The population of polar bears is decreasing, according to the IUCN Red List of Threatened Species

CHAPTER 1

From the science to the economics and politics of climate change: An introduction

by Robert N. Stavins

The science on climate change is pretty clear: if we stay on the current path and continue burning oil, coal and gas at present rates, the earth will eventually warm to what could be a catastrophic degree. Although many politicians and scientists largely agree on what would constitute a "safe" path towards mitigating climate change, there are economic consequences of such action. These consequences would be expensive, but they would not be unwarranted – given the alternatives.

If we stay on the current path, the earth will eventually warm to what could be a catastrophic degree

However, the fiendishly complicated politics of climate change have held back progress, in particular the once strict distinction between developed countries – which committed to cutting CO_2 – and developing ones – which did not. Now that this distinction is blurring, the chances of moving towards a meaningful global agreement are rising.

Most important is that the world's biggest emitters take action, most notably the US and China. While domestic politics in the US remains intractable and China prioritizes growth, I can find six areas of convergence between the two nations that might give cause for cautious optimism.

The science of climate change

2°C
the degree of global warming that we must not exceed if we want to avoid serious consequences

The ever growing concentrations of greenhouse gases in our atmosphere, caused by the burning of fossil fuels, appear likely to change our earth's climate in ways that many will come to regret. As reports from the Intergovernmental Panel on Climate Change (IPCC, see introduction to part A) make clear, decades of political inaction have now left us with little choice but to make intensive efforts over coming decades to avoid the worst consequences of global climate change.

Scientists predict that severe consequences are most likely to occur when global average temperatures increase by more than 2 degrees C. Such a degree of warming would be caused by concentrations of greenhouse gases of about 450 parts per million (ppm) in CO_2-equivalent (CO_2eq) terms. But we are now on a path to more than double greenhouse concentrations, to about 1,000 ppm CO_2eq by the end of this century. This would result in average global temperature increases of 3 to 8 degrees C relative to pre-industrial levels.

2020
the year in which greenhouse gas emissions will have to peak if we want to avoid huge costs in the fight against climate change

Increased temperatures – which might be welcome in some places – are only part of the story. The most important consequences of climate change will be changes in rainfall patterns, the disappearance of glaciers, droughts in mid to low-low lying areas, decreased productivity of cereal crops, a rise in sea levels, the loss of islands and coastal wetlands, increased flooding, more frequent and intense storms, the risk of species disappearing and the dangerous spread of infectious disease.

From science to economics

The anticipated damage of climate change is grave, but avoiding it by cutting greenhouse gas emissions will be neither cheap nor easy. Since the industrial revolution, 300 years of economic growth have been fueled by the combustion of fossil fuels – first coal, then petroleum, and most recently, natural gas. As a result, in the industrialized world, transport, energy and other infrastructure is dependent upon energy generated from fossil fuels (see figure 1.1). And the large emerging economies – China, India, Brazil, South Korea, Mexico and South Africa – are rapidly putting in place new infrastructures that are likewise linked with the consumption of fossil fuels, and hence the emissions of more and more CO_2.

The IPCC found that the 450 ppm target can be achieved at an apparently low cost, namely a slowdown in consumption growth of only 0.06 per cent

a year from now through 2100. The numbers are accurately reported, but potentially misleading. A small difference in the interest rate on your savings account can make a big difference in your bank balance after a couple of decades. Likewise, a very small difference in the average growth rate is very significant when it occurs over a 100-year period, which is the case here. The widely reported 0.06 per cent difference in annual growth amounts to an estimated 5 per cent loss of global consumption.

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Furthermore, this cost estimate is based on a scenario with "optimal conditions". The assumption is that all countries immediately reduce their emissions to the necessary degree in a cost-effective manner. They could do so in reaction to a single global carbon price and with the help of various new technologies. These optimal conditions are highly unlikely to be met. For example, if technologies for capturing the carbon emitted from

burning fossil fuels ("carbon capture and storage") are unavailable, then the cost of cutting emissions to the necessary levels more than doubles.

So, from a purely economic perspective, the cost of achieving the 450 ppm target will be significant, but not necessarily unwarranted. A reasonable economic assessment of the target might be "very difficult, but not impossible". Things become more challenging when we move from economics to politics.

From economics to politics

Two fundamentals of the science of climate change – one spatial and one temporal – are of utmost importance for the politics of climate change.

First, greenhouse gases mix globally in the atmosphere, and so damage is spread around the world irrespective of where the emissions come from. This means that any jurisdiction taking action – a country, state, or city – will bear the direct cost of its actions, but the direct benefits (averted climate change) will be distributed globally. Hence, the direct benefits any jurisdiction reaps from its actions will inevitably be less than the costs it incurs, despite the fact that global benefits may be greater – possibly much greater – than global costs. This means that climate change presents us with a classic "free-rider" problem: no country sees taking action as being in its own interest, yet each hopes to reap the benefits from the actions taken by other countries. This is why international, if not global, cooperation is essential. Since our atmosphere is a globally shared good, scientists also refer to the dilemma as a "global commons" problem.

No country sees it in its interest to take action, and each hopes to reap the benefits from the actions taken by other countries

The other scientific reality is that many greenhouse gases, in particular CO_2, linger in the atmosphere for decades and up to a century or more.

The stock of CO_2 in the atmosphere is like a bathtub that is filling up as water continues to flow from the spout

The frequently heard cliché about the baseball season applies even more to international climate change policy: it is a marathon, not a sprint. Here are four reasons why:

I Scientifically, what matters is the stock of carbon in the atmosphere, not how much we emit at any given point in time. The damages from climate change are linked with concentrations, not with emissions per se. The stock of CO_2 in the atmosphere is like a bathtub that is filling up as water continues to flow from the spout. But this atmospheric bathtub has a very slow drain, as it takes decades to centuries for greenhouse gases to precipitate out of the atmosphere (mainly as oceans slowly absorb CO_2).

II Economically, virtually all reliable analyses have found that the cost-effective path of climate action would involve a gradual tightening of emission targets globally so as not to render our entire (fossil-fuel burning) infrastructure obsolete in one go (see box 4).

In other words, an affordable climate policy will not outlaw the use of current carbon-intensive technologies, but will instead provide incentives (or possibly requirements) for the adoption of more carbon-friendly technologies as we go on renewing our infrastructure and machinery. It would be absurdly costly to confiscate and destroy your gasoline-powered car today and force you to purchase a zero-emission vehicle. Rather, it makes economic sense to put in place policies that increase the likelihood that your next car will be significantly more fuel efficient, if not carbon neutral.

100

non-OECD countries had renewable energy policies in place in 2014, compared with only 15 in 2005

III Technological change (innovation) will be crucial to bringing down the costs of fighting climate change in the long term, both for economic rationality and political feasibility. Companies will only develop and adopt low-carbon technologies in response to long-term price signals.

IV Administratively, the creation of durable international institutions will be essential. The climate challenges the world faces today are at least as great as the challenges faced by world leaders when they gathered in Bretton Woods, New Hampshire, in 1944 to establish international monetary and financial order after World War II. Five decades were required to develop and solidify the World Bank, the International Monetary Fund and the World Trade Organization. A new international climate regime will not be effective overnight.

A new international climate regime will not be effective overnight

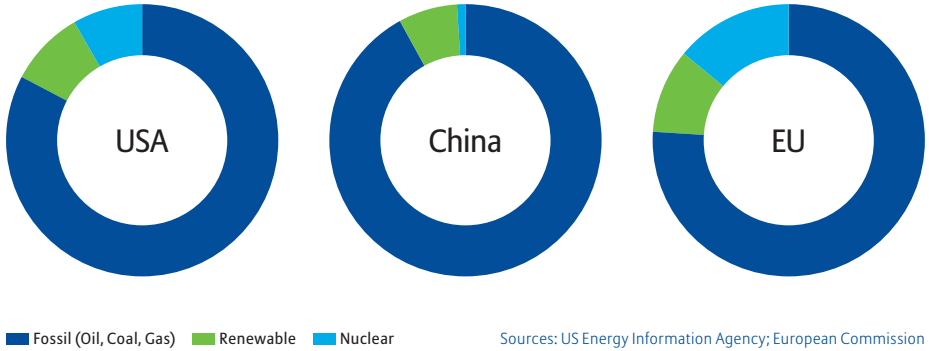
For all of these reasons, international climate negotiations will be an ongoing process – not a single task with a clear end point. Climate negotiations should aim at progress towards the foundation of meaningful long-term action, rather than focusing on an unattainable immediate "solution".

The challenge presented by the long-term character of the climate problem is immense. Politicians in representative democracies have strong incentives to appeal to today's voters by giving them benefits that will be financed by future generations. The climate challenge calls for precisely the opposite – today's citizens agreeing to costly actions that will protect future generations.

The climate challenge calls for today's citizens agreeing to costly actions that will protect future generations

Figure 1.1 Share of fuel type in total energy consumption

In per cent, 2011



Sources: US Energy Information Agency; European Commission

The global commons and geopolitics

These fundamental realities – the global commons nature of the problem together with its long-term character – present fundamental geopolitical challenges (see also chapter 3). Twenty years ago, when 172 governments met in Rio de Janeiro, Brazil, for the original Earth Summit, they agreed on a legally binding framework for climate policies – the United Nations Framework Convention on Climate Change (UNFCCC) – and established two key principles. One was the "stabilization of greenhouse gas concentrations at a level that would prevent dangerous anthropogenic (man-made) interference with the climate system". The other defined how this goal should be pursued: "The Parties (to the UNFCCC) should protect the climate system… on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities".

This second principle signaled the conviction that, although the climate problem is a global commons issue with all countries contributing to it, some countries had contributed more to the stock of emissions in the atmosphere than others – and those countries were the wealthier countries of the world. Hence, a specific set of industrialized countries (listed in Annex I of the convention) were committed to take actions "with the aim of returning [their greenhouse gas emissions] individually or jointly to their 1990 levels".

Some countries had contributed more to the stock of emissions in the atmosphere than others

When the members of the UNFCCC met for the first follow-up meeting in 1995 in Berlin, they agreed that "common but differentiated responsibilities" meant that only the industrialized countries listed in Annex I would commit to emission reductions. The developing countries not listed in Annex I would take on no such commitments. This so-called Berlin Mandate was then codified with numerical national targets and timetables in the 1997 Kyoto Protocol. It opened up a dramatic gap between rhetoric and reality.

By the time of the Berlin Mandate, the developing countries already emitted more greenhouse gases every year than the richer countries listed in Annex I. Even in terms of emissions per head, they were not far behind. By 2005, when the Kyoto Protocol entered into force, almost 50 of the non-Annex I countries already had per capita fossil fuel CO_2 emissions that were higher than those of the lowest-emitting Annex I country.

In the end, the Kyoto Protocol failed to constrain the world's six largest greenhouse gas emitters – either because they were still classed as developing countries and therefore did not take on commitments to reduce emissions (China, India, Brazil and Indonesia), or because they failed to ratify the Protocol (the US), or ratified it but adopted only a non-binding emissions target (Russia).

Since 1990, the base year of the Kyoto Protocol, emissions have grown by approximately 5 per cent annually in the non-Annex I countries, while remaining relatively constant in the Annex I nations. Furthermore, the split into countries with commitments and those without has made fighting climate change much more expensive: it has effectively quadrupled the global cost of emissions cuts that are necessary to stabilize atmospheric concentrations of greenhouse gases, relative to a cost-minimizing scenario.

In the end, the Kyoto Protocol failed to constrain the world's six largest greenhouse gas emitters

But prospects for change began to emerge in 2009, when the UNFCCC members met in Copenhagen, Denmark, and a year later in Cancun, Mexico. The agreements they reached there began to blur the distinction between Annex I and non-Annex I.

They departed even further from the distinction into developed and developing countries at their meeting in Durban, South Africa, in 2011. Here they agreed on a structure that would entail the participation of all parties in the effort to mitigate greenhouse gas emissions. Under this

"Durban Platform", delegates agreed to craft a future legal regime that would be "applicable to all Parties ... under the Convention". This has the potential essentially to eliminate the Annex I/non-Annex I distinction and could be an important step toward breaking the logjam that has prevented progress. All eyes are now on the Paris climate conference scheduled for the end of 2015.

International cooperation is necessary for fighting climate change. But fully global action is not. Therefore, forums other than the global UNFCCC (now with 196 parties) may be productive as complements, if not substitutes, in the search for solutions. Such forums include the "Major Economies Forum for Energy and Climate" (which includes 17 large economies, both developed and emerging) and the Group of Twenty Finance Ministers and Central Bank Governors – the G-20.

International cooperation is necessary for fighting climate change; but fully global action is not

The reality is that 16 countries and regions (counting the EU as one) account for approximately 80 per cent of global emissions. And two countries stand out as the greatest current – and historical – contributors: the US, estimated to have accounted for 15 per cent of global CO_2 emissions in 2012; and China, with 29 per cent of the estimated global total in that year. Next in line are the 27 EU countries (12 per cent), India (6 per cent), Russia (5 per cent) and Japan (4 per cent). With the top two contributors accounting for nearly half of all emissions, attention has understandably focused on China and the US.

44%
of global carbon emissions came from just two countries in 2012: China and the US

US climate policy

In 2012, US President Barack Obama renewed his commitment to aggressive climate change policy. In his efforts to reduce US emissions, he has since used executive orders aimed at cleaning up car exhaust fumes and power stations – knowing full well that he cannot get any climate change legislation through Congress.

It would be worth reflecting on what happened since Congress's great success two decades earlier, when it enacted president George H.W. Bush's path-breaking sulfur dioxide (SO_2) cap-and-trade system to cut acid rain by 50 per cent, as part of the Clean Air Act Amendments of 1990.

For a long time, market-based approaches to environmental protection bore the label of the Republican party, including "cap-and-trade schemes", under which companies and utilities are allowed to emit only a certain amount of pollutants and then have to pay for additional pollution permits.

In the 1980s, under president Ronald Reagan, the US Environmental Protection Agency (EPA) put in place a trading program to phase out leaded gasoline. President George H.W. Bush not only pushed through the use of cap and trade to cut SO_2 emissions, but his administration also advocated in international forums the use of emissions trading to cut global CO_2 emissions – a proposal initially resisted but ultimately adopted by the EU. In 2005, under President George W. Bush, the EPA issued the Clean Air Interstate Rule, aimed at reducing SO_2 emissions by a further 70 per cent from their 2003 levels. Cap and trade was again the policy instrument of choice.

54%
of Americans agree that climate change is largely the result of human activity

93%
of Chinese agree that climate change is largely the result of human activity

From the 1970s through much of the 1990s, environmental and energy debates in the US typically broke along geographic rather than partisan lines. A politician's stance on environmental legislation would depend more on whether his or her state was urban or rural and on which fuel the state primarily relied. For example, the Clean Air Act Amendments of 1990 passed by both houses of Congress were supported by large majorities of both Democrats and Republicans.

But 20 years later, when climate change legislation received serious consideration in Washington, environmental politics had changed dramatically. Congressional support for environmental legislation now mainly reflects partisan divisions.

In 2009, the House of Representatives passed the American Clean Energy and Security Act (known as the Waxman-Markey bill) that included an economy-wide cap-and-trade system to cut CO_2 emissions. The bill passed by a narrow margin, with support from 83 per cent of Democrats, but only 4 per cent of Republicans. In July 2010, the Senate abandoned its attempt to pass similar legislation in the face of opposition from Republicans, as well as coal-state Democrats.

What are the implications of this somewhat sordid political history for US climate change policy? The bad news is that the enactment and implementation of a cost-effective, economy-wide carbon pricing mechanism in the US is very unlikely in the short term. Emissions of CO_2 from coal-fired power plants will no doubt be reduced by EPA rules on other pollutants (SO_2, NOx, mercury, coal fly ash) that are working their way through the regulatory process, because those rules will drive up the cost of generating electricity with coal. But those rules – and others now proposed by EPA in response to a Supreme Court requirement that it

In the US, congressional support for environmental legislation now mainly reflects partisan divisions

regulate CO_2 under the Clean Air Act – are unlikely to be cost-effective policies for reducing economy-wide greenhouse gas emissions in the long run.

Chinese developments

The prognosis for meaningful, economy-wide climate policy in China is similar to the US case, despite positive developments in China on several fronts (see also chapter 5). China may achieve its stated goal of reducing the carbon intensity of its economy (measured as emissions per unit of GDP) 45 per cent below the 2005 level by 2020. But China's coal consumption and total CO_2 emissions are expected to continue to increase.

Much has been written in the Western press regarding the Chinese government's concern about worsening local air pollution – the mix of particulates, ozone, sulfur and nitrogen oxides that hangs over Beijing and other cities. Pollution has been growing gradually, but daily and hourly peak levels – especially of particulates – have been increasing more rapidly, with hourly concentrations in Beijing now having exceeded the worst experienced in Los Angeles in the 1960s by more than 10 times.

China's burgeoning middle class has begun to demand action to improve air quality, partly facilitated by the spread of social media, and government statements have started responding to this pressure. Prime Minister Li Keqiang opened the 2014 session of the National People's Congress with a resounding declaration of war on environmental pollution, warning about the downside of the rapid and unconstrained economic development China has enjoyed.

China's burgeoning middle class has begun to demand action to improve air quality

Emissions of many of the local air pollutants – including those from coal-fired power plants, industrial facilities, and motor vehicles – are correlated with emissions of CO_2 from the same sources. Hence, actions aimed at improving air quality will also be likely to curb CO_2 emissions (although in some cases, CO_2 and local air pollutants are substitutes, not complements, as in the case of using coal gasification to produce clean-burning methane).

Convergence of US and Chinese perspectives

China and the US have engaged in debates on climate change regarding the fundamental question of who should do what. They and their respective allies in the developing and developed worlds have clashed over the call under the Durban Platform for a global climate deal that is "applicable

to all Parties… under the Convention". The US and other industrialized countries insist that this calls for an agreement that brings about emissions reduction pledges from all countries. In particular, they understand it to include industrialized countries plus the large emerging economies.

But China and India – as well as most countries in the developing world – point out that the Durban Platform was adopted under the auspices of the UNFCCC, with its key principle of "common but differentiated responsibilities" – the idea that rich countries should bear a greater share of the burden of tackling climate change – as well as the subsequent mandate calling for emissions reductions only by developed (Annex I) countries. Therefore, they now say, the Durban Platform calls only for emission reduction commitments from the industrialized nations.

Bilateral negotiations between China and the US may be where real progress is eventually made

In the midst of this frustrating finger-pointing, there may be reason for cautious optimism – namely, bilateral discussions on climate change policy between China and the US. Such bilateral negotiations – possibly outside of the UNFCCC – may be where real progress is eventually made. If this happens, it will occur partly because of an emerging convergence of interests.

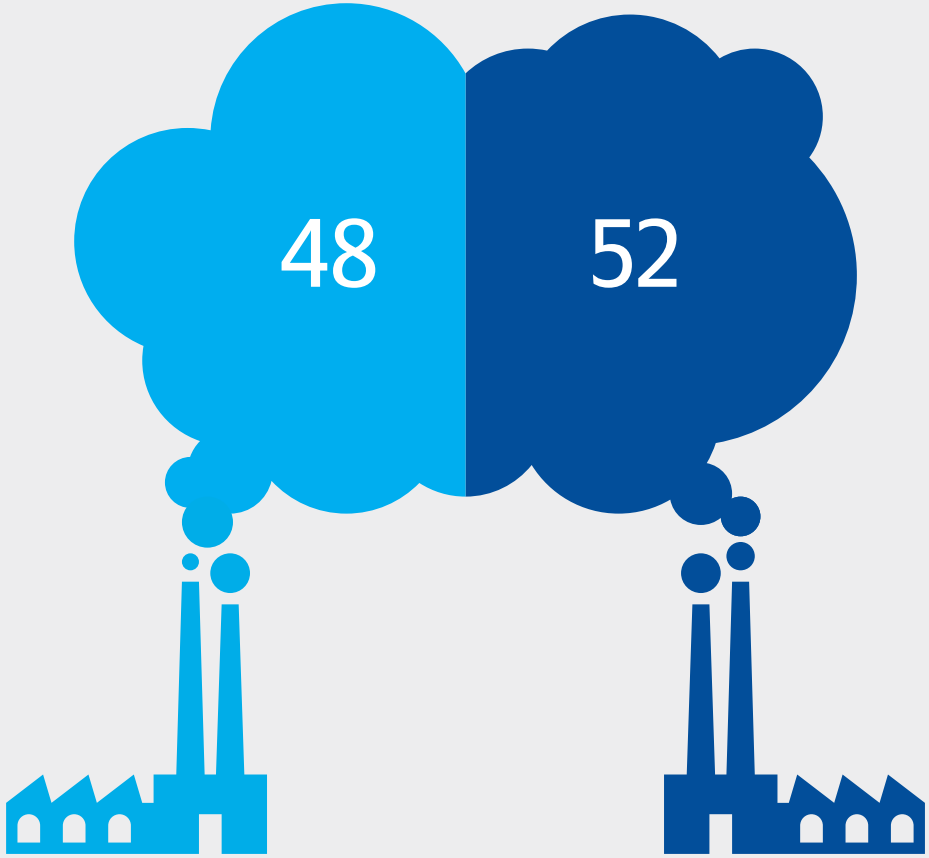
I The annual levels of CO_2 and greenhouse gas emissions of these two countries have converged. While US CO_2 emissions in 1990 were almost twice the level of Chinese emissions, by 2006 China had overtaken the US. These are the world's two largest emitters.

II Cumulative emissions are particularly important, because it is the accumulated stock of greenhouse gases in the atmosphere that cause climate change. Any discussion of distributional equity in the climate realm therefore inevitably turns to considerations of "historic responsibility".

Looking at the period 1850–2010, the US led the pack, accounting for nearly 19 per cent of cumulative global emissions of greenhouse gases; with the EU in second place at 17 per cent; and China third, accounting for about 12 per cent of global cumulative emissions (see figure 1.2). But that picture is rapidly changing. Emissions are stable to declining throughout the industrialized world, while increasing rapidly in large, emerging economies – in particular China. Depending on relative rates of economic growth, China may top all countries in cumulative emissions within 10 to 20 years.

Figure 1.2 Cumulative greenhouse gas emissions

Per cent of total emissions in 1850–2010



Developing countries
of which, in per cent of total:

11.6	China
4.8	Indonesia
4.1	India
3.9	Brazil
1.3	Mexico

Developed Countries
of which, in per cent of total:

United States	18.6
EU-27	17.1
Russia	7.2
Japan	2.8
Canada	1.9

Source: PBL Netherlands Environmental Assessment Agency

III Historically, China and the US have both relied mostly on coal for generating electricity – and both are trying to do something about it. At a time when US dependence on coal is decreasing (largely due to increased supplies of natural gas and hence lower gas prices), China continues to rely on this dirty fuel. But China's concern about the health impacts of local air pollution may lead it to wean itself away from coal.

Importantly, both countries have very large shale gas reserves. US gas output (and use for electricity generation) has been increasing rapidly, bringing down CO_2 emissions. Chinese exploitation has been constrained by available infrastructure – it lacks pipelines – but that will change.

IV Both countries have been moving forward with policies that explicitly address greenhouse gas emissions, and in both countries, these have featured sub-national, market-based policy instruments – in particular, cap-and-trade systems. In China, the government has launched local and regional CO_2 cap-and-trade systems in Shenzhen, Shanghai, Guandong, Beijing, Tianjin, Hubei, and Chongqing. In the US, California's ambitious AB-32 cap-and-trade system continues to make progress, while in the northeast, the Regional Greenhouse Gas Initiative is witnessing higher allowance prices due to the more severe targets recently adopted by the nine participating states.

Both China and the US have very large shale gas reserves, which can bring down CO_2 emissions

V CO_2 policy action is also immanent at the national level in both countries. In China, the government has stated its intention to link its local and regional CO_2 cap-and-trade systems together in a nationwide system. In the US, the failure in 2009 of meaningful carbon-pricing policy in Congress has led the Obama administration to turn to regulatory action, including its June 2014 announcement of proposed CO_2 regulations for existing power plants.

It is striking that, just as CO_2 emissions reductions in China are most likely to be achieved as a byproduct of policies targeting particulates and other local air pollutants, the Obama administration's economic analysis of its proposed CO_2 limits on power plants justifies the costs of those limits by appealing to the health benefits of reductions in correlated local air pollutants.

VI Finally, there is the reality of geopolitics. If the 20th century was the "American century", then many observers – including leaders in China – anticipate (or at least hope) that the 21st will be the "Chinese century", one of global leadership, not obstruction.

The path ahead

The political climate in the US presents its own challenges to progress. Indeed, it will take a great deal of dedicated effort – and profound luck – to find political openings that can bridge the wide partisan divide that exists on climate change policy and environmental issues more broadly.

Nearly all major US environmental laws were passed in the wake of highly publicized environmental events or disasters

Think about the following. Nearly all major US environmental laws were passed in the wake of highly publicized environmental events or "disasters", such as the spontaneous combustion of the Cuyahoga River in Cleveland, Ohio, in 1969, and the discovery of toxic substances at Love Canal in Niagara Falls, New York, in the mid-1970s. But the day after the Cuyahoga River caught fire, no press reports commented that the cause was uncertain, that rivers periodically catch on fire from natural causes. On the contrary, it was immediately apparent that the cause was waste dumped into the river by local industry. A direct consequence of the observed "disaster" was, of course, the Clean Water Act of 1972.

But climate change is distinctly different. Unlike the environmental threats addressed successfully in past US legislation, climate change is essentially unobservable to the general population. We observe the weather, not the climate. Until there is an obvious, sudden and perhaps cataclysmic event – such as a loss of part of the Antarctic ice sheet leading to a dramatic sea-level rise – it is unlikely that US public opinion will provide the tremendous bottom-up demand that inspired previous national action on the environment.

That need not mean that there can be no truly meaningful, economy-wide climate policy until disaster has struck. But it does mean that bottom-up popular demand may not come in time, and that instead what will be required is inspired leadership at the highest level that can somehow begin to bridge the debilitating partisan political divide.

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BOX 1

International climate talks: A short history of a long process

by Verena Treber

A truly global framework for climate protection

The United Nations Framework Convention on Climate Change (UNFCCC) is an international treaty that seeks to address climate change and its consequences. To date, 196 countries have signed this treaty. This universal membership ensures that decisions taken within the UNFCCC framework are regarded as legitimate by all nations, but it also makes working within this framework uniquely complex.

Every year, delegates from all the signatory countries meet at the Conference of the Parties (COP) to assess progress and discuss new greenhouse gas reduction targets. At the sidelines of the COP meetings, a growing number of activists, businesses, researchers and other groups are making their voices heard.

The UNFCCC's first success was the drawing up of national greenhouse gas inventories. Before that, countries simply had no common matrix with which