

# GSA TODAY

 THE GEOLOGICAL SOCIETY  
OF AMERICA®

VOL. 30, NO. 2 | FEBRUARY 2020

## The Future for Geoscience in the Context of Emerging Climate Disruption



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I speak to climate disruption, the result of the most sweeping tragedy of the commons, when nations use a resource owned by none, in this case the atmosphere (Hardin, 1968), and then individually degrade it to achieve individual advantage. The tragedy of the commons originally referred to common

pastures where farmers would graze their animal stock. When each farmer incrementally added more animals—thinking nothing bad would happen—the pasture failed. Much as humanity has incrementally added greenhouse gases to our collective atmosphere.

Sadly, I see no evidence that most nations releasing greenhouse gases will make the necessary economic and political decisions to prevent at least a two-degree increase in average tropospheric temperature—a temperature beyond which severe climate disruption will almost certainly affect our way of life and the survival of many, if not most, current ecosystems (e.g., Knutti et al., 2016). Large swaths of our planet will suffer hell or high water or both.

Hypothetically, of course, humanity could scale up and generate sufficient green energy by covering hundreds of thousands of square miles in the world's major deserts with solar panels and then retooling up our electric grids. Landscapes would be created filled with solar panels and turbines as far as the eye could see, like cornfields in Iowa. Here in the United States, we'd cover an area equivalent to at least two states and globally, the area of a medium-sized country. You just have to look at the figure at <https://ourworldindata.org/energy-production-and-changing-energy-sources> to see how far we have to go. Historically, it takes about three decades for a new energy to replace even 20% of what was used prior. How can we possibly go renewable globally (the operative word to make a difference) given this historical reality?

In addition, humanity will also have to develop orders-of-magnitude more electrical storage capacity and find and mine up to ten times more rare elements than we now get from open pits or playa lakes to do the green energy. Humanity already has mined out the easy elements to find. Where will the rest come from?

We also may have to remove greenhouse gas from the atmosphere too. Think of this—another huge energy demand on top of the rest!

It's mind-boggling to me that this can be done in the next few decades.

There are other options to go green beyond solar and wind. We could build out large numbers of twenty-first-century modular modern nuclear power plants, perhaps fueled by thorium. Much safer nuclear than before constitutes a reality now. The technology of the three reactors (out of about 450 reactors) worldwide that critically failed because of gross human error or mega-earthquakes has long gone.

We could also add hydrogen-based energy to our energy portfolio, or miraculously discover a brand-new energy source that can be tied to the current grid. But given the time to do this, I find the odds are long to globally accomplish this task.

Why? Because of the toxic mix of modern nationalism, environmentalism unwilling to accept technological changes in energy and food production, a western public unwilling to understand absolute risk or accept economic inconvenience, and poor nations who logically want to have good health and opportunities like us.

Does anyone really think that hydrocarbons and coal will globally disappear as fuels? That poorer nations with these resources will not exploit them to help their economies? Does anyone think when Venezuela once again becomes a viable country it will not exploit the biggest economic resource it has—Maracaibo Basin crude? Or, that other nations will not buy what we here in America don't use and at lower prices?

My consulting partner Ed Hinchey (also a GSA member) tells me that using fossil fuels constitutes a zero-sum game. Globally, oil and gas may very well be used to the very last drop, like coffee in the Maxwell House advertisement. I sadly have to agree with him. The future energy demand remains that great, and fossil fuels are the densest energy source next to nuclear.

Please understand, I am not suggesting we abandon “going green.” I repeat. I am not suggesting that we abandon going green with solar and wind. Far from it. Humanity globally needs to build out solar and wind to the extent that identified natural resources, economics, and politics allow us to do it. Globally. That is the problem. Globally. How can that be done fast and efficiently today to replace fossil fuels? And be politically and economically acceptable.

I have to conclude that until climate disruption seriously affects large swaths of economically well-to-do populations, little will be done at the scale needed to make a global difference—I repeat—at the scale needed. The global scale (I am purposely being redundant). It will not work at the village scale. Villages and towns can't solve the problem because most of the world's population lives in giant megacities that need continual baseline uninterrupted power.

Adapting to environmental disruption and trying to go green as best we can will be humanity's best hope for our future. By adaptation I mean developing new science and engineering technology designed to build extensive wetlands, dikes, and other ways to attenuate floods; new regional water delivery systems and desalination plants; genetic advances designed to grow plants under stressful climatic conditions; and extensive exploration for rare elements and then extracting them with attendant additional environmental cost—perhaps even from the ocean floor.

I also see experiments in the near future on how to best place aerosols into the high atmosphere to reflect sunlight. The National Academy of Sciences (NRC, 2015) suggested we should begin these experiments sooner than later because geoengineering the atmosphere will be humanity's last resort. Technically geoengineering the

atmosphere seems remarkably easy and inexpensive, but the uncertainty of what regionally will happen with the climate will remain large without small-scale experimentation first.

To this end, I suggest that GSA's Environmental & Engineering Geology Division, Energy Geology Division, Geology and Society Division, and Hydrogeology Division, at the very least, could put GSA in a leadership position with respect to developing climate adaptation strategies. They could begin to offer sessions on it at meetings or organize Penrose Conferences. I urge them and other GSA Divisions to consider taking on this challenge individually or collectively.

If GSA does not, I guarantee that other societies and disciplines will quickly rise to the challenge, possibly to poorer success. I especially urge geoscientists beginning their careers and those in mid-career to reflect how they could participate in future adaptation ventures—even if they don't like the idea, don't want to hear about it, or think nobody can predict the future. Maybe.

But I hereby predict that climate disruption will continue to worsen in the next 20 years, well beyond the two-degree centigrade threshold. I am 72 years old. The last twenty years roared past me—like a finger snapping. Thirty years from now, those of you in your twenties will be in mid-career. Snap. Those of you approaching retirement will be... well, I'll let that one slide.

To those of you who disagree with me, I welcome emails or messages to me on Facebook, Twitter, Instagram, LinkedIn, even stamped letters that scientifically counter what I say. But please base your comments on the combination of observable scientific, social, and political facts and trends—not wishes and hopes that doing the right thing by incrementally going green, changing how people in the west consume, or miraculous discoveries will solve the problem. There remains too little time for hoping, wishing,

incremental change, and placing bets on miraculous discoveries or large masses of people choosing large-scale sacrifice for the betterment of humanity and the environmental worldwide. History tells me these will not happen.

To end my talk, I propose a set of environmental freedoms, extensions of the four freedoms that President Franklin Roosevelt gave to America during World War II, another time of existential threat to our way of life.

First, I propose the freedom from recurrent extreme climate-driven disasters—not all climatic harm—just extreme harm.

Second, I propose the freedom from worrying we won't have reasonably clean and safe water, air, and food. Reasonably. Not perfectly.

Third, I propose the freedom from losing environments we cherish. Not everywhere, but in places we collectively choose. I frankly wonder if this freedom can be met—even theoretically—given the rising pace of ecological disruption from climate change.

Finally, I propose the freedom from worrying that the necessary additional environmental harm and economic sacrifice needed to achieve the first three freedoms will not be made in vain.

Four environmental freedoms for our future. From my lips—perhaps to our politicians' ears.

Thank you very much.

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