MITIGATION AND HEALTH

Climate policy not so costly

Climate change mitigation can benefit human health by reducing air pollution. Research now shows that the economic value of health improvements can substantially outweigh mitigation costs, and that more flexible policies could have higher benefits.

Jonathan Buonocore

Policies and actions designed to mitigate climate change can also reduce the risks of asthma, heart attack, respiratory disease and even premature death. Even though these policies and actions are designed to reduce carbon emissions, as a side-benefit, or 'co-benefit', they can also reduce emissions that contribute to local and regional air pollutants such as ozone and fine particulate matter. Decades of research has shown that these pollutants are associated with health effects ranging from asthma exacerbation to premature death, and that they impose a substantial public health burden. Despite research showing that these benefits can be substantial, health co-benefits are rarely included in assessments of climate policies and mitigation methods[1]. Writing in *Nature Climate Change*, Thompson and colleagues[2] examine different policies for carbon mitigation in the United States, and find that the economic value of the human health benefits of the air quality improvements resulting from these climate policies are substantial and can offset or even exceed the costs of implementation.

Both climate change and the health impacts of air pollution are pressing societal issues. Worldwide, ambient air pollution is responsible for approximately 3.4 million deaths, making it the ninth-highest contributing risk factor to the global burden of disease[3]. In 2005, air pollution in the United States was attributed to between 130,000 and 320,000 excess cases of premature mortality, 180,000 non-fatal heart attacks, 150,000 hospitalizations for respiratory and cardiovascular disease, and other health impacts[4]. Additionally, climate change can cause reduced agricultural yield, increased severity and frequency of extreme weather events, and coastal flooding — all of which can have a direct impact on health in the form of food security and public safety[5].

Policies that mitigate climate change by reducing reliance on fossil fuels can also improve air quality by decreasing emissions of air pollutants such as sulphur dioxide, nitrogen oxides and primary fine particulate matter, or 'soot', along with their main goal of reducing emissions of carbon dioxide. In addition to policies, other efforts to reduce carbon dioxide emissions can benefit human health by improving air quality: personal choices, such as taking public transportation or cycling, business decisions to construct wind and solar plants, and efforts to increase energy efficiency of engines, appliances and electronic devices are all helpful in mitigating climate change and reducing air pollution.

KEVIN FOY / ALAMY

Policies designed to mitigate climate change, such as those that would regulate carbon dioxide emissions from vehicles, can also improve air quality and have important benefits for public health.

Recent research shows that the economic value of the health benefits associated with the displacement of fossil fuel energy with wind energy in the United States is approximately 60% higher than the Production Tax Credit, a federal subsidy for wind energy[6]. Also, the US Environmental Protection Agency's proposed Clean Power Plan to regulate carbon emissions from the electricity sector has health benefits, when put in economic terms, which exceed the estimated cost of implementation. These health benefits are approximately equal to the estimated climate benefits[7].

Thompson and colleagues[2] add to the growing body of literature connecting actions to mitigate global climate change with local and regional public health benefits. They simulate three different carbon policies in the United States that achieve a 500 million ton (about 10%) reduction in US carbon emissions in 2030, from a 2006 base year. Their simulations explore policy scenarios in which there is an economy-wide carbon cap-and-trade, a clean energy standard for electricity generation, and carbon reductions for cars and trucks. Using a set of advanced models to simulate the full pathway from policy, to economics, to changes in emissions, to changes in health, Thompson *et al.*

assessed the health co-benefits of these three policies and illustrated that they could range from 26% of the cost of the policy up to approximately ten times the cost of the policy. They also found that more flexible policies are much cheaper to implement, and therefore can have much larger net benefits.

The work by Thompson and colleagues underscores how policies and actions designed to reduce carbon emissions will not only help mitigate global climate change, but also directly benefit human health. This study and others[6–10] also demonstrate that existing models are robust enough to include health co-benefits through improved air quality in analyses of climate mitigation policies, and that they can be a vital component of the total benefits of these policies. Climate change is global and mitigation is long-term, whereas health improvements from decreased air pollution provide localized and more immediate benefits — an important issue from a policymaking standpoint. In other words, health benefits can occur in the same areas that are bearing the costs of the policy and within a timeframe more relevant for policymakers.

Future climate and health assessments can build on the work by Thompson *et al.*, and other analyses[6–10], to include additional elements, such as improvements in water quality or the health improvements from more active forms of transportation. This is possible using readily available scientific tools from public health and other fields. The co-assessment of health and climate benefits when evaluating policies is emerging as an important and powerful instrument to choose strategies that help achieve a high standard of human health and maintain a liveable climate, while still providing the energy necessary for the functioning of society today. Thompson and colleagues contribute significantly to the body of research that points a way forward to meet these goals. ❐

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References

1. Nemet, G. F., Holloway, T. & Meier, P. *Environ. Res. Lett.* **5,** 014007 (2010).
2. Thompson, T. M. *et al. Nature Clim. Change* **4,** 917–923 (2014).
3. Lim, S. S. *et al. The Lancet* **380,** 2224–2260 (2012).
4. Fann, N. *et al. Risk Anal.* **32,** 81–95 (2012).
5. IPCC Summary for Policymakers in *Climate Change 2014: Impacts, Adaptation, and Vulnerability* (eds Field, C. B. *et al.*) 1–32 (Cambridge Univ. Press, 2014).
6. Siler-Evans, K. *et al. Proc. Natl Acad. Sci. USA* **110,** 11768–11773 (2013).
7. *Regulatory Impact Analysis for the Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants* (US Environmental Protection Agency Office of Air Quality Planning and Standards Health and Environmental Impacts Division Air Economics Group, 2014).
8. Gilmore, E. A. *et al. J. Power Sources* **195,** 2405–2413 (2010).
9. Anenberg, S. C. *et al. Environ. Health Perspect.* **120,** 831–839 (2012).
10. Shindell, D. *et al. Science* **335,** 183–189 (2012).

OCEANOGRAPHY

Oxygen and climate dynamics

Low oxygen levels in tropical oceans shape marine ecosystems and biogeochemistry, and climate change is expected to expand these regions. Now a study indicates that regional dynamics control tropical oxygen trends, bucking projected global reductions in ocean oxygen.

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The subsurface ocean in the eastern tropical Pacific contains a large volume of water with very low dissolved oxygen (O_2) levels. Reduced O_2 in the ocean can exclude fish and other marine life that need O_2 for aerobic respiration and, at low enough O_2 levels, even alter key pathways of microbial biogeochemical cycling[1–3]. Historical observations indicate that the size of oxygen minimum zones (OMZs) around the world are growing with time[4], consistent with a global trend of ocean deoxygenation that has been linked to ocean warming and climate change[2,5]. Writing in *Science*, Curtis Deutsch and colleagues[6] argue the opposite, that the size of the eastern tropical North Pacific OMZ (Fig. 1) has been shrinking over a century timescale in response to weakening tropical trade winds and that this trend should continue in a future, warmer world.

Periods of climate warming are expected to reduce subsurface O_2 because of lower gas solubility in warm sea water and strengthened vertical stratification limiting the direct vertical exchange of oxygen[7]. Dissolved O_2 gas levels in the subsurface ocean reflect a balance between transport of freshly ventilated water from the surface and biological O_2 demand driven by the consumption of organic matter by microbes and animals. The main source of organic matter is plankton growth in overlying surface waters and the subsequent sinking of dead cells and fecal pellets into the ocean interior. Coastal upwelling along the eastern margins of the tropical Pacific, and other ocean basins, supplies a rich source of nutrients that supports some of the highest biological productivity (and therefore organic matter formation) in the ocean. In the tropical thermocline (an area with a sharp temperature gradient separating the warm surface waters and the cold deeper waters, found below the productive zone at 100–1,000 m depth) oxygen levels are already low because of the long pathways the waters have travelled since their most recent contact with the atmosphere in subtropical or temperate latitudes. Combined with the high stratification found in the tropics and high productivity, unsurprisingly this results in the formation of bands of very low oxygen waters.

Ocean field observations often span only the past few decades and can be heavily aliased by natural interannual and decadal climate variability. Proxy records are therefore critical for extending our time horizon back further in time to identify long-term anthropogenic trends. Deutsch *et al.*[6] use a new sediment-proxy reconstruction, a high-resolution time series of the nitrogen isotope content of