Why Not Geoengineering as Part of a 100% Wind-Water-Solar (WWS) and Storage Solution to Global Warming, Air Pollution, and Energy Security

In

Jacobson, M.Z., *100% Clean, Renewable Energy and Storage for Everything*, Cambridge University Press, New York, 427 pp., 2020
https://web.stanford.edu/group/efmh/jacobson/WWSBook/WWSBook.html

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3.7. Why Not Geoengineering?

Geoengineering is the large-scale alteration of the natural properties of the Earth or the atmosphere in an attempt to reduce global near-surface temperatures. The two primary categories of geoengineering that have been proposed are techniques to remove carbon from the air (**carbon capture techniques**) and techniques to increase the reflectivity of the Earth or its atmosphere in order to decrease sunlight hitting the Earth's surface (**solar radiation management** techniques).

Carbon capture techniques have already been discussed. These include fossil fuels with carbon capture (Section 3.2), bioenergy with carbon capture (Section 3.4), synthetic direct air carbon capture (Section 3.6), and natural direct air carbon capture (Section 3.6). These are geoengineering techniques because they are intended to reduce the amount of CO_2 in the air to modulate the Earth's average temperature. Of the carbon capture techniques, only natural direct air carbon capture is recommended in a 100 percent WWS world.

The main solar radiation management techniques that have been proposed include (1) injecting reflective aerosol particles into the stratosphere to reflect sunlight directly, (2) injecting fine sea spray particles into the air just above the ocean surface to increase the number and decrease the average size of cloud drops, thereby increasing the overall cross-sectional area of cloud drops to increase their reflectivity, and (3) installing white roofs or roads.

The first problem with all these techniques is that none reduces fossil fuel or bioenergy emissions of gases or particles that cause global warming and the 7.1 million deaths that occur annually (Table 7.13). To the contrary, with geoengineering, the public and policymakers become complacent, no longer feeling the urgency to reduce global temperatures or fossil fuel emissions. As such, pollutant gases and particles continue to cause damage and, in fact, increase due to the complacency.

Second, geoengineering temporarily masks some warming damage, but because long-lived greenhouse gases continue to accumulate, their growth requires even more investment in geoengineering to keep up with the increase in emissions. Any interruption or stoppage of the geoengineering results in an immediate worsening of the climate problem compared with prior to starting the geoengineering because of the increased accumulation of CO_2e emissions during the period of geoengineering.

Third, since geoengineering does nothing to stop air pollution, air pollution mortality and morbidity continue to occur without abatement compared with no geoengineering. Such health impacts worsen if complacency allows more fossil fuel and bioenergy combustion.

Fourth, since geoengineering does not reduce fossil fuel or nuclear use, it does nothing to help reduce energy insecurity associated with those energy sources (Section 1.3).

Fifth, if the money spent on geoengineering were spent instead on WWS, not only would the WWS eliminate CO_2e emissions, but it would also eliminate air pollution emissions and resulting mortalities and morbidities, mining for fossil fuels and uranium, and energy insecurity. As such, geoengineering is an opportunity cost compared with WWS.

A sixth problem with all the proposals is the unintended consequences. For example, reducing solar radiation to the land reduces crop yields, which can result in starvation in some parts of the world. Injecting aerosol particles into the stratosphere catalyzes ozone loss in the presence of halogens currently in the stratosphere. Injecting particles into the stratosphere or into the air above the ocean results in changes in weather patterns. Injecting particles into marine air also increases the concentration of particles entering populated coastal cities, increasing morbidities and mortalities from air pollution. Particles injected into the stratosphere ultimately deposit to the ground, increasing air pollution health and acid deposition problems as well.

An example of the possible unintended consequences of a geoengineering proposal is the potential impact of white roofs and roads on global climate. Although white roofs and roads reflect radiation, cooling buildings and the ground in cities locally, they may cause large-scale global warming (Jacobson and Ten Hoeve, 2012).

The first reason is that, because white roofs cool the ground locally relative to the air, they reduce the ability of air to rise, thus clouds to form. Since clouds are reflective, reducing cloudiness increases solar radiation to the surface. This increase may be greater than the decrease resulting from white roofs and roads, especially since clouds travel and spread beyond a city, so reducing clouds over a city has the impact of increasing solar radiation reaching the ground outside of the city.

Second, black and brown carbon in the air absorb sunlight, then convert that sunlight directly to heat, which is released to the air. In the presence of white roofs or roads, black and brown carbon absorb not only downward sunlight but also sunlight reflected upward by the white surfaces.

Finally, while white roofs cool buildings, thereby reducing air conditioning energy requirements at low latitudes and during summers, the cooling increases heating energy requirements at high latitudes and during winters. In many places worldwide, heating requirements exceed cooling requirements, so adding a white roof to a building simply increases fossil fuel use to heat buildings more.

A better solution than using a white roof is to install solar PV panels on a rooftop. The primary purpose of installing a PV panel is to generate electricity; however, panels also have several side benefits. Not only does a rooftop PV panel remove 20 percent of incoming solar radiation, converting it to electricity and cooling the underlying building, but the electricity it produces also displaces fossil fuel use and its emissions. The reduction in solar radiation due to a solar PV panel results in a negative anthropogenic heat flux (Section 3.2.2.2) thus a negative carbon-equivalent emission (CO_2e) (Table 3.5). In addition, because solar panels do not reflect solar radiation upward as white roofs do, solar panels don't allow absorption of upward reflected sunlight by black and brown carbon pollution particles. Similarly, because PV panels are warmer than is a white roof, PV panels don't increase air stability thus don't reduce cloudiness like white roofs do.

In sum, geoengineering through carbon capture is not recommended, with the exception of natural direct air capture by trees and reducing deforestation (NDACCS). Geoengineering through solar radiation management techniques is also not recommended. However, the use of rooftop PV panels, which reduce rooftop temperatures in addition to displacing fossil fuel electricity, is recommended as part of a 100 percent WWS energy infrastructure. Similarly, wind turbines not only displace fossil fuel emissions, but they also help to reduce globally averaged temperatures (Section 3.2.2.3, Table 3.5).

Reference

Jacobson, M.Z., and J.E. Ten Hoeve, Effects of urban surfaces and white roofs on global and regional climate, *J. Climate*, *25*, 1028-1044, doi:10.1175/JCLI-D-11-00032.1, 2012.