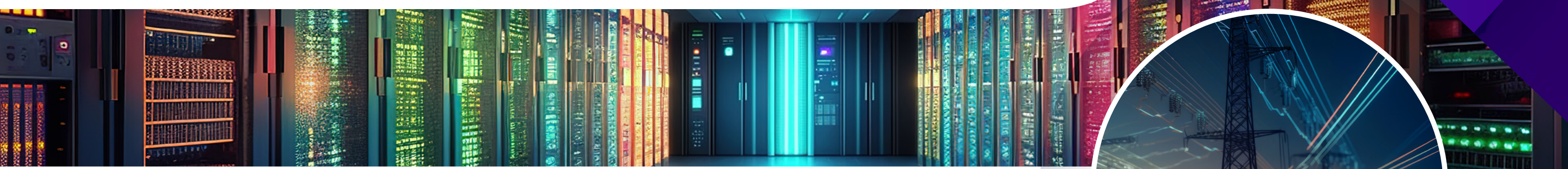

Solar Geoengineering

Technology Innovation Spotlight

Key Takeaways

Solar geoengineering encompasses a range of proposed interventions that could reduce the impact of climate change by altering the amount of heat trapped within the earth's atmosphere.

Recent developments have encouraged researchers to consider SG as a potentially feasible solution to climate change. However, proposed methods face scrutiny because of ecological, geopolitical, and ethical concerns.

Bodies such as the United Nations, European Union, and White House Administration are calling for an increase in research and modeling, which includes the feasibility and benefits of implementation as well as analysis of associated risks.

Next Steps

EPRI is monitoring solar geoengineering developments as well as potential impacts implementation could have on electricity generation and demand.

What Is Solar Geoengineering?

Heat radiated by the sun reaches the earth as shortwave (ultraviolet [UV]) radiation. The earth's albedo is approximately 30%, which means it absorbs 70% of incoming radiation. This heats the earth and is reemitted as long-wave (infrared [IR]) radiation. A portion of this radiation is trapped because of a type of internal albedo, causing the greenhouse effect. Anthropogenic emissions have enhanced this effect, resulting in global warming.

Solar geoengineering (SG) aims to reduce this warming by altering the amount of heat trapped in the earth's atmosphere. Most methods attempt to increase the proportion of incoming radiation reflected (albedo enhancement); however, several aim to reduce the greenhouse effect by allowing more heat to emit from earth. Some methods replicate natural processes such as the cooling effect of volcanic emissions, solar eclipses, or periods of low solar activity.

April 2022	February 2023	June 2023	July 2023
News of U.S. startup **Make Sunsets'** testing of stratospheric aerosol injection (SAI) in Mexico is released.	The **UN Environmental Program** releases a report calling for regulation of solar geoengineering testing.	Both the **U.S. presidential administration and the European commission** release publications discussing solar geoengineering. The U.S. publishes a research plan and governance framework, the EC statement opposes deployment.	**NCAR** launches a new supercomputer, Derecho, capable of advanced atmospheric modeling. One of the first planned projects involves investigating solar geoengineering. Articles in *Science* link increasing ocean temperatures with 2020 IMO emissions regulations.

Recent Developments

Interest in SG has been growing—in both academic and government spaces—and the number of publications discussing SG has almost tripled since 2014. Because the impacts are not fully understood, there has been an increase in regulation. For example, recent small-scale commercial deployments have prompted research institutes and governmental bodies to publish statements on SG policy and research goals, such as the National Research Council, which expressed concern about technical capabilities being much more advanced than understanding of potential consequences.

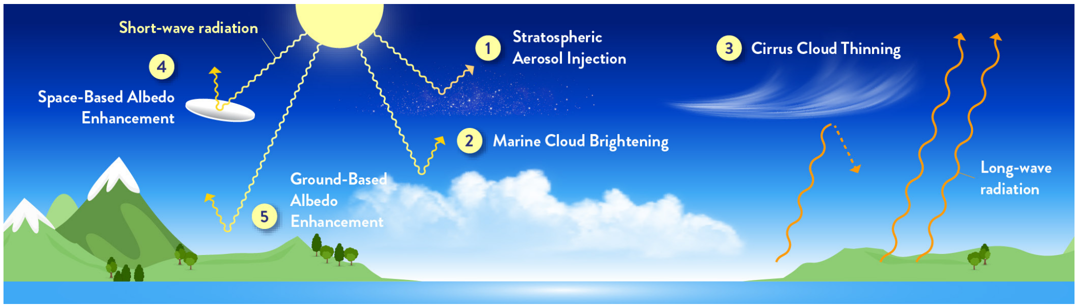

Figure 1. *A selection of commonly discussed and researched proposed methods of solar geoengineering*

Proposed Methods

1. **Stratospheric aerosol injection (SAI):** Small particles are injected into the upper atmosphere using balloons, airplanes, or rockets. The particles could be extremely effective at scattering incoming radiation but would need to be reinjected every one to two years.

2. **Marine cloud brightening (MCB):** The concentration of marine boundary layer clouds is increased through cloud seeding. This method is possible on approximately 10% of the earth's surface and would provide local cooling only.

3. **Cirrus cloud thinning (CCT):** This method reduces the concentration of high-altitude cirrus clouds. These clouds reflect longwave (IR) radiation back toward the earth, so a reduction would allow the emission of more heat.

4. **Space-based albedo enhancement:** This involves installing sunshields or refractive lenses between the sun and earth to reduce the proportion of sunlight reaching the earth. Although this method is attractive because of controllability and reversibility, the required scale and timeline of mobilization reduce feasibility.

5. **Ground-based albedo enhancement:** This method increases ground albedo by painting surfaces, growing more reflective crops, or covering surfaces with reflectors. The method would have few atmospheric effects; however, it would require a large footprint to be effective.

Potential Concerns

Although solar geoengineering has huge potential to reduce the extent of global warming, several ecological, political, and ethical concerns have prevented widescale implementation:

1. **Ecology:** Methods that involve the release of chemicals (SAI, MCB, CCT) could have widespread effects on the environment. Changes to atmospheric chemistry could affect precipitation patterns, reduce the ozone layer, or alter stratospheric dynamics. Those that reduce inbound sunlight could have significant effects on human and animal welfare as well as agricultural production.

2. **Geopolitics:** The risk of nations unilaterally implementing solar geoengineering or experiencing nonuniform adverse results has led to hesitation to explore these methods. There are also concerns that some techniques could be manipulated for military uses, such as targeted weather modification (although this is prohibited by the UN ENMOD convention).

3. **Ethics:** Many of the potential adverse effects of solar geoengineering are concentrated on low-income regions near the equator and in the tropics. With research publications currently concentrated in high-income countries, the views of those potentially most affected risk being overshadowed. Finally, successful SG efforts could reduce motivations to reduce greenhouse gas emissions, potentially leading to permanent "lock-in" to geoengineering.

EPRI CONTACT

POORVI PATEL, *Manager Strategic Insight*
704.2324551, ppatel@epri.com

For more information, contact:

EPRI Customer Assistance Center
800.313.3774 • askepri@epri.com

3002028002 August 2023

EPRI

3420 Hillview Avenue, Palo Alto, California 94304-1338 USA • 650.855.2121 • www.epri.com