beyond the environmental orthodoxy that's stuck on petty technical fixes (however desirable) and dares not mention higher gas taxes or "behavioral change."

The calculations here show that whether we like it or not, when it comes to wringing oil savings from the transportation sector, tech fixes alone won't get us where we need to be — at least not for a very long time. It's time for serious environmentalists to go back to our roots, and talk to our fellow citizens about ways to live good lives without continuing to drive all these miles.

Since Sept. 11, I've seen plenty of reason, in scores of personal conversations, and in op-eds, letters to the editor, even editorials, to believe that many people are far out in front of our "leadership" — not just elected officials but <u>environmental</u> leaders — in demanding to be detoxed off the oil spike; they are perfectly willing to contemplate higher gas taxes and reduced driving to do it.

Just look in yesterday's (Nov. 27) *Times*: all four letters commenting on Kennedy's op-ed say that his call for higher CAFÉ standards didn't go far enough! (The letter-writers demand, respectively: higher gas taxes, public transit and other non-car alternatives, targeting corporate energy pushers, and full-cost pricing of energy.)

Before we environmentalists painted ourselves into the efficiency corner, no one was more eloquent and insightful than Amory. In *Soft Energy Paths* and a hundred other beautiful broadsides, he insisted on examining the <u>purposes</u> of using energy (along with ways to use it more efficiently). C'mon ABL and RFK and the rest of you — let's bust the environmental movement out of this timorous, self-defeating "efficiency" box and engage Americans in a deeper, richer, more effective discussion about changing how we live.

[a half-dozen graf's removed for length]

How far wrong is the claim in RFK's op-ed piece? If we go out far enough (the proper time horizon for mpg savings, particularly through stronger CAFÉ standards, is a goodly number of years), where gasoline and crude savings are in or close to a 1-to-1 relationship, we find that eliminating petroleum use equal to Persian Gulf imports via mpg savings alone requires boosting average car and light truck mileage from an assumed baseline of 20 mpg, to as much as 29.2 mpg (using 2001 data).

Using 2000 data, of 2.5 mbd of Gulf imports and 8.47 mbd of U.S. gasoline consumption, the mpg average necessary to save the equivalent of Gulf imports is as high as 28.4 mpg.

(The equation is: oil displaced = (1 – 20/mpg) x baseline gasoline consumption, assuming a current mpg average of 20. The "mpg" in the parentheses is the higher necessary mileage level.)

Thus, the range of improvements required, as high as 8.4 to 9.2 mpg, is more than triple the 2.7 mpg claimed by Kennedy. (If this seems excessive, bear in mind that each increment in mpg translates to a smaller percentage gain in efficiency and, therefore, smaller saving in gasoline.)

— Charlie

**4. ABL to CK, Nov 28, 2001**

Date: Wed, 28 Nov 2001 10:00:33 -0500
To: Charles Komanoff <kea@igc.org>
From: Amory B Lovins <ablovins@rmi.org>
Subject: Re: we're overstating oil savings from mpg gains (long)
Cc: tfeiler@keystone.rmi.org

With all due respect, Charlie, I don't think this is correct for modest mpg gains, where I believe light product demand will continue to drive marginal imports. It's hard for refiners, already tilted far toward the light side of the barrel after huge investments in extra hydrogenation etc, to idle that investment by switching their product slate very far back toward middle distillates. I also disagree that gaining 2.7 mpg on the light-vehicle fleet takes a long time: when we were last paying attention, we used to do this every <3 y.

However, since there is certainly some level of gasoline demand reduction and some equilibration period over which the actual crude demand will move from my toward your number, our annotated Foreign Affairs article states this qualification in some detail. (I also repeated it to Bobby every time I told him the numbers.) An energy-security factsheet I'm updating shows the numbers both ways, so users can pick whichever convention they wish.

When I have more time, I'll go through your numbers in the appendix below -- there are probably some quibbles. But before dashing off to all-day mtgs, I wanted at least to get the basics straight.

And of course I welcome lifestyle change, but don't find it either morally or tactically useful to mix it with technical change. And I happen to think that accelerated-scrappage feebates will be far more likely to happen, and more effective, than higher gasoline taxes or CAFE stds. -- ABL

**5. CK to list-serve and ABL, Dec. 3, 2001**
**Subject Line: saving oil: nukes then, mpg now?**

The last time America's oil addiction was a national-security issue, in the 1970s, the nuclear power industry claimed that U.S. reactors were saving vast

amounts of imported petroleum. That claim was politically potent, and so the more numerate among us in the antinuclear movement — the pocket-calculator brigade, you could call us — expended considerable effort analyzing it. We identified the key misrepresentations, such as overstating reactor capacity factors and assuming that all electricity was oil-generated at the margin, and showed — surprise! — that the pro-nukers were overstating nuclear power's actual oil savings by a factor of two or three. Our rebuttals not only helped stop the stampede to weaken reactor safety and licensing standards, but also bolstered the antinuclear movement's credibility with public officials, journalists and the public.

Now, in what feels like a very strange sequel, I find myself at odds with several list members on the matter of whether environmentalists such as NRDC's Robert F. Kennedy Jr. are right to claim that a mere 2.7 mpg gain in gas mileage would equate to all U.S. oil imports from the Persian Gulf. Though half-a-dozen folks have written to me praising my conclusion, posted here on Nov. 28, that Kennedy understated the necessary gain in gas mileage by a factor of three, NRDC hasn't retracted Kennedy's claim and no one here has called on them to do so. Amory Lovins, who originated the claim, says "[both] our analyses are valid" and suggests bringing the matter before oil industry experts. Marty Kushler says in effect that my point has been made and it's time to shut up and fall in line with environmentalist orthodoxy . . . whatever it may be, and however formed.

Well, friends, neither of these replies will do. There's a technical issue, of some importance, and there's also a political issue.

Here's the technical issue: Does a one-barrel reduction in gasoline demand lead to a reduction in crude-oil extraction of one barrel (my position), or two-plus barrels (Amory's and RFK's position)? My main points, supported in a detailed argument here on Nov. 28, were that (i) refiners seek to respond to drops in gasoline demand by reducing output of gasoline only, so they may continue supplying other petroleum products, and (ii) they have considerable leeway to change their product yield do so, by altering their runs and/or by switching from high- to low-gasoline-yield crude oil.

Amory replied that "gasoline demand drives marginal crude-imports demand." This statement may well be true, but it's too unspecific to be useful; the question is, what is the multiplier between the two? Amory implicitly assumes that the multiplier is fixed at the present ratio between oil extracted and gasoline refined. But it is nonsensical to say, as Amory's position requires, that refiners would respond to lower gasoline demand by curbing production of heating oil and jet fuel and all other petroleum products in lock-step with gasoline.

It's not prudent to base our strategy on an unsupported and indeed unexamined assumption; nor, as Ned Ford noted here over the weekend, is it wise to open ourselves to the same sort of criticism that we rightly direct at the Bush Administration and the energy corporations for exaggerating the benefits of supply-side measures such as drilling in ANWR. Amory needs to provide a substantive argument that at the margin under consideration here (a several-mpg gain in average U.S. automobile gas mileage), each barrel of gasoline saved would translate to two-plus barrels of crude oil left in the ground.

This is a very strong assertion; it is by no means the null hypothesis. I would argue, in fact, that the view I've advanced — that a reduction in demand of X barrels for one petroleum product implies little or no more than an X barrel reduction in crude demand — has a much better claim to be considered the null hypothesis than Amory's axiom of refiner rigidity.

The political issue is essentially this: why is our community so invested in mpg incrementalism that it's become acceptable to exaggerate mileage gains' true effectiveness several-fold? I'll hold my fire on this point for another time. Suffice it to say that one of the things that attracted me to the environmental movement in the 1970s was its unyielding commitment to accurate representation of

the underlying facts. I believed in that commitment then, and I'm not about to start walking away from it now.

**6. ABL to CK, Dec. 26, 2001**

Date: Wed, 26 Dec 2001 15:59:04 -0500
To: kea@igc.org, Mgkushler@aol.com, tfeiler@keystone.rmi.org
From: Amory B Lovins <ablovins@rmi.org>
Subject: relationship between reduced gasoline use and reduced crude-oil imports
Cc: mpostman@law.pace.edu, phred@well.com

I've just come up for air for just long enough to revisit this question. Since Charlie raised it so widely on and after 31 October, I've discussed it in depth with an additional refinery and oil-industry-strategy expert. This confirmed my understanding that the way the industry *actually* works effectively decouples the several layers of decisions that should logically link changes in gasoline demand (and its refinery out) to changes in crude runs (inputs to refineries). The linkages are extremely complex and, from an economic perspective, often illogical. Hence, as I'd thought, it is not analytically possible to derive from first principles the ratio of reduced crude oil demand to reduced gasoline demand.

However, it did seem worth exploring what the *empirical* data might show. I therefore dug into EIA's Annual Energy Review 2000. To look for the most useful evidence, I looked solely at the difference between 1978 and 1982. In 1978 (Table 5.11), motor gasoline supplied hit an all-time high of 7.41 Mbbl/d, not exceeded until 1993+. (Table 5.12c shows that the same was true for transportation-sector demand for motor gasoline. That figure was slightly smaller, 7.26 Mbbl/d, because 2% of the motor gasoline supplied are booked to non-transportation sectors.) In 1982, motor gasoline supplied hit a low of 6.54 Mbbl/d, a decrease of 0.87 Mbbl/d or 11.7% from 1978; this level of gasoline demand matched 1974's, and hasn't been reapproached since 1982. The 3.55 Mbbl/d drop in total petroleum products supplied (Table 5.11) included the #1, #2, and #3 all-time record-percentage-drop years (respectively 1980, 1981, and 1982). The period 1978-82 showed a drop in each year after, but not including, 1978. This therefore seems a good period in which to examine the relationship between decreases in gasoline demand and crude-oil consumption.

As a cross-check, motor gasoline output from U.S. refineries (Table 5.8) fell during 1978-82 by 0.83 Mbbl/d. This is slightly less than the drop of drop of 0.87 Mbbl/d in motor gasoline supplied (Table 5.11). That's because of a drop of 0.012 Mbbl/d in net gasoline imports (Tables 5.3 and 5.5), an average decrease of 0.002 Mbbl/d in primary gasoline stocks (Table 5.14), and presumably mostly changes in some unknown combination of secondary stocks, losses, and unaccounted-fors.

Let's use both these similar figures, 0.83 and 0.87 Mbbl/d, and try to understand what happened to the way U.S. refineries were run during 1978-82 as gasoline and most other product demand decreased. The change in U.S. refineries' motor gasoline output was abrupt -- from the all-time high until '93 to the all-time low since '71 -- again confirming that 1978-82 ought to be a reasonable period to look at.

Table 5.8 shows that during this period, refinery inputs changed by:

| | | |
|---|---|---|
| crude oil | -2.97 Mbbl/d | -20.2% |
| NGL | -0.12 | -18.8% |
| other liquids | +0.48 | +533% |
| **TOTAL INPUT** | **-2.61** | **-16.9%** |

while refinery outputs changed by:

| | | |
|---|---|---|
| petroleum coke | +0.04 Mbbl/d | +10.8% |
| asphalt/road oil | -0.15 | -31% |
| resid | -0.60 | -36% |

| | | |
|---|---|---|
| distillate fuel | -0.56 | -17.7% |
| jet fuel | +0.01 | +1% |
| motor gasoline | -0.83 | -11.6% |
| LPG | -0.08 | -22.9% |
| **TOTAL OUTPUT** | **-2.58** | **-16.2%** |
| still gas | -0.05 | -8.3% |
| other products | -0.35 | -29.4% |
| processing gain | +0.03 | +6.0% |

These changes in inputs and in the output slate suggest several further inferences:

- Reduced inputs are overwhelmingly due to lower crude runs. (However, the mix of crudes may well have changed, and there was also an accounting change in the definition of "other liquids." Before 1981, this term meant unfinished oils [net], hydrogen, and hydrogen not included elsewhere. Starting in 1981, it also included motor gasoline blending components (net), aviation gasoline blending components (net), and alcohol. Table 10.1, using the EIA ARE conversion value of 3.539 MBTU/bbl, shows that U.S. fuel alcohol consumption [essentially all for blending into gasoline] was 0.0054 Mbbl/d in 1981 and 0.0147 Mbbl/d in 1982, both measured in physical volumes of fuel alcohol rather than in any petroleum equivalent; so this is not a significant term. [No data are available before 1981 but the quantity is apparently negligible.] Other blending components may have mattered more: the "other liquids" input did jump up from 0.09 Mbbl/d in 1978 and 0.08 in 1979-80 to 0.49 in 1981 and 0.57 in 1982, suggesting that the change in definition was probably important.)

- Motor gasoline accounted for 45% of output volume in 1978 and 47% in 1982, but for only 32% of the decrease in output during that period. This suggests that refiners, many of whom had captive gasoline distributors, were anxious to hold onto whatever gasoline market share they could and to utilize their costly upgrading capacity as fully as they could.

- The output slate did show bigger percentage decreases for the heavy than the light side, although it's impossible to tell, without very detailed plant-by-plant and crude-by-crude analysis using proprietary data, how much this imbalance was due to relative market prices and how much to operational considerations, such as what cuts would work for each crude within the constraints of each refinery at the time. In general, refinery managers would probably try hardest to hold onto market share for their highest-value (generally lighter) products within the operating constraints imposed by their crude mix, hydrogen availability, and many other plant and market factors.

- Middles such as #2 fuel oil showed less sharp percentage drops than the heaviest products. However, this may have depended on changes in market conditions, such as the pace of roadbuilding and the #6/natural-gas price spread for industrial boiler fuel.

- The nearly flat jet-fuel output, for which product supplied fell by 0.05 Mbbl/d, shows that U.S. refiners might have slightly increased market share, but were not very successful in substituting another relatively light product for the dwindling gasoline output. The 23% drop in LPG output may show the same or may merely reflect market conditions.

- Most importantly, <bold>the ratio of drops in U.S. refineries' crude input to drops in their gasoline output was 2.97/0.83 = 3.58. The ratio of drops in crude input to drops in gasoline supplied was 2.97/0.87 = 3.41. If, hypothetically, we removed a potential distortion in these

ratios by backing out the increase in "other liquids" input by setting its 1982 value equal to its 1978 value, 0.09 Mbbl/d, and reallocated all that volumetric input to crude, then these figures would change to 2.58/(0.83 or 0.87) = 3.11 or 2.97. In any event, these ratios of around 3+ are considerably larger than my ratio of 2.16, which Charlie complained was far too high (he prefers 1.0).</bold> A 1:1 ratio would imply, for example, that the 0.83 Mbbl/d drop in U.S. refineries' gasoline output should have dropped their crude input by only 0.83 Mbbl/d, or 28% of the actual decrease.

Incidentally, there's evidently an accounting difference between the gasoline/crude yield I used, from EIA's 2000 *Petroleum Supply Annual* Table 19, cited in the annotated *Foreign Affairs* article, and the yields implied by Table 5.8. The latter shown as a time-series are:

| EIA AER 2000 Table 5.8 | |
|---|---|
| 1973 | 0.53 |
| 1974 | 0.52 |
| 1975 | 0.52 |
| 1976 | 0.51 |
| 1977 | 0.48 |
| **1978** | **0.49** |
| 1979 | 0.47 |
| 1980 | 0.48 |
| 1981 | 0.51 |
| **1982** | **0.54** |
| 1983 | 0.54 |
| 1984 | 0.54 |
| 1985 | 0.54 |
| 1986 | 0.53 |
| 1987 | 0.53 |
| 1988 | 0.53 |
| 1989-91 | 0.52 |
| 1992 | 0.53 |
| 1993 | 0.54 |
| 1994 | 0.52 |
| 1995-98 | 0.53 |
| 1999 | 0.54 |
| 2000 | 0.53 when PSA said 0.462; I haven't gone back for other years |

I haven't bothered to track down the difference in accounting basis, which may have to do with the difference between finished and unfinished motor gasoline output or with the treatment of certain inputs or of processing gain (which is shown as 5.8% in ARE and 6.1% in PSA). However, I don't think this point is important. What's interesting is the big jump in ARE-reported yield, mostly sustained thereafter, during precisely the period we're considering, 1978-82. My inference is that this was related to the increase in "other liquids input" (which by itself could account for two percentage points of the apparent 1978-82 yield increase), to a combination of market and operational conditions, and to the idling of much of the worst, most heavy-side-oriented capacity: Table 5.9 shows a bloodbath in capacity utilization, which fell 20% during that period (22% at the record low in 1981), though not in refinery capacity itself (that drop happened a bit later). These effects are nicely shown in the attached graphs. I haven't researched the exact timing, but do seem to recall that around 1980 is when much of the new hydrogenation capability was coming onstream as refiners sought to shift to the lighter side of the barrel -- just, alas, as gasoline demand was dipping (see upper graph).

Getting back, then, to Charlie's basic point, let me add a couple of concluding observations.

1. When Bobby Kennedy was asking me for the numbers he later used in his *NY Times* ANWR op-ed, I did explain repeatedly, probably in more detail than he wanted, why I was using the convention of 1/0.462 = 2.16x leverage from gasoline savings to crude-oil savings and hence to notional crude import reductions: namely, that for modest and relatively short-term changes on the margin, such as he was asking about, it's light-product demand that generally drives crude-import demand. I also consistently explained to him and his staff that one could instead use other conventions, such as 1:1, that would yield
different results. I further explained this choice in several places in the heavily annotated Web-posted version of the *Foreign Affairs* article. The original article contained an explicit footnote to the same effect, but the editor removed it, and allowed me only to make the message implicit at the bottom of p. 83, which says that 292,000 bbl/d of crude, "Once refined,...would yield 156,000" bbl/d of gasoline.

2. In accordance with RMI's usual practice, the *Foreign Affairs* paper had been extensively peer-reviewed in several drafts by experts at many levels (from operational to strategic planning to top management) in several major oil companies, as well as by other energy experts. Nobody but Charlie, before or since publication, has commented on the issue he's raised -- not even Jim Schlesinger, who actually liked the article.

3. More specifically: as far as I know, Charlie is the only person who has objected to the convention I chose whether via private communications to me, a letter to *Foreign Affairs* (the journal has reported none on any topic), or any other forum. This doesn't mean he's wrong, but if matters were so simple, one would have expected drilling proponents to have pounced on it in the hope of discrediting our *FA* article. (The only error I'm aware of so far, just spotted by Joel Swisher, is the possible implication on p. 75 that CAFE was a Carter policy; he strongly supported it and his Administration formulated its implementating regs, but in fact President Ford signed CAFE into law about a month before Carter's term began.)

4. The one, apparently reasonable, set of empirical data I've examined, shown above, doesn't support Charlie's thesis, and indeed suggests that mine might be conservative. If anyone else has contrary findings, let's see 'em.

5. The actual ratio of crude savings to gasoline savings is unknown and probably unknowable. I doubt that Fred Heutte's hope of achieving a rough consensus number, nice though that would be, is realistic: everyone I've asked in the industry about this for the past several years has thrown up his or her hands after a few minutes' thought. The ratio depends on far too many interlinked factors whose relationships are not well characterized and undoubtedly change with time. Moreover, the way refinery managers actually make their slate decisions bears little relation to the strategic interests of their parent firm or to its behavior as inferred by economists.

6. When I eventually get time to finish preparing an updated energy-security factsheet, I'll probably use several conventions so the reader can choose. I'll also try to make some reference to this issue in the [nontechnical] two-part energy-policy piece that Hunter and I have in press at *The American Prospect* (www.prospect.org) -- most likely in its Web version, where notes are permissible. But at this point I continue to believe that the way our *FA* article, and my advice to Bobby, expressed how much gasoline must be saved to reduce crude imports by a given amount is reasonable and requires no correction.

7. In the future I would hope that busy, well-intentioned, and competent friends who are all committed to rigorous analysis and to environmental protection could find better ways to resolve issues privately.

I haven't copied this to eadvocate-l@igc.topica.com because I'm not on that listserv and don't want to be, nor to Ned Ford. Whether anyone else thinks it

appropriate to circulate or post is up to them. Meanwhile, we all have a lot of good work to do.

Best wishes and Happy New Year -- Amory

**7. CK to ABL, Jan 4 2002**

Date: Fri, 04 Jan 2002 10:19:20 -0500
To: Amory B Lovins <ablovins@rmi.org>
From: Charles Komanoff <kea@igc.org>
Subject: relationship between gasoline savings and crude-oil savings
Cc: mpostman@law.pace.edu

January 4, 2002

Dear Amory --

I want to take an opportunity to discuss with you in private what we have been airing in public. Our partnership has been important, even inspirational, to me over the long period in which we have worked to transform energy policy. As well, the issue we are wrestling with, while focused on a seemingly minor point, has critical implications for the direction of the energy and transportation reform movements.

With both these considerations in mind, I ask you to take a fresh look at your position that gasoline savings "leverage" double or more crude oil savings.

In your 26-Dec-01 e-mail, you argue that, because during a chosen historical period (1978-82), crude inputs to U.S. refineries fell 3.5 times as fast as gasoline outputs, one may infer that, going forward today, a one-unit drop in gasoline usage will bring about a 3.5-fold drop in crude production.

But as you, of all people, know well, the situation in 1978-82 bears no resemblance to the hypothesized present situation in which the only exogenous change in the world is a small (2.7 mpg) boost in average U.S. automobile mileage. In contrast, 1978-82 was a time of deep economic contraction and meteoric increases in actual and anticipated prices of petroleum products. Accordingly, demand for all petroleum products, not just gasoline, plummeted, as end-users eliminated waste, invested in efficiency, switched fuels and/or did without. (Jet fuel was the lone exception, remaining constant.) Most strikingly, as electric utilities substituted coal for oil, petroleum consumption by utilities fell by more than a million barrels a day -- a decline greater in absolute terms than the drop in gasoline consumption.

In short, refiners reduced refinery runs not because crude inputs and gasoline output were locked in an immutable ratio, but because the market for all petroleum products was saturated -- a situation that is irrelevant to the argument you want to make today about the effect of marginal mpg improvements.

Furthermore, the 1978-82 data exercise in your e-mail appears to me to be a textbook case of spurious correlation: imputing a predictive relation between two factors (gasoline output and crude inputs) that are highly correlated only because they are both influenced by the same factors (petroleum prices and economic activity). And I'm equally puzzled by your assertion that the refinery industry is rife with economic illogic. I've always looked upon oil refining as a bastion of rational economic behavior. From that perspective, it seems fantastical that refiners would react to falling gasoline demand by cutting production of all petroleum products rather than varying their output mix -- as they can easily do -- to preserve sales of those products.

None of this would matter much, but for the fact that overselling the effect of mpg improvements, as I believe you are doing, falsely reassures our colleagues and the broader public that no changes are needed in key policy areas such as

fuel taxes, road pricing and land use, or in attitudes about automobility -- just crank gas mileage up a notch or two and watch the oil problem disappear.

Would that adding 2.7 mpg to U.S. automobile mileage actually would displace 2.5-2.7 million barrels a day of oil imports from the Persian Gulf, as you claimed unequivocally in your piece for www.tompaine.com in October. But as I pointed out in my initial (28-Nov) e-mail, we can't be at all confident of savings much above one million barrels a day, or around 40% of Gulf imports. That means the other 60% must come elsewhere -- from reducing vehicle miles traveled.

Denying this doesn't just obfuscate the problem; it marginalizes the full spectrum of VMT-based solutions -- everything from raising gasoline taxes, charging auto insurance by the mile, and cashing out free parking, to attacking American hyper-mobility head-on -- as I believe many Americans are now ready to do.

I understand that you may not wish to work on these approaches yourself (though, in light of your visionary work on alternatives to four-laning Colorado State Road 82, back in 1989, it would be sensational if you did). But it does no good if, in your zeal to improve automotive efficiency, you claim benefits far greater than can be reasonably supported.

Amory, for the sake of the cause you have served so well, please reconsider your position.

Sincerely,

Charlie

**8. ABL to CK Jan 4, 2002 [w some of the CK passages included in ABL's reply]**

Date: Fri, 4 Jan 2002 13:30:22 -0500
To: Charles Komanoff <kea@igc.org>
From: Amory B Lovins <ablovins@rmi.org>
Subject: Re: relationship between gasoline savings and crude-oil savings

CK: In your 26-Dec-01 e-mail, you argue that, because during a chosen historical period (1978-82), crude inputs to U.S. refineries fell 3.5 times as fast as gasoline outputs, one may infer that, going forward today, a one-unit drop in gasoline usage will bring about a 3.5-fold drop in crude production.

ABL: One could, but I don't. I think the actual ratio is unknown, unknowable, and variable with time and circumstances. I used the 2000 average yield as the most reasonable placeholder I could come up with.

CK: In short, refiners reduced refinery runs not because crude inputs and gasoline output were locked in an immutable ratio, but because the market for all petroleum products was saturated -- a situation that is irrelevant to the argument you want to make today about the effect of marginal mpg improvements.

ABL: The ratio wouldn't be expected to be immutable. The question is whether it's anywhere near unity, larger, or what in general magnitude.

ABL: I can't imagine an idealized world in which light-vehicle fuel economy improves while nothing else changes. Other things are always changing, whether related or not. Moreover, we both agree, I think, that the first-order effect will be reduce crude-oil demand to some degree, with all the consequent reequilibrations in price, demand, and supply of all the coproducts and competitors.

ABL: As the master of regression analysis untangling complexly interlinked multivariate systems, you are hereby cordially invited to undertake the kind of historic analysis that I lack the time and skill to do! That's the nearest I can

come to suggesting any conceivably tractable analytic approach to what should in principle be an empirical question.

CK: Furthermore, the 1978-82 data exercise in your e-mail appears to me to be a textbook case of spurious correlation: imputing a predictive relation between two factors (gasoline output and crude inputs) that are highly correlated only because they are both influenced by the same factors (petroleum prices and economic activity). And I'm equally puzzled by your assertion that the refinery industry is rife with economic illogic. Iíve always looked upon oil refining as a bastion of rational economic behavior. From that perspective, it seems fantastical that refiners would react to falling gasoline demand by cutting production of all petroleum products rather than varying their output mix -- as they can easily do -- to preserve sales of those products.

ABL: It's far more complex than that. But broadly, and simplifying a very complex situation, refinery managers are rewarded both for capacity utilization and for the product of volume times margin across their product slate. They behave as relatively isolated decision-makers, not integrated with any vertically owner's upstream or corporate-wide objectives. They also seldom behave in ways an outside analyst would consider economically optimal. They have personalities as well as business logics.

CK: None of this would matter much, but for the fact that overselling the effect of mpg improvements, as I believe you are doing, falsely reassures our colleagues and the broader public that no changes are needed in key policy areas such as fuel taxes, road pricing and land use, or in attitudes about automobility -- just crank gas mileage up a notch or two and watch the oil problem disappear.

ABL: That's not my belief or objective: see e.g. second half of Ch 2 of NatCap.

CK: Would that adding 2.7 mpg to U.S. automobile mileage actually would displace 2.5-2.7 million barrels a day of oil imports from the Persian Gulf, as you claimed unequivocally in your piece for www.tompaine.com in October.

ABL: Not actually our edit, and I'd hope people would look up the refs/annotations.

CK: But as I pointed out in my initial (28-Nov) e-mail, we can't be at all confident of savings much above one million barrels a day, or around 40% of Gulf imports. That means the other 60% must come elsewhere -- from reducing vehicle miles traveled.

ABL: That's one good possibility. I'm strongly in favor, for example, of not subsidizing and mandating sprawl, so we'll have far less of it, and of having full and fair competition at honest prices between all modes of physical mobility. However, I think setting 1 Mbbl/d or any other upper bound on plausible or with-confidence technical efficiency gains is highly artificial. Especially such a low one! Last I looked, US light vehicles use nearly 10 Mbbl/d of gasoline.

CK: Denying this doesn't just obfuscate the problem; it marginalizes the full spectrum of VMT-based solutions -- everything from raising gasoline taxes, charging auto insurance by the mile, and cashing out free parking, to attacking American hyper-mobility head-on -- as I believe many Americans are now ready to do.

ABL: This perception may originate from Foreign Affairs's severe cuts to that part of our article. It certainly doesn't change my long-expressed beliefs, of which Ch 2 of NatCap, though again severely truncated by my editors, remains a good terse summary.

CK: I understand that you may not wish to work on these approaches yourself (though, in light of your visionary work on alternatives to four-laning Colorado

State Road 82, back in 1989, it would be sensational if you did). But it does no good if, in your zeal to improve automotive efficiency, you claim benefits far greater than can be reasonably supported.

ABL: We continue to differ about what's reasonable. I think a unity ratio of crude to gasoline savings is unreasonably low. RMI is currently exploring ways to become much more active in integrated transport/land-use/... policy and implementation; we've tried it several times but not yet found the right person, and last night I may have met one.

CK: Amory, for the sake of the cause you have served so well, please reconsider your position.

ABL: I'm always amenable to both conversation and supporting analysis. Wanna try a regression and see if there's any way to disentangle the variables?

Cordially – ABL

**CK note to file, January 30, 2002:** And there it sits. Note that Lovins states his original claim explicitly in an article in the Feb. 11, 2002 *American Prospect*: "Just a 2.7-mpg gain in the fuel economy of this country's light-vehicle fleet could displace Persian Gulf imports entirely, and this is no pipe dream."