Would use of CO_2 for enhanced recovery of oil make up any significant fraction of tens of gigatons per year? How much CO_2 would be released in burning the additional oil produced? Does the CO_2 come back up with the oil? Then what?

Kramer mentions "improved forest management" but doesn't explain it. In the western US, politicians and others often use that phrase as code for "more logging." (They usually avoid the word "logging" in favor of "thinning," "forest health," or similar language.) A purported goal is to reduce the fuel available to forest fires. Proposals to increase CO_2 storage by reforestation and large-scale tree planting on public land are incompatible with demands for forest-fire fuel reduction. Studies by wildfire scientists and ecologists[1,2] show that such fuel reduction is generally ineffective in reducing large fires and is ecologically damaging. It is not improved management.

References

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2. T. Schoennagel et al., *Proc. Natl. Acad. Sci. USA* **114**, 4582 (2017).

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Carbon pricing needs a dividend

Media outlets have emphasized how our changing climate fuels such tragic events as the blazing Australian bushfires in 2019–20. One should also remember that policies can be enacted to address the daunting challenge of climate change. David Kramer's story "Should carbon emissions be taxed or capped and traded?" (PHYSICS TODAY, December 2019, page 28) provides a timely comparison of market-based policies aimed at reducing greenhouse gas emissions. One approach that is catching unprecedented attention among economists and members of the US Congress is a carbon fee coupled with a dividend.

I think about the economics of carbon pricing in terms of uncertainty. In physics, we are used to thinking of trade-offs in uncertainty when measuring conjugate variables such as position and momentum. Economists inevitably trade off uncertainty in price and quantity when designing carbon-pricing policies; a carbon fee addresses the former, and cap and trade the latter. The distinction may sound pedantic, but it matters when courting stakeholders.

Ensuring certainty in carbon's price is a practical political move. Although we must reduce our carbon emissions, the exact quantity of that reduction can afford some uncertainty. The benefit of fixing carbon's price is the ability to minimize economic risk,[1] a choice that businesses generally prefer. Under the carbon fee policy, a fixed fee is charged for each ton of emitted carbon dioxide and is gradually increased each year.

Kramer's story briefly mentions what might happen to the revenue generated from the carbon fee. Should it be used at the government's discretion or returned as an equal dividend to each citizen?

Incidents of resistance to carbon pricing point to the need for a dividend. Kramer cites the French yellow vest protests as an example of how a faulty policy can cause social unrest. But the crucial lesson is that any carbon-pricing policy must adequately address economic inequality. By returning a dividend equally to all taxpayers, the policy becomes overall progressive and effectively revenue neutral—a more politically viable option in line with a conservative desire for limited government.

Economists are in nearly universal agreement that carbon pricing is best accompanied by a dividend. A historic statement published in the *Wall Street Journal*[2] made the consensus explicit. Among the signatories are 27 Nobel laureates, 4 former chairs of the Federal Reserve, and more than 3500 US economists.

Beyond that remarkable level of unity among economists, more than half a dozen carbon-pricing bills were introduced in Congress last year. The one with the most congressional cosponsors, by about an order of magnitude, is the Energy Innovation and Carbon Dividend Act of 2019 (HR 763). Last October Columbia University's Center on Global Energy Policy released an assessment of HR 763 that projects emissions reductions by 2030 will "exceed the US commitments to the Paris Agreement" and that the "substantial revenue" returned as a dividend will generally benefit low- and middle-income households more than the fee hurts them.[3]

Despite growing support for the bill, I sympathize with Kramer's concern regarding "today's polarized US political climate" and the likelihood of opposition to carbon pricing. But I have found that participating in our democracy is an antidote to that pessimistic outlook. Passing national carbon-pricing legislation requires a sufficient level of political will, which we create by asking our elected representatives to support HR 763.

References

1. C. Hepburn, *Oxf. Rev. Econ. Policy* **22**, 226 (2006).
2. "Economists' statement on carbon dividends," *Wall Street Journal*, 16 January 2019.
3. N. Kaufman, J. Larsen, P. Marsters, H. Kolus, S. Mohan, *An Assessment of the Energy Innovation and Carbon Dividend Act*, Columbia University (2019).

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Time, the revelator

I am now retired, but throughout my career as a professor I consistently argued that student opinion forms collected in the last week of a course were nearly useless for the evaluation or improvement of teaching effectiveness, though the free-form comments were occasionally useful or at least amusing. I was surprised that an ideal mechanism to evaluate teaching—which I've championed for at least 25 years—was not included in Toni Feder's article "Reevaluating teacher evaluations in higher education" (PHYSICS TODAY, January 2020, page 24).

Technology has made it simple to keep track of students who took a particular class and to send them an email questionnaire about it a few years later. Did that course have a positive effect on their education—for example, on their preparedness for subsequent courses—or on their careers? Answers to questions like the following would help make that determination:

- Did you find the material taught in Physics 000 by Professor X useful in subsequent courses?
- Do you ever go back to your notes or textbook from that class to review information because it is important in another course or in your current job?
- Did the solution to a problem or exercise in Professor X's course turn out to be applicable in your current position?
- Have you applied a technique learned in Professor X's class to solve a different problem you've subsequently encountered?
- In hindsight, would you recommend that a student take Physics 000 with Professor X or with some other instructor?

Students would be unable to answer those questions in the last week of class, but years later they could make a much better and more relevant assessment. In addition, such evaluations are not needed in the short term. By the time a faculty member is coming up for tenure in their seventh year, many students will have taken their courses and graduated.

I made a similar suggestion when I was on my college's sabbatical committee. A faculty member is generally allowed to take a sabbatical after receiving tenure at seven years of service. When eligible for the next sabbatical, that faculty member should be asked what benefits from the last one were realized during the intervening years. That suggestion was received with the same lack of enthusiasm as my suggestion for evaluations of teaching effectiveness that used a longer-term student perspective.

Although a student will generally know if a professor is unprepared for class or is irresponsible in grading and returning assignments, that kind of information would probably be brought to a department chair's attention during the semester. A common saying best summarizes what is more important for faculty evaluations: "You don't get what you expect, you get what you inspect."[1]

If instructors know that their performance will be judged by the impact their course has on students' futures, the debate will change from a survey that assesses classroom experience to a focus on the true purpose of that experience.

Reference

1. See, for example, K. R. Smith, *Energy Sustain. Environ.* **11**(2), 3 (2007).

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Units, for good measure

In his editorial in the March 2020 issue of PHYSICS TODAY (page 8), Charles Day commented that Lord Rayleigh cited cubic millimeters for the volume of pipes but inches for their length. In the US, we measure gasoline consumption in miles per gallon, whereas in Europe, it is measured in liters per 100 kilometers, the inverse. The European metric unit has dimensions of area, but the US unit is 1/area. What is the meaning of that area? My hybrid car has a consumption of about 40 miles per gallon. The corresponding area—much easier in metric—is about 0.6 mm². That is the cross-sectional area of a gasoline-filled pipe that, if laid along the road, will keep my car going if I scoop up the gas. It may be 2 mm² for a gas-guzzler. I propose measuring fuel consumption in square millimeters.

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Corrections

March 2020, page 45—The equation should read as follows:

$$\underbrace{\frac{1}{v_0}\frac{\partial\eta}{\partial t}+\frac{\partial\eta}{\partial x}}_{\text{Transport}}+\underbrace{\frac{h^2}{6}\frac{\partial^3\eta}{\partial x^3}}_{\text{Dispersion}}+\underbrace{\frac{3}{2h}\eta\frac{\partial\eta}{\partial x}}_{\text{Interaction with seabed}}=0,$$

March 2020, page 46—The $L_{ij}^{(k)}$ and $L_{xy}^{(z)}$ terms should have been $\mathcal{L}_{ij}^{(k)}$ and $\mathcal{L}_{xy}^{(z)}$, respectively. PT