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Review Article

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Increasing the Albedo of Artificialized Soils to Reduce Climate Change

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ABSTRACT

This article reviews the causes of the greenhouse effect: GHGs (well known worldwide) and infrared radiation (very rarely mentioned). It then presents concrete, albeit rare, examples of how to reduce the absorption of solar radiation and thus increase albedo, thereby reducing infrared emissions and consequently the Earth's greenhouse effect, which causes global warming. We cite Duha, Qatar, which is repainting its streets pale blue (the albedo increases from 0.2 to 0.6). Quebec prefers white for its roads. They are all doing this to avoid what they call the urban heat island effect. We call this radiative trapping, as scientifically adopted, or, more commonly, the greenhouse effect.

Keywords: Climate Change, Greenhouse Effect, Greenhouse Gases, Terrestrial Infrared Radiation, Artificialized Soils

Introduction

The energy transition is primarily focused on solar power, where thermal and photovoltaic conversion occurs without greenhouse gas emissions. However, when exposed to the sun, the panels become very hot. Combating global warming with a system that generates so much heat is not a viable approach. We adopted a solution that exacerbates the problem instead of solving it. We moved away from the drips to the gutter. The COPs (United Nations, IPCC) have influenced the 8 billion inhabitants of the earth towards misinformation. Everyone is raising the same shogun: decarbonization against global warming. Global warming due to the Earth's greenhouse effect is scientifically called: RADIATIVE IMPRISONMENT.

Decarbonization is about reducing this imprisonment. Everyone has understood the message: switch to renewable energies, nuclear power…; but what about the second term, RADITIVE, i.e., the radiation emitted by the earth and especially by artificial surfaces (roads, urban expansion… but also photovoltaic power plants)? In the 1980s, it was said that photovoltaics was for low power outputs of a few kilowatts and thermal power for high power outputs. Now, photovoltaics dominates, even for gigawatts [1-10]. In previous articles, we demonstrated that reducing greenhouse gas emissions is insufficient to combat climate change, as this is only one component of the greenhouse effect, clearly visible to the naked eye [11]. The other component, invisible but essential for causing the greenhouse effect and consequently global warming, is the infrared radiation emitted by the ground. Currently, this is due to the vast extent of paved surfaces, i.e., roads and pavements, as well as urban development. These dark-colored paved surfaces have a low albedo, unlike bare soil, which is light-colored and has a high albedo.

It is noteworthy that photovoltaic modules, and therefore solar photovoltaic power plants, whose expansion is exponential, unfortunately have a low albedo, emit a significant amount of infrared radiation, and thus implicitly and/or explicitly contribute to the formation of the Earth's greenhouse effect and, consequently, global warming. Using solar energy because it emits no greenhouse gases is therefore clearly controversial due to its invisible infrared emissions. In our opinion, infrared emissions must be reduced regardless of their origin, including from artificial surfaces such as photovoltaic power plants.

Causes of the Earth's Greenhouse Effect

Aside from the well-known role of greenhouse gas emissions in global warming, we will discuss here the infrared emissions from artificial surfaces [12-13].

A power plant with an electrical power output P will emit a heat flux ϕ in the form of infrared radiation of: $\phi = P.(1/\eta - 1)$ where η is the photovoltaic efficiency. Example: A 500 MW power plant will emit a heat flux in the form of infrared radiation of: 500 x ((1-0.15) /0.15) = 2833 MW, or 2.833 GW!!!

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Figure 1: Soil artificialization due to urban development



Figure 2: Soil artificialization due to roads, highways, and pavements



Figure 3: Soil artificialization due to photovoltaic solar power plants [14-15]

Remedies

Reduce the spread of artificial surfaces: roads, urban development, and even photovoltaic solar power plants.

Roads: Move from low albedo to high albedo. The color should be light, not dark, to minimize the absorption of solar radiation and consequently the emission of infrared radiation. This radiation is then absorbed by greenhouse gases (clouds, CO2, etc.) which partially re-emit it back towards Earth, thus creating radiative trapping, commonly known as the greenhouse effect.

Urban: Development As with roads, the color of buildings (roofs and facades) should be light, preferably white, especially during the summer. There are paints that change shades (dark to light and vice versa) depending on the temperature. Photovoltaic Solar Power Plants Currently, photovoltaic panels are black, which is a source of infrared radiation emission and therefore contributes to the greenhouse effect and consequently to global warming.

Concrete examples in cities

Some cities around the world have experienced urban heat islands. To combat this warming caused by the dark color of asphalt, which absorbs too much solar radiation, these cities have repainted their streets in light colors.

Case Study 1: White asphalt to combat urban heat islands

Quebec has 325,000 km of highways, boulevards, avenues, and streets of all kinds across its territory, a third of which are in urban areas. In the summer, these black roads bake under the sun's rays, to the point that their temperature regularly reaches 70 degrees Celsius. Could white asphalt help counteract the urban heat island effect and contribute to cooling cities, where temperatures are often several degrees higher than in the countryside? A global discussion has emerged around this question. “Roads and parking lots bear a significant share of the responsibility for the urban heat island effect,” explains Alan Carter, head of the Roads and Bituminous Materials Laboratory at the École de technologie supérieure (ETS). Currently, few places in the world can afford to ignore this phenomenon.

Qatar, for example, where temperatures can climb as high as 45 degrees Celsius, began painting some of its roads as early as 2017 to counteract heat absorption. Red, green, blue, purple: in this country, roads become a rainbow [16].



The logic behind Qatar's approach is based on science. The black of asphalt decreases its albedo, the measurement used to determine a surface's capacity to reflect or absorb light. A very low albedo indicates a material that absorbs heat. Conversely, freshly fallen, pristine snow has a very high albedo, which causes sunlight to "bounce" off its white surface.

Because it would increase the albedo of roads, a white pavement would certainly reduce heat, says Mr. Carter, following the same principle as white roofs. However, what is possible above our heads is not necessarily possible under our tires and feet. The advent of white asphalt is therefore not imminent, primarily for technical reasons, but also for safety reasons.

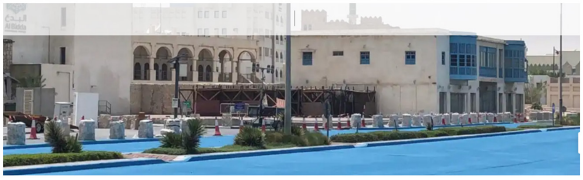
Technical Constraints

It is indeed difficult to counteract the black color caused by the "glue" that holds our roads together. "One of the components of asphalt is bitumen, a petroleum derivative. Even though it represents only 5% of our asphalt mixes, it makes them very black, and there's not much we can do about it," explains Mr. Carter. Making white asphalt would require a colossal amount of dye, the researcher points out, and would therefore be very expensive. It is possible to "dye" pavements by adding materials that act as pigments. "The easiest way is probably to add a red tint," says the ETS expert. "If you add iron oxide—commonly known as rust—it's relatively simple to go from black to a reddish color."

Other materials allow roads to have a higher albedo, particularly concrete, which has a paler hue than traditional asphalt. These roads absorb less heat early in their lifespan. However, these surfaces get dirty from passing vehicles and, within a few years, turn from gray to black. "What happens," explains Professor Carter, "is that this pavement starts with a high albedo and a paler color, but we get it dirty over time, so the concrete pavement gets darker and darker, and its albedo decreases significantly. I don't think anyone wants to scrub our asphalt to keep it pale."

Safety Concerns

It would theoretically be possible to paint the surface of our roads white to increase their albedo. This solution, however, is not desirable for several reasons. First, snowplows would likely damage the paint. Second, a white coating would make the road blinding, reflecting light as much as a first snowfall. Alan Carter states firmly: “We don’t want white, because we wouldn’t be able to drive.” Science, however, is opening up other avenues to combat the urban heat island effect caused by asphalt. The laboratory headed by Mr. Carter, for example, is currently working on incorporating recycled materials into asphalt mixes, such as glass or crushed brick. The results are conclusive: these mixes are not only more economical but also more effective.



Testimony 2: Doha Repaints Its Roads Blue to Combat the Heat

In a city where temperatures exceed 50°C in the summer, any means are being used to cool the atmosphere. The Qatari capital is testing a reflective blue coating, which not only helps combat the heat but also reduces pollution and fuel consumption. Initiatives of this kind are multiplying around the world, from artificial snow sprayed on the streets to mini-gardens perched on the roofs of buses [17].

Temperatures in Qatar's capital can easily exceed 50°C in the summer. In order to combat urban heat islands, the authorities in Doha decided to conduct a pilot project by repainting the roads with a "cooling" blue paint. Unlike conventional black asphalt, which absorbs 80 to 95% of solar radiation, this coating, developed by the Japanese company Japanese Oriental Company, reflects 50% of the rays. It would thus be capable of lowering the temperature of the asphalt by 15°C to 20°C, according to Ashghal, the Qatari authority leading the project. "By lowering the temperature, this cooling coating slows down the chemical reactions that cause pollution," reports the Qatar Tribune.

This special asphalt also reduces friction with tires, which lowers fuel consumption, reduces polluting emissions, and extends their lifespan. "The colored asphalt also improves pedestrian safety by making cars more visible and reflecting streetlights at night," the newspaper reports.

Two hundred meters of road have been repainted along Abdullah bin Jassim Street, and another 200 meters have been created on a cycle path and pedestrian walkway near the Katara Cultural Village. The tests will last 18 months. If they prove successful, other blue routes could be developed in Qatar, authorities indicate.

Titanium Dioxide to Cool the Streets

Qatar isn't the only one adopting this tactic. In 2017, Los Angeles tested white paint on some roads to reduce the stifling summer heat in the city. This year, the city is unveiling a brand-new technique: a kind of "snow" made from titanium dioxide, a white pigment commonly used in food products, medicines, and toothpaste. According to Greg Spotts, deputy director of the city's road department, this product reduces the surface temperature by 5.5°C. "Even dogs and cats love it. They cross the street just to try it!" he told The Guardian. These initiatives, however, come at a cost: around €60 per square meter for the titanium dioxide snow

A Bonus Offered to Residents to Install Climbing Plants

Yet there's a much cheaper way to cool cities: greening. “Beyond their aesthetic appeal, urban greenery offers several benefits: reducing the urban heat island effect, sequestering CO2, limiting air pollution, and promoting biodiversity,” emphasizes Ademe (the French Agency for Ecological Transition). Not only do trees create welcome shade during heat waves, but they also provide natural cooling through the evaporation of water from their leaves. This concept is so popular with municipalities that they are running out of ideas for bringing greenery into their cities. Bordeaux has pledged to plant 20,000 trees by 2025. Brussels offers a subsidy for every climbing plant on a building's facade visible from the street. In Madrid and Singapore, buses have even been fitted with mini-gardens on their roofs.

In Doha, blue is clearly preferred to green. But why blue and not pink, beige, or yellow? This color was simply deemed “more pleasing to the eye,” according to the Gulf Times.

Testimony 3: Climate Change: Should France Be Repainted White?

Light-colored roofs and roads can lower the temperature of cities and buildings by several degrees. Advocates of white paint are setting their sights on conquering France [18].



The village of Oia, in northern Santorini (Greece). © imageBROKER.com/SIPA

City dwellers experienced this firsthand during the three heat waves this summer: even several hours after sunset, the city seems trapped in a heat vice that only dissipates at dawn. This is due to a phenomenon now well known to urban planners: the urban heat island effect. During the day, in full sunlight, the bitumen, asphalt, or concrete that covers our streets and buildings absorbs much of the heat they receive from the sun—then releases it at night, creating an artificial microclimate that prevents the atmosphere from cooling down as quickly as in the countryside. What do all these materials have in common? Their dark color, often chosen by default. And according to many researchers and manufacturers, a significant part of the solution lies in a simple gesture: a good coat of paint. “White paint is an obvious choice, packed with technology. It just needs to be made more accessible,” explains Julien Martin-Cocher, Deputy Managing Director of Cool Roof France, a Brest-based company that designs and distributes thermoreflective coatings intended to last twenty years. The concept originated from research by NASA, the US space agency, on rocket paint best suited to preventing overheating during atmospheric reentry.

From the Greek islands to the IPCC report

White villages of Andalusia, Greek islands with immaculate houses: "We didn't invent anything," readily admits Julien Martin-Cocher. Regions of the globe historically subject to heat didn't wait for engineers to realize that light-colored houses are less prone to overheating. "The principle is to reflect infrared radiation, because infrared radiation is heat," explains Maxime Claval, engineer and founder of Enercool, a Nantes-based startup that markets a cooling paint. "White naturally contributes to this; it's already a very good base, but we can do even more with special pigments." The opalescent houses of Santorini are therefore a low-tech version of the sophisticated coatings that are gaining ground all over the world, from the suburbs of Sydney (Australia) to the Indian city of Ahmedabad, and even on the rooftops of Senegal.

At the heart of this phenomenon lies the concept of albedo, which is the proportion of light reflected by a surface based on its characteristics—particularly its color. Bitumen has an albedo close to zero because it absorbs almost all incident light; a mirror would score 1 because it reflects it entirely. The February 2022 report from the Intergovernmental Panel on Climate Change (IPCC) states that high-albedo surfaces "can help reduce the

urban heat island effect." In a May 2021 study entitled "Cooling Cities," the French Agency for Ecological Transition (Ademe) similarly concludes that they are highly effective.

Breaking the Vicious Cycle of Air Conditioning

On a smaller scale, white can drastically change the atmosphere inside a building. Compared to a dark roof, a light-colored roofing material can "lower the temperature by 6 or 7°C: when it's 40°C outside, that's fantastic," exclaims Julien Martin-Cocher. This translates into a similar reduction in air conditioning bills, the main selling point for companies seeking savings – approximately 20% less energy demand according to a 2004 study. However, air conditioning is a worrying source of carbon emissions for the future: according to the International Energy Agency, air conditioning use could triple in Europe by 2050. Choosing white, in addition to being a way to adapt to climate change, could therefore also contribute to combating it. Roofs are far from being the only candidates for whitening. Since 2017, Los Angeles has been experimenting with white roads with conclusive results: the surface temperature of the light-colored pavement is about 7°C lower than that of conventional asphalt. A similar test is underway in Lyon, which will decide this fall on the next steps. "Today, because of the heat, the SNCF (French National Railway Company) is reducing the speed of its trains," points out Julien Martin-Cocher. "Putting white on the tracks would help."

Testimony 4: Whitening car roofs

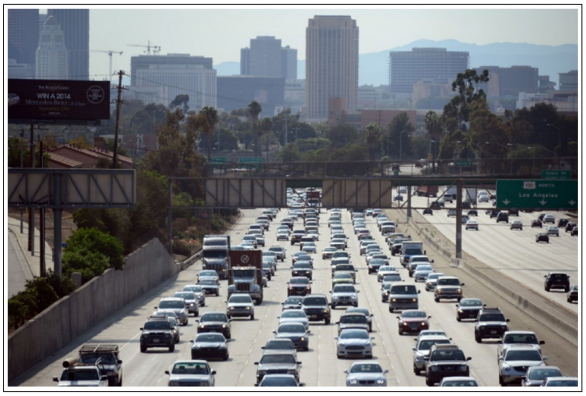
But transportation also represents a significant loss of potential revenue. 500 million liters of gasoline saved per year, or one million tons of CO2, if the entire French car fleet were equipped with white roofs: this is the hypothesis put forward by Raphaël Ménard, president of the international architecture firm Arep, a subsidiary of SNCF Gares & Connexions (French National Railway Company Stations & Connections). In a document published in July, the engineer advocates for a "master plan for lightening" in order to "mitigate some of the impacts of global warming." He proposes, in particular, the implementation of an "albedo bonus" when roofs are replaced, and the mandatory inclusion of this indicator in building permits.

So, should we rethink the entire color scheme of the globe? In 2009, Steven Chu, Nobel Prize winner in Physics and Secretary of Energy under Barack Obama, enthusiastically proposed repainting all the roofs, roads, and pavements on the planet, for savings he claimed would be equivalent to "the carbon emissions of all the cars in the world for eleven years." "There are at least fifty shades of light!" counters Raphaël Ménard. "The issue can be addressed with subtlety. I am, however, more radical regarding transportation." The Drawdown Project, an NGO that brings together researchers to identify the most effective ways to reduce carbon emissions, generally approves of white roofs, but notes one important caveat: "Cooling during the hot seasons is good, but not during the cold seasons, and cool roofs are a constant from one season to the next."

In Los Angeles, Painting Roads White to Combat the Heat

A crowded highway in the Los Angeles area.

A coat of paint on the roads against global warming? This is the seemingly iconoclastic technology, but taken very seriously by ecology experts, that Los Angeles is currently testing. VERONIQUE DUPONTAGENCE FRANCE-PRESSE [19].



The City of Angels, where temperatures can exceed 40 degrees Celsius in the height of summer, is one of the first major cities in the world to experiment with these "cool pavements," painting a few streets across the city with a special grayish-white coating.

The usual black asphalt absorbs 80 to 95% of sunlight, while the pale-colored coatings reflect it, dramatically lowering the ground temperature, according to proponents of this technology. "The heat here, on the black surface... it's 42, 43°C right now. And on the dry surface on the other side, where we've only applied one coat of white and still have to apply the second coat, it's 36°C." "So we're seeing a temperature difference of 6 to 7°C," Jeff Luzar, vice president of Guartop, the company that supplies the coating, explained during a demonstration to AFP.

George Ban-Weiss, assistant professor of civil and environmental engineering at USC, believes that "cool pavements" hold real promise in combating climate change in cities where asphalt and high population and traffic density create a "heat island" effect.

Cooling Roofs and "Cool" Pavements

"Pavements that reflect solar heat are one of the strategies, like cooling roofs or planting trees, that cities can adopt to reduce urban temperatures," this technology expert told AFP on Monday [20]. Los Angeles is the first city in California to test this "cool pavement" on a public road, notes Greg Spotts, deputy director of the Los Angeles Bureau of Highway Maintenance. "It has already been done in parking lots. We hope that other cities will be inspired (...) and that manufacturers will develop new products," he says. The city must now observe residents' reactions to these unusual white pavements and see how quickly they become dirty from passing cars, oil spills, gasoline spills, etc.

Alan Barreca, a professor of environmental science at UCLA, notes that "there is already an effective technology to protect us from heat waves: air conditioning," but that "not everyone can afford it at home," while "the benefits of cool pavements are felt by everyone."

Furthermore, "less reliance on air conditioning means fewer greenhouse gas emissions" and less energy consumed, he adds.

According to him, this inexpensive technology—it costs $40,000 per mile (1.6 km) for seven years—has the potential to protect "many people at a low cost in densely populated urban areas" like Los Angeles, and thus seems more appealing in these areas than in less densely populated suburbs.

White Cities

It therefore seems logical to make ground surfaces and building envelopes as light as possible... provided the colors are not reflective. "The lighter the color of the surface, the more sunlight is reflected back into the atmosphere, and, without clouds, some of it returns to space," explains Frédéric Bonneaud, director of the Toulouse Architecture Research Laboratory. A good way to combat the greenhouse effect, then. Even if many parameters can interfere: humidity levels and especially pollution... Moreover, in 2011, researchers from Stanford University showed that this radiation, which re-enters the atmosphere, can contribute to the greenhouse effect due to a complex "domino effect." "White roofs modify the albedo and influence energy exchanges. If we only consider the albedo effect, a global white roof would lead to an increase in the Earth's temperature of 0.07 K," according to the researchers. Nevertheless, they agree on the limitations of their study, which remains hypothetical since they did not account for the effect on energy consumption.

For context, Steven Chu, the Nobel Prize winner in Physics appointed by the Obama administration, proposed in May 2009 painting roofs and sidewalks white worldwide to limit global warming. He further argued that this would require less air conditioning energy to cool buildings. A Leclerc hypermarket in Quimper (Finistère) commissioned the company Cool Roof France to install a 7,000 m² "cool roof" in July 2015. According to Antoine Horellou, marketing manager, the carbon footprint of the project represents a reduction in greenhouse gas emissions of more than 175 tons of CO2 equivalent.

Climate change: Repainting roofs white, a solution to combat heat inside buildings Reflecting up to 90% of the sun's rays [21].

Aymeric Mouret decided to repaint the roof of his cabin white to protect his surfboards, which had swollen from the heat. The result was immediate: the temperature dropped from 50 to 30°C after just one coat. The white roof technique reflects up to 90% of the sun's rays, thus blocking the overheating mechanism inside the building. A company in Brittany has even developed its own reflective paint. Its natural coating, made from oyster shells, improves comfort and reduces energy bills.

Concluding Remarks

While the COPs, policymakers, and the public are mobilizing to combat climate change by focusing solely on its visible aspect—greenhouse gases—they are neglecting the invisible aspect, characterized by infrared radiation emitted by paved surfaces. Indeed, the Earth's greenhouse effect, analogous to that of an agricultural greenhouse or a solar collector, is mitigated by the opacity of greenhouse gases to infrared radiation emitted by artificial surfaces. Scientifically, this is called radiative trapping. Will the day come when we combat the increase in terrestrial infrared emissions in the same way we combat greenhouse gases, finally addressing the underlying causes of the Earth's greenhouse effect and, consequently, global warming?

Highlights

The causes of global warming are not solely greenhouse gas emissions. Infrared radiation emitted by paved surfaces also contributes to the greenhouse effect. The reduced albedo of dark-colored surfaces means they absorb more solar radiation and therefore warm the Earth. Dark-colored photovoltaic solar power plants are considered paved surfaces, just like roads, pavements, etc.

References

1. Ben Slama R. Greenhouse effect vs. infrared radiation emissions. J Climatol Weather Forecasting. 2016. 4.
2. Ben Slama R. L'effet de serre et les radiations infrarouges des zones urbaines et goudronnées sombres. In: International Congress on Energetic and Environmental Systems. 2017. Djerba, Tunisia IEES-2017.
3. Ben Slama R. Role of the dark surfaces of cities on the greenhouse effect increase. In: International Conference on Sustainable Development. Ottawa, Ontario, Canada. Videoconference. 2017.
4. Ben Slama R. Greenhouse effect vs. terrestrial infrared radiation emissions: the greenhouse effect is not solely due to the release of greenhouse gases. In: 85th ACFAS Congress, Symposium 604; May 10, 2017; McGill University, Montreal, Quebec, Canada. 2017.
5. Ben Slama R. Impact of the artificial surfaces sunk on the global warming by the absorption of the solar radiation and the albedo coefficient modification. J Climatol Weather Forecasting. 2018. 6.
6. Ben Slama R. Modification of the terrestrial albedo following the absorption of the solar radiation by the dark artificial surfaces and its influence on the greenhouse effect. Phys Astron Int J. 2018. 2.
7. Ben Slama R. Dual anthropogenic origin of global warming through GHGs and IR radiation emissions from artificialized soils. J Atmos Sci Res. 2021. 4: 36-41.
8. Ben Slama R. The real cause of global warming: infrared radiation emissions. J Envi Sci Agri Res. 2024. 2: 1-6.
9. Ben Slama R. The infrared emission from artificial soils: the great forgotten aspect of the terrestrial greenhouse effect. Phys Astron Int J. 2025. 9: 245-252.
10. Ben Slama R. The great forgotten aspect of the terrestrial greenhouse effect is the infrared emission from artificial soils: an energy specialist's perspective on global warming. Adv Envi Man Rec. 2025. 8: 1-13.
11. Dufresne JL. Le bilan radiatif de la Terre.
12. Time for Change. Radiation, wavelength and greenhouse effect.
13. Vincent D. Le bilan radiatif de la Terre. ENS-Lyon. 2003.
14. Khan A, Anand P, Garshasbi S, Khatun R, Khorat S, Hamdi R, et al. Rooftop photovoltaic solar panels warm up and cool down cities. Nat Cities. 2024. 1: 780-790.
15. Le Soleil. Solar panels that warm the climate: is it possible? 2021.
16. Le Devoir. White asphalt to combat heat islands.
17. Futura Sciences. Doha paints its roads blue to combat the heat.
18. Le JDD. Global warming: should France be painted white?
19. La Presse. In Los Angeles, painting roads white to combat heat. 2017.
20. Tribune de Genève. Roads painted white to combat heat.

21. Franceinfo. Global warming: painting roofs white—a solution to combat indoor heat.

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