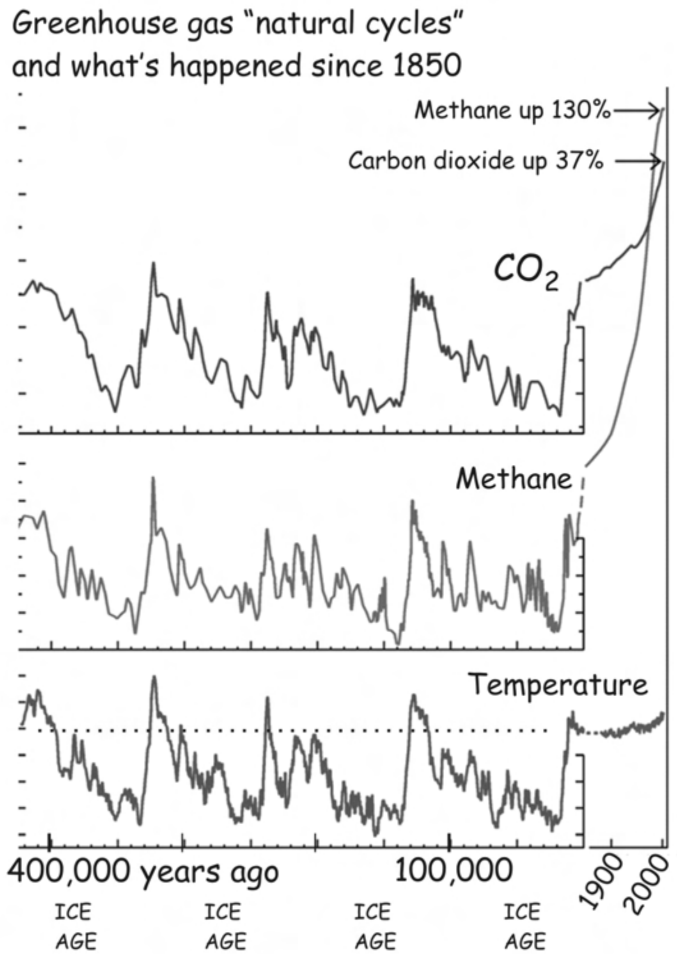


When snow turns into ice, bubbles of air are trapped. Ice cores into the depths of Antarctica can sample 800,000 years of air, and thus determine how much CO_2 and methane there was in the air. Because air mixes in only a few years, these are worldwide averages. (The temperature is that of the air in Antarctica when the snow fell; global mean temperature has different peaks.)

12

Methane Is the Double Threat

> The [permafrost methane problem] does not have only a scientific character: it has passed to the plane of world politics. If mankind does not want to face serious social and economic losses from global warming, it is necessary to take urgent measures. Obviously we have less and less time to act.
>
> —botanist Sergei Kirpotin, 2005

"It's all just some natural cycle." It might have been true, but it isn't. Contrary to what you might have heard, the present trends in heat-trapping gases are not just part of some natural cycle. They are evidence of our fossil-fuel fiasco.

There are now ice-core records from Antarctica going back 800,000 years for the major heat-trapping gases, allowing us to see their range of natural variation. For the last four ice ages, temperature has closely tracked methane (CH_4 is "natural gas") and CO_2 levels in the air.

To put the trends since 1850 in perspective, the scale is expanded at right. The two major heat-trapping gases have now gone far off scale. Temperature is beginning to follow (it would be much higher except for bright pollution from sulfur and ash masking a third of the expected rise in temperature).

Natural gas is mostly methane. It plays two roles in global fever. In its role as a fossil fuel that is burned, it produces the usual CO_2 as a by-product. But if the methane is not burned and leaks into the atmosphere, methane is 23 to 70 times more potent as a heat-trapping gas than CO_2.

There is naturally some methane in the air—indeed, methane vented from below the Temple of Apollo is probably the source of the trance and delirium of the Oracle at Delphi—but (see page 150) its concentration has risen about 130 percent over preindustrial levels, compared to 37 percent for CO_2. This is about a hundred times faster than anything observed in natural processes so far.

The alarm about methane came more recently than for CO_2, with Jim Hansen and Sherry Rowland warning of its increase in the early 1980s. Some climate scientists now worry that methane could become an even bigger actor on the global fever stage than CO_2 presently is.

> {The] Mississippi was the only river in the world that had 'mud lumps.' [They] could rise suddenly enough to lift a ship as it passed. [They were] masses of tough clay, varying in size from mere protuberances looking like logs sticking out of the water to islands several acres in extent, [sometimes] three to ten feet [high]. Salt springs are found upon them, which emit inflammable gas.
>
> —historian John M. Barry, 1997

Once upon a time, methane (CH_4) mostly came from rotting vegetation in swamps ("swamp gas") and that buried under river deltas. Now we have anthropogenic methane as well: not just all that extra soil carried by the rivers from poor agricultural practices but methane from garbage dumps, rice paddies, cows that belch, pipelines that leak, and gas furnaces that emit some unburned methane every time they cycle on and off. (So do kitchen ranges and furnaces. That characteristic smell on startup is unburned natural gas.)

Over half of the gas given off by landfills is methane. At modern landfills, it may be captured and used for power generation. Thanks to the EU's Landfill Directive, much of the biodegradable waste stream that used to go to European landfills is being redirected to anaerobic digestion plants that deal with methane more efficiently. But in most of the world, landfills are releasing a lot of methane.

And then there is ancient methane. As with CO_2, you can always distinguish ancient from modern methane by a version of radiocarbon dating. Methane occurs in association with coal and oil. It is what causes anoxia and explosions in coal mines. That's why canaries were watched to make sure they hadn't fallen off their perch. Mine methane is generally vented to the atmosphere. There are

still oil fields in the world which vent methane. More commonly, it is captured or burned off atop tall towers.

For the U.S. in 1996, about 1.4 percent of natural gas production was leaked, two-thirds of that from the pipes and compressors. No one knows how much the customers leak after the meter and the study excluded what is released during oil drilling and the like.

Most natural gas from the wellhead has substantial amounts of CO_2 mixed in. This has to be separated from the methane before use—and, of course, it is typically vented to the atmosphere. Norway and Algeria have pilot projects that pipe this CO_2 back underground.

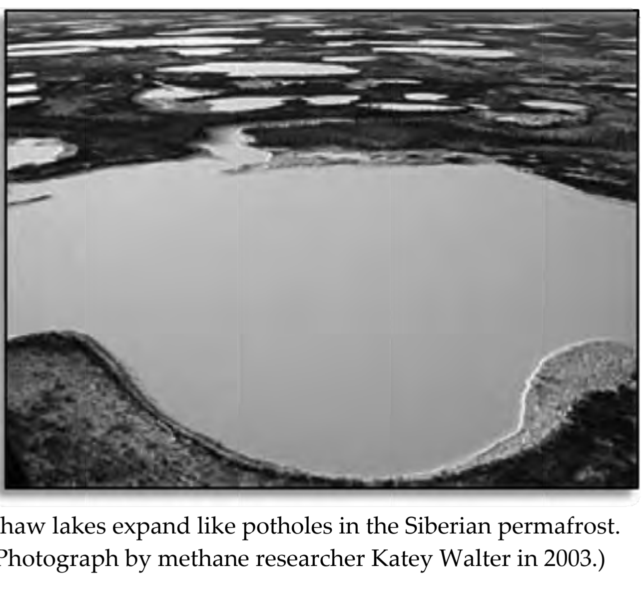
Liquid natural gas (LNG) is now a booming business, being transported in a new generation of tankers to a new set of offshore ports that feed pipelines. LNG keeps itself cold by evaporation, adding methane to the atmosphere. Though the tankers may fuel themselves by capturing some of that methane, there are substantial losses of methane at every stage of the operation, especially in the land-based separation, compression, cooling, and (on the other end) rewarming processes.

In short, a quarter-century since the methane warnings, the industry is still building capacity as if unburned methane were not a potent greenhouse gas.

Then there's nature. The release of ancient methane from the ocean floor off California between Santa Barbara and the offshore islands is associated with periods of rapid rise in sea level. At a guess, the additional pressure of overlying ocean might be squeezing out the hydrocarbons. If so, our greenhouse warming and sea-level rise could un-

leash fresh plumes of seabed methane, making the planet warmer and speeding the acidification of the oceans.

At the higher northern latitudes in Canada and Siberia, there is a lot of frozen ground beneath the surface. Some of it, especially in western Siberia, is from old lake bottoms littered with decaying vegetation. When the ground thaws, it releases a lot of methane and CO_2. This escapes into the air and adds to the insulating blanket around the Earth.



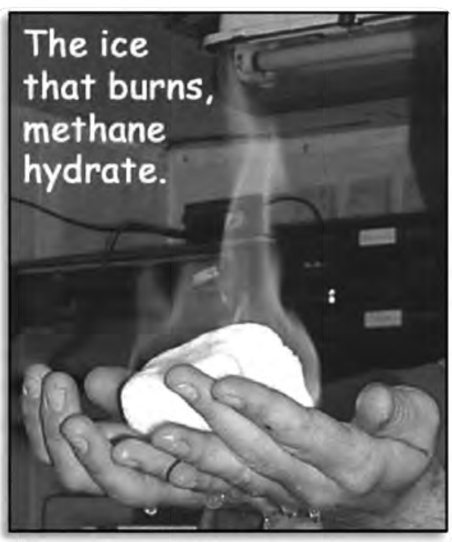
Thaw lakes expand like potholes in the Siberian permafrost. (Photograph by methane researcher Katey Walter in 2003.)

This, of course, produces a vicious cycle. Global fever (twice as high in the Arctic) thaws more permafrost, which releases more methane and adds to the greenhouse effect.

Though methane is the least offensive of the fossil fuels, in terms of electricity generated per unit CO_2 released, it is the most dangerous of the three fossil fuels when unburned. Coal adds twice as much CO_2 to the atmosphere per megawatt, but at least it doesn't evaporate.

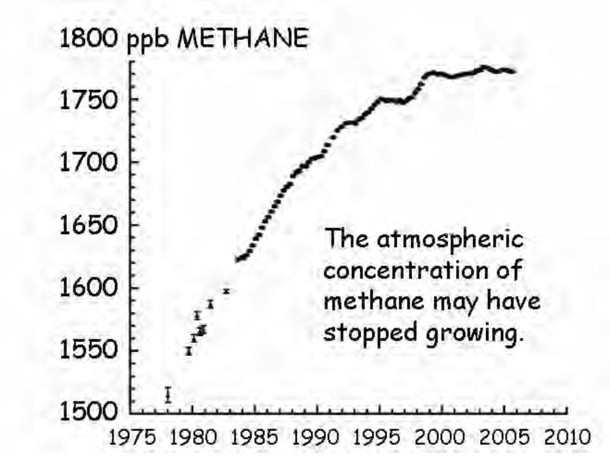
In a rational world, we'd burn methane only near its wells, sinking its CO_2, and exporting the electricity via efficient DC transmission lines that can reach long distances. Even better, retired natural gas pipelines could be re-used as conduits for superconducting power lines.

For the long-term, there's another concern about methane. There's a lot of it held in an ice-like form called a methane hydrate, often buried under the ocean floor or slope. It sometimes comes unstuck and pops up to the surface. Sailors will fish out a piece and amuse themselves by setting it afire.



It is thought that huge amounts of methane were released about 55 million years ago, perhaps by earthquakes causing an avalanche on an underwater slope.

But there are signs of progress. While the methane concentration in the air was growing at the rate of 100 ppb per decade, something slowed the rate of addition so that, in 2000 to 2006, it matched the rate of decay (losing methane for making CH_3 methyl groups). Before a problem gets better, it has to stop getting worse—and perhaps the methane contribution to global fever is about to head down.

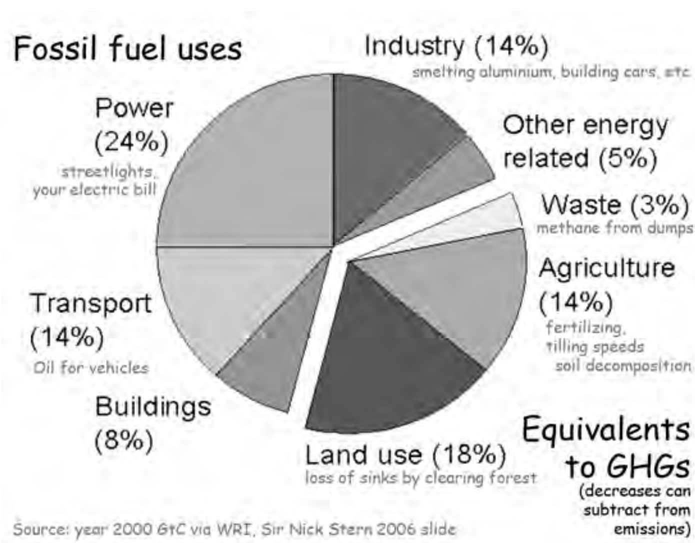


The prior high for methane, about 320,000 years ago, was half of the 1978 value.

The only good thing you can say about our methane problem is that methane doesn't hang around in the air for as long as CO_2. We will lose about half of this year's methane additions in the next 6 years, which makes it much faster than the CO_2 decay rate (we lose half within

200 years but that's the easy half; most of the remaining half will still be around a thousand years from now unless we start removing it from the atmosphere). Unlike methane, we're going to have to remove CO_2 rather than wait it out.

No one really knows why the methane release has slowed, though there have been many steps taken that are candidates. If it really is a turnaround and methane is on the way back down, it might be the second greenhouse-gas success story after ozone (back at page 27).



Since CO_2 is not the only problem, what number should we really pay attention to? What best expresses the damage done? The climate modelers use a technical term called "forcing" but I find that this pie chart does a good job. It shows that two-thirds of the insulation problem comes from fossil fuel uses. What's interesting is the remaining third.

There are a series of equivalents to adding CO_2, such as taking away CO_2 sinks. The biggest one is the loss of sinks by land clearing. This piece of the pie (mostly thanks to Indonesia, with Brazil far behind in second place) is even bigger than oil's use for transportation. Agriculture contributes another 14 percent by tilling the soil (speeds decomposition), fertilizing (nitrous oxide), burping cattle, and all that waste. About 3 percent of the pie comes from garbage dumps and the like.

The global climate models of the past have not taken much account of the positive feedbacks that exaggerate temperature rise from fossil fuel CO_2 uses. A 2006 analysis reports that

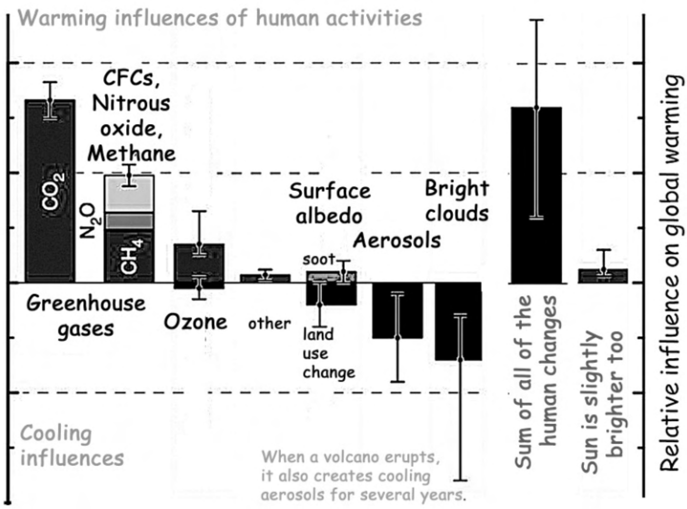
> Increased photosynthesis at higher CO_2 levels and temperatures implies a negative feedback, but positive feedbacks seem likely to override this effect. For instance, higher temperatures may lead to increased release of CO_2 , methane and N_2O from terrestrial ecosystems…

For example, the soil decomposes faster when warmer, one reason why tropical soils are so poor, compared to those that stay frozen in winter. Decomposition releases CO_2 and methane into the air.

Such feedback increases the warming already "in the pipeline" up to 1.5°C. And it amplifies the effect of doubled CO_2 from an additional 1.5°C to as much as 4.5°C.

That's why runaway warming can occur at some point. That's when we lose existing sinks for carbon dioxide via drought, fire, ocean acidification, narrowing the leaf pores, and baking the soil. Losing sinks works just like adding CO_2, pushing up the fever to kill off even more sinks. The temperature spike just keeps building up, totally disrupting much of life on Earth. While no one is predicting a result like Venus, the Earth's outgassing would be a profound extinction event.

The CO_2 runaway scenario is perhaps the biggest danger that we are currently flirting with.



The largest anthropogenic (human-caused) actor is CO_2. The net forcing (the difference between inflows and outflows) was thirteen times greater for human-linked effects than that from the sun's brightening. So while the sun is a player, the score now stands at:

William H. Calvin, GLOBAL FEVER (University of Chicago Press, 2008)

Sponsoring Global Fever	
HUMANS	SUN
13	1
FOURTH QUARTER	

As you come through the door of a supermarket, a unit above your head blasts you with hot air in the winter and cold air in summer (sometimes, when the manager has not been paying attention, it is the other way around). You must stand blinking for a moment as your eyes adjust to the [bright] lights.

Then you walk past banks of fridges and freezers which have no doors. This would be impossible to believe, if it were not by now one of the most ordinary facts of life. But, though you walk through valleys of ice, you remain warm.

All day long, the freezers and the heaters must fight each other. They must do so in a building which is huge, generally uninsulated and often widely glazed: that is capable, in other words, of trapping neither heat nor cold.

—George Monbiot, 2006

GLOBAL

How to Treat Climate Change

FEVER

William H. Calvin

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