Changing Oils, Changing Management

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Peak oil is a myth. Oil-bearing resources are plentiful—and diverse. True, supplies of conventionally produced lighter and sweeter crude oils are dwindling. But technological advances such as hydraulic fracturing, thermal recovery, in situ extraction methods, and more, are turning unconventional hydrocarbon deposits, such as tight oil, extraheavy oils, and oil sands, into viable resources, whereas complex refining techniques are converting even semisolid and -gaseous oils into petroleum products. The capacity to access trillions of barrels of increasingly heterogeneous oil in place will only grow over time. This new oil reality must be factored into appropriate climate mitigation goals.

There is far too little information regarding new oils and how they differ from yesterday's oil—and from one another. The Carnegie Endowment for International Peace collaborated with researchers at Stanford University and the University of Calgary to develop the Oil-Climate Index (OCI) . . . that compares global oils' total barrel forward GHG emissions. The OCI can identify where in the oil supply chain each oil's main climate challenges lie.

Outdated and incomplete figures are being used to assess the greenhouse gas (GHG) emissions associated with the global oil sector. The GHG intensity that is most commonly cited dates back to a 2008 Department of Energy (National Energy Technology Laboratory; NETL) study estimating the life cycle emissions for an average barrel of crude oil consumed in the United States in 2005.[1] But a lot has changed in the oil sector over the past decade. The main purpose of the NETL study was to compare gasoline and diesel to alternative transport fuels, not to assess the GHG emissions in a full barrel of oil. Therefore, emissions are calculated per megajoule of gasoline, not per barrel of oil. It turns out that the NETL method undercounts total GHG emissions from a "barrel forward," including emissions from upstream production, midstream refining, and downstream end use of *all* petroleum products. Moreover, total barrel-forward emissions vary significantly from oil to oil.

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Comparing Oils' Greenhouse Gas Emissions

The Carnegie Endowment for International Peace collaborated with researchers at Stanford University and the University of Calgary to develop the Oil-Climate Index (OCI), a first-of-its-kind, open-source Web tool that compares global oils' total barrel-forward GHG emissions.[2] The OCI is comprised of three underlying fully transparent models: Oil Production Greenhouse Gas Emissions Estimator; Petroleum Refinery Life Cycle Inventory Model; and Oil Products Emissions Module that estimates petroleum product transport and end use. These life cycle oil models, when taken together, offer a new, finer-grained perspective for those involved in the industrial ecology of oil.

The OCI estimates total GHG emissions that differ significantly from oil to oil—and this life cycle assessment tool identifies differences that are large enough to matter. A small sample of 30 global oils run through the OCI found an 80% difference in GHG emissions between the lowest-emitting oil and the highest. This large emissions variance in less than 5% of current global oil production raises questions of whether there are oils in current production or slated for future production that are outside this range. In the next phase due out in mid-2016, 75 global oils—approximately 25% of current global production—will be run through the OCI.

In addition to comparing oils' total GHG emissions, the OCI can identify where in the oil supply chain each oil's main climate challenges lie. The first phase of the OCI identified a range of oil-climate challenges whose result depends on the resource base and the processes employed, including: extraheavy oils and oil sands whose extraction and upgrading are energy intensive and whose complex refining either requires significant hydrogen addition or results in high-carbon residual by-products such as petroleum coke; light oils whose associated gas is wasted when methane is leaked, vented, or combusted through a flare; and depleted, often watery and heavy, oils that take energy-intensive enhanced oil recovery methods to extract and process. Each of these climate concerns calls for different oil solutions.

Innovating Oil Solutions

Significant technological and economic opportunities exist to reduce GHG emissions in the oil supply chain. For extra-heavy oils and oil sands, this entails better management of the excess embedded carbon. Conventional techniques either reject excess carbon or add hydrogen to convert it to additional petroleum products. New pathways are under development. Research on underground conversion using microbes and other techniques are one option[3]; hydrogen produced using renewable feedstocks and electricity is another (Gandia et al. 2013; Rausch et al. 2014). And, it may be necessary to develop alternative uses or permanent storage systems for petroleum coke (or petcoke), an unwanted by-product that rivals coal in its GHG emissions.

For light gassy oils, innovative techniques are needed to handle the associated natural gas, collecting, using, and selling the methane and natural gas liquids that are co-produced with each barrel of oil. Improved governance oversight can be guided by Norway, which has worked to effectively eliminate venting and flaring since the 1970s—first with a mandate to responsibly use or sell all extracted resources and later with an offshore carbon tax. The flaring challenges of today, in Russia, Nigeria, and North Dakota's Bakken, must be tackled with similar political tenacity.

As oil fields deplete, their mature resources become harder to extract and process, as a result of declining reservoir pressure, lower gravity (higher oil density), and higher water-to-oil ratios. Extracting and processing oil under these conditions requires significant energy inputs that, in many cases, can be reduced with cogeneration, concentrated solar heat systems, or other renewable technologies.

Although they have yet to be run through the OCI, prospective oils—including kerogen oil shales, oil sands buried in carbonate rock, gas-to-liquids and coal-to-liquids technologies, and oils buried beneath Arctic permafrost or in other carbon-sequestering ecosystems—have highly uncertain GHG emission footprints. It will take greater data transparency to analyze, using the OCI, unconventional oils that are slated for expanded development in the future.

Providing Greater Data Transparency

We can endeavor to manage what we know; but it is more difficult to manage the unknown. There is far too little information regarding new oils and how they differ from yesterday's oil—and from one another. Oils are sourced from different regions, buried in different geological formations, have varying physical and chemical properties, and require a new array of complex technologies to access and transform them for the market.

This growing diversity in the oil supply chain requires informed decision making underpinned by a high degree of public data transparency that heretofore has not existed in the oil industry. Measurements are inconsistent. Data uncertainty is high. Too few records are disclosed. Companies often require their express permission to use online information. Government databases lag and are incomplete. And more often than not, up-to-date, high-quality databases are the property of private consultancies and are extremely costly or not for sale.

To fully account for oil sector emissions, policy makers need to institute a new public oil data repository that addresses inconsistencies, inaccuracies, uncertainty, and the lack of data transparency. At a minimum, this resource would include:

- Oil-field data (well depths, steam-to-oil and water-to-oil ratios, flaring and venting rates, fugitive emissions, recovery techniques used, technically recoverable reserve bases, and current production rates);
- Oil data (updated assays using standardized temperature cuts);
- Refinery data (process energy requirements and equipment updates); and
- Oil marketing data (origins and destinations for crude and petroleum products, and oil sector economic indicators).

Oil data disclosure must be the new normal, especially given twenty-first century oil sector dynamics. For decades there has been a push for oils to compete more openly in the global marketplace. Robert Mabro wrote that it is a "fallacy to believe that withholding information . . . improves [market] position. Transparency pays much higher dividends" (Mabro 1998). This transparency will count even more in designing climate policies based on the data in question.

Managing the Full Oil Barrel

To many stakeholders, oil is synonymous with transport. For this reason, the oil sector's climate management has historically centered on vehicle fuel-efficiency regulations. But oil's climate responsibility extends far beyond the gasoline and diesel consumed in cars and trucks.

The OCI is informative in this regard. The model shows that, depending on the particular oil and refinery configuration selected, a wide range of petroleum products—25% to 80% of the total oil barrel—end up being consumed in motor vehicles (Gordon et al. 2015). On average, the OCI estimates that approximately one half of today's oil is easily processed into fuels for road transport.[4] The other half, however, is used for jet fuel, heating fuel oil, marine bunker fuel, petroleum coke to generate electricity, and light ends for petrochemicals, propane, and refinery fuel gas.

Sector by sector, progress is being made mitigating climate impacts in transport, electricity, industry, and buildings. But the new oil reality presents problems for maintaining global

GHG concentrations at safe levels. Oil will be hard to beat in the transport sector; the energy density of petroleum is ideal for mobile applications, whereas the light ends are today's petrochemical building blocks. Focusing on vehicle efficiency, biofuels, electric vehicles, and green chemistry,[5] though important, is not sufficient.

Supply-side oil management is also critical and should not be overlooked. A new global open-source oil data strategy is needed to further investigate the sector's dynamics—technical, environmental, economic, and geopolitical. Expanding the OCI and using it to compare more oils will help identify different oils' climate challenges, develop more effective governance structures, inform low-carbon energy investments, and spur oil-sector innovations. Such deeper analysis illustrates the value of a more comprehensive life cycle *sustainability* assessment (Guinée 2016).

The durable, yet evolving, oil sector calls for an updated, more comprehensive life cycle perspective. This hallmark of industrial ecology, which carefully accounts for total emissions and other trade-offs in different barrels of oil, will be increasingly critical to guide decision making in oil production, refining, and end use in a warming world.

Notes

1. See NETL study, 26 November 2008: www.netl.doe.gov/File%20Library/Research/Energy%20Analysis/Publications/DOE-NETL-2009-1346-LCAPetr-BasedFuels-Nov08.pdf
2. For the Web tool and the report on OCI Phase 1 that accompanies it, see http://oci.carnegieendowment.org/
3. For a comprehensive report on reducing the environmental impact of Canada's oil sands, see www.scienceadvice.ca/uploads/eng/assessmentspublicationsnewsreleases/oilsands/oilsandsfullreporten.pdf
4. Calculated using OCI spreadsheet; see http://carnegieendowment.org/2015/03/11/know-your-oil-creating-global-oil-climate-index
5. See www2.epa.gov/greenchemistry/basics-green-chemistry

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