Credit for Reducing Sunshine

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Abstract

Climate Change is a driver for solar energy and sustainable growth. Since developed nations still dominate anthropogenic heat release and per capita Carbon Footprint, partly for the conveniences of a high standard of living, an exclusive focus on reducing Greenhouse Gases is controversial. It is too slow to stop the temperature and sea level rise and may also trigger unfavorable short-term responses. We propose to expand the concept of Carbon Credits to include other Sustainable Development Goals, specifically including reduction of heat input. Our Glitter Belt architecture comprises swarms of controlled, solar-powered data-gathering reflectors floating in the upper atmosphere worldwide. In the first phase, small swarms of Flying Leaf vehicles serve to reduce uncertainties in system performance, high altitude weather and overall Climate measurements and simulation. Scale-up phases with optimized systems are discussed. With proposed policy support in equating sunlight reflection to Carbon reduction, this is not only affordable but also self-sustaining. Perfect reflectors at the edge of the atmosphere are equivalent to 0.068 Certified Emission Units per square meter. Sunshine credits can be generalized to Nature Credits that recognize many other priorities of nations in a coherent manner, linked to UN Sustainable Goals and Nationally Determined Contributions.

Keywords: Glitter Belt, Sunshine Credits, Nature Credits, Reflection, Anthropogenic Heat Release.

Introduction

We have developed a method called the Glitter Belt (GB) to reduce insolation in a controlled, reversible and non-intrusive manner. It appears to be the best way to combat Climate Change in complete conformance with the recommendations put out by the Intergovernmental Panel on Climate Change (IPCC) and the US National Academy of Sciences (USNAS). Our method offers platforms and networks, to conduct continuous, widespread and well-resolved long-term measurements needed to refine simulation and prediction methods. It is being tested as a way to both build global collaboration, and conduct detailed, continuous measurements. In addition, GB can be used to develop an advanced communications network accessible from remote parts of the world. With advancements in positional certainty and swarm control, GB also offers platforms to observe Space Weather and make some astronomical observations from the edge of the atmosphere.

1.1 Net Radiative Forcing as Metric of Global Warming

In this paper we discuss steps needed to credit reduction of insolation. Reduction of Greenhouse Gas (GHG) emissions is recognized by Certified Emission Units (CEUs), commonly called Carbon Credits, which are Metric Tons of Carbon Dioxide equivalent in potential to absorb Infrared radiation. First a quick glimpse of the opportunity, and a rough equivalency between CEUs and proposed Reduced Insolation Credits (RIC). Net radiative forcing on Earth due to Well-Mixed Greenhouse Gases (WMGHG) exceeds 2.83 W/m^2 of Earth's surface, per Myhre, 2013. We will project this to 3 W/m^2 by 2025. Earth's surface area is 5.11E14 m^2. Total GHG accumulation in the atmosphere from 1990 to 2025 is 154 Gigatons (GT), out of the 806 GT emitted.

1.2 A glimpse of an Insolation Reduction Credit (IRC):

Our control architecture is to use reflectors that float at the edge of the atmosphere and move to keep up with the peak summer sun every day. Solar reflection is taken as 1367 W/ m^2. Under the peak summer sun, 12 hours of bright sunlight, essentially at AM0 (Air Mass Zero, the value in Space at Earth's orbit around the Sun) is a conservative assumption at high altitude. This works out to 2.245 trillion m^2 of reflector area needed. The equivalence then is 0.068 CEUs per square meter of high-altitude reflector. At a nominal market price of $10 (ten US dollars) per CEU, each square meter of reflector should be creditable at $0.68. At the expected Kyoto quota value of $40/CEU, each square meter of reflector is worth $2.72. However, this may be too low, since the actual Anthropogenic Emission of GHG is closer to 806 Gigatons, of which much has been absorbed into the oceans or land already. CEUs credit reduction of emission, not just removal of net CO2 present in the atmosphere. In other words, the part of GHG emissions that is absorbed by the oceans or trees, is also credited if reduced at source. Hence, we could demand a fair equivalence of $14.23/m^2 of high-altitude sunlight

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reflection as Insolation Reduction Credit (IRC). Aluminized Mylar reflective sheets such as those we propose for initial use, achieve 95% reflection, over 98% in the Infrared range, earning $13.51 per deployed square meter. This should only be earned for staying deployed: a 10-year deployment lifetime amortization may have to be accepted, similarly to what is done for solar PV panels.

This is a starting point to credits for other restorations of Nature. Reflecting sunlight buys time for many other urgent priorities, whose implementation will alleviate or adapt to Climate Change. Many of these have no relation to "carbon reduction" but are listed in the Sustainable Development Goals of the UNO.

1.2 Background: Anthropogenic Global Warming

The increased heat release in the past 300 years comes primarily from waste heat of heat engines. Per Smil (2021), US heat engine efficiency rose from 14% circa 1900 to 50% by 1950 with multi-stage power plants. However, by 2020, efficiency had dropped to 33%, primarily due to proliferation of air conditioning and other electric powered accessories of a high standard of living. Chen et al, 2014, show that Anthropogenic Heat Emission (AHE) worldwide comes mostly from industrial economies of Western Europe and North America.

International campaigns to counter warming have focused instead on reducing release of Infrared-absorbing Greenhouse Gases into the atmosphere. This focus on "Carbon Reduction", and extreme fears cited regarding moves to counter heat input, must be viewed in the light of the above. The UNFCCC's Kyoto Protocol (Kyoto, 1998) established a market for tradeable CEUs. Gains in efficiency earned CEUs, either directly or by crediting development of efficient factories and renewable energy plants to replace fossil and wood burning. Industrialized nations accepted quotas to reduce emissions to 1990 levels. Quota deficiencies would incur charges of $40/MT. As deadlines approached, CEU prices would rise, driving investment in CEU-generating activities, enough to justify the large expense of getting certification from Brussels or Geneva.

Initial enthusiasm about rising prices ended as prices dropped near $2/CEU with the recession of 2008-2009. It has recovered since, but there is wide price disparity across the world due to a growing array of national and regional regulations. Carbon Market Watch, 2019 cites the main challenges: too many credits available; not enough projects to buy them. A risk of double counting credits. Protecting local stakeholders and the environment, and delivering on sustainable development goals are challenges. The system risks setting up perverse incentives that hamper ambition.

2. Need for Broader Credits

Several reasons point to the need for broader credits than CEUs and a broader market.

2.1 Imbalance in Carbon Footprints

Industrialized nations exhibit Carbon Footprints (average per capita annual emission of GHG) up to 1500 times those of many developing nations. Thus, reducing carbon footprint is a good priority for developed nations, but not justifiable for developing ones seeking to raise standards of living. This is a primary area of conflict.

2.2 Tailored Bilateral/Trilateral Agreements

Nations that refused to sign or ratify the Kyoto Protocol, nevertheless moved in their own ways to counter Climate Change. US entities set up Green Credits. Large wind energy projects in South Dakota, located far from energy markets, were funded by the promise of Green Credits for the electric energy that they would generate. Bilateral and multilateral agreements such as those between the USA and India funded initiatives on Solar Power, simultaneously addressing massive power shortage and capital in India. World Bank initiatives have addressed critical needs to improve ground water quality, particularly in congested communities and mountain glacier watersheds infested with tourists (Neighbor 2020). This translates to major health benefits, a much higher priority than "Carbon Reduction".

2.3 Near-Term Response to Carbon Segregation

Koch, 2021 show a disturbing result. In the near term, reducing CO2 concentration in the atmosphere by reforestation may simply cause increased emission from the oceans, which are by far the massive repository of CO2, frustrating the aim of reducing Net Heat Retention. In 30 to 50 years, the benefits of reforestation will become significant. A sharp increase in tall vegetation over substantial areas will also reduce albedo over now-bare land (increasing heat absorption near the ground), and shift rainfall patterns as the ground cools. Present agricultural investment is based on fairly recent weather. This short-term response is alarming in that extreme expenditures to "reduce Carbon" may leave us with no real answer as sea level rises and climate changes, and perhaps causes weather shifts. Thus, merely removing anthropogenic GHGs will not suffice unless heating is also countered.

2.4 GHGs to NDCs to SDGs

Discomfort with exclusive focus on CO2 reduction is evident at the UN. First came Nationally Determined Contributions (NDCs) which enabled ambitious programs at the Paris Accords of 2016. Next came the REDD+ or Reduced Emissions from Deforestation and Land Degradation. This appears to recognize that actions for the common good should be credited, but is hindered by the view that it can be 'gamed' to avoid real action. So can Carbon Credits, as experienced in California, per Song, 2021. The third is the establishment of Sustainable Development Goals (SDGs), where Climate Action is 13th out of 17. So, the intent and perceived need have been established for much broader credits.

UNDP, 2021 includes an expanded financing system after the Paris Accords: Nationally Determined Contributions (NDCs) allowed more ambitious mitigation actions. Countries would still be able to use Internationally Transferred Mitigation Outcomes (ITMOs) towards NDCs. The NDCs broaden the system of credits far outside the formal Carbon emission trading system. Recently, a market called REDD+ (Reduced Emissions from Deforestation and Land Degradation) was set up to drive the 17 SDGs developed by UNESCO. Several governments and international funding agencies require new proposals to identify their relevance to the SDGs.

2.5. Rising Urgency

Carbon reductions are not on track to slow down the rise of heat retention. Tougher measures are being put into implementation in several nations, with pressure on others to follow suit. California (2021) discusses plans to cut GHG emissions 15% below 1990 levels by 2020, to 80% below 1990 by 2050, still leaving Carbon footprint of 2MT/person/year. A shift to EVs does little to improve basic heat engine efficiency. The Swedish EPA (2021) describes a program similar to the UN SDGs, but based on Carbon Credits. Bird (2021) describes Norwegian efforts, including road-building in Laos to help meet Norwegian Carbon Reduction goals using CEUs. Finland, 2021 aims to cut GHG by 80% from 1990 levels by 2050, become carbon-neutral by 2035. However, household consumption has increased by 4% since 2015 with rising standard of living. As ordered by their highest court, Germany now aims to hit carbon neutrality by 2045. Wettengell (2021) says the EU has declared climate action its top priority with the Green Deal to become the first carbon-neutral continent by 2050. The US Government has come out with a $1.6 T plan based on Carbon Reduction

4. Proposals to Directly Counter Global Warming

From the above, we see that effective response to Climate threats must include a broad range of measures that address the real priorities of nations, going far beyond just Carbon Reduction. To buy time, reducing insolation must be considered, to control the heat retention rate. This is controversial. On the one hand, critics express suspicion that this is a way to avoid the difficult measures needed to reduce emissions. On the other hand, they point to the danger of unintended Climate response to drastic measures. The US National Academy of Sciences in a recent report (NAS 2021), has come out with recommendations on how to prepare for measures to reduce insolation. Alternatives include reducing economic activity, curbing air and ground travel, switching to electric propulsion for all transport, switching to a solar-hydrogen economy, and technological installations on vehicles and buildings to make various small improvements in efficiency. There have been many other proposals, radical and otherwise (Table 1). Some involve very intrusive laws. None have shown scalability and controllability, at manageable costs, or an evolutionary growth path accompanied by data acquisition and the ability to swiftly reverse or modulate. Table 2 summarizes the expressed concerns and recommendations of the US National Academy of Sciences (USNAS2021). The NAS approach outlines a spiral development through the phases of Engagement, Research and Research Governance, from initial program design, through assessment and revision, informing decisions through knowledge acquisition, and with several "Exit Ramps".

Table 1 summarizes prior proposals to counter global warming, classified into 6 approaches.

	Approach	**References**
1	Reflectors, bubbles or balloons in Space to reflect sunlight.	Early, 1989, Palti, 2008
2	Ground-based reflectors.	Kawai, 2009
3	Chimneys ingesting air and removing GHG	Shankman, 2018
4	Reflective particles in industrial exhaust. Sulfuric acid aerosols.	Chang, 1991, Kunzig, 2008
5	Increasing urban albedo by mandating white paint on roofs and sidewalks. Glass Beads On Arctic Ice Cap.	Akbari et al, 2009, Menon et al, 2010
6	Wind turbines pumping Antarctic sea-water onto the ice cap to compensate for ice cap melting in summer. May be powered by sunlight thus requiring solar PV farms on ice cap.	Moreau 2016, Feldmann, 2019

Table 2: Responses to GeoEngineering concerns

Item	Expressed Concerns	NAS recommendation	Glitter Belt Approach
1	Unauthorized/ unilateral actions; Uncontrolled in case of unknown response	Authorization, consultation, notification; Transparency & Trust across nations & generations; Ethical accountability; Research in public interest; Legitimacy and accountability. Fairness & inclusion; Maximized benefits; minimized harm.	Informed collaboration with national & international agencies. Completely monitored test & deployment
2	Impractical or poorly understood	Timely technical availability, respecting ethical and ecological norms; Predictability	Flight tests integrated with measurement & simulation
3	Public awareness & policy-relevant knowledge, inclusion, stakeholder participation	Disciplinary balance, stakeholder engagement; self-organized coalition of state & non-state actors; Coordinate across international entities; Peer Review & transparency. Participation and engagement independent of whether a proposed experiment has any known environmental risks	Seeking tech./ policy collaboration, global interests. Continuous data; International NGO & Consortium. Publication. International Participation
4	Removes urgency; reduce other climate funding;	Funding for geoengineering must be limited to be small relative to expenditures for emission reduction and other proactive measures	Broaden from CEU for global buy-in. Micro credits. No zero-sum approach.
5	Emissions	Test materials should be relatively inert and nontoxic. Individual experiments must not release over 1,000 kg, global less than 10,000 kg/yr.	Zero emissions except electromagnetic signals for data, control and navigation.
6	Temperature Change in Experiment Stage	Induced change in global mean surface temperature under 100 nK ($100x10^{-9}$ C) for a 100-yr time horizon (or 10μK normalized to a 1-yr horizon) for individual experiment, 1μK ($1x10^{-6}$ C) for 100-yrs/ 100μK normalized to 1-yr horizon.	Detectable changes only with massive scaleup when agreed. No concentration: swarms move w/ Summer Sun.

5. The Glitter Belt Project

Without going into other aspects of the Carbon debate, we conclude that all contemplated steps to counter the ill effects of Climate Change, require good, continuous, well-resolved data and ever-more-refined predictive simulations. The first order of business is to reinforce the global capability for such measurements, and from those, to develop reliable predictions with the fine resolution to address local effects.

Present methods of atmospheric and oceanographic data collection use local measurements using ground-based instruments, aerial measurements using balloons, aircraft-based instruments, drop-sondes, ocean buoys, and Space satellites. Aircraft-based measurements have broad reach near land, but have limited range and endurance over the remote stretches of the oceans. Satellites provide global coverage, but it is intermittent and very fast-moving, as well as being 250 to 400 km above the surface.

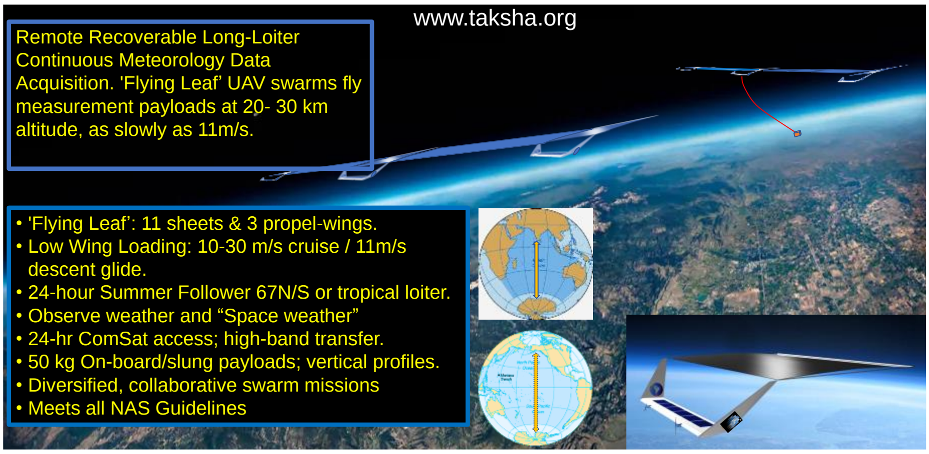

Figure 1: Summary of Flying Leaf Use for Metereology. From Komerath (2021) by permission

5.1 Ultralights at 32 km

Our Glitter Belt (GB) project (Figure 2) is developing the technology for swarms of ultra-light vehicles flying in the atmosphere near 32 km altitude. Flying Leaf vehicles are flying wings supporting large thin sheets. The sheets are aluminized on the upper surface and have black lower surfaces. They reflect daytime sunlight back into Space, and absorb night-time radiation from Earth and radiate part of that out. Driven by propellers through motors driven from photovoltaic cells along the wing surface, they cruise at speeds as low as 12 m/s. During the night the very low wing loading enables gliding descent at low speeds. The descent rate is low enough to keep the vehicles far above controlled airspace (18 km) through a 12-hour night. By drifting steadily northward or southward, these vehicles keep up with the Sun as it moves across latitudes through the year. The swarms thus stay with peak summer, year-round. The concept is described in Komerath (2017, 2020, 2021a) and Shukla (2017). Wind tunnel test results were shown in Smith-Pierce (2018).

5.2 Surviving Night-Time Glide

Aerodynamic vehicles have a "speed for minimum drag" which is not zero: it is roughly the speed where the drag that is not associated with lift (such as skin friction, flow separation, interferences) equals the lift-induced drag, which is basically the force associated with energy used in causing flow to spin as in the vortices generated at wing-tips. The latter is minimized by (a) minimizing the lift coefficient by minimizing the Wing Loading (weight or lift supported per unit wing area) and (b) going to as high an Aspect Ratio as possible. In simple terms, putting the wingtips as far away from each other as possible, relative to wing area. The former is minimized by flying slowly enough to keep the boundary layers laminar (avoid turbulence) and having a clean and streamlined design. In this case, also by keeping the sheet from flapping in "flag instability". With these features, the present design of the Flying Leaf is predicted to have minimum drag at around 11 to 12 m/s at 32 km altitude. The Flying Leaflets, which take off with the sheets rolled up to avoid damage, also have very low takeoff and landing speeds, consistent with launching from playgrounds and beaches rather than airport runways. Once joined up, the Flying Leaf configurations, by virtue of low wing loading (shallow glide angle) and low speed (small vertical velocity component), achieve a very low sink speed. This is low enough to stay well above controlled (Class A) airspace which extends just above 18 km (60,000 feet), through 12 hours of glide. This is why the Summer Follower arrangement is adopted initially: the longest night is 12 hours when crossing the Equator. Other designs of High-Altitude Long Endurance aircraft seen to-date use auxiliary power storage such as batteries or fuel cells to provide power through the night, because they are primarily designed to stay above one temperate-zone region through an entire year. The extremely low Wing Loading of the Flying Leaf makes these unnecessary and thus further reduces weight, or enables carrying measurement payloads or antennae.

5.2 Phase 1: Development and Global Measurement System

Starting with the first test vehicles, these swarms provide an unprecedented opportunity to gather continuous data, sweeping across remote parts of the world at low speeds. Thus, atmospheric measurements as well as effectiveness measurement are integral to the project. The data collection will also permit better predictions as well as continuous monitoring of regional weather. These aspects were presented in Komerath (2021). We expect that development and flight testing of the Glitter Belt components, including launch facilities, recovery systems, ground stations and communication network to control and monitor the swarms, will be developed through international collaboration and participation during this initial measurement phase. The measurement system and infrastructure are planned as long-term investments, far beyond the phase where any targeted climate intervention is needed.

5.2 Phase 2: Gradual Scale-Up

As concerns are examined and resolved, we project an expansion to massive levels that could indeed reflect enough sunlight to make a difference to net heat retention. This of course will involve a rapid scale-up of manufacturing and launch infrastructure, with a temporary scale-up of system monitoring. If and when such an expansion is approved, funding it becomes an issue. As stated at the beginning, most people may agree that Global Warming is a problem, but do not have any personal incentive to fund its alleviation, beyond government funding through taxes. We show that there are good supplements and alternatives that make sunlight reflection not merely affordable but sustainable through the duration needed to really solve the problem.

5.3 Mature System Scale-Up

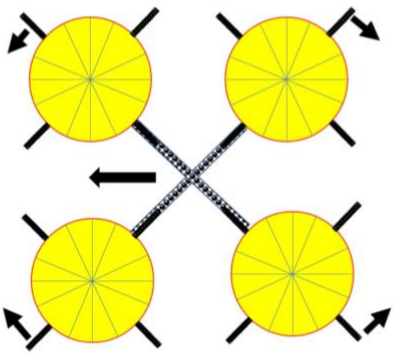

Figure 2: Scale-up concept "Quad-Frisbee" with 4 sheets built up from Flying Leaflet launches, propelled by solar-powered Leaves as rotors.

Initial designs are based on high aspect-ratio aerodynamic flyers described above. If and when scaleup is approved, most of the reflector area added will be optimized for reflection. One concept is shown in Figure 2. This can be built up as a high stratospheric platform using elements similar to the initial Flying Leaflets. The central element is a large sheet structure, with Leaflets attached to the periphery acting as rotor blades. In this case the central quadrotor hub structure may have to be lifted and held for assembly by smaller rotorcraft, until a set of telescoping elements is deployed with rotors to support lift at a moderate altitude. The rest of the structure is conceived as being assembled from modified Leaflet elements, launched with the same existing infrastructure used in the first Phase. Most of the Leaflets in this case will be returned for re-use as the radial sheet structure requires mainly tensile elements. The central support structure of the quad frisbee supports solar cells for power. Once the first set of “blades” is operating, the 4 “rotors” are rotated at a higher speed, progressively slowed down as more and more reflective, lifting sheet is deployed. The assembly operates as a “quadrotor frisbee” to survive night-time glide without power storage other than in the momentum of rotation, and potential energy of altitude. Against the cost and difficulty of initial deployment, each of these vehicles offers 10 times the reflector area per unit weight as the Flying Leaves. Thus, we reason that much of the eventually deployed reflector system will consist of these large ultralight platforms.

5.4 Cost Estimation

Initial system development, we assume, has to be funded by government entities or others who can rationalize expenditures for the public good. Note that the NAS guidelines practically rule out private/ venture capital investments. In this Phase 0, the focus is on reducing uncertainties of all kinds, including engineering, construction, flight performance, high-altitude winds, vehicle longevity, measurement systems, data transmission, numerical analyses and predictive simulations to gauge the safety of control measures, versus the cost of not implementing them. For Phase 1 expansion, our studies show that the proposed system is most

Figure 3: Cost estimate by comparison to automobile manufacturing.

similar to automobile mass manufacturing which is done all over the world. We estimate the cost to reach “Net Zero Heat Retention” by GB Phase 1 Reflectors alone. Figure 3 suggests an upper bound cost of $600B. The profit portion of automobile cost is removed while including the cost of sales and service infrastructure for a fair comparison. Note that if we go ahead with GB implementation, we will seek to shift to the more optimized Phase 2, bringing a large reduction in costs. However we emphasize that the conversation on controlling Global Warming must be shifted to self-sustainable models. This is discussed in the rest of the paper.

6. Credit for Reflecting Sunlight

6.1 Method 1: Albedo Equivalence

Preventing atmospheric heating is at least as important as reducing the absorption of heat in the atmosphere, to achieve the end objective of preventing continuous climate change. In other words, 1kWh of heat that is stopped from entering the atmosphere should count the same as 1kWh absorbed and retained in the atmosphere, and can be measured using Carbon Credits. This assumption is used explicitly in Akbari (2009) and Menon (2010) from US Federal Labs considering laws to mandate greater albedo in coverings for road surfaces, sidewalks and roofs. Akbari and Menon established a number of 57 Gigatons (GT) of CO2 as equivalent to an increase in albedo that could be achieved by mandating white-painted roofs, roads and sidewalks in urban areas worldwide. The total cost of implementing such a mandate was not given.

6.2 Method 2: Integrated Anthropogenic GHG vs. Net Heating Rate Difference from 1990

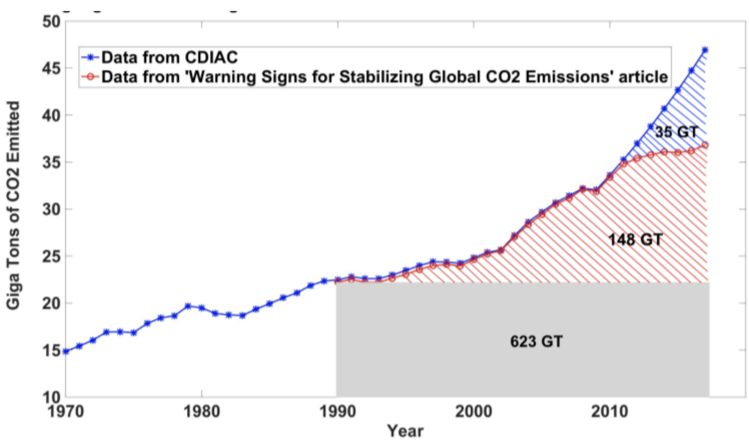

Figure 4: Anthropogenic GHG emission. Smith-Pierce 2018, by permission.

We first limit credit to anthropogenic addition of GHG (A-GFG) since 1990, the Kyoto cutoff date. Summing the annual GFG emission since, equals total creditable A-GHG. The difference between net radiative forcing (NRF) today and in 1990, is equated to this A-GHG. In other words, reducing the difference in NRF to zero is equivalent in immediate effect to removing all of A-GHG since 1990. Figure 4 shows the sharp recent rise in GHGs and the total of 806 GT since 1990. Per Stocker et al, 2013 NRF rose by 1.02 W/m^2 from 1.9 to 2.92 since 1990. This approach ignores the value in reducing insolation beyond the equivalence to accumulated CO2 since 1990. A more direct approach would establish a value for reflecting sunlight in terms of the radiation reflected, independent of GHG measures.

The above calculation illustrates that there is a valuation that can be attached to each sheet and its supporting vehicle. The number of years over which the full credit is earned will be a point of contention, but here the argument about addiction and habit change can be turned around: the Glitter Belt buys time and reverses the heating so that damage is controlled, while the global community removes the underlying causes of heat retention. Perhaps in 20 to 30 years the Glitter Belt can be removed without starting a temperature rise again.

6.3 Carbon and Heat Footprint of Glitter Belt Vehicles

The Flying Leaf systems as envisaged, consist of carbon fiber and other composite framework, Aluminized Mylar sheets, photovoltaic panels, motors, propellers, landing gear, control wires and actuators, and electronics. Each Flying Leaf consists of 11 reflective sheet systems and 3 supporting/propelling wings. Expanded designs will deploy 64m x 60m sheets per reflector module, for a total of 40,000 sqm of reflector. The Carbon Footprint of each 2100 kg Flying Leaf is estimated at 18.6MT. Subtracting from the CEU equivalent, at 0.068 MT per sqm, net credit for a Flying Leaf is 2700 CEUs. Thus, with any reasonable system of credits, Glitter Belt architecture is quite viable and self-sustaining in cost and payoff. Deploying such a system can provide a strong employment base. The Carbon Footprint is dominated by the present petroleum genesis of carbon fiber. Alternatives that use captured, segregated carbon would reverse this by funding carbon segregation from GB credit revenue.

6.4 GB System Levels to Compensate for Specific Heat Emitters

Let us look at system size and accompanying credit sources, to cancel out anthropogenic heat release (AHR) from specific sources. The basic unit is an expanded Flying Leaf vehicle, that carries 11 64m x 60m sheets supported by 3 propelling 64m x 4m wing/tail structures. When fully deployed at altitude, this is 40,000 sqm. of reflector. Aluminized Mylar sheets reflect over 98% of solar Infrared for incidence as shallow as 30 degrees above the horizontal. With the Summer Follower, reflectors catch sunlight for a minimum of 14 hours per day, which we approximate as 12 hours of full-spectrum AM0 reflection, at 95% efficiency. This is 15534 Watt-hours per square meter, giving roughly 60 MWH per day per Leaflet. A Flying Leaf with 11 such Leaflets reflects 658MWH. Following the Summer Sun maintains this value year-round. So each Flying Leaf reflects 240 GWH, or 0.24TWH per year. Table 3 estimates the number of such Flying Leaves to cancel out AHR from various sources:

Table 3: Number of Flying Leaves To Cancel Their Heat Release from Given Anthropogenic Heat Release Sources

AHR Source	TWH/yr AHR @efficiency	Reference	# of Flying Leaves under Summer Sun
Terrestrial Power Generation 26730 TWH	26730 @50%	IEA(2020	111,375
Aviation: 95B gallons, 3420TWH	1710 @50%	Statistica(2021)	7,125
Transportation 118 Quad. BTU 40% efficient	20749 @40%	EIA(2016):	103,745
Air conditioning: 10% of global electricity	2637@50%	IEA(2018)	11,138
Light vehicles 45Quad BTU extrapolated	15109 (@40%)	TME(2015)	63816

6.5 How Intrusive Is GB?

Floating 111,375 Flying Leaves, all under the zone of peak sunshine, year-round, could cancel out all the heat release from terrestrial power generation. Assuming a uniform distribution, strung out under the peak Summer Sun line, there would be 4.5 per kilometer. If they are spaced over 100 kilometer north-south, there would be 9 per 200 square kilometers, covering under 0.2% of the sunlight area at 32km altitude. From the ground neither vehicles nor shadows will be discernible to the naked eye. But laws of physics still assure the reflected amount. A reasonable expectation is that the Glitter Belt may have to do about 10% of the above at its most mature implementation. Compare this to 93 million road vehicles produced every year.

7. Broader Credits

7.1 Reforestation

Many nations have priorities higher than just Carbon Reduction. These do have strong implications for combating Climate Change. They are better seen as ways of advancing towards the Sustainable Development Goals of the United Nations. Reforestation is a top priority. It can restore some wildlife species and biodiversity. Forests can produce significant commercial crops such as rubber, fruits, medicinal herbs and mushrooms, and controlled harvesting of wood for construction and furniture. Restoring and managing forests takes significant resources. Trees must be planted and provided enough water and protection in the growing years. Denied land usage must be compensated by providing other means of support for local residents.

Reforestation is not without negative effects. California’s high-density forests release massive amounts of CO_2, toxins and heat in annual fires. This calls for careful management as well as fast-response fire spotting and fighting. Investments must go well beyond those creditable with CEUs.

7.2 Vertical Farming, flood-drought control

Major human habitats depend on narrow time windows for arrival of the annual Monsoon rains. Most of their water arrives in heavy downpours over 2 or 3 months, and most of it flows to the sea, often with devastating floods. Vertical Farming, modified from ancient Greenhouse ideas, now uses Space technology to grow plants with artificial LEF lighting reaching multiple tiers, along with metered water, air circulation, temperature and humidity. CO2 emission can theoretically be directed where needed, such as in mushroom cultivation. Addressing rising sea-levels, and breaking the flood-drought sequences, are top priorities. Increasing demand for indoor plumbing and urbanization, and subsidized electric power for irrigation pumps, have depleted groundwater. This ground water must be replenished.

7.3 Biogas/Biomethanation; Clean Air and Water

Floating-lid (constant pressure) generators are conveniently located in residential backyards and are suitable to digest vegetation. They are eco-friendly and yield enough gas to replace most of a family's needs for (often imported) liquefied petroleum gas for cooking. They reduce the waste disposal problem. The sludge is excellent natural fertilizer. These generators have large value for energy independence, as well as in environmental cleanup and topsoil replenishment. Biomethanation refers to extracting methane from human waste and other sewage, typically in underground, constant-volume facilities. Biomethanation yields enough methane to light up communities, removes hazardous bacteria from soil and ground water, and is thus crucial to health and wellness. Groundwater cleanup removes industrial toxins. Building toilets has significantly reduced outdoor defecation in emerging nations. Pristine areas such as Mt. Everest are being cleaned to remove garbage and sewage left by climbing expeditions. Cleaning up air pollution goes beyond carbon particles and exhaust gases such as sulfur dioxide: soil and metal dust is also a threat.

7.4 Micro Credit Certification

One key to moving ahead on a global scale is to "democratize" the certification of CEUs. Countries in Asia and Africa have taken the lead in transacting most financial transactions through mobile phones. Thus the identity, documentation and responsibility verification aspects are already well in hand. Technical measurements are an essential part of CEU certification, and will need verification protocols. Once again, the process has much in common with that of many present projects, where the proposal, contract, progress monitoring, result transmission and payments and final reporting are all done electronically. This is no more complex than running university sponsored research programs. A template can be set up, permitting projects at small cost levels to be administered and certified reliably. This will open up Micro Credit certification all over the world, to small local community projects, without an expensive and complex pyramid structure.

8. Summary: Equivalence Calculations

Sunlight is a much more general unit for expressing value than a particular gas or set of gases such as CO2 or GHG. Air purity could be tied to oxygen rather than CO2, but even this is narrow. Fresh water is a basic resource and easily quantified. Inspired by the Carbon Market, there could be a worldwide valuation metrics for fresh air (Burston & Smith 2020) and water (averaged from international values in OECD, 2021) and land with allowances for urban market spikes. Urban values may be seen differently with reverse migration to rural areas offering better quality of life, equal productivity and access to facilities. Table 4 summarizes results.

Table 4: Suggested Ways and Amounts to Credit Human Priorities

Creditable Activity	Basis for awarding credit	Suggested
GHG vs. reflector area: 32 km altitude	Direct conversion. 0.068 to 0.355CEU/m^2 at AM0	$2.72 to 13.71/sqm
Ground reflector or Albedo Paint	AM1 modified by ground loss	
Solar PV & thermal Power	Heat to work; replacing fossil power	
Reforestation	GHG absorption minus albedo reduction	
Vertical Farming, Clean Manufacturing	Forest area; CH4, water savings	

BioGas & BioMethanation	LPG& CH4 value, ground & water cleanup, amortized energy import rates	\$10/MT to \$800/MT
Air Pollution Removal: Combustion products and chemicals, dust	Fresh Air Credit, Health & water saving.	\$1/MT
Groundwater Replenish & cleanup	Freshwater Credit: average of global costs.	\$1/MT
Flood prevention, Seawalls & land-raising, Drought Alleviation	% of Disruption value saved, Freshwater Credit	\$0.01/MT
Education, Healthcare, telemedicine	Priceless. Determined from National budgets.	
Reverse migration	Travel&time saved; heat and emissions.	

Detailed valuations for Nature Credits will involve extensive policy discussions far beyond the scope of this paper. Value perception is with the particular community and nation rather than global experts. Table 3 shows our present suggestions. Sunlight reflection and albedo increase are direct computation as we showed. Solar PV, solar thermal and reforestation are already valued in equivalent fossil fuels or CO2 credits. Biogas and biomethanation have value beyond the methane capture. Fresh water already has widely varying costs. Clean air, including dust removal by green cover and moisture, can also be assigned credit value, with threshold of purity defined. Curing flood and drought and staving off sea-level rise can be valued by land, infrastructure and water. Health and Wellness, and most of all Education are priceless national and global priorities.

9. Suggested Structure

Given the NAS concerns, international priorities and need to get moving, we suggest a Consortium structure as in Figure 4. Except for national government, there are few entities that have power over others, possibly enabling a focused collaborative effort to slow, stop and reverse Global Warming while moving full speed on what really matters to the people of each nation. The structure is drawn generally from the reasoning in (Komerath et al, 2007) to implement the infrastructure needed for extraterrestrial economic growth. Here urgency to implement plans adds pressure, which must be addressed.

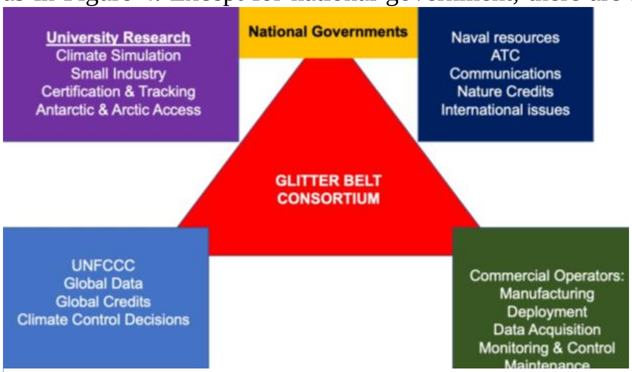

Figure 4: Consortium structure to implement Nature Credits and reverse Global Warming while addressing national priorities.

10. Conclusions

- Most Anthropogenic Heat Emission (AHE) patterns and Carbon Footprint are from developed nations.
- Present focus on reducing Greenhouse Gases is controversial and too slow to avert significant damage from temperature and sea level rise.
- Our Glitter Belt (GB) concept of high-atmosphere ultralight aerodynamically-sustained reflectors, promises to achieve needed sunlight reflections to buy time while satisfying scientific, societal and national concerns.
- In the first phase, small numbers of Flying Leaf vehicles of the GB will be used to make continuous, low-speed measurement sweeps over the tropical and temperate zones of the entire planet. This presents an unprecedented opportunity to obtain complete meteorological data to support physics-based predictive simulations, finely resolved enough to predict local phenomena and interactions.
- Once concerns are allayed, GB can be expanded to Phase 1 with Flying Leaf vehicle swarms that follow the Summer Sun for best efficiency in reflecting sunlight into Space.
- In Phase 2, optimized systems will use much larger "Quadrotor Frisbees", offering an order of magnitude more reflector area per unit mass.
- Automobile industry analogues suggest that Net Zero Heat Retention Rate can be achieved under \$600B in cost, even without Phase 2 efficiencies.

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- Phase 1 and Phase 2 expansion should be self-sustaining.
- Insolation Reduction Credits (IRC) should earn from 0.068 to 0.356 CEUs per square meter by equivalence to Carbon Credits
- IRCs can be part of broader Nature Credits tied to units of sunshine towards Sustainable Development Goals under Nationally Determined Contributions of the UNFCC Paris Accords.
- Micro level Nature Credits must be accessible to small entities to enlist mass participation in Restoring Nature. Initial equivalency calculations are presented.
- In conclusion, Insolation Reduction and other Nature Credits mobilize global participation and enthusiasm, while buying time to implement a comprehensive quantum leap in quality of life, and a sustainable future, worldwide.

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