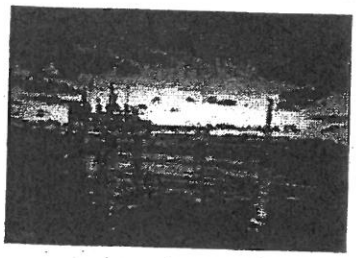
Ocean Floor Could Be Greenhouse Gas "Dump," Scientists Say

(1)

Richard A. Lovett
for National Geographic News
August 16, 2006

The ocean floor could provide storage for more excess carbon dioxide than the world can ever produce, scientists say.

A team of researchers proposes disposing of the carbon dioxide produced from burning fossil fuels by injecting it into seabed sediments nearly two miles (three and a quarter kilometers) below the ocean's surface.



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There the combination of cold temperatures and extreme pressure will trap the gas for millions of years, says the study's lead author, Kurt Zenz House, a graduate student in geoscience at Harvard University in Cambridge, Massachusetts.

House's team published its proposal last week in the *Proceedings of the National Academy of Sciences*.

The accumulation of carbon dioxide (CO_2) in the atmosphere from fossil fuel use is believed to be a leading contributor to global warming.

(See *National Geographic* magazine's "Global Warning: Signs From Earth.")

One way to reduce global warming without drastic reductions in energy consumption is by removing carbon dioxide from power-plant emissions and putting it where it cannot enter the atmosphere.

In the past scientists have proposed storing CO_2 in geologic formations such as depleted natural gas fields.

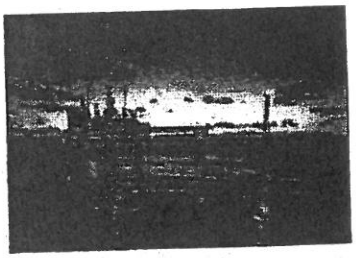
(Read related story: "Clean Coal? New Technology Buries Greenhouse Emissions" [May 2006].)

"Those storage options make sense and can be used to large degree," House said.

But they don't eliminate the possibility that the gas could make its way back to the surface, he adds.

"If it can find a conduit through a well or a fault, it has the potential to escape," House said.

Undersea storage is different, House says.



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At depths below 8,900 feet (2,700 meters) the pressure is great enough that CO_2 is compressed into a liquid that is denser than water. Therefore it can't bubble back to the surface.

But simply putting carbon dioxide on the surface of the seabed would wreak ecological havoc, House explains.

Not only would the carbon dioxide smother life on the ocean floor, but it would also react with seawater to form acid.

House proposes to bypass this problem by injecting the carbon dioxide into sediments below the seabed.

This would take advantage of the unique changes in temperature and pressure found beneath the deep ocean, he says.

About 1,000 feet (300 to 400 meters) deep in the sediment, the Earth is warm enough that the carbon dioxide will no longer be denser than the seawater in the rock's pores.

That's a good thing, House says, because as the gas percolates up through the waterlogged sediment, it will react with seawater to produce a type of ice called a hydrate.

This ice will block the pores in the sediments, House says, creating a cap that keeps additional carbon dioxide from moving upward.

"Enormous" Capacity

The seabed of the U.S.'s territorial waters alone has enough suitable sediments to hold thousands of years' worth of CO_2 produced from fossil fuel use, House says.

"The storage capacity is enormous," he said.

The prospects are even greater for a country like Japan, where there are very few depleted gas fields or other land-based options for storing CO_2.

"If Japan wanted to do something with their carbon dioxide, this might be their best option," House said.

But the technology would come with a big price tag.

House estimates that it would cost about U.S. $35 to $75 per ton of CO_2—about the amount produced by burning two barrels of oil.

At the moment the new idea is a proposal, not a mature technology.

"This is one of those ideas that you have to try out to see if it works," said David Goodstein, vice provost of California Institute of Technology in Pasadena and author of *Out of Gas: The End of the Age of Oil.*

But that doesn't mean that innovative ideas for getting rid of carbon dioxide aren't important, he says.

"We are doing an uncontrolled experiment on the climate of the only planet we have," Goodstein said, regarding carbon dioxide emissions from fossil fuels. "That is very foolish." 1 cont

Sea Level Rises 50 Percent Faster (2)

ENVIRONMENT—For sinking cities like New Orleans and Venice, ocean warming trends will make a bad situation even worse. When ice sheets melt and oceans heat up, the sea level rises. A fleet of satellites has been monitoring the situation, and in July Steve Nerem, a geophysicist at the University of Colorado at Boulder, and his colleagues pulled together the evidence. Bottom line: Oceans are rising about 50 percent faster than in previous decades.

The sea-level readings come from NASA satellites called TOPEX/Poseidon and Jason-1, which map the oceans every 10 days. On average, sea level has risen more than a tenth of an inch per year over the last 12 years. That's a sizable increase over the rate of the previous 50 years, as estimated by tide gauges around the world. Nerem cautions that it's too soon to pin the result on global warming; it could be due to regular changes in ocean climate. "It's hard to know whether this reflects a long-term change or a short-term change," he says. It will take another 10 to 15 years to settle the case. Still, the increase is about what's predicted by computer models of global climate.

81

According to calculations by other scientists, roughly half the rise comes from the thermal expansion of the oceans as they warm. Melting mountain glaciers and polar ice are also adding to new heights. And climatologists suspect that the ice sheets of Greenland and Antarctica are involved, although exactly how much is not known. These ice sheets have been sliding ever faster toward the sea, but research this year showed that parts of Antarctica are actually getting thicker. That means the overall contribution to sea level "is still a little fuzzy," says glaciologist Richard Alley of Pennsylvania State University. Finding out how ice sheets are behaving is crucial, Alley and others say: The ice of Antarctica and Greenland contains enough water to raise the sea level by more than 200 feet.

—Erik Stokstad

Climate change may cause more icebergs, such as this one in Disko Bay, Greenland, to fall into the sea.

Scum of the Air

One man's quest to cool the planet—with blue-green algae

Atop the Massachusetts Institute of Technology's 20-megawatt campus power plant stands a structure resembling a pipe organ. Instead of shiny metal, the 30 clear plastic pipes are pond-scum green, full of one-celled algae fighting global warming.

The algae are eating carbon dioxide and nitrogen oxides from the plant's emissions—40 percent of the former and 86 percent of the latter—and turning them into harmless oxygen and nitrogen. Each day, an algae crop is harvested that could be dried and converted to solid fuel or processed into biodiesel or ethanol, transforming a pollution problem into a moneymaker.

Chemical engineer Isaac Berzin came across the algae idea in a 1996 government report while working on a project for the International Space Station and was immediately impressed with the possibilities. "You could take something no one knew what to do with and turn it into fuel," he says. With the MIT test a success, Berzin has attracted $2.4 million in capital, founded GreenFuel Technologies Corporation, and begun field trials at an unnamed power plant in the Southwest.

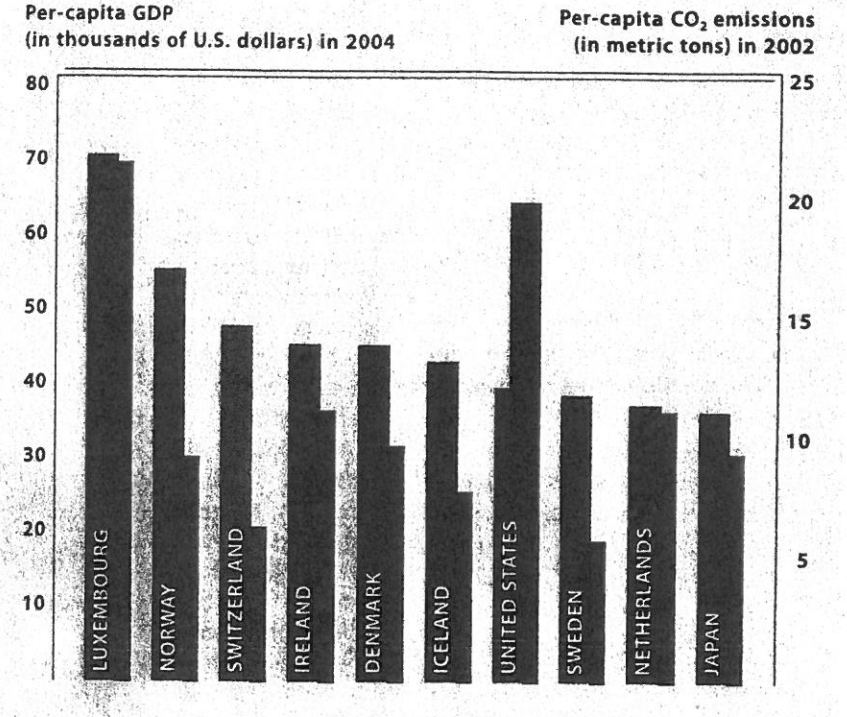
The idea "has a lot of promise," says Barry Worthington, executive director of the U.S. Energy Association, which represents the electric power, oil, and gas industries. "If the GreenFuel technology works on a large scale, then all of a sudden you are looking at being able to sequester carbon dioxide not just as a cost of doing business, but you actually get some revenue."

It would be a dream solution for the industry, given that 40 percent of carbon dioxide and 25 percent of nitrogen oxide emissions in the country come from electric power plants. Other ideas for getting rid of CO_2 include burying it underground or discharging it into the deep ocean, both expensive ideas with unknown consequences. But who can complain about a lot of algae?

—Frances Cerra Whittelsey

BIG AND BAD

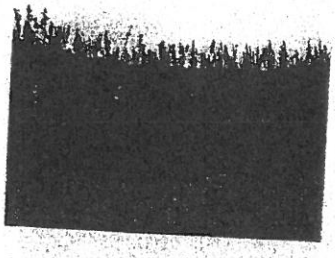
Sure, the United States is a conspicuous contributor of greenhouse-gas emissions, but that comes with the territory when you're one of the richest countries on the planet, right? Not necessarily. Citizens of many other nations live quite comfortably, thank you, and do so without mortgaging the health of future generations. Below, we chart the per-capita gross domestic product of the world's ten wealthiest countries and their per-capita carbon dioxide emissions.



SOURCES: ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT, WORLD RESOURCES INSTITUTE'S EARTHTRENDS DATABASE

35 EARTH SCIENCE
Melting Permafrost May Rev Up Global Warming

By 2100 Siberia as we know it may not exist—all that frozen ground may have thawed. The defrosting could release nearly 1,000 gigatons of carbon stored in the permafrost and hasten global warming, according to a report in June. The unnerving new estimate puts permafrost up there with soils (1,500 gigatons) and vegetation (650 gigatons), Earth's second and third largest repositories of carbon after the oceans. In a separate study, Katey Walter, an aquatic ecologist at the University of Alaska at Fairbanks, showed that much of this buried carbon may emerge as methane, a greenhouse gas some 20 times more powerful than carbon dioxide. One type of permafrost called yedoma is full of grass roots, bones, and other biological material. For tens of thousands of years, this organic matter has been in cold storage; when permafrost melts, it gives rise to thaw lakes, where the organics decompose and release bubbles of methane. While monitoring two Arctic thaw lakes for 13 months, Walter's team found that they gave off five times as much methane as previously estimated. She also showed that the lakes are growing, potentially starting a feedback loop that could lead to more rapid warming.



Samir S. Patel

(6)

Greenhouse Gas Makes Oceans Acidic and Dissolves Marine Life

OCEANOGRAPHY—Increasing levels of carbon dioxide in the atmosphere are turning the oceans more acidic and may endanger marine life, according to a report released in September. An international team of 27 oceanographers churned through 13 global models and concluded that carbon dioxide emissions could cause pH levels in the ocean to drop from an average of 8.1 today to 7.7 by the end of the century. That may doom small but essential sea creatures.

As seawater becomes more acidic, it dissolves carbonate minerals, which many plankton require to build their shells. The researchers found that if carbon emissions continue to rise at the current rate, the entire Southern Ocean and part of the North Pacific will be so corrosive by the year 2100 that many calcifying plankton will be unable to grow properly; others may dissolve outright. The worst-case scenarios move up the timetable to the year 2050.

"We know with certainty what's going to happen to the seawater chemistry," says Victoria Fabry, a biological oceanographer at California State University at San Marcos. "What we don't know for certain is the impact that will have on the biology." In an experiment, Fabry exposed planktonic snails called pteropods to seawater with a level of acidity matching that predicted for the Southern Ocean in 2100. "The shells were dissolving before my eyes," Fabry says.

Conditions may worsen after 2100, w Ken Caldeira, a chem oceanographer at Carnegie Institut "Our model predicts if we don't do anyth within a few centuri will produce ocean ditions that will pre coral reefs from exist

—*Anne Casse*

(7)

EARTH SCIENCE
Storms May Be Getting Worse

In 2005 MIT climatologist Kerry Emanuel stirred intense debate with a study indicating that global warming had caused hurricanes to nearly double in strength since the 1970s. In 2006 other researchers rushed in to test the claim. Their studies strengthen the theory that a warmer climate heats the ocean surface and fuels massive storms. But the core question—is global warming leading to more extreme weather?—remains frustratingly unresolved.

Although hurricane records date back more than a century, they have been gathered using techniques of varying accuracy, such that it is often hard to compare new data with old. This motley record has divided researchers. Meteorologists, attuned to ever-shifting daily weather, are less familiar and less comfortable with the long-term data set. Climatologists, who study longer timescales and are used to working with incomplete records, have more faith in the data, yet know less about the day-to-day dynamics of hurricanes.

"Tropical meteorologists, we're a skeptical bunch," says John Knaff of Colorado State University. Kevin Trenberth, a climatologist at the National Center for Atmospheric Research, counters that the hurricane records, although messy and full of confounding factors, can reveal long-term trends, particularly in the Atlantic.

So far, the results from climate models do not match the dramatic rise in storm intensity seen by Emanuel. But researchers on both sides agree that current models are still inadequate. Georgia Tech climatologist Peter Webster and others are looking at better ways to mine the hurricane record by excluding the most heavily disputed data.

Webster is now studying the duration of the hurricane season each year, from the first tropical cyclone to the last. His findings, which are not yet published, are not reassuring. "The length of the hurricane season has been expanding," he says, "increasing by about five days per decade—about 15 days since 1970."

Elise Kleeman

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ON LAND

AT SEA

1 Surface melting begets more melting

Snow reflects the sun's light and heat, keeping ice below it from melting. Where it melts, exposed dark ice absorbs heat.

As glaciers thin, their surface sinks to lower altitudes, where temperatures are higher.

2 Meltwater fractures ice and lubricates the bottom, speeding flow

Summer meltwater pools on the ice surface and forms lakes.

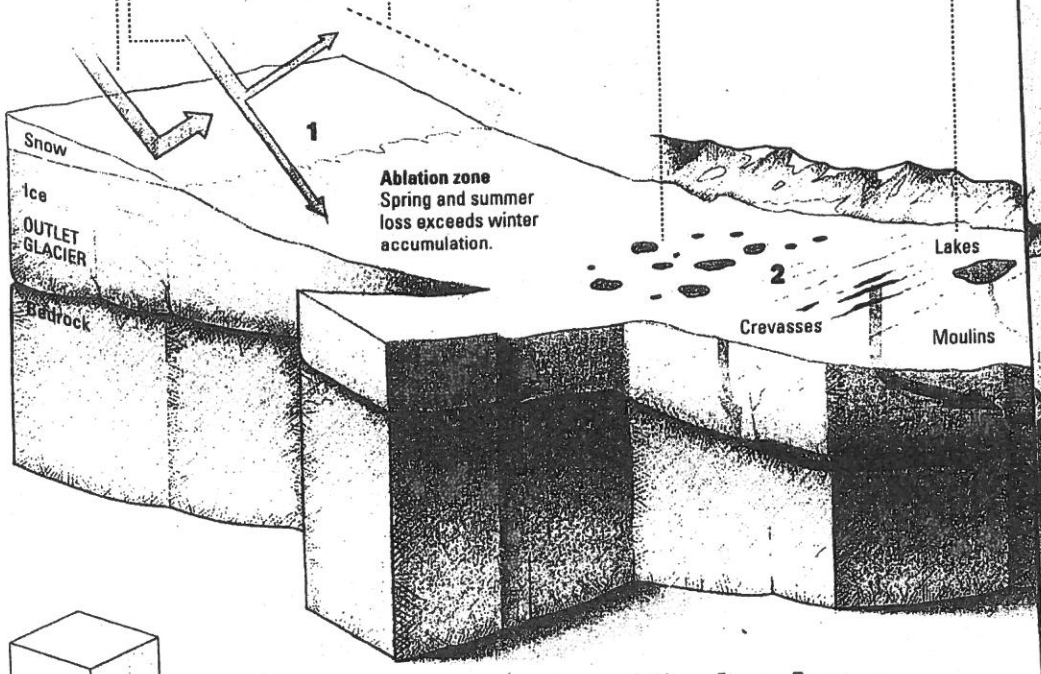
Meltwater plunges into open crevasses and moulins, breaking up the ice and lubricating its base, which accelerates flow.

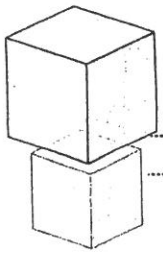
3 Thinner ice has a weaker grip on the land and can't hold the accelerating glacier

4 Warmer oceans erode floating ice at its base

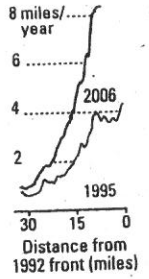
Some glaciers end in a floating tongue, which buttresses the la behind it. As the ocean warms, the ice tongue from below, wea it and causing it to break up.

Warm currents eat away the gr line, where the floating ice mee bedrock. Pressure at depth low melting point, making it even r vulnerable to warmer water.

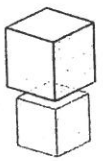


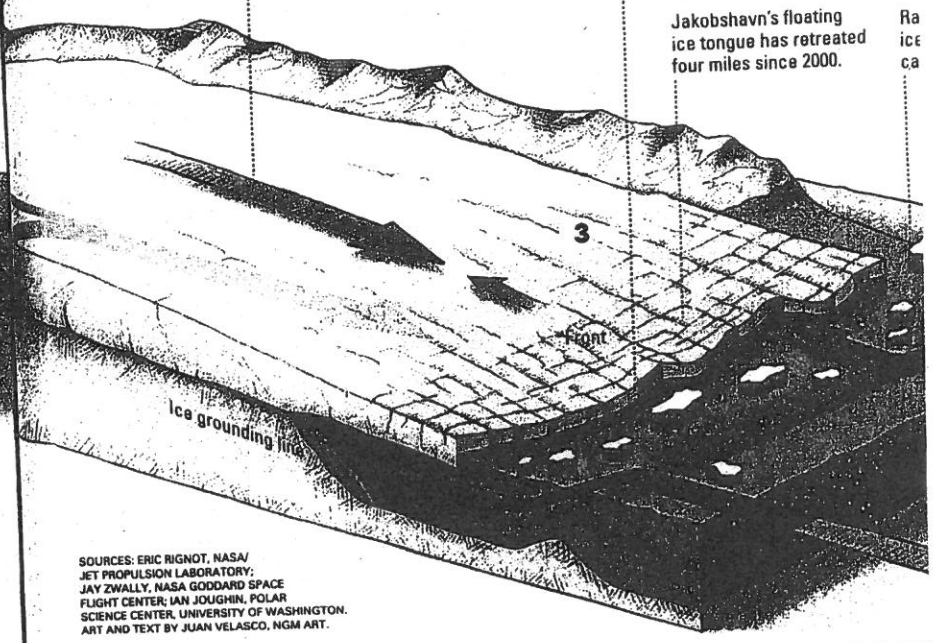


One estimate of net annual loss of ice in Greenland



Jakobshavn Isbræ, the biggest outlet glacier in Greenland, flows twice as fast as in 1995. The ice moves fastest at the front.





Ice Slipping Away

Ice sheets covering Greenland and West Antarctica are shrinking unexpectedly fast, and the outlet glaciers that carry inland ice into the sea are accelerating. Multiple processes are speeding the loss of ice.

SOURCES: ERIC RIGNOT, NASA/ JET PROPULSION LABORATORY; JAY ZWALLY, NASA GODDARD SPACE FLIGHT CENTER; IAN JOUGHIN, POLAR SCIENCE CENTER, UNIVERSITY OF WASHINGTON.
ART AND TEXT BY JUAN VELASCO, NGM ART.

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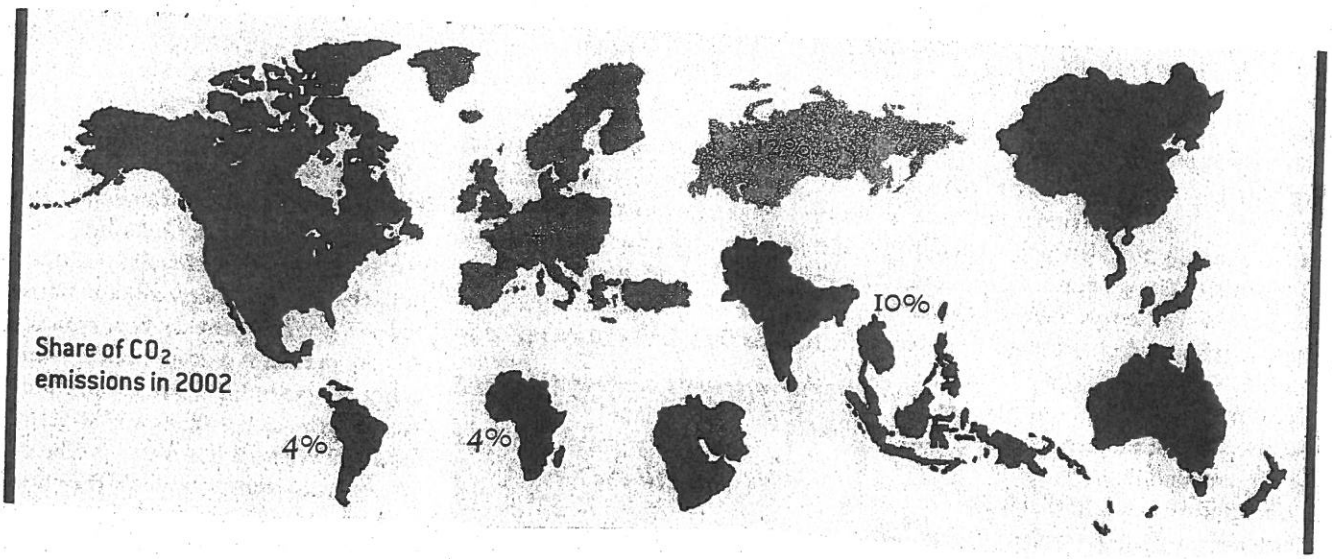
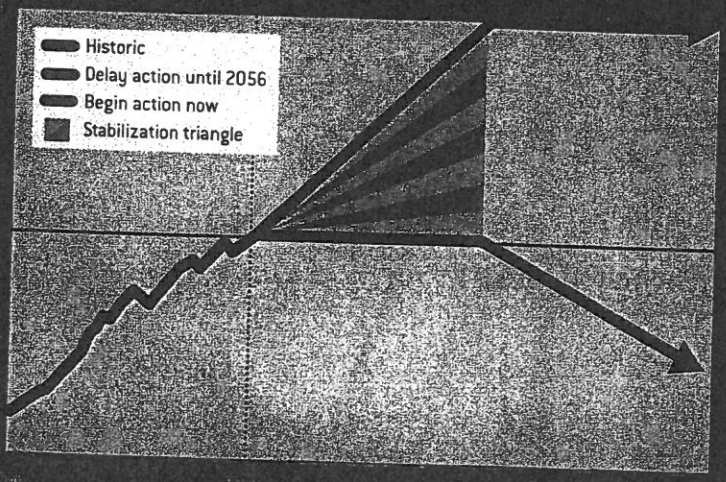
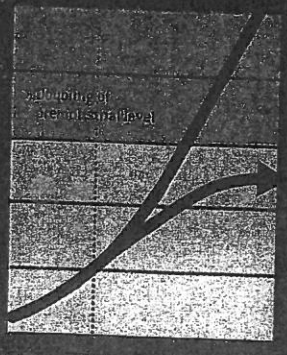


MANAGING THE CLIMATE PROBLEM

At the present rate of growth, emissions of carbon dioxide will double by 2056 (*below left*). Even if the world then takes action to level them off, the atmospheric concentration of the gas will be headed above 560 parts per million, double the preindustrial value (*below right*)—a level widely regarded as capable of triggering severe climate changes. But if the world flattens out emissions beginning now and later ramps them down, it should be able to keep concentration substantially below 560 ppm.





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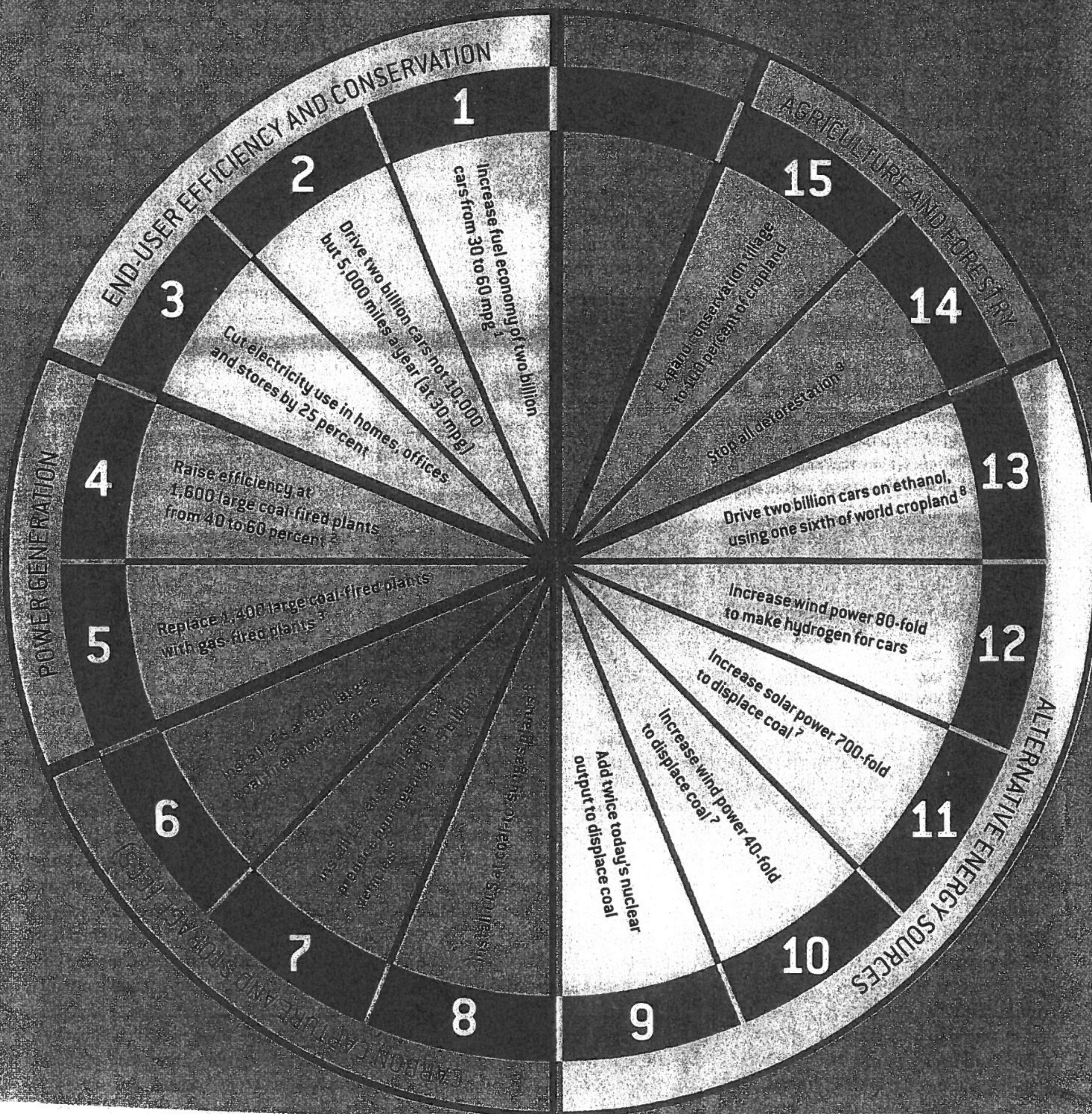
15 WAYS TO MAKE A WEDGE

An overall carbon strategy for the next half-century [illegible] seven wedges' worth of emissions reductions. [illegible] 25 billion tons of carbon. [illegible]


END-USER EFFICIENCY AND CONSERVATION
1
Increase fuel economy of two billion cars from 30 to 60 mpg [1]
2
Drive two billion cars not 10,000 but 5,000 miles a year (at 30 mpg)
3
Cut electricity use in homes, offices and stores by 25 percent
POWER GENERATION
4
Raise efficiency at 1,600 large coal-fired plants from 40 to 60 percent [2]
5
Replace 1,400 large coal-fired plants with gas-fired plants [3]
6
7
8
9
Add twice today's nuclear output to displace coal
10
Increase wind power 40-fold to displace coal [?]
11
Increase solar power 700-fold to displace coal [?]
12
Increase wind power 80-fold to make hydrogen for cars
13
Drive two billion cars on ethanol, using one sixth of world cropland [8]
14
Stop all deforestation [9]
15
Expand conservation tillage to 100 percent of cropland
AGRICULTURE AND FORESTRY
ALTERNATIVE ENERGY SOURCES