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To whom it may concern,

I am a Professor of Civil and Environmental Engineering at Stanford University with 35 years of experience examining the impacts of natural and human emitted gases and particles, including from transportation, industrial, and electricity-generating sources, on climate, stratospheric ozone, urban air pollution, and human health. I have published over 185 peer-reviewed papers and 6 educational books. Among the topics I have studied is geoengineering. Below is an excerpt from my recent book, "*No Miracles Needed*," on the topic of geoengineering. This excerpt reflects my expert opinion on the topic. Based on this opinion, I strongly urge you to prohibit the use of solar radiation management as a method of addressing climate; instead, I urge a focus on eliminating air pollutant and climate-relevant gas and particle emissions by electrifying all energy sectors (transportation, buildings, and industry) and providing the electricity from clean, renewable sources, namely wind, solar, geothermal, and hydroelectric sources.

Section 8.10 of N*o Miracles Needed*

"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 are geoengineering techniques because they are intended to reduce the amount of carbon dioxide 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 wind-water-solar (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 seven million deaths per year. 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.

Second, geoengineering may temporarily mask some warming regionally. However, because long-lived greenhouse gases continue to accumulate with geoengineering, even more investment in geoengineering is needed to keep up with the increase in emissions. Any interruption or stoppage of the geoengineering results in an immediate worsening of the climate problem because of the accumulation of even more greenhouse gases during the period of geoengineering.

Third, since geoengineering does nothing to stop air pollution, death and illness continue to occur without abatement compared with no geoengineering. Such health impacts worsen since complacency allows more fossil fuel and bioenergy to be burned. Health problems may also worsen due to the particles injected into the atmosphere to assist with the geoengineering. Such particles, when breathed, are harmful for health.

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

Fifth, if the money spent on geoengineering were spent instead on WWS, not only would WWS eliminate greenhouse gas emissions (thus reduce temperatures, as geoengineering does), but WWS would also eliminate air pollution emissions, death and illness resulting from the air pollution emissions, mining of fossil fuels and uranium, and energy insecurity. As such, geoengineering is an opportunity cost compared with WWS.

A sixth problem with geoengineering is its unintended consequences. For example, reducing sunlight reaching the ground reduces crop yields, which can cause starvation in some parts of the world. Injecting aerosol particles into the stratosphere catalyzes stratospheric 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 increases the concentration of particles entering populated coastal cities, increasing death and illnesses from air pollution. Particles injected into the stratosphere ultimately deposit to lower levels and the ground, increasing air pollution health and acid rain problems as well.

An example of the 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.

The first reason is that, because white roofs cool the ground relative to the air locally, they reduce the ability of air to rise, thus clouds to form. Since clouds are reflective, reducing cloudiness increases sunlight to the surface, offsetting some of the reduced sunlight to the surface caused by the white roofs. However, since clouds travel and spread

beyond a city, their reduction increases sunlight reaching the ground and temperatures outside of the city.

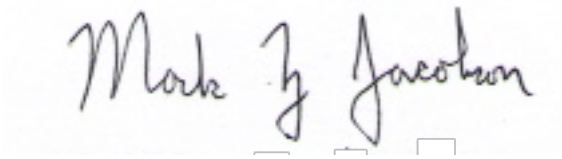
Second, black and brown carbon pollution particles in the air absorb sunlight, then convert that sunlight directly to heat, which is released to the air. In the presence of white roofs or roads, black and brown carbon absorb not only downward sunlight but also sunlight reflected upward by the white surfaces,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

Finally, whereas white roofs cool buildings thus reduce air conditioning energy requirements at low latitudes and during summers, their reflectivity increases heating requirements during winters. In many places worldwide, heating requirements exceed cooling requirements, so adding a white roof to a building simply increases the fossil fuel use required to heat the building.

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 do rooftop PV panels remove 20 percent or more of incoming sunlight, converting it to electricity and cooling the underlying building, but the electricity they produce also displaces fossil fuel use and its emissions. In addition, because solar panels do not reflect sunlight upward as white roofs do, solar panels do not allow absorption of upward reflected sunlight by black and brown carbon pollution particles. Similarly, because PV panels are warmer than a white roof, PV panels don't increase air stability thus don't reduce cloudiness like white roofs do.

In sum, with the exception of natural direct air capture by trees and reducing deforestation, geoengineering is not recommended in a WWS world."

Sincerely,



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