



Haze from coal and other fossil fuels dims the sky in Changchun, China.

# CLIMATE CROSSROADS

After decades of failure, a new approach to negotiations has raised hopes that nations meeting in Paris will agree to meaningful climate steps

By **Eli Kintisch**

It's reasonable to view the upcoming Paris climate talks with skepticism. More than 2 decades have passed since nations met in Rio de Janeiro, Brazil, to create the 1992 United Nations Framework Convention on Climate Change. Since then, a succession of international meetings under the framework—most notably in Kyoto, Japan, in 1997 and Copenhagen in 2009—have done little to alter our planet's worrisome trajectory. Annual global emissions of carbon dioxide have risen steadily from 21 billion tons in 1992 to 32 billion tons in 2012. The rate of increase in the atmospheric concentration of greenhouse gases has accelerated, by roughly 30% since the 1990s. Nine of the 10 warmest years on record have occurred since 1998, and the impacts of climate change are already being felt from the tropics to the poles.

Optimists point to the growing use of solar, wind, and other renewable power sources and the success of some nations, such as Denmark (see p. 1020), in curbing emissions. But rising emissions from China, India, and other developing nations are swamping that progress. And the dismal track record of global climate talks inspires little confidence that nations can agree to make the huge changes required to stop treating the atmosphere like a carbon sewer.

Negotiators huddling in Paris next week are convinced these talks will be different. In Kyoto, nations attempted to create a legally binding agreement, which subsequently failed to deliver results in part because the United States would not ratify the treaty. This time, nations—164 of them, by the time *Science* went to press—have each prepared pledges, called Intended Nationally Determined Contributions (INDCs), which detail their promised emissions cuts and other actions through 2030.

Negotiators hope the bottom-up INDC approach will prevail where the top-down Kyoto strategy failed. Developing nations largely stuck to the sidelines in previous talks. This time almost everyone—including China and India (see p. 1024)—has pledged to limit emissions. And by arriving in Paris with pledges in hand, negotiators hope to avoid the last-minute deadlocks that have doomed past efforts.

That's not to say that negotiators aren't under pressure. There's still the question of how developing nations will raise the hundreds of billions of dollars they'll need to curb emissions and adapt to climate change. And it's not clear how national pledges will be monitored and verified.

Another thorny question is whether nations will agree to review any Paris deal every 5 years. That would create regular opportunities for countries to extend their reduction policies past 2030 and ratchet up cuts. Climate experts say such action is needed, because the Paris pledges alone won't keep planetary warming by 2100 below the 2°C ceiling that many consider safe.

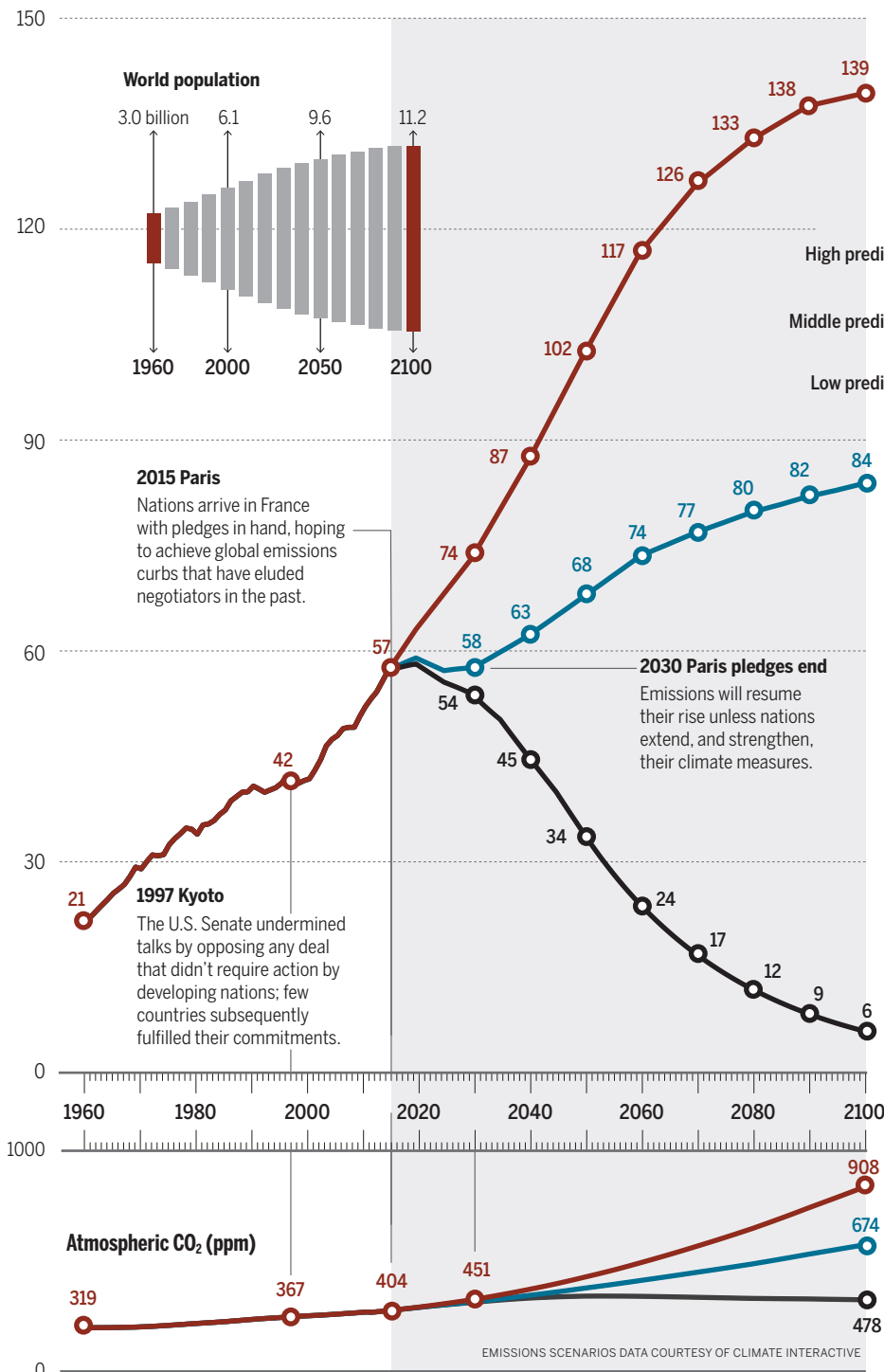
The Washington, D.C.-based nonprofit Climate Interactive, for example, estimates that without further action, the pledges will allow the world to warm 3.5°C by 2100 (see page 1018). The U.N. Environment Program (UNEP), however, assumes that nations will extend their pledges, which could keep the warming to 2.7°C. The lower number is “a reason for hope,” says Cassie Flynn, a UNEP official, because it puts the 2°C threshold within reach—if nations can agree to work together after Paris. ■

PHOTO: WANG ZHE - IMAGINECHINA

# AFTER PARIS: THE ROCKY ROAD AHEAD

Officials call the Paris talks a beginning, but what's the destination? Below are three possible future paths for annual global greenhouse gas emissions. Models suggest each would produce very different ranges of atmospheric greenhouse gas levels and warming in 2100. And all would cause the seas to rise for centuries after 2100. — *Eli Kintisch*

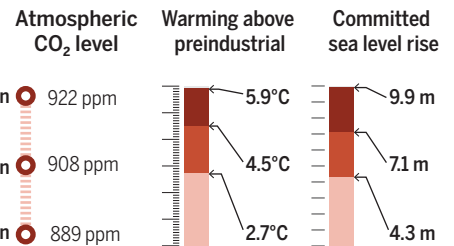
## Global emissions in CO<sub>2</sub> equivalent (Gtons per year)



## Alternative worlds

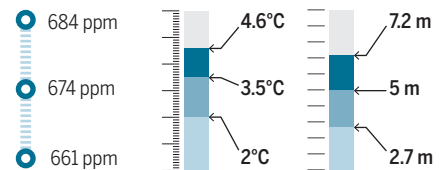
### 1. Business as usual

If nations don't fulfill their pledges, temperatures could rise by 2100 to levels not seen for millions of years. The world would be committed to centuries of sea level rise after 2100. (Range of sea levels shown for a 3.3°C rise.)



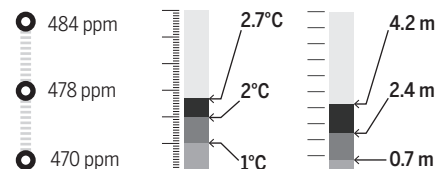
### 2. Paris pledges only

The Paris commitments are expected to cause global emissions to dip initially. But emissions will surge after 2030 if nations take no further action. (Range of sea levels shown for a 2.3°C rise.)



### 3. The path to 2°C

Avoiding dangerous warming will require no less than a global energy revolution. But even with aggressive action global coasts will see a battering from rising seas. (Range of sea levels shown for a 1.1°C rise.)



### Lasting consequences

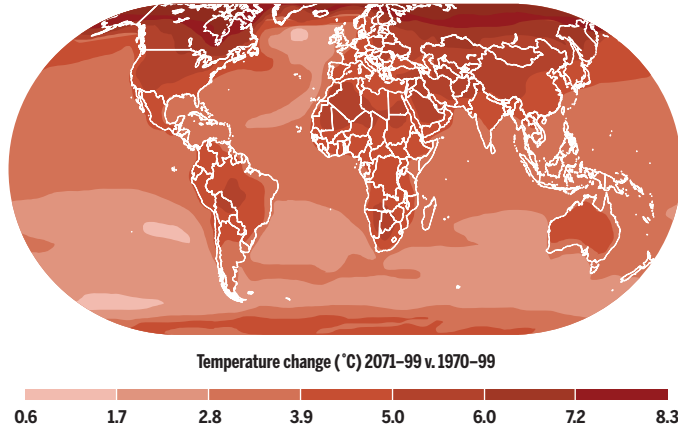
Even under the 2°C path, one measure of progress—atmospheric CO<sub>2</sub> levels (left)—will remain flat for centuries as the gas is very stable. Another benchmark, CO<sub>2</sub> equivalent (above) includes emissions of shorter lived gases such as methane, as well as emissions from agriculture and deforestation.

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SOURCES: CLIMATE INTERACTIVE; STRAUSS, B. H. ET AL., PNAS (2015); ADAPTED BY A. CUADRA/SCIENCE

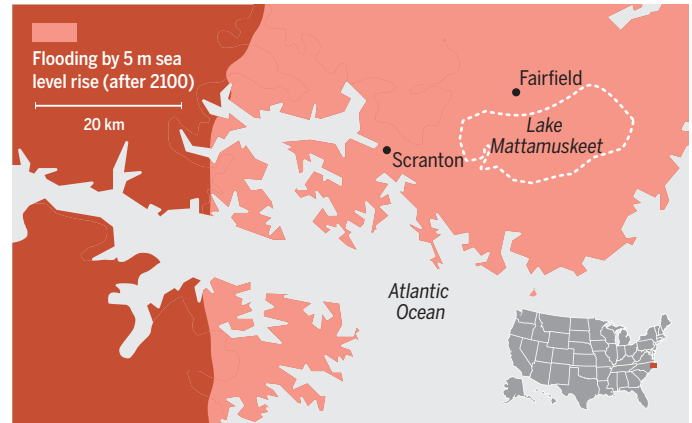
# 1. With business as usual, a world transformed

Average temperatures would rise most dramatically at the poles and over the continents (left), whereas rising seas would swamp countless communities (right).

## Modeling a hotter planet



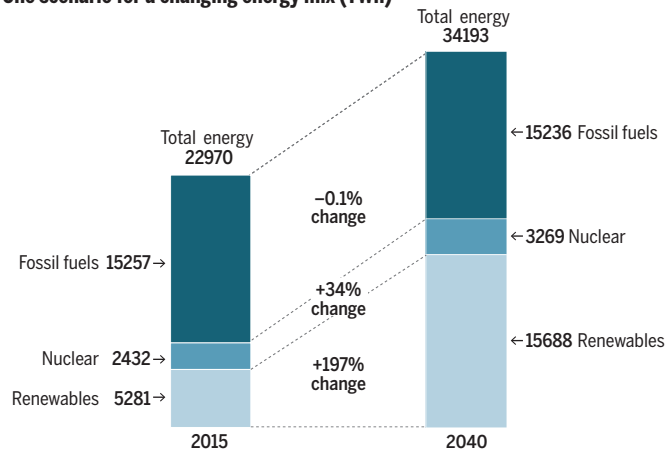
## Ocean engulfs the North Carolina coast



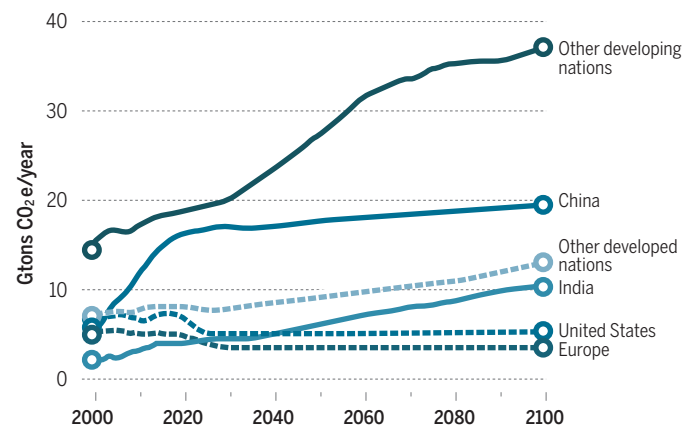
# 2. With Paris pledges only, gains could be swamped by developing nation growth

An ongoing shift to renewables will help nations meet their Paris pledges. But population and economic growth in developing nations could push up emissions after 2030.

## One scenario for a changing energy mix (TWh)



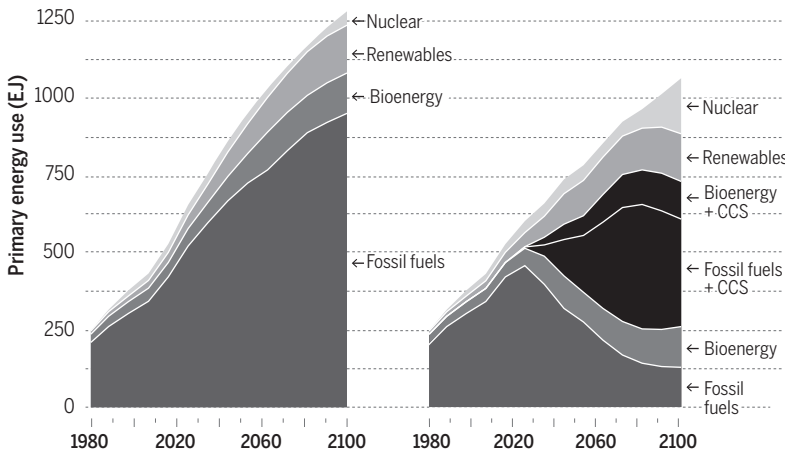
## Emissions surge after 2030 with no new action



# 3. The path to 2°C will require new technologies and major investments

Present trends lead to massive fossil fuel use (left). Under some scenarios, slashing emissions will require carbon capture and storage (CCS) on a huge scale (middle), and a major shift in spending away from fossil fuels and to efficiency and renewables (right).

## Fossil fuel dominance...



## or an energy transformation...

## propelled by shifts to greener spending.

