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How Much Will Tar Sands Oil Add to Global Warming?

To constrain climate change, such unconventional oil use needs to be stopped, according to scientists

January 23, 2013 | By David Biello |

James Hansen has been publicly speaking about climate change since 1988. The NASA climatologist testified to Congress that year and he's been testifying ever since to crowds large and small, most recently to a small gathering of religious leaders outside the White House last week. The grandfatherly scientist has the long face of a man used to seeing bad news in the numbers and speaks with the thick, even cadence of the northern Midwest, where he grew up, a trait that also helps ensure that his sometimes convoluted science gets across.

This cautious man has also been arrested multiple times.

His acts of civil disobedience started in 2009, and he was first arrested in 2011 for protesting the development of Canada's tar sands and, especially, the Keystone XL pipeline proposal that would serve to open the spigot for such oil even wider. "To avoid passing tipping points, such as initiation of the collapse of the West Antarctic Ice Sheet, we need to limit the climate forcing severely. It's still possible to do that, if we phase down carbon emissions rapidly, but that means moving expeditiously to clean energies of the future," he explains. "Moving to tar sands, one of the dirtiest, most carbon-intensive fuels on the planet, is a step in exactly the opposite direction, indicating either that governments don't understand the situation or that they just don't give a damn."

He adds: "People who care should draw the line."

Hansen is not alone in caring. In addition to a groundswell of opposition to the 2,700-kilometer-long Keystone pipeline, 17 of his fellow climate scientists joined him in signing a letter urging Pres. Barack Obama to reject the project last week. Simply put, building the pipeline—and enabling more tar sands production—runs "counter to both national and planetary interests," the researchers wrote. "The year of review that you asked for on the project made it clear exactly how pressing the climate issue really is." Obama seemed to agree in his second inaugural address this week, noting "we will respond to the threat of climate change, knowing that the failure to do so would betray our children and future generations."

At the same time, the U.S. imports nearly nine million barrels of oil per day and burns nearly a billion metric tons of coal annually. China's coal burning is even larger and continues to grow by leaps and bounds. Partially as a result, global emissions of greenhouse gases continue to grow by leaps and bounds too—and China is one alternative customer eager for the oil from Canada's tar sands. Neither



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developed nor developing nations will break the fossil-fuel addiction overnight, and there are still more than a billion people who would benefit from more fossil-fuel burning to help lift them out of energy poverty. The question lurking behind the fight in North America over Keystone, the tar sands and climate change generally is: How much of the planet's remaining fossil fuels can we burn?

The trillion-tonne question

To begin to estimate how much fossil fuels can be burned, one has to begin with a guess about how sensitive the global climate really is to additional carbon dioxide. If you think the climate is vulnerable to even small changes in concentrations of greenhouse gases—as Hansen and others do—then we have already gone too far. Global concentrations of greenhouse gases in the atmosphere have reached 394 parts per million, up from 280 ppm before the Industrial Revolution and the highest levels seen in at least 800,000 years. Hansen's math suggests 350 ppm would be a safer level, given that with less than a degree Celsius of warming from present greenhouse gas concentrations, the world is already losing ice at an alarming rate, among other faster-than-expected climate changes.

International governments have determined that 450 ppm is a number more to their liking, which, it is argued, will keep the globe's average temperatures from warming more than 2 degrees C. Regardless, the world is presently on track to achieve concentrations well above that number. Scientists since chemist Svante Arrhenius of Sweden in 1896 have noted that reaching concentrations of roughly 560 ppm would likely result in a world with average temperatures roughly 3 degrees C warmer—and subsequent estimates continue to bear his laborious, hand-written calculations out. Of course, rolling back greenhouse gas concentrations to Hansen's preferred 350 ppm—or any other number for that matter—is a profoundly unnatural idea. Stasis is not often found in the natural world.

Concentrations of greenhouse gases in the atmosphere may not be the best metric for combating climate change anyway. "What matters is our total emission rate," notes climate modeler Ken Caldeira of the Carnegie Institution for Science Department of Global Ecology at Stanford University, another signee of the anti-Keystone letter. "From the perspective of the climate system, a CO₂ molecule is a CO₂ molecule and it doesn't matter if it came from coal versus natural gas."

Physicist Myles Allen of the University of Oxford in England and colleagues estimated that the world could afford to put one trillion metric tons of carbon into the atmosphere by 2050 to have any chance of restraining global warming below 2 degrees C. To date, fossil fuel burning, deforestation and other actions have put nearly 570 billion metric tons of carbon in the atmosphere—and Allen estimates the trillionth metric ton of carbon will be emitted around the summer of 2041 at present rates. "Tons of carbon is fundamental," adds Hansen, who has argued that burning all available fossil fuels would result in global warming of more than 10 degrees C. "It does not matter much how fast you burn it."

Alberta's oil sands represent a significant tonnage of carbon. With today's technology there are roughly 170 billion barrels of oil to be recovered in the tar sands, and an additional 1.63 trillion barrels worth underground if every last bit of bitumen could be separated from sand. "The amount of CO₂ locked up in Alberta tar sands is enormous," notes mechanical engineer John Abraham of the University of Saint Thomas in Minnesota, another signer of the Keystone protest letter from scientists. "If we burn all the tar sand oil, the temperature rise, just from burning that tar sand, will be half of what we've already seen"—an estimated additional nearly 0.4 degree C from Alberta alone.

As it stands, the oil sands industry has greenhouse gas emissions greater than New Zealand and Kenya—combined. If all the bitumen in those sands could be burned, another 240 billion metric tons of carbon would be added to the atmosphere and, even if just the oil sands recoverable with today's technology get burned, 22 billion metric tons of carbon would reach the sky. And reserves usually expand over time as technology develops, otherwise the world would have run out of recoverable oil long ago.

The greenhouse gas emissions of mining and upgrading tar sands is roughly 79 kilograms per barrel of oil presently, whereas melting out the bitumen in place requires burning a lot of natural gas—boosting emissions to more than 116 kilograms per barrel, according to oil industry consultants IHS Cambridge Energy Research Associates. All told, producing and processing tar sands oil results in roughly 14 percent more greenhouse gas emissions than the average oil used in the U.S. And greenhouse gas emissions per barrel have stopped improving and started increasing slightly, thanks to increasing development of greenhouse gas-intensive melting-in-place projects. "Emissions have doubled since 1990 and will double again by 2020," says Jennifer Grant, director of oil sands research at environmental group Pembina Institute in Canada.

Just one mine expansion, Shell's Jackpine mine, currently under consideration for the Albian mega-mine site, would increase greenhouse

gas emissions by 1.18 million metric tons per year. "If Keystone is approved then we're locking in a several more decades of dependence on fossil fuels," says climate modeler Daniel Harvey of the University of Toronto. "That means higher CO₂ emissions, higher concentrations [in the atmosphere] and greater warming that our children and grandchildren have to deal with."

And then there's all the carbon that has to come out of the bitumen to turn it into a usable crude oil.

Hidden carbon

In the U.S. State Department's review of the potential environmental impacts of the Keystone project, consultants EnSys Energy suggested that building the pipeline would not have "any significant impact" on greenhouse gas emissions, largely because Canada's tar sands would likely be developed anyway. But the Keystone pipeline represents the ability to carry away an additional 830,000 barrels per day—and the Albertan tar sands are already bumping up against constraints in the ability to move their product. That has led some to begin shipping the oil by train, truck and barge—further increasing the greenhouse gas emissions—and there is a proposal to build a new rail line, capable of carrying five million barrels of oil per year from Fort McMurray to Alaska's Valdez oil terminal.

Then there's the carbon hidden in the bitumen itself. Either near oil sands mines in the mini-refineries known as upgraders or farther south after the bitumen has reached Midwestern or Gulf Coast refineries, its long, tarry hydrocarbon chains are cracked into the shorter, lighter hydrocarbons used as gasoline, diesel and jet fuel. The residue of this process is a nearly pure black carbon known as petroleum (pet) coke that, if it builds up, has to be blasted loose, as if mining for coal in industrial equipment. The coke is, in fact, a kind of coal and is often burned in the dirtiest fossil fuel's stead. Canadian tar sands upgraders produce roughly 10 million metric tons of the stuff annually, whereas U.S. refineries pump out more than 61 million metric tons per year.

Pet coke is possibly the dirtiest fossil fuel available, emitting at least 30 percent more CO₂ per ton than an equivalent amount of the lowest quality mined coals. According to multiple reports from independent analysts, the production (and eventual burning) of such petroleum coke is not included in industry estimates of tar sands greenhouse gas emissions because it is a co-product. Even without it, the Congressional Research Service estimates that tar sands oil results in at least 14 percent more greenhouse gas emissions than do more conventional crude oils.

Although tar sands may be among the least climate-friendly oil produced at present—edging out alternatives such as fracking for oil trapped in shale deposits in North Dakota and flaring the gas—the industry has made attempts to reduce greenhouse gas pollution, unlike other oil-producing regions. For example, there are alternatives to cracking bitumen and making pet coke, albeit more expensive ones, such as adding hydrogen to the cracked bitumen, a process that leaves little carbon behind, employed by Shell, among others.

More recently, Shell has begun adding carbon-capture-and-storage (CCS) technology to capture the emissions from a few of its own upgraders, a project known as Quest. The program, when completed in 2015, will aim to capture and store one million metric tons of CO₂ per year, or a little more than a third of the CO₂ emissions of Shell's operation at that site. And tar sands producers do face a price on carbon—\$15 per metric ton by Alberta provincial regulation—for any emissions above a goal of reducing by 12 percent the total amount of greenhouse gas emitted per total number of barrels produced.

The funds collected—some \$312 million to date—are then used to invest in clean technology, but more than 75 percent of the projects are focused on reducing emissions from oil sands, unconventional oils and other fossil fuels. And to drive more companies to implement CCS in the oil sands would require a carbon price of \$100 per metric ton or more. "We don't have a price on carbon in the province that is compelling companies to pursue CCS," Pembina's Grant argues.

In fact, Alberta's carbon price may be little more than political cover. "It gives us some ammunition when people attack us for our carbon footprint, if nothing else," former Alberta Energy Minister Ron Liepert told *Scientific American* in September 2011. Adds Beverly Yee, assistant deputy minister at Alberta's Environment and Sustainable Resource Development agency, more recently, "Greenhouse gases? We don't see that as a regional issue." From the individual driver in the U.S. to oil sands workers and on up to the highest echelons of government in North America, everyone dodges responsibility.

Price of carbon

A true price on carbon, one that incorporates all the damages that could be inflicted by catastrophic climate change, is exactly what Hansen believes is needed to ensure that more fossil fuels, like the tar sands, stay buried. In his preferred scheme, a price on carbon that

slowly ratcheted up would be collected either where the fossil fuel comes out of the ground or enters a given country, such as at a port. But instead of that tax filling government coffers, the collected revenue should be rebated in full to all legal residents in equal amounts—an approach he calls fee and dividend. "Not one penny to reducing the national debt or off-setting some other tax," the government scientist argues. "Those are euphemisms for giving the money to government, allowing them to spend more."

Such a carbon tax would make fossil fuels more expensive than alternatives, whether renewable resources such as wind and sun or low-carbon nuclear power. As a result, these latter technologies might begin to displace things like coal-burning power plants or halt major investments in oil infrastructure like the Keystone XL pipeline.

As it stands, producing 1.8 million barrels per day of tar sands oil resulted in the emissions of some 47.1 million metric tons of CO₂-equivalent in 2011, up nearly 2 percent from the year before and still growing, according to the Canadian Association of Petroleum Producers. In the same year coal-fired power plants in the U.S. emitted more than two billion metric tons of CO₂-equivalent. "If you think that using other petroleum sources is much better [than tar sands], then you're delusional," says chemical engineer Murray Gray, scientific director of the Center for Oil Sands Innovation at the University of Alberta.

In other words, tar sands are just a part of the fossil-fuel addiction—but still an important part. Projects either approved or under construction would expand tar sands production to over five million barrels per day by 2030. "Any expansion of an energy system that relies on the atmosphere to be its waste dump is bad news, whereas expansion of safe, affordable and environmentally acceptable energy technologies is good news," Carnegie's Caldeira says.

There's a lot of bad news these days then, from fracking shale for gas and oil in the U.S. to new coal mines in China. Oxford's Allen calculates that the world needs to begin reducing emissions by roughly 2.5 percent per year, starting now, in order to hit the trillion metric ton target by 2050. Instead emissions hit a new record this past year, increasing 3 percent to 34.7 billion metric tons of CO₂ and other greenhouse gases.

Stopping even more bad news is why Hansen expects to be arrested again, whether at a protest against mountaintop removal mining for coal in West Virginia or a sit-in outside the White House to convince the Obama administration to say no to Keystone XL and any expansion of the tar sands industry. The Obama administration has already approved the southern half of the pipeline proposal—and if the northern link is approved, a decision expected after March of this year, environmental group Oil Change International estimates that tar sands refined on the Gulf Coast would produce 16.6 million metric tons of CO₂ annually just from the petroleum coke, which would be enough to fuel five coal-fired power plants for a year. All told, the increased tar sands production as a result of opening Keystone would be equal to opening six new coal-fired power plants, according to Pembina Institute calculations.

Even as increased oil production in the U.S. diminishes the demand for tar sands-derived fuel domestically, if Keystone reaches the Gulf Coast, that oil will still be refined and exported. At the same time, Obama pledged to respond to climate change and argued for U.S. leadership in the transition to "sustainable energy sources" during his second inaugural address; approving Keystone might lead in the opposite direction.

For the tar sands "the climate forcing per unit energy is higher than most fossil fuels," argues Hansen, who believes he is fighting for the global climate his five grandchildren will endure—or enjoy. After all, none of his grandchildren have lived through a month with colder than average daily temperatures. There has not been one in the U.S. since February 1985, before even Hansen started testifying on global warming. As he says: "Going after tar sands—incredibly dirty, destroying the local environment for a very carbon-intensive fuel—is the sign of a terribly crazed addict."

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