



DEBORAH GORDON
JESSICA T. MATHEWS

SMART TAX

PRICING OIL FOR
A SAFE CLIMATE



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ABOUT THE AUTHORS

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From 1996 to 2010, Gordon ran a successful consulting practice specializing in transportation, energy, and environmental policy. She has served on National Academy of Sciences committees and the Transportation Research Board's Energy Committee. Gordon has authored and contributed chapters to numerous books. The most recent, *Two Billion Cars* (with Daniel Sperling), provides a road map for navigating the biggest global environmental challenges of this century—cars and oil (Oxford University Press, 2009).

JESSICA T. MATHEWS is a distinguished fellow at the Carnegie Endowment for International Peace. She served as Carnegie's president for eighteen years. Before her appointment in 1997, her career included posts in both the executive and legislative branches of government, in management and research in the nonprofit arena, and in journalism and science policy.

From 1982 to 1993, she was founding vice president and director of research at the World Resources Institute, an internationally known center for policy research on environmental and natural resource management issues. She earlier served on the staff of the Energy and Environment Subcommittee of the House Committee on Interior and Insular Affairs. In both posts, and later as a columnist for the *Washington Post*, she focused on energy policy and climate change.

Mathews has published widely in newspapers and in scientific and foreign policy journals, and she has co-authored and co-edited three books. She holds a PhD in molecular biology from the California Institute of Technology and graduated magna cum laude from Radcliffe College.

ACKNOWLEDGEMENTS

From a number of public, private, and nonprofit perspectives over our careers, we have both championed a carbon tax as the most effective policy to address the increasingly urgent challenge of a warming global climate. Nonetheless, it has taken us until now to elucidate what a smart carbon tax for oil would actually look like. Our ability to do this now is derived directly from the Oil-Climate Index (OCI), a first-of-its-kind methodology and web tool that compares global oils' greenhouse gas emissions along the oil supply chain from production through consumption.

The OCI was developed and continues to be elaborated in a collaboration among researchers at the Carnegie Endowment for International Peace, led by Deborah Gordon; Stanford University; and the University of Calgary. We want to thank our partners in this work: Adam Brandt (Department of Energy Resources Engineering, Stanford University), Joule Bergerson (Schulich School of Engineering, University of Calgary), and Jonathan Koomey (Steyer-Taylor Center for Energy Policy and Finance, Stanford University). Their contributions—along with that of many of their talented graduate students—directly underpin the analysis reported here.

We are also grateful to our Carnegie colleagues David Livingston and Tom Carothers, and to David Burwell, George Frampton, Jonathan Koomey, and Adele Morris, all of

whom reviewed and helped us greatly improve earlier drafts. Any remaining flaws are, of course, our responsibility.

Carnegie's communications team has been critical to our effort at every step. Particular thanks go to Rebecca White, Jocelyn Soly, Courtney Griffith, Samuel Brase, Tara Medeiros, and Chris Dockrey. Tim Martin and Jessica Katz have been instrumental in creating an online user interface for a smart carbon tax. Florencia Franzini and Jeff Feldman offered critical assistance, bridging this report and simultaneous OCI updating. Development Seed has provided its visualization and mapping skills to incorporate the smart tax into our updated OCI web tool.

This report and the underlying research for the Oil-Climate Index on which it is based would not have been possible without the generous support of the William and Flora Hewlett Foundation, ClimateWorks Foundation, blue moon fund, Oak Foundation, and Rockefeller Family Fund. We are enormously grateful to them.

As the globe continues to warm, in truth, we are all already paying a price on carbon through a rapidly changing climate, weather extremes, rising seas, and other impacts. But this effective "tax" has only costs—no benefits. It is our hope that this report offers the United States, North America, and other nations and regions the design of a market- and innovation-friendly tool that is desperately needed if the climate commitments set in Paris (and additional measures that will have to follow) are to be met.

SUMMARY

Regulation and government funding of R&D are necessary but not sufficient to slow climate change. To transform energy use and supply across the economy, greenhouse gas (GHG) emissions will have to be priced and the power of the market brought to bear.

Oil is the most demanding fossil fuel in this regard. It is largely used for a single purpose—transportation—for which it has few substitutes. It is the most diverse of all fuels—chemically, geologically, and geographically. And it is heavily capitalized and the most traded global commodity. Each characteristic makes the design of an effective and fair tax particularly difficult.

Moreover, the United States faces a hydrocarbon landscape transformed by new, unconventional oils. The long-standing expectation of a gradual, shortage-driven shift to clean fuels has been replaced by the need for a swift transformation in the face of abundant supply. National policy making has not begun to catch up. A new *smart* tax design offers a way to do so.

FROM BLUNT TAX TO SMART TAX

- Traditional tax designs are blunt instruments that treat all oils alike and tax only consumption of end products.

- Blunt taxes leave major unconventional oil emissions untaxed, treat dirtier oils more favorably than cleaner ones, provide no incentive for technological innovation, and offer no incentive for refiners to consider climate in determining product mix.
- For the first time it is possible to quantify the amount and profile of GHG emissions from all oils throughout the supply chain using the Oil-Climate Index developed by researchers at the Carnegie Endowment for International Peace, Stanford University, and the University of Calgary, allowing replacement of blunt taxes with a smart tax design.
- A smart tax differentiates among the chemical entities called “oil,” accounts for GHG emissions along the entire oil supply chain, and includes byproducts that do not fuel transport, thereby correcting the shortcomings of a blunt tax.

MOVING AHEAD IN THE UNITED STATES

- A smart tax can be simply administered at the refinery level, allowing refiners to pass the charges up the supply chain to producers and crude transporters and down to product transporters and consumers in a mechanism comparable to net-back pricing.
- A means of applying border tax adjustments will be necessary. A range of new data must be standardized, collected, and made available, and a lead government agency made responsible for the task.
- Political barriers to enactment can be lowered by making the smart tax revenue neutral with a formula for returning revenues to the economy that is simple, transparent to the public, and equally attractive to both major political parties.

OIL: THE TOUGHEST CLIMATE CHALLENGE

AT THE PARIS CLIMATE SUMMIT IN DECEMBER 2015, 195 nations committed themselves to transform the world to a low-carbon economy through steep reductions in greenhouse gas emissions over the coming few decades.¹ Keeping the world's average warming to the goal of 2 degrees or less above pre-industrial levels will require sweeping change across rich and poor economies in a very short space of time.² The task is enormous and will entail transforming virtually all areas of energy use and supply.

Yet, in Paris, countries' pledges to reduce their emissions (the so-called intended nationally determined contributions, or INDCs³) largely ignored the world's largest single source of fossil fuel energy and second-largest source of greenhouse gas (GHG) emissions—namely, oil. The U.S. INDC, for example, mentioned oil just once—in relation to reducing methane emissions from oil and gas operations—even though oil accounted for 36 percent of U.S. energy supply in 2013.⁴ The overall agreement in Paris explicitly exempted emissions from marine and air transport—both fueled almost entirely by oil.⁵

There are several reasons why oil is such a difficult challenge in the global effort to cut GHG emissions. Foremost among them is that oil is largely used for a single purpose—transportation—and in that role it today has far fewer alternatives than do the

fuels used for heating, cooling, and generating electricity; in those cases, nuclear, wind, solar, biomass, and natural gas can all be used instead of coal. (The lack of alternative liquid fuels to oil would, of course, change if the transport sector came to rely heavily on electricity.)

Also, oil is massively capitalized and is the world's most traded commodity.⁶ The enormous sunk costs in oil production and the global web of extraction, transport, refining, and use make it hard for any single country to push this huge, integrated industry in new directions.

The price signal, important to controlling emissions from all sources of energy, is vital in the case of oil.

Finally, oil is by far the most diverse of all fuels—ranging from light mixtures of liquids and gas to solid, heavy bitumen and kerogen, differing profoundly in their chemistries and in the refined products they produce. Oils come from a wide range of regions, are buried in very different kinds of

geologic deposits, and require an array of complex technologies to extract and refine them before reaching consumers. This great diversity limits the applicability of regulatory and technological approaches to cutting emissions from oil.

Each of these characteristics makes the price signal, important to controlling emissions from all sources of energy, vital in the case of oil. Regulation and the development of new technology can be effective in the absence of a clear price signal, but both are far more effective if they work in step with market forces, rather than separate from or even against them. Government can pay for R&D, for example, pushing new technologies into the marketplace, but the flow of innovation will be stronger and faster if demand from the market makes commercial investment in new technology attractive, pulling those technologies into use.

The price signal most relevant to slowing climate change is a tax or fee that puts a price on the greenhouse gases that are emitted when fossil fuels are consumed. This is commonly known as a carbon tax even though carbon dioxide is not the only greenhouse gas involved (see box). Economists from across the ideological spectrum virtually unanimously hold the view that pricing carbon in this way is the most effective, most economically efficient, and least costly way to achieve the needed transformation. Since mid-2015, the urgent need for such pricing has been voiced by, among many others, the heads of the World Bank and the International Monetary Fund, the governor of the Bank of England, and the CEOs of six of the world's major oil companies.⁷

Defining a Carbon Tax

For simplicity and ease of recognition, we use the shorthand term “carbon tax” throughout to signify a tax on all GHG emissions. The GHGs considered here and in the Oil-Climate Index include carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O). The emission figures referenced in this report are carbon dioxide equivalent (CO₂e) emissions that are calculated using the global warming potential (GWP) with one-hundred-year warming and climate feedback. The GWP represents the combined effect of the differing times these substances remain in the atmosphere and their effectiveness in causing radiative forcing. GWPs for each greenhouse gas are CO₂ = 1, CH₄ = 34, and N₂O = 298. Other GHGs emitted through the supply chain (for example, black carbon) exist, but they can be difficult to quantify and have not been included here. Similarly, the term “carbon pricing” means pricing of all content that produces GHGs.

For more information see: Gunnar Myhre et al., “Anthropogenic and Natural Radiative Forcing,” in *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, eds. Thomas F. Stocker et al. (Cambridge, UK: Cambridge University Press, 2013), https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/drafts/WG1AR5_SOD_Ch08_All_Final.pdf. For details, see Table 8.7.

A carbon tax is best designed expressly for oil because crude oil and petroleum products are so different from other energy sources—in their chemical diversity, their long international supply chains, their processing complexities, the value that causes them to trade at an economic premium, and the lack of ready substitutes. This is not to suggest that pricing carbon in other fuels is not also called for, only that oil presents a suite of unique challenges and opportunities.

The question to which this analysis is addressed is whether a workable carbon tax or fee can be designed that will account for oil’s chemical, geologic, economic, and geopolitical features. Ultimately, of course, the challenge is a global one, but as the Paris approach wisely recognized, the steps along the path to a safe climate will be designed and introduced country by country. Accordingly, the focus here is on the United States, one of the world’s largest users, producers, and refiners of oil; the second-largest emitter of greenhouse gases; and, at least potentially, a natural leader in the effort to keep the planet’s climate within safe bounds.

OIL POLICY IN THE UNITED STATES TODAY

FOR NEARLY A HALF CENTURY, Americans have believed that affordable oil would become increasingly scarce and have worried about the degree of U.S. reliance on foreign sources of it.⁸ The call for energy independence—a feature of campaign rhetoric for decades—has not been about energy in general, but about oil. Since the Organization of the Petroleum Exporting Countries (OPEC) oil embargo of 1973, policymakers have accordingly focused on safeguarding the security of the U.S. supply, employing an array of strategies including automobile mileage standards to reduce demand and an ethanol mandate to provide a source of domestically produced supply. As environmental and climate considerations rose in importance, regulatory policies such as low-carbon fuel standards and zero-emission vehicle requirements were adopted to guide a gradual transition to clean, low-carbon, alternative fuels.

Instead of running out of oil, however, the new millennium ushered in a paradigm-shattering change. Bolstered by surging demand, high prices, and technological breakthroughs, unconventional oils began to be produced in large volumes, including oil sands, hydraulically fractured tight oils, extra-heavy oils, ultra-deep oils, ultra-light condensates, and more. Faster than anyone believed possible, the United States left behind decades of worry over its dependence on oil imports and became a major oil producer and exporter almost overnight.

The United States became a major oil producer and exporter almost overnight. Neither public understanding nor national policy has begun to catch up to this profound change.

America is now confronting explosive production of an array of plentiful, little understood, still evolving, and, in some cases, environmentally damaging new oils. Old mind-sets, backed by insufficient information and outdated rules and governance structures, are struggling to adapt to a drastically altered hydrocarbon landscape. Security of supply has given way to the impera-

tive of controlling climate change. The expectation of a gradual, shortage-driven transformation to clean fuels has been replaced by the wholly different challenge presented by the need for a swift transformation in the face of abundant supply. Neither public understanding nor national policy has begun to catch up to this profound change.

THE CLIMATE SIGNIFICANCE OF THE NEW OILS

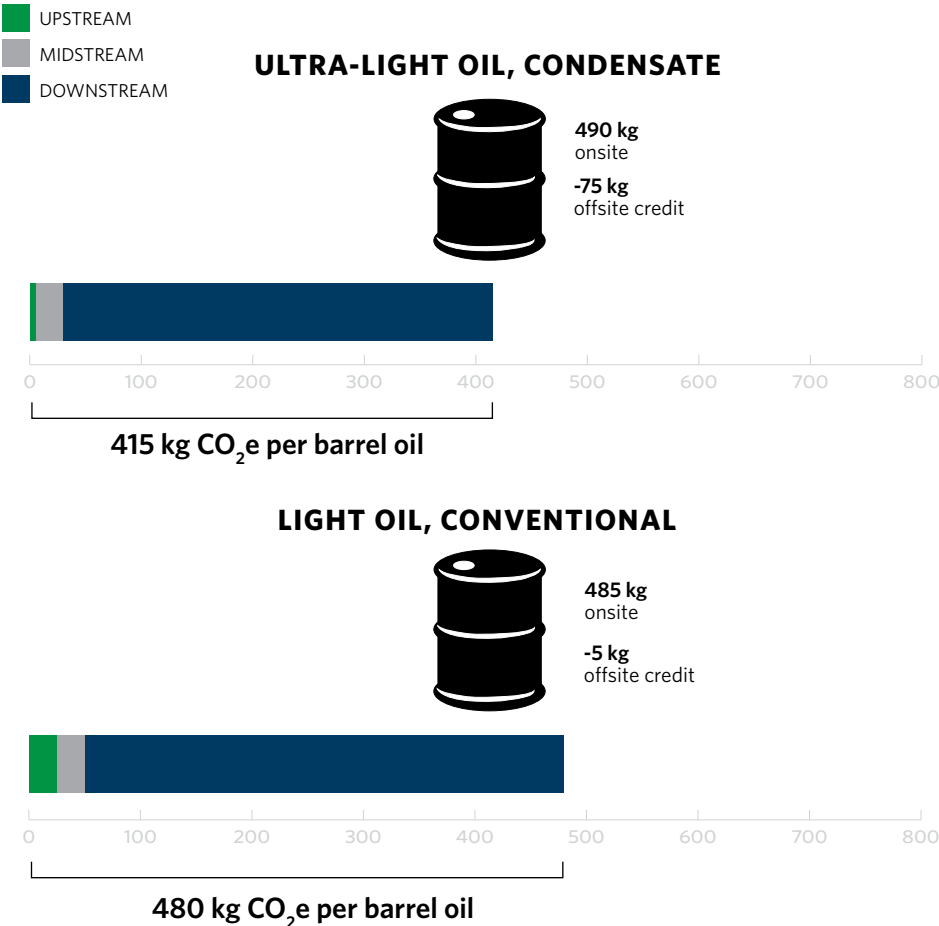
THE OIL SUPPLY CHAIN is responsible for significant GHG emissions beyond the combustion of its end-use petroleum products. Extracting, processing, refining, and transporting oil is energy-intensive; large energy inputs are needed, and energy is wasted in operations. When the differences in energy inputs and waste in the supply chain and the variability of types of oil are accounted for, oil-to-fuel pathways differ dramatically in their full GHG emission profiles.

The Oil-Climate Index (OCI)—developed by researchers from the Carnegie Endowment for International Peace, Stanford University, and the University of Calgary—is able to quantify, for the first time, the differences in both the amount and profile of GHG emissions produced throughout the supply chain.⁹ Some oils generate higher emissions in their extraction and others during refining. Still others have a more GHG-intensive slate of products. In the OCI's first sampling of oils, overall emissions vary by nearly a factor of two.

The long-standing assumptions that oil is oil and that most or all of its GHG emissions occur when its end products are burned are simply wrong, as the examples shown in figure 1 make abundantly clear. Yet, both of these assumptions have shaped the design of virtually all oil taxes proposed over the past several decades. We call these measures

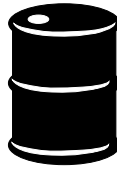
blunt taxes. They are of two types. One type treats all barrels of oil alike through a flat fee based most commonly on volume (a per barrel tax) or energy content (a BTU tax). This made sense when barrels of crude oil were very similar. It no longer makes sense when a barrel of crude could be anything from ultra-light condensate to semisolid bitumen. The other type of blunt tax addresses only the end products of oil use—most often gasoline (a gas tax). This puts the entire burden of reducing GHG emissions from oil on consumers, thereby removing any incentive for producers, refiners, and transporters to reduce their own emissions. Targeting only consumers of end products would indeed dampen oil demand, but would do so at a needlessly high cost and with many unwanted effects.

FIGURE 1
GHG EMISSION BREAKDOWNS FOR DIFFERENT OILS

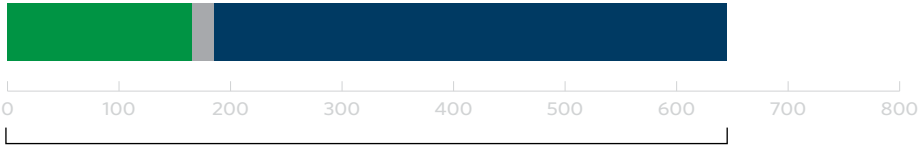


Source: Calculations from the Carnegie Endowment for International Peace, "Oil-Climate Index," <http://oci.carnegieendowment.org>.

LIGHT OIL, HIGH FLARE

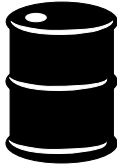


755 kg onsite
-110 kg offsite credit

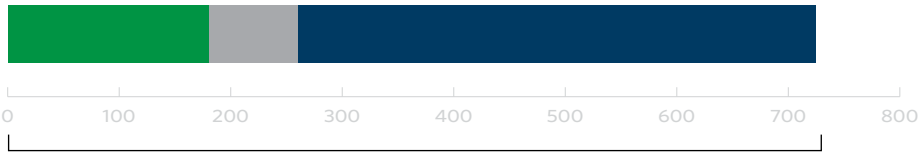


645 kg CO₂e per barrel oil

HEAVY OIL, DEPLETED



745 kg onsite
-20 kg offsite credit

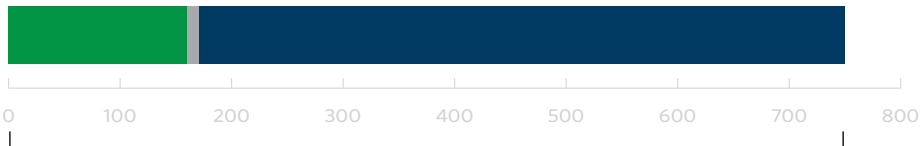


725 kg CO₂e per barrel oil

EXTRA-HEAVY OIL, UPGRADED



750 kg onsite
+5 kg offsite credit



755 kg CO₂e per barrel oil

Notes: Calculations include Phase 2 updates made to the OCI. Upstream emissions apply to oil producers and crude oil transporters; midstream emissions apply to oil refiners; and downstream emissions apply to product transporters and the end products consumers use. All emission estimates rounded to the nearest zero or five.

Many oils have significant amounts of associated natural gas trapped with them in reservoirs. If this gas is not collected and sold upstream but is instead flared or vented, GHG emissions from upstream production make up a large share of each barrel's much larger total emissions. The particular light, high-flare oil example shown in figure 1 produces 35 percent more emissions per barrel than light oil that is not flared, even though the high-flare oil generates emission credits when some of the associated gas is used for export and to produce electricity consumed in the oil's production.

Depleted oil fields have generally been producing for several decades. The oil extracted from them is often heavier, more viscous, and more water-saturated than oil from younger fields. Pressure at the wellhead is often diminished in a depleted field, hampering its flow. Depleted oils therefore often require large energy inputs to produce steam, which reduces the oil's viscosity to help force it out of the ground, and to run pumps to induce its flow and remove entrained water. The carbon-heavy, depleted oil requires the production and addition of hydrogen to convert the carbon contained in heavier oils into valuable petroleum products, which increases the emission intensity of midstream refining.

The most emissions-intensive oil depicted in the figure, an extra-heavy oil, requires a physical and chemical transformation to make it flow more like a conventional crude and convert it into petroleum products. Different pathways for such conversion are

currently in use and under development. For example, upgrading is an energy-intensive upstream process that removes the oil's excess carbon to produce a synthetic crude oil along with the byproduct, petroleum coke (or petcoke, a solid fuel that is high in sulfur and other contaminants and used for power generation). When petcoke is combusted, its climate and air-quality

impacts can be even greater than coal's. Another such process involves diluting the extra-heavy oil with lighter hydrocarbons to make the oil flow to a refinery where hydrogen is added and excess carbon is removed.

Depending on future oil demand, these already large differences among oil types could widen substantially as advances in technology create ways to extract and transform new sources of hydrocarbons. Climate policies must be designed to accommodate these differences in oil resources and engineering processes with their attendant variance in GHG emissions.

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A SMART TAX VERSUS BLUNT ONES

BECAUSE OF THESE LARGE DIFFERENCES in the quantity and sources of emissions in the supply chain, a *smart* tax on oil must have the following three characteristics:

- It must differentiate among the very different chemical entities that today all go by the name “a barrel of oil.”
- It must account for GHG emissions along the entire oil supply chain: production, refining, transport, and end product use.
- It must include the emissions from oil byproducts that do not fuel the transport sector, the most important of which is the bottom-of-the-barrel material known as petcoke (which is sold, exported, and burned, but is classified and is often used as a solid fuel to blend with or displace coal).

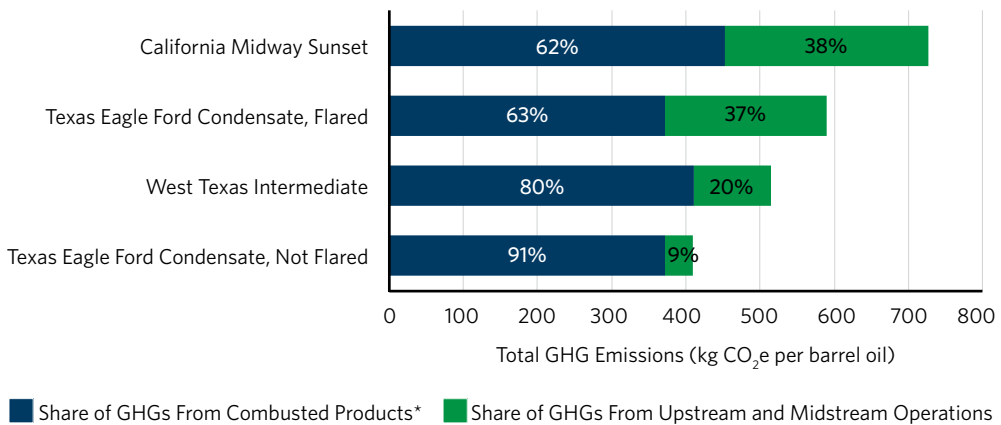
Blunt taxes and a smart tax differ dramatically in economic efficiency, equity, and effectiveness in curbing GHG emissions. Specifically:

A BLUNT TAX LEAVES MAJOR EMISSIONS UNTAXED

Figure 2 reveals the dimensions of this shortcoming. The OCI results of four U.S. oils (including both flaring and no-flaring scenarios in Texas’s Eagle Ford condensate

formation) are used as proxies to illustrate the range of possibilities. A blunt tax applied to only combusted end products leaves 9–38 percent of emissions untaxed. In the case of Midway Sunset—a depleted, heavy oil from California—over one-half of the emissions are untaxed if petcoke is not counted.

FIGURE 2
EMISSION TOTAL AND SHARE FOR SAMPLE U.S. OIL SUPPLY CHAINS



Source: Authors' calculations based on the OCI. See <http://oci.carnegieendowment.org>.

Note: *Doesn't include product transport emissions

As a thought experiment, if the nearly 5 billion barrels of crude oil and condensates produced in the United States in 2015 were allocated in equal shares to the four cases in figure 2, an estimated 730 million metric tons (MMT) of carbon dioxide equivalent emissions would go untaxed annually under a blunt tax applied only to end products. This is not a minor omission: it represents an estimated one-third of currently reported emissions from the U.S. oil sector.¹⁰

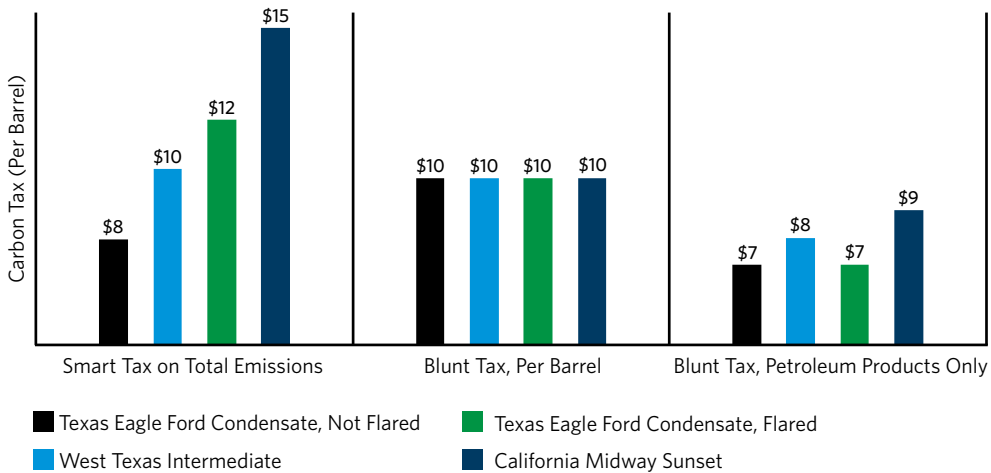
BLUNT TAXES SEND A PERVERSE MARKET SIGNAL

If all oils were treated the same way, or if the tax were assessed only on end products, then the most polluting—in the climate sense—oils would receive the most favorable tax treatment because more of their emissions would go untaxed. Figure 3 illustrates

how a flat tax and a tax on only end products consumers use send a distorted market signal for lower- versus higher-emitting oils. At a carbon price of \$20 per metric ton of carbon dioxide equivalent emissions, a smart tax would assess \$8 on a barrel of Eagle Ford ultra-light condensate, not flared—less than the other sample oils. A blunt, per barrel tax would charge Eagle Ford \$2 a barrel more—higher relative to other sample oils. Oils with even larger total climate footprints, including extra-heavy oils, oil sands, and other future oils, would introduce even greater market distortion.¹¹

Rather than encourage the production of dirtier oils, a tax designed to slow climate change should indicate to the market that the GHG emissions of these oils must be reduced, bringing them into line with other oils. Or it should send a clear sign that these oil types should be developed last, if at all—hence discouraged rather than favored.

FIGURE 3
SMART TAX VERSUS BLUNT TAX DESIGNS



Source: Authors' calculations based on the OCI. See <http://oci.carnegieendowment.org>.

Note: Tax estimates based on \$20 per metric ton of GHGs and rounded to the nearest dollar. This rate can be easily adjusted. It was selected for comparison because it equalizes a smart tax and per barrel tax on West Texas Intermediate oil.

A BLUNT TAX CREATES NO INCENTIVE FOR TECHNOLOGICAL INNOVATION IN THE SUPPLY CHAIN—ANOTHER PERVERSE EFFECT

Oil production and refining are highly competitive activities, often operating with small profit margins. A small change in price can make a big difference in operations. Innovation and greater efficiencies are always being sought in this constantly evolving industry.

A tax should encourage and reward technological advances that reduce GHG emissions. An example would be the incentive to develop cost-effective processes for collecting and using any associated gas that is now flared. Figure 2 shows that, if only end product combustion is taxed, flaring its associated natural gas *improves* the Eagle Ford condensate's competitive position compared to safely managing its associated gas by leaving 37 percent of total emissions untaxed rather than 9 percent.

Other examples of innovations for dealing with depleted and extra-heavy oils are illustrated in the Oil-Climate Index. For example, the same California Midway Sunset oil illustrated in figure 2 requires process heat to generate the steam needed for its production. The necessary energy could come from a fossil fuel, or it could be generated from concentrated solar energy. A blunt oil tax would penalize that step forward. Discouraging innovation in this way is, of course, the very last thing a climate control policy should do.

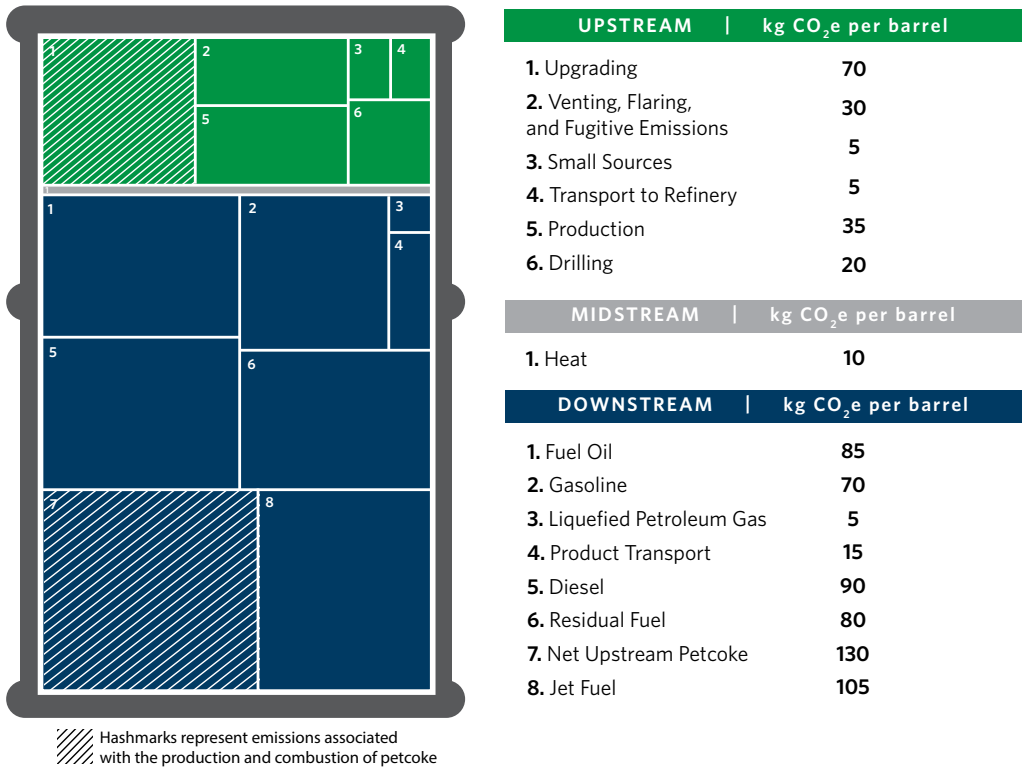
A BLUNT TAX CREATES NO INCENTIVE FOR CHANGES IN THE PRODUCT SLATE

Important petroleum products—including petcoke, residual fuel oils, petrochemical feedstocks, and asphalt—fall outside the traditional boundaries for liquid transport fuels. But the emissions from their use are equally relevant to what matters: the amount of GHGs in the atmosphere.

Petcoke is the most important of these ancillary petroleum products. If this very high carbon, solid, oil byproduct were not included, approximately 25 percent of total emissions from extra-heavy oils would go untaxed, as highlighted in figure 4.

A smart carbon tax on oil must give refiners reasons to consider climate in determining their product mix. A smart tax creates the necessary incentives; a blunt tax does not.

FIGURE 4
EMISSIONS FROM EXTRA-HEAVY OIL
(PETCOKE EMISSIONS HIGHLIGHTED)



Source: Calculations from the Carnegie Endowment for International Peace, “Oil-Climate Index,” <http://oci.carnegieendowment.org>.

Note: Calculations include Phase 2 updates made to the OCI.

A BLUNT TAX IMPOSED ONLY ON END PRODUCTS REQUIRES A HIGHER TAX RATE THAN A SMART TAX FOR COMPARABLE EMISSION REDUCTIONS

Because oil demand is relatively inelastic, with few ready substitutes, a blunt tax that charges only end product consumers would likely necessitate a much higher tax rate in order to achieve a given level of emission reduction. Moreover, assessing the tax on all stakeholders in the supply chain—producers, transporters, refiners, and consumers—greatly expands the opportunities for cost-effective emission reductions.

ADMINISTERING A SMART TAX

HOW, IN PRACTICAL TERMS, COULD A SMART TAX, levied throughout the whole supply chain, be collected? Would it require millions of collection points? In fact, there is an elegantly simple way to manage such a tax. It could be levied on the very small number of refiners, allowing them to pass the charges up the supply chain to producers and crude transporters, and down the chain to product transporters and consumers. There were just 137 refineries, run by 59 corporate entities, in the United States processing 18 million barrels of oil a day as of January 2015. Just seventeen of these companies accounted for 85 percent of all refining capacity.¹²

Refiners know oil. In order to process crude into products, they need to accurately characterize it, both chemically and physically. And because they can procure crude oils from a wide array of producers, refiners have leverage over those from whom they choose to buy. The price they charge is based on the crude's quality and its transport costs (known as netback pricing).

This amounts to the same variable pricing mechanism that would be applied through a smart tax. Refiners can include in netback pricing the upstream carbon tax—the amount determined by the GHG emissions of upstream operations including, for example, the flaring and venting of associated gas. Imported oil can be managed through the same mechanism. Foreign producers would either have to provide the information

needed for U.S. refiners to determine the amount of the upstream tax or refiners would take their business elsewhere. Refiners would be directly responsible for the portion of GHG emissions they generate in their operations. Finally, they would pass down to consumers that portion of the tax attributed to combusting each end product.

**The administrative burdens
of a smart carbon tax would
pale in comparison to many
other common taxes.**

By contrast, a tax assessed on producers at the wellhead (point of extraction) could involve more than 1.5 million unique assessment points in the United States alone, and would have no plausible advantages over a tax assessed on the small number of refiners.¹³ Moreover, it would have to cover

in some way the nearly 8 million barrels a day of imported crude, which would involve multiple foreign taxpayers, many of whom are not prepared to adopt a carbon tax.¹⁴

Assessing the full tax on producers is far less feasible than placing it on U.S. refiners. To do so, assumptions will have to be made with regard to the refinery in which the oil is destined to be processed, the particular refining units through which it will be passed, and the final slate of products that will be produced. In cases where certain oils have consistently been sent to a single, easily characterized refinery, reasonable life-cycle emission extrapolations can be made at the point of extraction. But in most cases, these assumptions are likely to be rough and inaccurate. A tax is then vulnerable to exploitation and arbitrage by those who understand how to use such assumptions to their advantage, to the ultimate detriment of the policy's intended purpose.

In any case, the administrative burdens of a smart carbon tax would pale in comparison to many other common taxes. The U.S. corporate income tax, for example, in addition to taxing an economic "good" (corporate income) rather than a "bad" (pollution), also suffers from administrative complexity. In 2010, there were more than 1.8 million corporations collectively accountable for \$191 billion in corporate income taxes. A carbon tax, regardless of its incidence point, could bring in a sizeable portion of this sum via dramatically fewer taxpayers.¹⁵

INTERNATIONAL CONSIDERATIONS

CRUDE OIL AND PETROLEUM PRODUCTS are highly mobile commodities. Crude produced in one country can be transported to other countries to be refined, with those products transported again, over long distances, to be consumed in many other countries. Thus, until or unless a uniform price on carbon is adopted worldwide, countries that choose to use the market will also have to consider the use of border tax adjustments in order to avoid a loss of competitiveness if oil production and/or manufacturing enterprises move to countries that do not charge a carbon tax. These adjustments at the border are also needed to prevent some emissions from escaping taxation entirely.

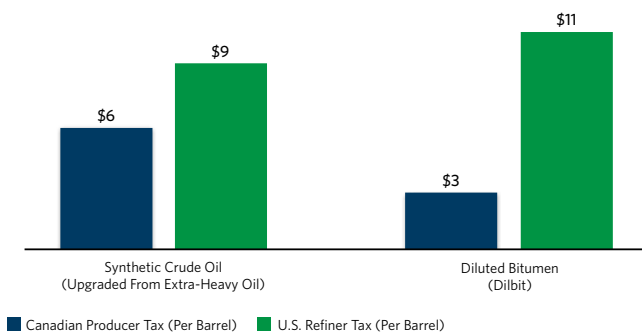
When it comes to meeting the emission reduction pledges made at the Paris summit, a country's responsibility to cut GHGs will depend on where along the supply chain it takes control of crude oil or petroleum products. In the parsing of oil sector GHGs, multiple INDCs could be involved depending on the country in which an oil and its products are produced, refined, and consumed. As countries report on their current INDCs and revise future INDCs, they will want to think strategically about what types of domestic and foreign oil resources they choose to utilize and how they account for their particular GHG emission responsibilities.

The case of Canadian oil sands exported to a U.S. refinery offers an example of the implications of this approach to allocation. There are many pathways to convert these

bituminous resources into usable products, and more are under development. Depending on the method chosen, Canada’s obligation could change dramatically, as illustrated in figure 5. In the case where the United States has a carbon tax that properly accounts for all emissions and Canada does not, different oil sands pathways are materially different in financial terms. If Canada opted to upgrade its oil sands, stripping off the excess carbon in Alberta, it would then ship synthetic crude oil to the United States and would retain possession of the petcoke byproduct. In this case, Canadian producers would pay a carbon tax of \$6 per barrel, and U.S. refiners would pay \$9 per barrel, a \$3 difference. However, if Canadian producers shipped diluted bitumen (dilbit) to U.S. refineries—which then converted the bitumen and produced the petcoke—Canada’s carbon tax responsibility would be substantially reduced in absolute terms and shifted to the United States, whereby Canadian producers would pay \$3 per barrel and U.S. refiners would pay \$11 per barrel, an \$8 difference. Thus, the gap in the taxes assigned to the two countries differs significantly for the same oil resource depending on where in the supply chain emissions occur. Countries, therefore, will have to be mindful of the sources of emissions in order to accurately parse their climate responsibilities.

Of course, if Canada (or any other nation) also enacted a smart carbon tax, it could readily impose the tax on its portion of emissions, avoiding the need for border tax adjustments entirely.

FIGURE 5
U.S. VERSUS CANADIAN CLIMATE EMISSION RESPONSIBILITIES,
SAMPLE ALLOCATIONS



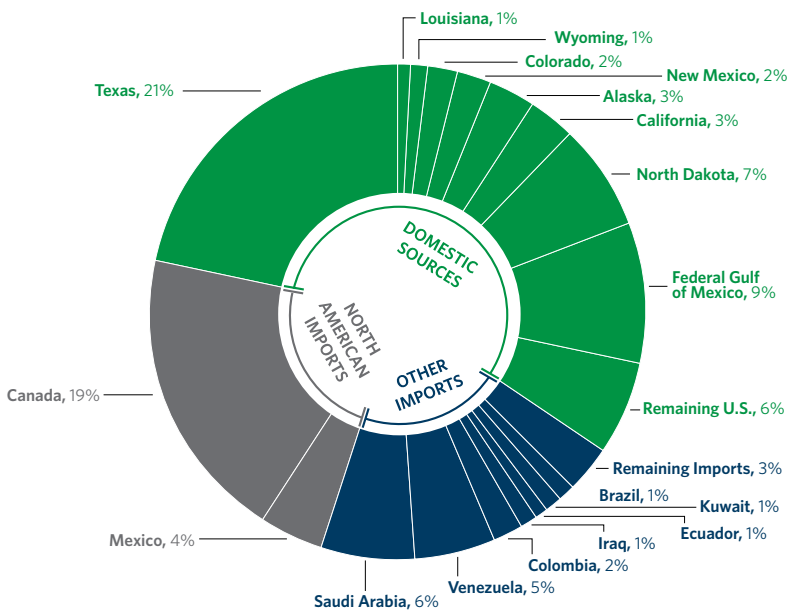
Source: Calculations from the Carnegie Endowment for International Peace, “Oil-Climate Index,” <http://oci.carnegieendowment.org>.

Notes: Tax estimates based on \$20 per metric ton of GHGs and rounded to the nearest dollar. Because a barrel of dilbit and a barrel of synthetic crude oil are fundamentally different oils, the tax in each case, while close, is not identical. A standard barrel of synthetic crude oil is not equivalent to a barrel of diluted bitumen, which is a blend of approximately 75 percent bitumen combined with 25 percent diluent (for instance, condensates). Refiner tax accounts for total refining GHGs, product transport GHGs, and GHGs from combusting the end products that consumers use. The figure assumes that all petroleum coke produced from upgrading and/or refining oil sands is ultimately burned and not permanently sequestered or reused in noncombustive use.

The United States’ oil imports are currently considerably simpler than one might expect. In 2015, 56 percent of U.S. crude supplies through the third quarter were produced domestically, as shown in figure 6. An additional nearly 4 million barrels a day came from within North America—three-quarters from Canada and the rest from Mexico. Thus, at present, approximately 80 percent of the U.S. oil supply comes from the North American continent.

While some of this concentration may be the result of various U.S. crude trade restrictions that were lifted at the end of 2015, it nonetheless highlights the enormous opportunity that could be seized by harmonizing the energy-climate policies of the three North American neighbors. It also underscores that the United States need not assemble data on every oil in the world when developing a smart tax. Essentially all of the remaining 20 percent of oil currently imported into the United States comes from only seven nations outside North America. Thus, the starting point for assembling data needed to underpin a smart carbon tax for oil in the United States is eminently manageable.

FIGURE 6
SOURCES OF U.S. CRUDE OIL, 2015

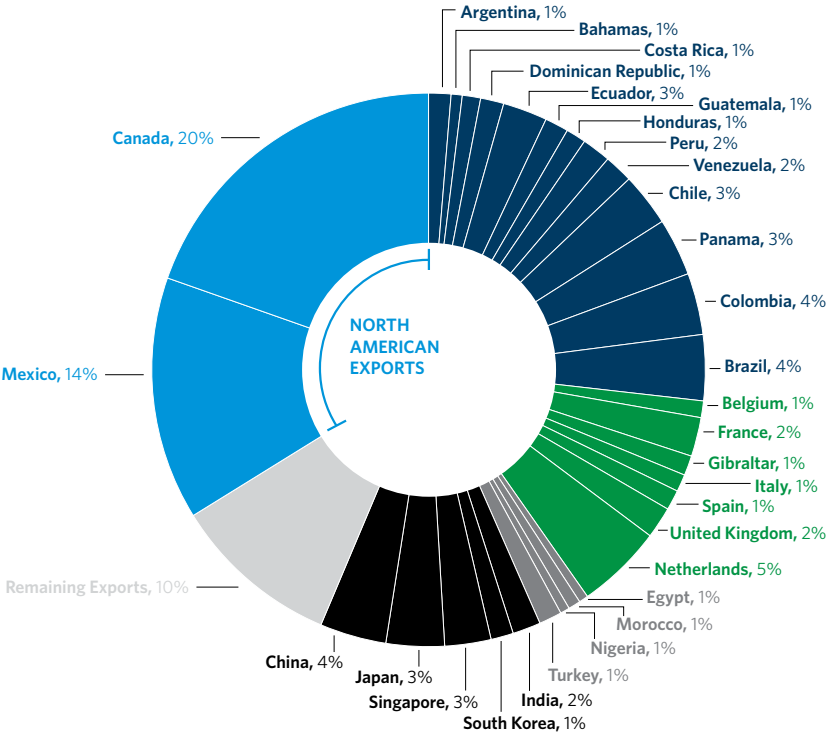


Sources: U.S. Energy Information Administration, “Crude Oil Production,” last modified April 4, 2016, https://www.eia.gov/dnav/pet/pet_crd_crpdcn_adc_mbbldpd_a.htm; and U.S. Energy Information Administration, “U.S. Imports by Country of Origin,” last modified April 4, 2016, https://www.eia.gov/dnav/pet/pet_move_impcus_a2_nus_epc0_im0_mbbldpd_m.htm.

Note: Due to rounding, the shares noted do not add up to 100 percent.

While over one-third of U.S. petroleum products are currently sold to Canada and Mexico, the remaining share of exports has a far wider geographic reach than U.S. crude oil imports, as shown in figure 7. Again the fact that the United States exports significant volumes of petroleum products to at least 30 other countries is an artifact of a historical asymmetry between the treatment of U.S. crude oil and petroleum product exports that has since been equalized. The climate footprints of these products vary widely, with the largest being for petcoke and residual fuel oil. As of the end of 2015, petroleum products accounted for nearly all of the 5 million barrels per day of U.S. oil exports (only an average of 500,000 barrels a day of crude was exported in 2015 under certain exemptions allowed under the crude export ban). The majority of U.S. petroleum product exports were diesel fuel (27 percent), natural gas liquid feedstocks (23 percent), petroleum coke (12 percent), and residual fuel oil (6 percent).

FIGURE 7
DESTINATIONS OF U.S. CRUDE AND PETROLEUM PRODUCTS, 2015



Source: U.S. Energy Information Administration, "Exports by Destination," last modified April 4, 2016, http://www.eia.gov/dnav/pet/pet_move_expc_a_EPCO_EEX_mbbldpd_m.htm.

Note: Due to rounding, the shares noted do not add up to 100 percent.

When it comes to implementing a smart carbon tax for oil, policy must account for this highly globalized market, including the future evolution of trade flows of crude oil and petroleum products.

Experts disagree over how effectively the United States or any other country could

act either unilaterally, in a “club” of countries representing a critical mass of global trade or global gross domestic product,¹⁶ or only through an internationally negotiated arrangement. The disagreement stems from varying expectations of how countries would respond to others’ border tax adjustments, including the likelihood of a trade war in the World Trade Organization (WTO) and beyond.

Border adjustments could give firms rebates for exports of petroleum products in the amount of emissions that had been taxed but not yet realized through combustion. Or, border adjustments could impose tariffs on imported oil or petroleum products to account for the embodied emissions that go untaxed abroad.

Legal scholars and some WTO officials believe that a carbon tax accompanied by a border adjustment could be designed to be compliant with WTO rules, analogous to WTO-permissible value-added tax border adjustments.¹⁷ The most significant challenge will likely relate to proving that various crude oils (and/or different petroleum products produced from different feedstocks and processes) are not “like” products under WTO law.¹⁸ A sound scientific and regulatory basis to establish that different oils are materially different under the standards of trade law will require a more comprehensive and more transparent collection of global data covering the entire oil supply chain.

There are huge opportunities from harmonizing U.S., Canadian and Mexican energy-climate policies.

ACCESSIBLE DATA—A REQUIREMENT

WITH OR WITHOUT A CARBON PRICE, the successful reduction of GHG emissions absolutely depends on accurate and transparent monitoring, reporting, and verification of national and sectoral emissions. This is true for all fossil fuels. Oil poses a particularly stiff challenge, however, since emissions vary so widely by oil type, by reservoir, by process, by company, and by country. These differences will likely increase over time due to technological improvements, operational decisions, demand shifts, and new resources entering the marketplace, underscoring the need for a durable protocol for routinely reassessing emissions.

An essential element of a smart tax, therefore, is standardized, open-source, and regularly updated data. Oil is a massive global enterprise that is highly dynamic and requires an enormous amount of information to function. At present, however, too few of these data are publicly available in verifiable and consistent form. Oil databases are sold as commercial products, but the price tag is extremely high, the data may not be independently verifiable, and the metrics needed to calculate climate impacts are often not included.

In the United States, the Environmental Protection Agency (EPA) is responsible for assembling a GHG emission inventory through the Greenhouse Gas Reporting Program established in 2010.¹⁹ However, this database has significant shortcomings.

The reporting program provides facility-level data for large sources of direct emissions, which only counts about one-half of all U.S. emissions. There is some degree of standardization, but reporting is voluntary and different formats are allowed.

Oil and gas operations are combined into a single sector in the database, which can make it difficult to parse oil sector emissions, and can introduce potentially large errors. For example, the EPA estimates that upstream oil production emissions in the Bakken formation account for over 8 MMT of carbon dioxide equivalent emissions.²⁰ The more detailed OCI estimates, however, calculate upstream emissions to be 25 MMT from Bakken production—a threefold difference. This high degree of undercounting is also evident in California production. These discrepancies raise concerns about GHG inventories in the refining sector as well.

These current limitations highlight the need for a new, public data repository. It will need to include, on a regularly updated basis,

- oil field data (well depths, steam-to-oil and water-to-oil ratios, flaring and venting rates, fugitive emissions, enhanced recovery techniques used, current production rates, and technically recoverable reserve bases);
- oil data (updated assays using standardized temperature cuts);
- refinery data (process energy requirements and equipment updates); and
- oil market data (origins, destinations, volumes, and modes for crude and petroleum product transport along with oil sector economic market pricing), especially for bottom-of-the-barrel residual fuels that are high in GHG emissions.

Some of this information is already available and published in academic journals, in industry publications, and on companies' websites. Oil resource characteristics are not trade secrets; they are typically advertised when marketing crudes worldwide. Oil field details are the subject of ongoing study in academia and oil consulting practices, and they are often openly published. Engineering equipment and process specifications, however, are often developed at the company level and may cross the line into the realm of valuable trade secrets.

On balance, the oil industry stands to benefit from making basic oil field data available because it must innovate to survive. Hydraulic fracturing and horizontal drilling that can access tight oil deposits in shale came about because government, academic, and industry research was conducted on data made available on tight reservoirs, which led to eventual breakthroughs. Conversely, the lack of consistent, verifiable data creates blind spots for industry. And, the more open-source the data from industry, the greater the pressure will be on nationalized oil companies to provide similar transparency.

There is currently no clear assignment of responsibility for data collection in the United States government. The EPA maintains a national GHG inventory, but these data have the limitations discussed above. The Energy Information Administration (EIA) in the Department of Energy analyzes data that industry provides, but there are strict limitations imposed on its ability to add new reporting requirements. The Department of Energy does not have standardized mechanisms to monitor the various processes in the domestic oil supply chain, although several of its national laboratories analyze new oil pathways and their GHG impacts. The same is true of the Department of State when it comes to the international oil supply chain, although its Bureau of Energy Resources may have the most up-to-date information on oil operations of other nations that supply the United States.

The U.S. Geological Survey produces data on oil field resource volumes and other characteristics that, if standardized, could provide valuable inputs for estimating oil-climate impacts. If a carbon tax were established, the Department of the Treasury would also be involved.

The maze of overlapping but incomplete data-collection roles has to be sorted out so that no key responsibilities fall through the cracks.

Clearly, this maze of overlapping but incomplete roles has to be sorted out so that no key responsibilities fall through the cracks. Designating a lead agency or entity for data collection and management is a top priority for successful climate control in the United States. The EIA may be the most suitable agency to take on this lead role. Once the large number of oils in current production is cataloged, it will be a matter of routinely updating these data. Then, as new oil prospects go through the permitting process under the National Environmental Policy Act, oil data will be routinely collected as a part of environmental impact reporting at the outset.

Responsibility must also be assigned for accounting for vented and flared emissions associated with oil operations. The information on these wasteful operations can be collected through satellite-based remote sensing. The National Oceanic and Atmospheric Administration (NOAA) currently operates the Visible Infrared Imaging Radiometer Suite (VIIRS) satellite,²¹ which, in addition to its primary role in weather detection, is also able to systematically detect flaring based on radiant output measurements.²² A satellite operated by the European Space Agency—the Scanning Imaging Absorption Spectrometer for Atmospheric Chartography—is equipped to collect methane venting data.²³ These and other instruments put into service in the future will be able to accurately track and calibrate remotely collected data worldwide if adequate funding is consistently provided.²⁴

Finally, it will be vital to track and account for bottom-of-the-barrel residual byproducts used outside the transport sector. These include petcoke, heavy fuel oils, and other climate-intensive residuals. U.S. exports of these byproducts to China, India, Japan, and other Asian markets have been increasing in recent years as the United States refines more extra-heavy oils.²⁵ China is just beginning to track petcoke imports and combustion in order to reduce its severe air pollution.²⁶ These emissions must be accurately reflected in national oil sector emission inventories. As the International Energy Agency has noted, the use of coke in blast furnaces or other industrial uses can lead to confusion, omission, or double counting of coke emissions in both energy and industrial processes.²⁷ But with the potential for petcoke production to rise as heavier oils are brought to market, it will be critical to address this issue head-on.

THE WAY FORWARD

It is by no means assured that the United States will be able to fulfill its pledge to cut GHG emissions by 26–28 percent below 2005 levels in just nine years. Legal challenges to measures that have been counted on for needed cuts pose a substantial uncertainty. Low oil prices encourage consumption, making the task even harder. The absence of a national consensus that rapidly changing climate caused by human actions is a threat that must be met is a continuing bar to success. And this challenge is just the beginning. Even *complete* fulfillment of the Paris pledges by *all* countries would not be enough to safeguard the climate.²⁸ Transformative as they are, the pledges that have been made are only a first step.

Notwithstanding the size of the cuts in emissions that will be needed, the measures the United States has taken to date, as well as those that are planned, are notably incomplete. They have relied on only two of the three types of policy levers to steer change: regulation and funding of R&D on new energy technologies. Arguably the most direct and most powerful of the three—price—has so far not been put to work at the national level. And with regard to oil—accounting for 36 percent of U.S. energy use—efforts have narrowly focused on reducing demand, putting most of the burden on motorists through the Corporate Average Fuel Economy (CAFE) mileage standards.

CAFE has been a striking success and can achieve more, but it is particularly vulnerable to price swings in the oil market. In 2015, with oil prices having fallen dramatically, American buyers chose low-mileage pickup trucks, heavy sport utility vehicles, and crossover models for more than half (57 percent) of their new purchases.²⁹ Those deci-

sions have long tails: the record-setting 17.5 million new vehicles sold in the United States in that year will be in service for well over a decade.

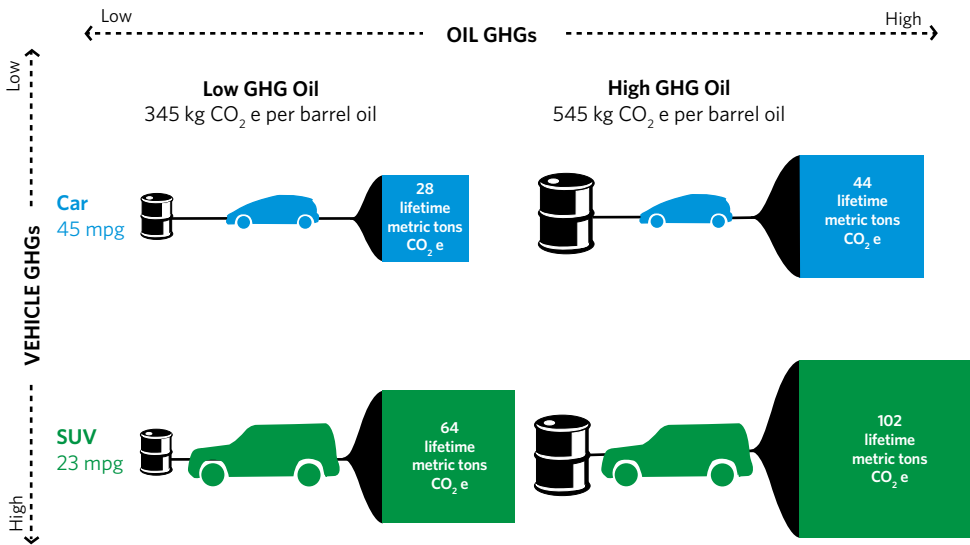
To make the cuts in emissions that are needed now, the United States—and the rest of the world—must address oil supply as well as use. Policies must be able to direct production to those resources with the lightest climate footprint and to stimulate innovation

throughout oil's supply chain. Only a smart tax provides the means to do so. Success requires harnessing the power of the marketplace. Trying to transform both supply and demand broadly across the whole economy without putting a realistic cost on GHG emissions' contribution to climate change is to work with not one arm, but several limbs, tied behind the nation's back.

In addition to its direct effects on emissions, a price on GHGs will send a vital signal, erasing, as nothing else can, the lingering uncertainty that holds back commercial investments and consumer choices of low-GHG, high-efficiency energy. A smart tax, in particular, will also act as a force multiplier of regulatory and R&D measures already in place. As figure 8 illustrates, a smart tax coupled with CAFE standards that result in low-GHG oils used in low-GHG cars leads to a fourfold reduction in emissions, doubling the impact of the standards alone. But climate progress will backslide with a blunt tax that does not distinguish among oils and that results in high-GHG oils being used to fuel inefficient sport utility vehicles.

A price on GHGs will send a vital signal, erasing, as nothing else can, the lingering uncertainty that holds back commercial investments and consumer choices of low-GHG, high-efficiency energy.

FIGURE 8
EMISSIONS RESULTING FROM COMBINING A
SMART TAX WITH REGULATIONS



Source: Authors' calculations based on the OCI. See <http://oci.carnegieendowment.org>.

Notes: The figure assumes that low-GHG oil is light conventional and high-GHG oil is extra-heavy; oil emissions are composed of each oil's total upstream and midstream emissions along with downstream emissions from only gasoline and residual fuels produced. The vehicles modeled are a Honda Civic Hybrid (car) and a Jeep Cherokee 4WD (SUV), with fuel economy ratings from the U.S. Department of Energy, "Fuel Economy," last modified April 7, 2016, <http://www.fueleconomy.gov/>; lifetime miles driven are cited in National Center for Statistics and Analysis, *Vehicle Survivability and Travel Mileage Schedules* (Washington, DC: National Highway Traffic Safety Administration, January 2006), <http://www-nrd.nhtsa.dot.gov/Pubs/809952.pdf>.

Notwithstanding these large returns, adopting a carbon tax on oil—like any tax—will be a heavy political lift. To make it feasible, the tax must be a smart one, able to produce the greatest returns in emission cuts with the greatest efficiency and at the least cost. It will require that new oil data reporting requirements be established so that all emissions can be fairly taxed and so that the climate impacts of prospective resources can be modeled through an open-source tool like the OCI before investment decisions are made.

Political, as well as economic, considerations argue strongly that the tax or fee be revenue neutral: that is, that all of its revenues are immediately and directly returned to the economy. Revenue neutrality has two great advantages. It minimizes the impacts of the tax beyond the targets at which it is aimed. And, it will greatly ease the path to enactment. Once opened to the political process, the lure of the tens of billions in potential revenue from a carbon tax will set off an unending contest for shares of its proceeds. There are any number of deserving purposes to which these could be put. Each of them has fierce proponents, many with large sums to spend on lobbying for their desired outcome. Only the discipline of a fixed boundary can avoid sinking the measure in a sea of competing priorities.

While revenue neutrality avoids one set of political battles, a closely related one remains in the matter of how the revenues are returned to the economy and to whom. There are an almost infinite number of possibilities. In our view, whatever formula is adopted must meet two criteria: it must be simple and transparent to the American public, and it must be equally attractive to both political parties. This standard would be met, for example, by allocating the revenues to just two purposes—cutting the corporate income tax to stimulate economic growth, and preventing any worsening of economic inequality by reimbursing poor and middle-income families for the added cost of their oil.

The massive shifts that must take place to meet the Paris pledges and eventually to decarbonize the U.S. economy simply cannot happen without the guiding signal of prices that reflect the true costs of hydrocarbon combustion. Only a steady price signal can cause all actors—energy producers, refiners, manufacturers, scientists, entrepreneurs, policymakers, and consumers—to face in the same direction, planning for the same future.

Because of the growing chemical and geological diversity of the new oils, the lack of alternative liquid fuels for transportation, and the size and global scope of oil production and trade, a tax is most needed in the oil sector. Blunt taxes, however, will miss as much as half of many oils' emissions and will steer the market toward dirtier (in climate terms) resources and processes over cleaner ones. Nor can such measures stimulate the needed innovations along the supply chain. Making the tax a smart one will make a huge difference to the health of the U.S. economy as well as to the success of the climate control effort.

NOTES

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- 9 The results from an initial sample of oils from around the world can be viewed using the OCI web tool, available at <http://oci.carnegieendowment.org/>. OCI Phase 1 modeled 30 global oils (5 percent of current production); Phase 2 will model 75 global oils (estimated at 25 percent of current production).
- 10 This calculation does not include the 3.4 million barrels a day of natural gas liquids (NGLs) that are produced in the United States and refined along with crude oil to make petroleum products. Including NGLs would increase the share of untaxed emissions. For oil volume baseline data, see: U.S. Energy Information Administration, “Petroleum & Other Liquids: Supply and Disposition,” accessed February 29, 2016, https://www.eia.gov/dnav/pet/pet_sum_snd_d_nus_mbbldpd_m_cur.htm. Estimates of GHG emissions from the petroleum sector, which are not transparently reported, are partially accounted for in tables 3-1 and 3-5 by U.S. Environmental Protection Agency, “Energy,” in *Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2014* (Washington, DC: U.S. Environmental Protection Agency, 2016), <https://www3.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2016-Chapter-3-Energy.pdf>.
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