Curbing climate change

The actions that have done the most to slow global warming

***The Economist*, Sep 20th 2014**

ON SEPTEMBER 23rd 120-odd presidents and prime ministers will gather in New York for a UN meeting on climate change. It is the first time the subject has brought so many leaders together since the ill-fated Copenhagen summit of 2009. Now, as then, they will assert that reining in global warming is a political priority. Some may commit their governments to policies aimed at reducing greenhouse-gas emissions. What few will say is how many tonnes of carbon dioxide these will save—because they almost never do.

According to scientists, cutting carbon-dioxide emissions is an essential part of reducing catastrophic risks from climate change. Yet governments are persistently averse to providing estimates of how much carbon a policy saves. That may be because, in countries where climate change is controversial, it makes more sense to talk about the other benefits a scheme offers rather than its effect on carbon. Or it may be that, in countries which are enthusiastic about renewable energy, pointing out that it may not save that much carbon is seen as unhelpful. Or perhaps governments think climate change is so serious that all measures must be taken, regardless of cost (though their overall lacklustre record suggests this is not the case).

Whatever the reason, the end result is that while the world's governments have hundreds of policies for tackling climate change, some of them very expensive—China, America and the European Union spend $140 billion a year on subsidising renewable energy—it is hard to say which policies are having the greatest effect.

So *The Economist* has made a stab at a global comparison of carbon-mitigation efforts. Chart 1 is the result. It ranks 20 policies and courses of action according to how much they have done to reduce the atmosphere's stock of greenhouse gases. We have used figures from governments, the EU and UN agencies. As far as we know, this exercise has not been carried out before.

To slash or to trim

1

Emission reductions by policies/actions, bn tonnes CO_2 equivalent

Policy/Action	Cumulative emissions	Period	Annual emissions*
Montreal protocol[1]	135.0bn	1989-2013	5.6bn
Hydropower worldwide[2]	2.8bn	2010	2.8bn
Nuclear power worldwide[2]	2.2bn	2010	2.2bn
China one-child policy[3]	1.3bn	2005	1.3bn
Other renewables worldwide[2]	600m	2010	600m
US vehicle emissions & fuel economy standards†[4]	6.0bn	2012-25	460m
Brazil forest preservation[5]	3.2bn	2005-13	400m
India land-use change[6]	177m	2007	177m
Clean Development Mechanism[7]	1.5bn	2004-14	150m
US building & appliances codes[4]	3.0bn	2008-30	136m
China SOE efficiency targets[8]	1.9bn	2005-20	126m
Collapse of USSR[9]	709m	1992-98	118m
Global Environment Facility[10]	2.3bn	1991-2014	100m
EU energy efficiency[11]	230m	2008-12	58m
US vehicle emissions & fuel economy standards‡[4]	270m	2014-18	54m
EU renewables[11]	117m	2008-12	29m
US building codes (2013)[12]	230m	2014-30	10m
US appliances (2013)[12]	158m	2014-30	10m
Clean technology fund[13]	1.7bn	*project lifetime*	*na*
EU vehicle emission standards[14]	140m	2020	*na*

CATEGORIES:
Energy production
Transport
Other regulations
Global treaties
Land & forests
Other

See following panel for sources and explanations

*Annual emissions are cumulative emissions divided by the relevant period. The estimate for the current emissions avoided under the Montreal protocol is eight billion tonnes of CO_2e. The annual figure for the collapse of the USSR refers to the years 1992-98. †Cars and light trucks ‡Heavy trucks

First, a health warning: the policies and actions on our list are not strictly comparable. Some are global, some regional and some national. Some are long-standing; some new. A couple are not policies at all, such as the collapse of the Soviet Union, which led to the closure of polluting factories and to inefficient state farms reverting to grassland, locking up carbon.

And the numbers almost all come with caveats. It is fairly easy to estimate how much carbon a new field full of solar cells or a nuclear-power plant saves by looking at the amount of electricity it produces in a year and how much carbon would have been emitted if fossil fuels had been used instead, based on the local mix of coal, gas and oil. But as Paul Joskow of the Massachusetts Institute of Technology has pointed out, the standard “levelised” calculations, which divide the total amount of power a plant will produce over its lifetime by its total lifetime cost, are a poor way to compare fossil fuels and renewable energy.

Other measures have problems, too. Take the effects of fuel-efficiency standards. Would companies have curtailed their cars’ emissions anyway to sell more of them to cost- and mileage-conscious drivers? And how much has better fuel efficiency encouraged drivers to drive farther?

A further complication is that many policies have benefits beyond—or indeed closer to hand than—those they offer in terms of climate. Burning less coal saves lives in the near future as well as reducing climate risks in decades to come. Saving forests preserves wildlife, not just carbon.

So our table should be treated with caution. It is only safe to say that one policy is better than another in climate terms if it beats it by a wide margin.

As it happens, though, there are some very wide margins to be found. One policy stands head and shoulders above all others. And it is one that few people other than climate-policy specialists will have thought of in this context: the Montreal protocol, a 1987 agreement to phase out substances such as chlorofluorocarbons (CFCs) used in air conditioners,

refrigerators and so on. It was enacted to limit the damage such substances were doing to the ozone layer, a goal which it has achieved.

Like carbon dioxide and many other gases emitted by industry and agriculture—methane and nitrous oxide, for example—CFCs are greenhouse gases. And they are extremely potent ones, causing thousands of times more warming per molecule than carbon dioxide does. That means stopping CFC production, which was in the range of millions of tonnes a year, delivered a climate benefit equivalent to cutting carbon-dioxide emissions by billions of tonnes.

Collateral benefits

Guus Velders of the Dutch National Institute for Public Health and the Environment has compared the warming effect that would have come about if the emissions of such chemicals had continued to grow at the rate they were growing before the protocol with what has come about thanks to their banning. The net effect is equivalent to that of a whopping 135 billion tonnes of carbon dioxide. That is more than twice today's total annual greenhouse-gas emissions, which are equivalent to about 50 billion tonnes of carbon dioxide (carbon dioxide itself makes up about three-quarters of that, with methane, nitrous oxide and some gases used in industry making up the rest). Durwood Zaelke of the Institute for Governance and Sustainable Development, a think-tank, says that if CFCs were uncontrolled the annual figure would be 8 billion tonnes higher. The Montreal protocol has had nearly as big an effect as all the rest of our list put together.

Trailing some way behind the Montreal protocol is a small group of measures—not really climate policies—that have been responsible for avoiding between 4% and 7% of greenhouse-gas emissions. According to the International Atomic Energy Agency, nuclear power avoided the production of 2.2 billion tonnes of carbon dioxide in 2010—that is, emissions would have been 2.2 billion tonnes higher if the same amount of electricity had been produced by non-nuclear plants. Energy from dams and other hydroelectric sources avoided 2.8 billion tonnes (though emissions of methane from the reservoirs behind some of those dams mean the net effects were less than that). Between them they generated 6,000 terawatt-hours of electricity in 2011, compared with 450TWhrs for wind and less than 60TWhrs for solar. The high rate at which new wind and solar capacity is being built will eat into this lead, but it will take some time to overturn it.

The other item in this group is something of a cheat. In 2007 Su Wei of China's foreign ministry said that his country's one-child policy, by reducing the number of births between the late 1970s and the mid-2000s by 300m, had reduced carbon emissions by 1.3 billion tonnes in 2005 (because there were fewer people to consume goods which generated greenhouse gases in their production). Taking this argument further, one could say that the fall in global fertility since 1960 cut emissions even more. That is not exactly a climate policy. But it is a reminder that greenhouse gases are powerfully influenced by factors far beyond the scope of climate-change policies.

Three other lessons emerge. First, policies to slow or reverse deforestation are more important than one might expect. Trees absorb carbon as they grow and release it when they are cut down. According to a recent study in *Science*, declining deforestation in Brazil meant that the country produced 3.2 billion tonnes less atmospheric carbon dioxide between 2005 and 2013 than it would have if the tree-felling had continued unabated. That is 400m tonnes a year. The slowdown in deforestation in tropical countries is one of the reasons that the conversion of forests to farmland now accounts for only 11% of greenhouse-gas emissions globally, much less than 20 years ago.

The other reason for deforestation's dramatically reduced share of total emissions, though, is that industrial emissions of carbon dioxide have continued to grow rapidly. The rise is not as fast as it might have been. Rules that make vehicles more efficient and improve the

energy efficiency of buildings and appliances have done more than might be expected. America has been setting standards for vehicle greenhouse-gas emissions and fuel efficiency since the mid 1970s; the current rules are forecast to reduce carbon-dioxide emissions by 6 billion tonnes in 2012-25, meaning by about 460m tonnes a year. America's Department of Transportation reckons that overall such rules have reduced carbon-dioxide emissions by a cumulative 14 billion tonnes. Europe's equivalent regulations for passenger cars and light trucks do less (European vehicles were more efficient to start with) but are still respectable; being adopted by overseas manufacturers who want to sell cars in Europe gives them an unquantified extra clout.

Their time will come

New EU rules on the design of boilers and water heaters are expected to save 136m tonnes of carbon dioxide a year within six years. China's Development Research Centre and the World Bank say that on the basis of 2010 figures energy-efficiency targets for Chinese state-owned enterprises save about the same amount; that scheme has recently been much expanded.

Subsidies for solar and wind power do less than you might expect, considering the attention they receive. The European Environment Agency calculates that between mid-2008 and 2012, what it calls changes in the carbon intensity of energy (mainly, the rise in renewables) accounted for a third of the decline in carbon-dioxide emissions in the EU. Emissions fell 350m tonnes in that period, so renewable policies seem to be responsible for about 30m fewer tonnes of carbon dioxide a year, making them less effective than energy-efficiency measures.

This estimate may be low. A separate calculation by Germany's environment ministry puts the figure for Germany alone at 100m tonnes in 2012. But even if the EU estimate is only half what it should be, renewables would still fall short of other carbon-mitigation policies. They are also extremely pricey. The cost of Germany's *Energiewende* (its transformation to a renewables-based electricity system) is €16 billion ($21 billion) a year. The cost of helping developing countries phase out CFCs under the Montreal protocol was just $2.4 billion all-told from 1990-2010. The Amazon Fund, which has done much to fight deforestation in Brazil, has mostly been funded by the Norwegian government at a cost of just $760m over 11 years.

Over the next few years, the relative weights of all these policies will change. Nuclear energy is being phased out in Germany and may not recover to its pre-Fukushima heights in Japan. Although it is growing in China, its share of worldwide electricity generation—currently about a seventh—is likely to decline. The same may be true of hydropower. The share of solar and wind power, on the other hand, will rise as costs fall and capacity increases (installed capacity for these renewables doubled in 2012-14).

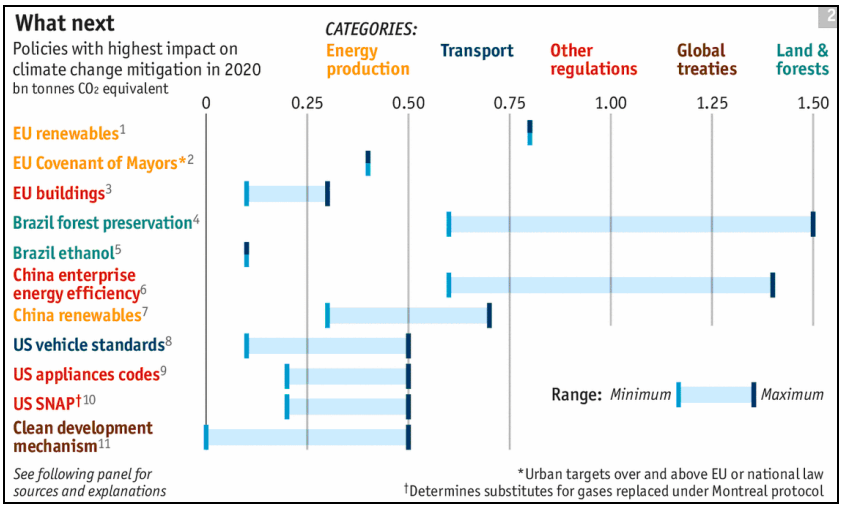
The Economist asked Climate Action Tracker, a group of scientists who study emissions policies and actions, to calculate the policies likely to have the biggest impact in 2020. Their findings, in chart 2, suggest that the influence of the EU's renewables regime will grow considerably, though Europe will still be far from the zero-carbon energy system greens long for. Chinese efforts to boost renewables and energy efficiency are also likely to start bearing a lot more fruit. So, they think, could the UN's Clean Development Mechanism (CDM), which finances greenhouse-gas reduction measures in developing countries to offset emissions in rich ones.

Much more to do

These estimates work on the basis of current policies. But one possible new measure would make a big difference. Hydrofluorocarbons (HFCs) are ozone-friendly replacements for CFCs, and are one of the fastest-growing greenhouse gases, having risen 40% since 1990. Emissions of HFCs are unrestricted, though CDM investments are used to reduce them in some cases. If the Montreal protocol were quickly amended to include them, says Mr

Zaelke, it might do almost as much for greenhouse-gas emissions in the next 35 years as it did in 1990-2010.

Saving the equivalent of some 130 billion tonnes of carbon dioxide so cheaply would be a big win. But it is still only a tenth of what would need to be done to ensure that the temperature in 2100 is no more than 2°C higher than it was at the time of the Industrial Revolution—the limit that the countries of the world have committed themselves to. Without the measures listed in chart 1 emissions might be equivalent to almost 70 billion tonnes of carbon dioxide a year, rather than 50 billion. But even the lower number is too high to meet the stated goal, and the overall trend is up, not down. World leaders gathering in New York are not only being vague about their climate policies. They are being dilatory, too.



Sources and explanations

Chart 1

1. UNEP, "The Montreal Protocol and the Green Economy" (2012) and "Growth of climate change commitments from HFC banks and emissions", by Velders G.J.M. et al. Atmos. Chem. Phys. Discuss. 2014.
2. "Climate Change and Nuclear Power, 2013", IAEA.
3. Reuters, August 30, 2007.
4. "The President's Climate Action Plan", Executive Office of the President, 2013.
5. "Slowing Amazon deforestation through public policy and interventions in beef and soy supply chains" by Daniel Nepstad et al. Science, June 2014.
6. "Deforestation Success Stories", Union of Concerned Scientists, 2014.
7. "Achievements of the Clean Development Mechanism", UN Framework Convention on Climate Change, 2014.
8. "China 2030", The World Bank and the Development Research Centre of the State Council, 2013.
9. Carbon Dioxide Information Analysis Centre.
10. GEF website.
11. "Why did greenhouse-gas emissions decrease in the EU between 1990 and 2012?" European Environment Agency, 2014.
12. White House Fact Sheet, May 9, 2014.
13. Climate Investment Funds Administrative Unit.
14. European Climate Foundation.

Chart 2

1. "Biennial Report 1" Table 1 Emission trends: summary, European Union, 2014.
2. "Biennial Report 1" Table 1 Emission trends: summary, European Union, 2014, and "The Covenant of Mayors in Figures", by A.K. Cerutti et al., 2013. Potential overlap with other EU policies.
3. "Biennial Report 1" Table 1 Emission trends: summary, European Union, 2014, and "Renovation Tracks for Europe up to 2050" by T. Boermans, K.Bettgenhauser, M. Offerman and S.Schimschar, 2012.
4. Government of Brazil, 2014. Assumes emissions in 2020 are at or below current levels.
5. "Ethanol and Bioelectricity", L.L. De Sousa and I. Macedo, 2010. Share for domestic use only.
6. China, 12th Five-Year Plan, 2011-2015, "The Race is on: China kick-starts its clean economy" by the Climate Works Foundation, 2011 and "Top-10,000 Energy-Consuming Enterprises Program", by the Industrial Efficiency Policy database, 2014.
7. "Analysis of current greenhouse-gas emission trends" by H. Fekete et al, Climate Action Tracker, 2013, and Ecofys, 2014.
8. National Statistics and "Assessment of climate and energy policies of major emitting countries" by M. Roelfsema et al., 2012.
9. "About the Appliance and Equipment Standards Program" by the Office of Energy Efficiency and Renewable Energy, 2014.
10. "Tracking Emissions and Mitigation Actions" by P. Hogan and A. Vasa, 2012 and US national statistics, 2014.
11. CDM Pipeline UNEP, 2014. Based on expected issuance in 2020 according to CDM pipeline, discounted for failure to issue, early shut down of projects and potentially inflated database.