MORE CLIMATE SOLUTIONS

Sev Clarke, May 2022

Contents

INTRODUCTION

Current investment to address climate change is focussed mainly on the mitigation of further greenhouse gas emissions by a wide variety of means and a handful of technologies, most of which are designed to extract carbon dioxide from the air and to either to sequester it geologically or to turn it into biomass or useful products. This handful includes Direct Air Capture (DAC) using machinery, Bioenergy with Carbon Capture and Storage (BECCS), and various forms of Afforestation. Even with some likely improvement in cost over time, most reputable analyses indicate that all three will suffer from showstoppers in the form of one or more of: scalability, cost, insufficient resource, timeliness, or risk of reversal under increasing global warming. In addition, none *directly* addresses the problems of other greenhouse gases, of solar or thermal radiation management, of ocean acidification and stratification, of species and habitat loss, of ice loss, of increasingly extreme weather events, of sea level rise, of passing tipping points, and of the long-term effects of prior emissions, land clearing, pollution, and ecological impoverishment.

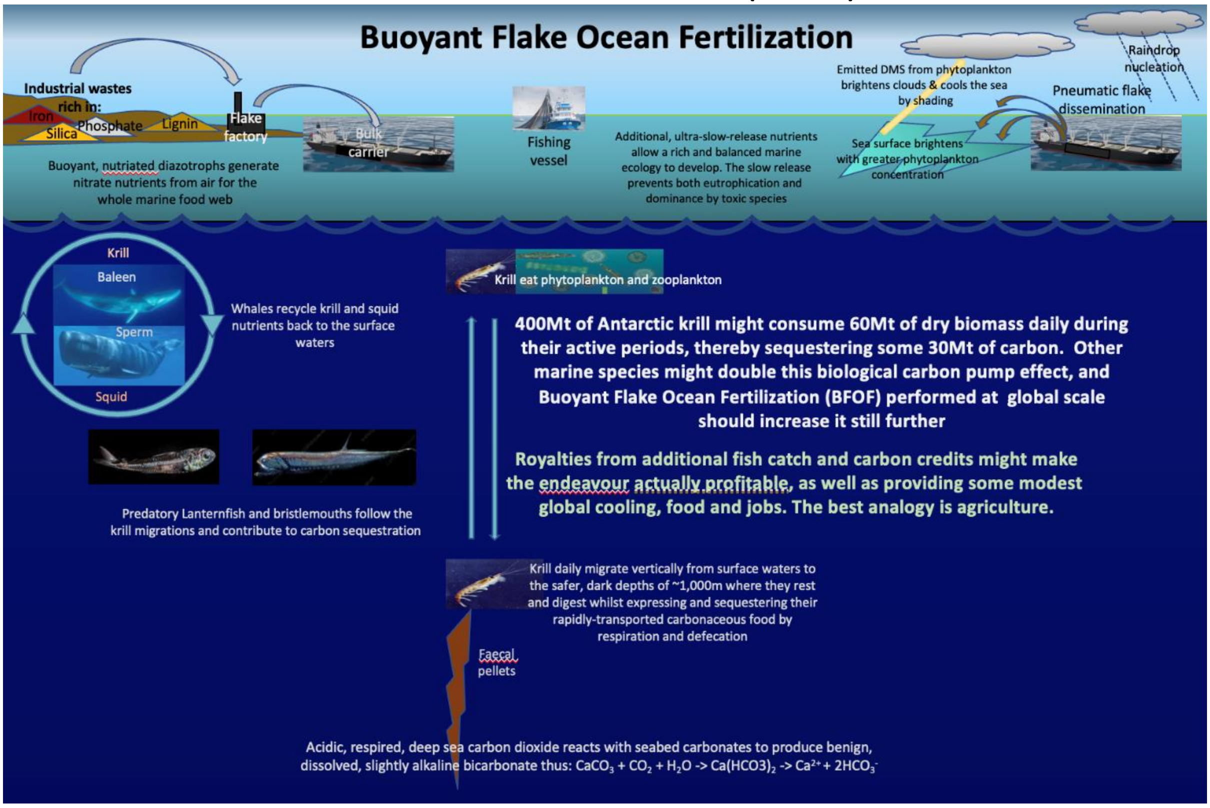
OFFER

What is offered below are sixteen conceptual methods, the combination of which addresses both carbon dioxide removal (CDR) and the above other problems in different ways. Most require validation, modelling, gated testing and approval prior to deployment. Whilst research is being undertaken at various organisations to develop, quantify, model, test and validate some of them, all such concepts that appear to have prospect need to be evaluated and compared. As well, all should be assessed for their potential cost-effectiveness, their effects, scalability, risk-to-risk profile, optimal interaction, measurability, reversibility, and community acceptability. Readers are requested to see how they might contribute to these efforts.

Each concept will be given a short description. Its key functions will be outlined, as well as the innovation dependencies on which it depends. Attached to it may also be a summarising graphic and/or document where that is short enough to be digested quickly. Longer, supporting documentation is available on request for most of the solutions. Whilst the order in which the concepts are presented is usually that of decreasing expected climate restoration effectiveness, exceptions are made when subsequent concepts are likely to depend on earlier ones.

PROPOSED SOLUTIONS

#1 BUOYANT FLAKE OCEAN FERTILISATION (BFOF)



Graphic

Short Description

Previous attempts to farm the sea or to increase oceanic carbon sequestration have used soluble, artificial chemicals that do not remain near the surface. However, long-lived, ultraslow-release buoyant flakes can be disseminated annually by ship over selected ocean areas. The tiny flakes are comprised of natural, organic materials and mineral wastes. Like a self-feed system, these do not so much release the nutrients to the environment, as to make them available at the sunlit sea surface where the phytoplankton which need them can 'suck' them out of the exposed mineral particles in the flakes using their transporter enzymes or ligands. Thus, there is little chance of either over-fertilisation, eutrophication, toxicity, or of the nutrients being lost rapidly to the dark depths. The foundation of each flake is a single rice husk, rich in the opaline silica needed by diatoms. Glued to this by plant-derived lignin hot-melt glue is a sealed matrix of air and minerals designed to provide phytoplankton communities with whatever nutrients are wanting in that part of the ocean. As dark blue ocean waters are deficient in one or more macronutrients or trace elements (typically phosphate, iron, silica and transition metals - reactive nitrogen nutrient being able to be made from air by cyanobacteria), using buoyant flakes could turn these blue or 'desert' ocean regions into productive, turquoise seas. Krill and most other diel vertically migrating (DVM) species consume much phytoplankton in surface waters at night, then respire and excrete the carbonaceous wastes in the dark, safe depths of up to a kilometre deep during daylight hours, thereby sequestering its carbon content.

Key Functions

Increases the biomass and biodiversity of marine life; sequesters atmospheric carbon dioxide (CO_2) securely as carbonaceous seabed ooze & rock, refractory dissolved organic carbon (DOC), and benign, dissolved, alkaline bicarbonate; increases oceanic albedo (reflectiveness) that cools the surface waters; increases atmospheric DMS aerosols that nucleate or brighten cooling marine clouds.

Innovation Dependencies

None known

#2 BUOYANT FLAKES FOR METHANE REDUCTION

Short Description

As above, but with the nutrient mix adapted to suit methanotrophs (methane eaters) present in water or soil, such as are found in the seabed, oceans, lakes, swamps, rice paddies, landfills, fracking & mining operations, abandoned mines, and feedlots. Key supplementary micronutrients for methanotrophs are iron, copper, nickel, tungsten, cobalt, molybdenum, manganese, zinc and boron.

Key Functions

Methane metabolization into biomass; regional and global cooling due to lower atmospheric levels of the greenhouse gas, methane.

Innovation Dependencies

None known

Graphics

See above, but apply where and when most needed.

#3 SEATOMISERS (SEAWATER ATOMISATION)

Short Description

Modestly sized, anchored, wind turbines could be used to power mastlike units that spray filtered seawater of different particle size ranges into the lower atmosphere. The two, lower spray nozzle assemblies are designed to spray droplets that partially evaporate to form cooler, moisture-saturated air and brine droplets that fall back into the sea before they reach land. The upper spray assembly sprays finer droplets using higher, triphasic pressures. The evaporating droplets are then winnowed cyclonically to desirable diameters by baffles to form optimally-sized droplets for cloud nucleation or sea salt aerosols (SSA). Both types tend to stay aloft for days, whilst reflecting sunlight that cools the air, soil, water and vegetation below. Their small size makes them capable of being lofted to cloud-making altitude by turbulence, where they may form marine cloud and eventually precipitation far downwind. Should such tiny salt crystals nucleate raindrops downwind, dilution causes the resulting water typically to be purer than river water and therefore not harmful should they fall on land. Their size may be changed by changing the pressures at which they are generated. This and downwind weather forecasts can be combined to influence where the precipitation occurs, its form and intensity. Anchored in deeper waters, arrays of Seatomiser units should be able to have significant regional cooling effects: on the warm ocean surface currents that power extreme weather events, on ocean stratification, on sea ice and on methane clathrate melting. The main effect is to increase the rate of evaporation of seawater and the subsequent long wave radiation of its released vapour heat content, on condensation, into space - mainly at night. As the method should increase ocean evaporation by orders of magnitude, so would the heat flow released by the condensing precipitation increase off-planet thermal radiation. A recent extension of this technology would allow for Oeste's iron salt aerosols (ISA) of ferric chloride to be sublimated into the atmosphere by heated crucibles at the topmost spar level. The chlorine atoms/radicals released by this would then catalytically photo-oxidise atmospheric methane and smog, reducing their global warming effect. Land-based Seatomisers might also be used for heat stress, smog and methane control, as well as for rainmaking and snowpack thickening.

Key Functions

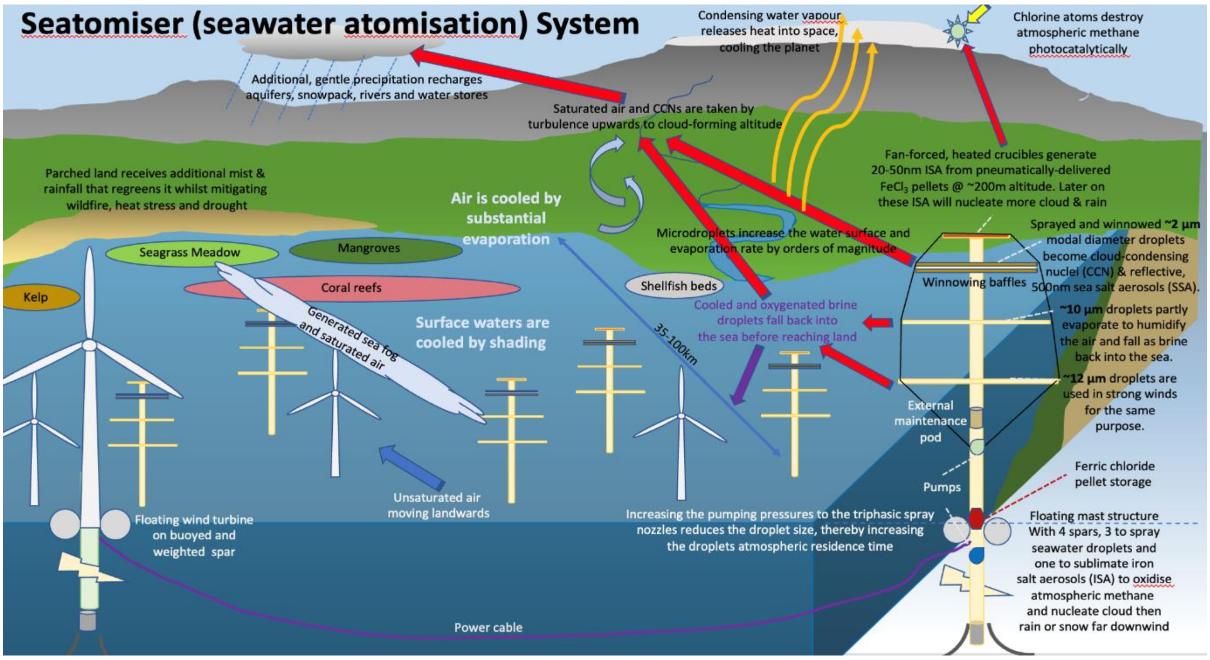
Regional cooling through sea fog and marine cloud formation & brightening and SSA reflection; increasing thermal radiation off-planet; protecting coral reefs, seagrass meadows, kelp forests, mangroves and shellfish beds; fishery and aquaculture enhancement; mitigating the effects of extreme weather events such as wildfire, drought, flood, storm damage and hurricane; reducing heat stress; reducing atmospheric methane and smog; oxygenation and cooling of surface waters; beneficially influencing precipitation, including reclaiming coastal deserts, farmlands and drought-stricken areas, together with increasing water stores, snowpack and aquifers. When not required for spraying, the power could be delivered onshore.

Innovation Dependencies

Successful modification of commercial spray nozzles to operate at much higher pressures and hence producing smaller droplet sizes.

ISA sublimation that generates effective, photocatalytic nanoparticles.

Graphic



#4 ICE SHIELDS/ICE THICKENING

Short Description

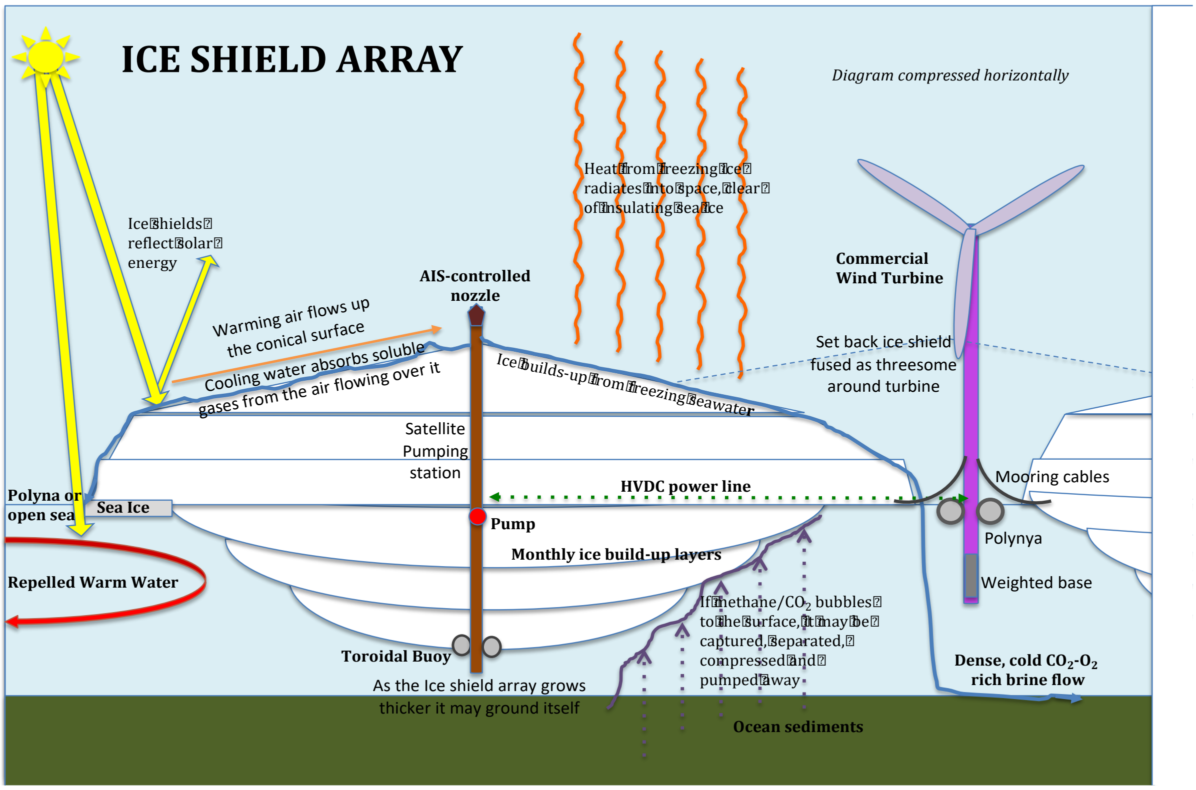
Thickening sea ice can be a means of sequestering CO_2, provided that the chilled, dense, and gas-rich brine left after most of seawater's water content has been turned into ice is allowed to sink to the seabed.

Anchored Arctic wind turbines could provide renewable energy to power low-lift seawater pumps and other system requirements. In the freezing season, AI-controlled satellite pumping stations would optimise intermittent flows of seawater, first onto newly-formed sea ice, then onto each low-angle conical ice shield as it built up – rather like how lava can form a mountain. A frigid atmosphere and ice surface causes forming ice crystals in the thinning, radial flow to attach themselves to the chilled ice below. The chilling residual brine concentrates the dissolved carbon dioxide and oxygen in the brine (and may absorb more from the atmosphere), together with most of the salt from the seawater. Falling off the edge of each ice shield, the 'brinefall' rivulets would take their contents directly to the seabed, where the CO_2 can react with seabed carbonates to form benign, long-lasting, dissolved bicarbonate, and the oxygenation can succour benthic life. Back of envelope work suggests that this method has the potential to sequester up to 16GtC/yr in Arctic abyssal waters alone. Brinefalls on a wide scale would also reinvigorate the overturning currents that keep our oceans productive. Ice shield-arrayed polar regions would help return the global climate to its previous benign state.

Over its extended life, a single, 2.5MW floating wind turbine might power the growth of up to 50, ~5km^2 ice shields in a linked array that could be grown and grounded in water up to several hundred metres deep. Designated channels and polynyas amongst the ice arrays would provide access and habitat for polar wildlife and shipping. Deep arrays would repel the intrusion of warm water into the Arctic Ocean, thereby reducing melt loss and glacial calving.

Thermals derived from released ocean heat to the atmosphere in the cold and dark seasons

Graphic



would take the heat directly by convection to the tropopause, whence it would radiate into space, unhindered by the insulating greenhouse gases below it, thereby cooling the planet. Increasing ice cover would reverse previous losses, whilst the semi-permanent increase in ice cover would effectively reflect warm season sunlight by its high albedo. Spare, warm season wind power might be used to generate cooling marine cloud brightening; be taken to market by HVDC cable; be used to capture and process seabed emissions locally into no-drill natural gas, hydrogen, ammonia, nanocarbon products and vat protein; be used to generate iron salt aerosols (ISA) from sublimated ferric chloride pellets that destroy polluting atmospheric methane, nitrous oxide, black carbon, ozone, CFCs and smog by photo-catalysis; or else be used to pump Arctic river water south for use by industry, for irrigation, homes and habitat restoration.

Key Functions

Restoring cryogenic habitat, whilst allowing ship and marine life to access the regions; sequestering CO_2 safely and for centuries; cooling the planet; reducing glacial loss; cooling the arctic and some sub-arctic regions; restoring benign hemispheric weather by increasing the polar vortices and the Atlantic Meridional Overturning Current (AMOC); preventing coastal erosion; helping to oxygenate the deep ocean; providing renewable energy; and allowing ebullient methane and CO_2 to be harvested before they reach the atmosphere.

Innovation Dependencies

Polar weatherisation of floating wind turbines and pumping stations; AIS capability to so vary the intermittent pumping regimes that linked and often-grounded ice shield arrays can be grown out from the shoreline; development of ebullient ocean gas harvesting, processing and transportation methods.

#5 WINWICK DIFFUSERS

Short Description

Current diffusers are typically made from either perforated metal or sintered glass. These are much too thick and costly per area for optimal use with energy-efficient fluidic oscillators generating monodisperse (same sized) microbubbles. A bilayer of titanium foil with a thin, PET plastic backing and pores made using a confidential and conceptionally cheap process should perform many gas-liquid exchange processes far more efficiently, as well as allowing greater scale.

Key Functions

Economically separating CO_2 from either raw natural gas or flue gas; fermentation; isothermal distillation; waste water treatment; aquaculture; and many Winwick drillhole reactor processes.

Innovation Dependencies

Perlemax DZFO technology; calendering technology.

Graphics

Confidentiallllllllllllllllllllkkk

#6 FIZTOPS

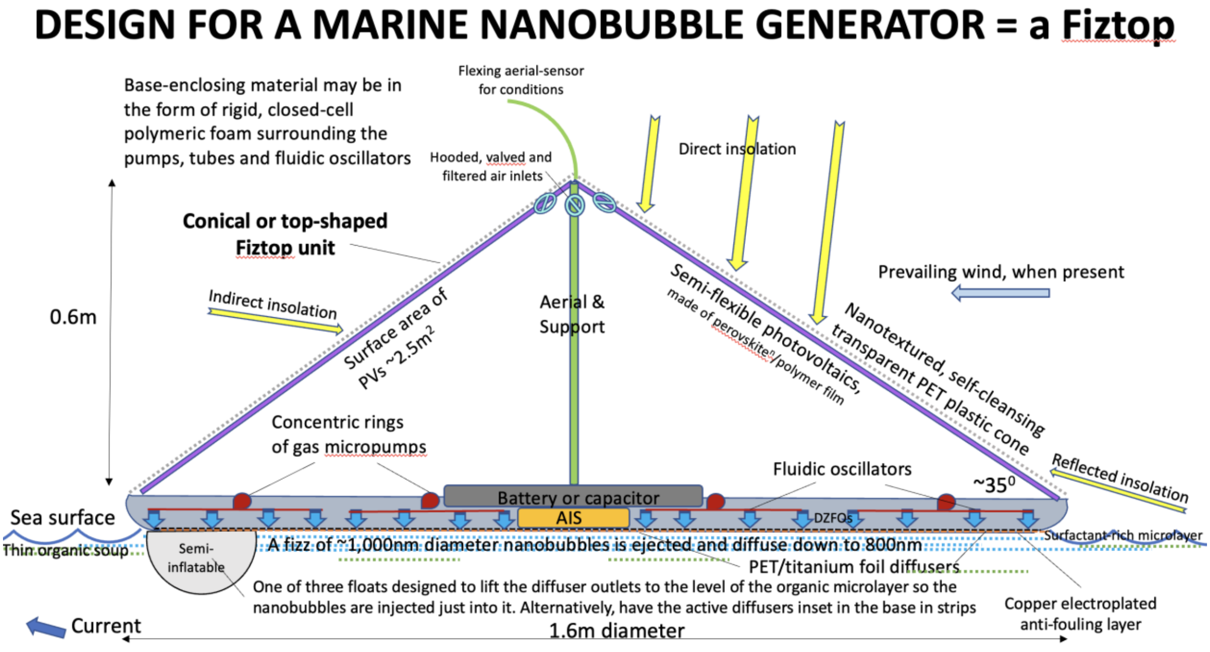
Short Description

A Fiztop (a top-shaped producer of fizzy bubbles) is a floating, lightweight, solar-powered unit designed to generate long-lived, reflective nanobubbles in the sea surface microlayer (SSML).

Key Functions

To so reflect a portion of sunlight from the ocean surface that the water is cooled, thereby protecting ecologies such as coral reefs, seagrass meadows, kelp forests, mangroves, fish nurseries and shellfish beds from bleaching or overheating, and the water from stratifying and losing some of its oxygen and nutrient content.

Innovation Dependencies
Perlemax DZFO technology; Winwick diffuser technology; Artificial Intelligence System (AIS), comms and sensor technologies; and anti-fouling technology.
Graphic



#7 AQUEOUS CARBON DIOXIDE SEPARATION/SODA POP METHOD

Short Description
Most CO_2 separation technologies depend on expensive chemicals, pollutable matrices, fragile membranes or energy-hungry processes. This conceptual process uses only recyclable water (which can even be salt water), mild changes in pressure, and modest energy requirements. It may be so designed that it fits into shipping container modules suitable for assembly stacking and transportation. Notionally, it should be both energetically cheaper and more scalable than other, better-known CO_2-separation processes. When deployed with associated infrastructure, it would mean that most large, point sources of CO_2 could be made virtually emissions-free.
Key Functions
It could be used economically to separate 94% pure CO_2 from cool or hot, possibly acidic and/or particulate-rich flue gas, or raw natural gas.
Innovation Dependencies
Perlemax DZFO technology and Winwick diffuser technology.
Graphics
Confidential

#8 SUNNY SCHEME

Short Description
The Sunny Scheme is designed to coordinate the use of renewable energy, energy storage systems, high voltage direct current (HVDC) transmission, waste CO_2, natural gas or biogas production, and several fast-developing industrial processes designed to provide us with an evolving hydrogen and electric economy and a path that allows many of today's major, industrial players to make their own transition less-disruptively to a low-carbon economy. One of the

technologies suggests how natural gas extraction might, counter-intuitively, be actually made carbon negative. The Scheme integrates solution elements that others have conceived.

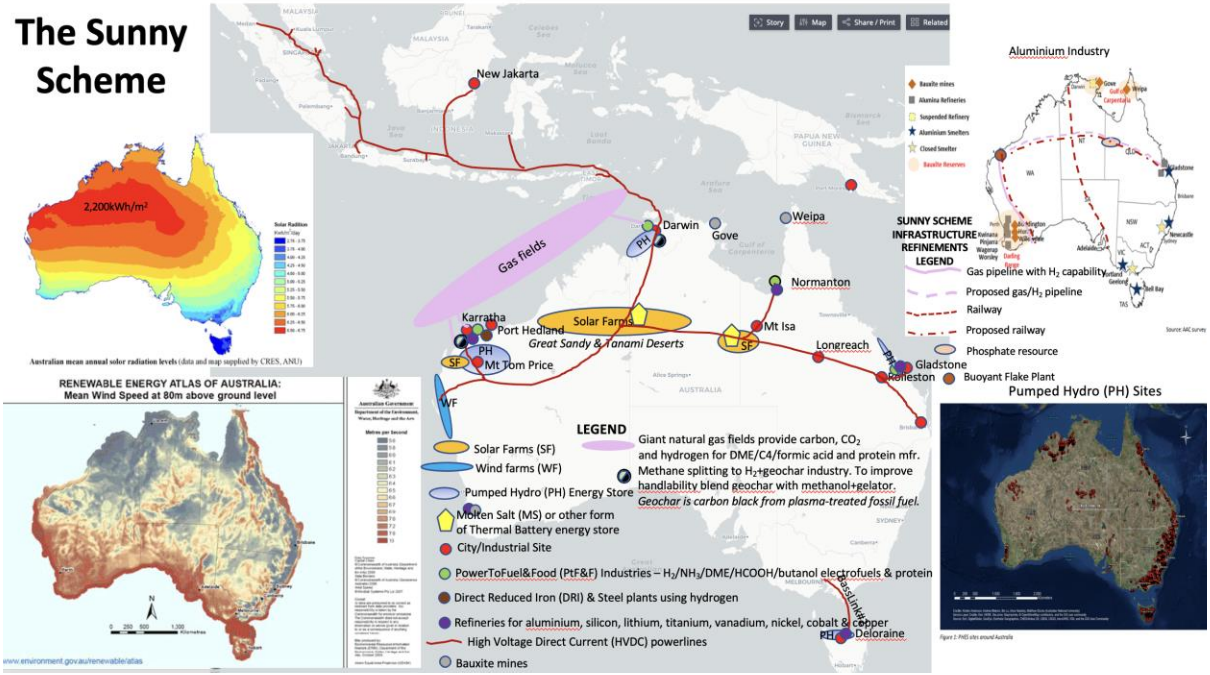
Key Functions

The scheme provides for: the economical generation, storage and transportation of renewable energy up to thousands of kilometres; the splitting of methane into emissions-free, blue-green hydrogen and the high-value nanocarbon co-products that should allow its hydrogen price to undercut that of electrolytic hydrogen for the foreseeable future, and hence to hasten global transformation to a net zero carbon economy; the blue-green hydrogen might also be used to replace much fossil fuel currently used in the metal refining and petrochemical industries, and would enable weather-independent food production.

Innovation Dependencies

None

Graphics



#9 TURBOSTRATIC GRAPHENE/ULTRACAPACITORS

Short Description

A high-purity, graphene sheet might be produced, along with low-cost, blue-green hydrogen, by using HiiROC's plasma torches and spare or stored, renewable energy to split methane derived from natural gas or biogas. Some of this graphene is to be used to produce ultracapacitors of an energy density, cost, and sustainability sufficient for them to replace most combusting fossil fuels, as well as chemical batteries heavier than 5kg – in particular, those used for transportation and energy storage uses, including those in most types of electric vehicle (road, rail, maritime and some aviation uses) and for economical domestic, industrial and utility energy storage.

Key Functions

Electrify 'everything'. Rapidly replace most fossil fuels and chemical batteries in their transportation and energy storage uses.

Innovation Dependencies

The condensation of HiiROC's gaseous carbon to few-layer, turbostratic graphene (FLTSG) on revolving copper drums. Kilowatt Labs's software that controls the release of the energy stored in super and ultracapacitors. Winwick's aqueous CO_2 separation of natural gas constituents may also be useful here.

Graphics

Confidential

#10 WINWICK HYDROTHERMAL CARBONISATION (WHC)

Short Description

A gravity well reactor, similar to that described in the Winwick Drillhole Reactor (WDR) patent for WHC, might be used to carbonise crop and forestry waste, in particular the less-used bark, twig and leaf waste, such that it produces a hydrothermal biochar more cheaply and sustainably than does pyrolysis. In turn, the cheap, industrial-scale biochar could be combined with manure, water and a gelator to generate a slurry or slug suitable for pumping into the soil behind a ripper to promote tree growth and carbon capture by photosynthesis, whilst reducing requirements for water and fertiliser.

Key Functions

Carbon capture and secure storage; afforestation; improving tree crop productivity and resilience; desert reclamation; better fire and forestry management; and the transformation of an artisanal activity into a full-fledged industry.

Innovation Dependencies

Gravity well reactors have been used for wastewater treatment and to destroy hazardous medical waste; and Perlemax' monodisperse microbubble technology.

Graphics or Documents

See https://patentimages.storage.googleapis.com/0b/9f/99/4f715f8f8aac52/US8715980.pdf

#11 SEAWEED CARBONISATION AT SEA

Short Description

A gravity well reactor, similar to that described in the Winwick Drillhole Reactor (WDR) patent for Winwick Hydrothermal Carbonisation (WHC), might be matched with one of the many small, modular reactors (SMR) designed for use in nuclear propulsion for shipping and submarines, to carbonise seaweed (kelp or *Sargassum*) and/or marine plastic waste at sea by hydrothermal means, such that the biochar or black carbon product sequesters itself safely, and probably for millennia, in the ocean depths, whilst the nutrients released at the surface can be used to grow more seaweed.

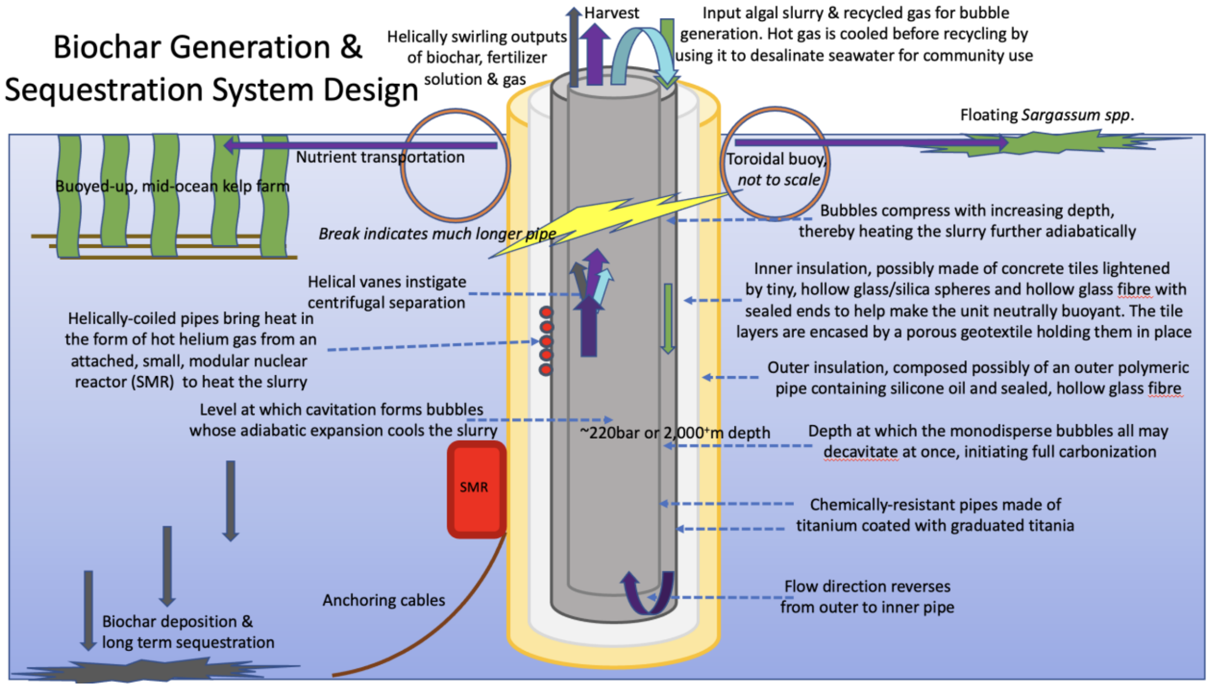
Key Functions

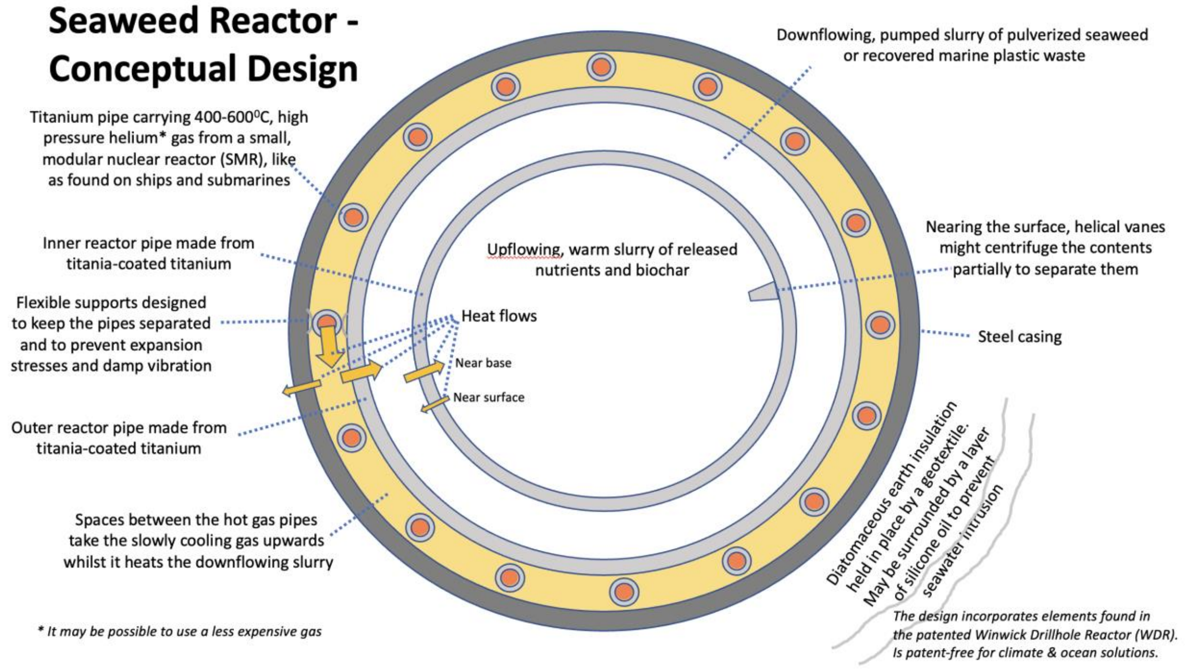
CDR at scale; and the removal of floating plastic pollution from the ocean and its threat to marine life. Carbonisation units might also be deployed at river mouths and in ocean gyres where plastic waste and seaweed harvesting is more economical.

Innovation Dependencies

Perlemax' monodisperse microbubble technology; SMR technology; insulation at ocean depth technology; and WDR conceptual technology.

Graphics





#12 WINWICK AMMONIA SYNTHESIS (WAS)

Short Description

The standard Haber-Bosch process for making ammonia is terribly inefficient and consumes some 1.5% of our energy use. Using a WDR and decavitating, monodisperse microbubbles of a mixture of blue-green hydrogen and nitrogen to make it might well reduce the energy use by half.

Key Functions

Generating lower-cost, more sustainable ammonia products. Reducing emissions. Improving agricultural productivity (provided care is taken to reduce runoff & waste).

Innovation Dependencies

Perlemax, HiiROC and Winwick technologies

Graphics

None

#13 WINWICK TRANSITION METAL ORE REFINING

Short Description

The standard method by which nickel, cobalt and possibly other transition metals are refined from lateritic ore is by high pressure acid leaching (HPAL) using a batch process. This suffers from having high energy costs, high equipment, labour and maintenance costs, and high downtime associated with it being a batch process involving high corrosivity, clogging and wear. Using a WDR variant, these deficiencies might be avoided. Gangue processing and disposal hazard might also be improved by other, specified means.

Key Functions

Improving mineral processing efficiency, whilst reducing hazardous waste.

Innovation Dependencies

WDR technology; solar thermal storage; Algal dewatering technology using porous conveyor belts; and Perlemax' isothermal distillation method for concentrating acidic solutions so they can be recycled or sold.

Graphics and Short Documents

Confidential

#14 WDR Depolymerisation of Biomass

Short Description

Various WDR processes are designed either to extract valuables from waste biomass or to depolymerise its polymers into their constituent sugars, phenols, and amino acids. Most make use of tuneable, sub- or supercritical water, adiabatics, catalysts, and the energetics of decavitating microbubbles in a WDR to accomplish these transformations.

Key Functions

The transformation of almost any form of waste biomass, particularly moist biomass, into valuable products.

Innovation Dependencies

Perlemax' DZFO microbubbles

Graphics and Documents

See the WDR patent

#15 WINWICK SYNGAS SYNTHESIS (WSS)

Short Description

Under harsher WDR conditions and with the addition of some air or oxygen bubbles, moist biomass may be transformed into syngas (a mixture of hydrogen, carbon monoxide and dioxide) which can form the feedstock to produce a wide range of chemicals, as well as being a biofuel in its own right.

Key Functions

Valorising waste biomass; replacing fossil fuels as carbonaceous feedstock.

Innovation Dependencies

Perlemax and Winwick

Graphics and Short Documents

See patent

#16 WINWICK PHOTOBIOREACTOR (PBR)

Short Description

A low-cost, efficient bioreactor for growing phytoplankton on marginal land, making good use of local resources, including sunlight and whatever water is available.

Key Functions
Generating food, fuel, power and potable water from desert or degraded land. Could make remote settlements nearly self-sufficient, as well as potentially profitable.
Innovation Dependencies
Perlemax + Winwick; requires a source of CO_2 better than that of the air. Ideally, would be matched with WDR facilities.
Graphics and Short Documents
See patent