

# THE PINEBANK ASSESSMENT:

## How we can still save the planet

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The Climate War has to be waged on four fronts to give us a fair chance of victory, that is to say of avoiding existential climate harm.

The First Front is called achieving Net Zero Emissions (NZE). Now, we could have won the war **if** we had moved decisively on this last century. We did not! The IPCC, the Intergovernmental Panel on Climate Change, has recently recognised that, now, reducing Greenhouse emissions to zero, even if achieved today, will **not** be sufficient to avert the crisis. As well, they say we will need to do considerable Greenhouse Gas Removal (GGR). This is the Second Front. However, a paper by Prof. Jim Hansen et al. that is about to be published conclusively indicates that both NZE **and** GGR would still **not** be sufficient to avoid existential damage because the IPCC advice to decisionmakers **still** has not factored in the slow, or in pipeline, effects of past emissions and warming.

Only two, new fronts are available to be developed and deployed. One, the Third Front, is called Solar Radiation Management (SRM), which includes methods designed to reflect more sunlight from warming the planet. The other, the Fourth Front, is called Thermal Radiation Management (TRM), which includes methods such as those which increase evaporation or transpiration, the water vapour condensing from which at altitude releases heat that can then radiate off-planet.

It is **only** the SRM and TRM methods that could cool the planet fast enough to allow the slower-acting NZE and GGR methods time to provide a long term solution.

The inventions that I and my colleagues have been working on apply to all four battle fronts. As there are many inventions, I will focus on just four. Typically, each is designed to have net beneficial effects on more than one front. However, as SRM and TRM are the most urgent methods to be investigated, developed, approved, and deployed, I will concentrate on these.

Taking SRM effects first, these can be applied at several altitudes and depths. Omitting space-based methods, which I regard as typically being either too costly, too risky or taking too long, the highest level is that of the stratosphere. The most discussed method for this is Stratospheric Aerosol Injection (SAI) that proposes emitting, typically, sulphur dioxide gas that transforms into highly-reflective aerosols of sulphuric acid. This method is likely to be relatively cheap, but in my mind is too risky and uncontrollable. Moreover, if **ever** it stopped, our climate problems would probably become **much** worse.

The next level down is the troposphere, where spraying droplets of seawater of appropriate size into the air can form short-term, readily-controllable and highly reflective droplets or particles of fog, marine cloud, and sea salt aerosol. Several methods have been designed to do this, but few have been tested. My own variant is

called Seatomisers, which is a condensation of seawater atomisation. This uses offshore wind turbine power to power banks of modified, commercial spray nozzles on floating masts that spray droplets of selected size ranges at different heights. The lowest yard on each mast supports the bank of nozzles designed to humidify the air in strong winds, to provide reflective sea fog, and to deposit the leftover brine back into the sea before the plume reaches land. The second yard up does the same in lighter winds. The third up yard carries flat-fan nozzles of which the spray is conditioned by baffles to remove the larger droplets, leaving behind droplets and sea salt crystals of sizes suited to act as condensation nuclei for subsequent precipitation at selected distances far downwind. The fourth and highest yard may contain vessels from which tiny amounts of iron salt aerosol (ISA) can be sublimated in order for them to destroy atmospheric methane and smog photo-catalytically.

The next level below the troposphere is the sea surface. This can be brightened by several means. One of my inventions is designed to thicken sea ice such that it becomes virtually permanent and could be securely grounded in water hundreds of metres deep. This method could help refreeze the polar and some sub-polar regions, leaving open the sea lanes and polynyas that we choose. This method is called Ice Shields. The low-lift pumping it requires also uses renewable energy from floating wind turbines, but ones and satellite pumping stations that are cold-adapted.

The second method I propose for brightening the ocean surface instead uses solar photovoltaics to power each unit. These units are lightweight, floating cones of around table size, called Fiztops. These are designed to inject reflective, but invisibly-small, long-lived (months) nanobubbles into the sea surface microlayer.

The three methods, Seatomisers, Ice Shields and Fiztops are also designed to generate TRM benefits, as all increase the evaporation of relatively-warm seawater, so that when the water vapour it produces condenses as rain, hail or snow, ocean heat is released at substantial altitude and extreme weather events are mitigated.

The fourth method designed to increase ocean brightness is also, conceivably, our best method for helping rapidly to cool the planet **and** of sequestering carbon cheaply and relatively safely in the ocean depths **and** of regenerating the marine biosphere that we have progressively been destroying over the past few centuries. This is called Buoyant Flake Ocean Fertilisation. Used in complement with selected methods for NZE, GGR, SRM and TRM, this represents our best way out of the climate crisis hole that we have, largely-unwittingly, dug for ourselves.

Buoyant Flakes are designed to work similarly to how dust storms and volcanic eruptions have nutrified the nutrient-poor surface waters that are typically far from the nutrient-rich runoff from continental land masses – but more gently, effectively and continuously. The method uses what are the renewable or waste materials of rice husks, finely-divided mineral wastes, and lignin ‘glue’ generated by treating cereal stalks with something like the Organosolv process that breaks lignocellulosic material down into its component sugars and lignin powder binder. Aerated by leavening, the buoyant flakes should last for about a year on the ocean surface whilst they release their contained nutrients ultra-slowly, thereby causing devastated green phytoplankton concentrations to increase and hence to provide the main basis for a diverse and prolific marine ecology. It is thought that the additional

phytoplankton resulting from global, buoyant flake dissemination over several years could result in sufficient ocean brightening as to first halt, and then reverse, somewhat more than the current level of global warming – when accompanied by other selected, restorative methods.

Methods to address global warming and ocean restoration need to meet several criteria. Chief of these are scalability, cost-effectiveness, and risk-to-risk management concerns. After these key requirements are a host of other criteria, including timeliness, equity, and public acceptance. Happily, my estimate is that these four methods may be shown by others more capable to meet **all** key requirements - **if** deployed expeditiously, at scale, and before too many other tipping points are surpassed by too much, as well as meeting many, merely-desirable criteria.

Thanks. Any questions?