SMS Before SPS

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Abstract

Governments' climate policies are unbalanced: more than a Trillion Euro-equivalents have already been spent to try to prevent possible problems caused by rising global atmospheric temperatures, but essentially no funds have been spent to prepare for possible problems caused by falling atmospheric temperatures. This policy stance is unsatisfactory from the point-of-view of cost-risk-benefit analysis, since more than 10 times more people die of cold every year than die of heat, and there is growing evidence that the Earth is now in the early phase of another "Little Ice Age". At the international SPS conference in Kobe in 2014, Professor Ge Changchun noted that "guerilla snowstorms" which dump snow to a depth of a metre or more in a few hours have grown more frequent in recent years in North-East Asia, and proposed the use of high-power microwave-beams transmitted from orbiting satellites as a counter-measure. Fortunately, much of the work that has been done in recent decades to develop space-based Solar Power Stations (SPS) for electricity generation by transmitting microwave power to large-scale receiving antennas at the Earth's surface, could alternatively be used for "Snow-Melting Satellites" (SMS) used to melt snow over large areas of the Earth's surface. Since the cost of SMS would be less than 50% of the cost of SPS, this paper advocates urgent development of a satellite to demonstrate microwave power transmission from low Earth orbit to the surface, which would contribute greatly to both SMS and SPS development.

PAPER

1 Introduction: Climate Policies Unbalanced

Most countries' policies towards climate change over the past few decades have become dangerously unbalanced. Instead of researching past conditions of the terrestrial climate, analyzing and quantifying potential risks, and preparing a range of defensive policies for each of the significant risks identified, almost every country's government has selected the same scenario of possible climate change for consideration, namely a progressive rise in the average temperature of the atmosphere, and a single mitigating policy for implementation on a global basis, namely reduction of human emissions of carbon dioxide (CO2). Based on this, to date more than 1 Trillion Euro-equivalents have been spent on trying to reduce humans' emissions of CO2. By contrast, governments have provided almost no funding to investigate the probability of a fall in the average temperature of the atmosphere accompanied by heavier and longer-lasting snowfalls, nor to study possible means of countering the threats that such a scenario might pose for human life. This policy stance is unsatisfactory from the point-of-view of cost-risk-benefit analysis, as summarized in Table 1.

Threat:	Anthropogenic Global Warming	Climate Cooling &/or Ice Age
Precedents	None	Many, cyclical
Probability of Occurrence	10%?	100%
Uncertainties	Many, including physical reality	Timing, Severity
Recent climate trend	Unclear / Opposite	Worsening
Earliest possible crisis	30 years?	<1 year
Maximum possible number of near-term deaths	Millions?	500 Million (Moscow – Seattle)
Maximum economic loss	$1 Trillion?	$1,000 Trillion?

Table 1: Comparative threats of atmospheric warming and cooling

The numerical estimates in Table 1 are approximate, so other researchers would estimate somewhat different values. Nevertheless, any realistic estimates show clearly the seriousness of the risks of climate cooling. Since more than 10 times more people die of cold around the world every year than die of heat, and since there is growing evidence that the Earth is already in the early phase of a "Little Ice Age" [1] such as has occurred repeatedly in the past (most recently during the "Maunder Minimum"), it is unclear why policy-makers in apparently every country focus exclusively on the threat of "global warming".

In published estimates of the potential costs of climate change caused by increasing atmospheric CO2 concentration, researchers typically ignore the benefits, notably "CO2 fertilisation" which stimulates growth of all plant life, including agriculture [2]. Researchers have already measured that greenery in the world's desert areas (which is relatively easy to measure from satellite data) has increased by about 10% over the past 30 years [3]. In addition, among the various possible counter-measures, the one selected and advocated by the UN's IPCC and most OECD governments, namely trying to greatly reduce CO2 emissions, is the most expensive and least certain policy. Notably, unless the major producers of CO2 – China, USA, India, Russia – reduced their emissions substantially , no other country's reduction would have any significant effect on global emissions.

By contrast, adoption of the policies already in wide use in countries with high average temperatures, notably widespread use of air-conditioning and refrigeration, are very cost-efficient and have very low uncertainty. In particular, there would be no need to pay the costs of implementing these policies unless the atmosphere became excessively hot, whereas the massive costs of "decarbonizing" the economy may well have no benefit at all – for example in the event of a "Little Ice Age.

It is also important to note that, among the various potential costs of global cooling, agriculture is very sensitive to cold weather: an unusually cool summer may prevent many crops from fully ripening, while a single unusually late frost in the spring can greatly reduce the following harvest of many different crops. As an example, severe frosts in France during April 2021 have reportedly reduced the 2021 French wine harvest by about one third.

In addition, there is no reason to believe that the cycle of full “Ice Ages” has ended, as a result of which the next 100,000 year cycle of much colder weather, leading to deep snow coverage of much of the northern half of the northern hemisphere, could start at any time. In this context it has recently been discovered that at least some, and possibly all, Ice Ages in the past began with “rapid onset” – that is, “metres of snow every day for months on end”.

In order to understand the threat which this represents, it should be borne in mind that a heavy snowfall of one metre or more in a day causes great disruption to the economy and society. In places where heavy snowfalls are common, so that snow-clearing equipment and systems are ready for use in the winter, most of the disruption caused by such a “guerilla snowstorm” can be cleared up within a week or so. However, even in such well-prepared places, if snowfall of one metre or more per day continued for even just a few days, it would rapidly lead to disaster, as no vehicles would be able to move; shops could not open, nor be resupplied; and services of water, electricity and gas would soon cease, causing a massive death toll. If this continued for weeks, it would kill almost everyone in the affected areas. Although the details of past Ice Ages differ, during the next Ice Age most of the area from Moscow west to Seattle will probably end up under kilometres of ice, much like Greenland today. If the onset of such cold and snowy weather was rapid, only those able to quickly escape to the south could survive.

By contrast, the climate change risk which governments have chosen to exclusively focus on, that of warming of the terrestrial atmosphere by human combustion of mineral fuels, would be unprecedented, and hence is entirely theoretical. Moreover, it is now predicted to take several decades to become dangerous, since repeated predictions of rapidly rising atmospheric temperatures in the nearer future have been mistaken. The fact that governments have already spent more than one Trillion dollars on a range of counter-measures for this anthropogenic climate warming, but have not even performed a systematic risk analysis of climate cooling scenarios, even as weather phenomena such as “guerillla snowstorms” are becoming more common, is evidence of a serious imbalance in policy-making for climate change.

2 Dependable electricity power supplies

One possible means of supplying electric power which would not cause large emissions of CO2, and would also not depend on the continuing use of mineral fuels or terrestrial power generation systems, is to use orbiting solar power satellites (SPS) to deliver microwave power to dedicated receiving antennas (“rectennas”) on Earth. Research and development work on this possibility has continued at a low level since it was proposed in 1968. Among other relevant progress, worldwide production of photovoltaic cells and panels has grown from about 100 kW/year in 1968 to tens of Gigawatts/year today. However, the development of comparably large orbiting antennas in order to deliver microwave power to receivers on Earth has not yet achieved similar progress.

The “SPS 2000 & Beyond” project was designed to enable rapid progress in this key technology. It envisages a series of operational demonstrator satellites in successively higher equatorial orbits, delivering microwave power intermittently to research rectennas at a number of different sites within a few degrees of the equator. The near-term development of solar-powered, microwave power transmitting satellites in order to demonstrate microwave power transmission from low Earth orbit to the surface in this way would contribute greatly to timely development of SPS as a new source of electric power supply.

3 Snow-Melting Satellites (SMS)

At the international SPS conference in Kobe in 2014, Professor Ge Changchun noted that “guerilla snowstorms” which dump snow to a depth of a metre or more in a few hours have grown more frequent in recent years in North-East Asia. As a possible counter-measure, Professor Ge proposed that high-power microwave-beams transmitted from orbiting satellites might be effective for melting such snow over a wide area. If this use of microwave beams from orbiting satellites to melt snow is found to be feasible, it would be an important additional benefit of developing SPS technology.

Fortunately, much of the research and development work that has been done in recent decades to develop SPS could be repurposed to develop “Snow Melting Satellites” (SMS) to melt snow over large areas of the Earth’s surface. Indeed, such an application would be much easier to realise than commercial electricity supply, since in order to melt snow there would be no need to build multi-square-kilometre “rectennas” on the Earth’s surface, each of which would be a massive civil engineering project with wide-ranging local and regional impacts. In addition, the technical constraints on the quality of the SMS microwave-beam would be significantly looser for melting snow than are needed for electricity generation. Commercial electricity supply is required to achieve very high reliability, which would necessitate very high SPS beam-pointing accuracy, strict continuity of power, and precise control of power intensity, wavelength and other parameters across the microwave beam profile. By comparison, each of these parameters would be much relaxed for melting snow: as long as a specified amount of microwave energy is delivered over a specified area over a specified period, such as an hour, day or week, small variations in such parameters as the power density or frequency would not reduce the system's snow-melting effect. As a consequence of these important differences, the cost of developing an operational SMS would be less than 50% of the cost of developing an operational SPS [4].

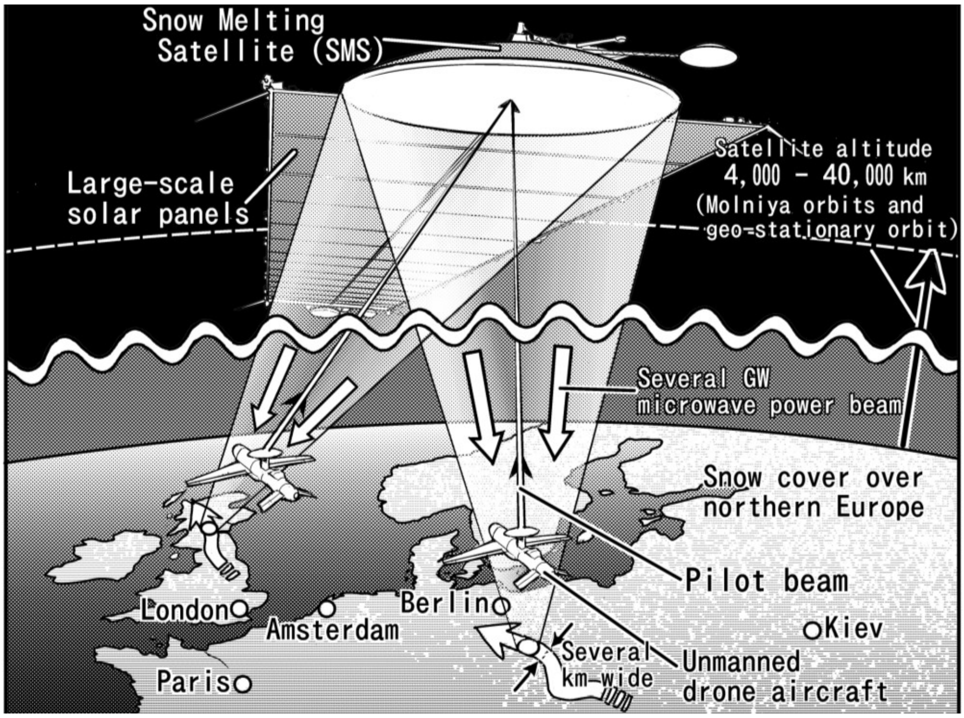

Figure 1: SMS operating over northern Europe

A further factor that could reduce costs for SMS for use in regions such as North-East Asia would be the use of Molniya orbits, which are convenient for transmitting microwave power to sites in the northern half of the northern hemisphere. These would be more economical than using GEO, since the lower altitude would reduce launch costs, while the shorter average microwave power transmission distances would enable higher power densities reaching the snow than beams from SMS in geo-synchronous orbits.

4 SMS as an Ice Age Counter-Measure?

Developing the ability to use microwave beams from orbit to melt snow locally would have the additional benefit of preparing the capability to implement this technology on very large scale, as would be necessary in order to mitigate the cost of a coming Ice Age. In such a case, the area of snow to be melted would not be local, but would cover several millions of square kilometres. In order to have a significant effect in holding back such massive snowfall, the use of the order of one million square kilometres of solar panels powering SMS would be needed.

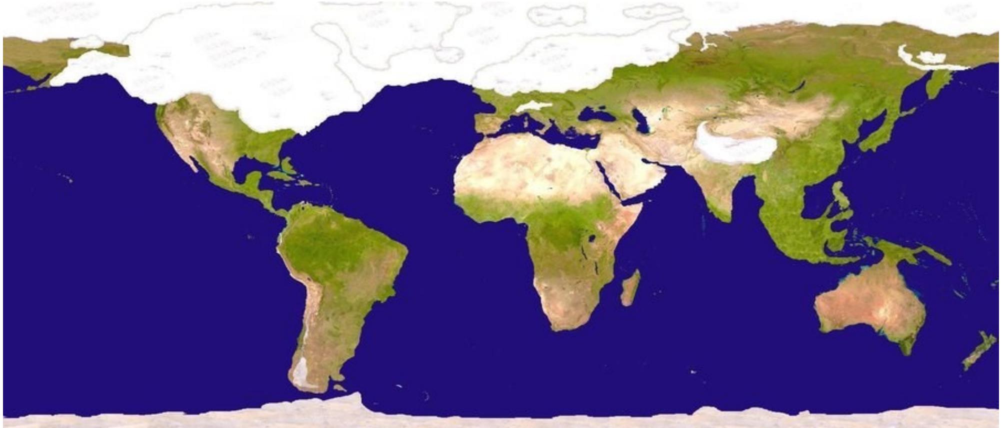

Figure 2: Typical Deep Snow & Ice Cover During Past Ice Ages

While the next Ice Age threatens to start in the relatively near future, many years of preparation would be needed in order to prepare a realistic plan to resist it. Although such a gigantic project may sound like fantasy, the cost of the destruction of most of the accumulated infrastructure in the northern half of the northern hemisphere would be many trillions of Euro-equivalents, and so would justify similar costs to protect it. Moreover, in the absence of any other suggestions, SMS seems to be the only known approach to holding back the next Ice Age. Figure 3 shows another approach to reducing snowfall over a limited area: by contrast, orbiting satellites would be able to transmit power over a much wider geographical range.

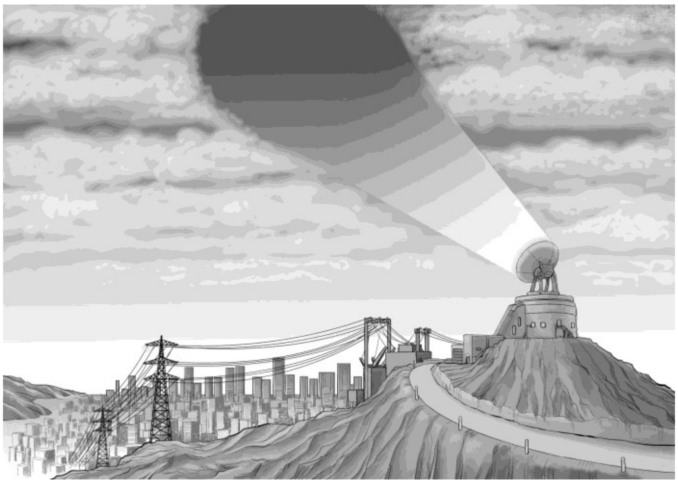

Figure 3: Ground-based microwave power transmitter for snowfall reduction

A ground-based system transmitting microwave power up into snow-clouds could in principle reduce snow fall, or at least move it to somewhere else. However, as a geographically fixed system, its range of operation would be limited. Nevertheless, such a system might be able to protect a city and its surrounding region.

With the recent rapid progress in the development of robotics, including drones, 3-D printing, nano-technology, AI and other engineering techniques, a scenario of rapid growth of orbiting SMS capacity can be envisaged. Space-based solar panel manufacture, matched by production of space-based, microwave power transmitting antennas on a similar scale is surely not impossible. However, more research is equally surely needed in order to understand the possible timing of a growth scenario sufficiently to prepare reliable plans.

5 Summary

More balanced policy towards climate change would lead to substantially greater funding of research on the risks and feasible counter-measures for climate cooling and coming Ice Ages than the almost zero level at which, inexplicably, such research is funded today. In this case, research on the feasibility and design of SMS systems, which are an alternative use of SPS technology, would be one logical topic for collaboration between the fields of climate policy and electricity generation. By also contributing directly to the development of SPS, work towards realizing SMS will contribute to the implementation of counter-measures for both possibilities of cooling or warming climate. Such policies are very helpful for policy-makers in an area of such uncertainty.

Continuing failure to fund any significant research on climate cooling scenarios would leave policy-makers open to serious criticism in the event that recent cooling trends continue. In other words, the use of the "Minimax Regret" criterion – making a decision that minimizes decision-makers' maximum possible regret (due to having misjudged actual conditions) – also supports increased funding of research on counter-measures for climate cooling, including SMS. The worst-case cost of being unprepared for a severe "Little Ice Age" could include massive losses of agricultural production causing widespread famines in the near future. Even the richest countries do not hold large stocks of food with which they could survive a single year without a full harvest of their staple crops. For governments to continue to ignore these risks would be unscientific and irresponsible policy-making, due to depending on incompetent scientific advisers, and/or dysfunctional systems for selecting experts.

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