What is geo-engineering and adaptation and CO2 mitigation all in one?

By: Digg
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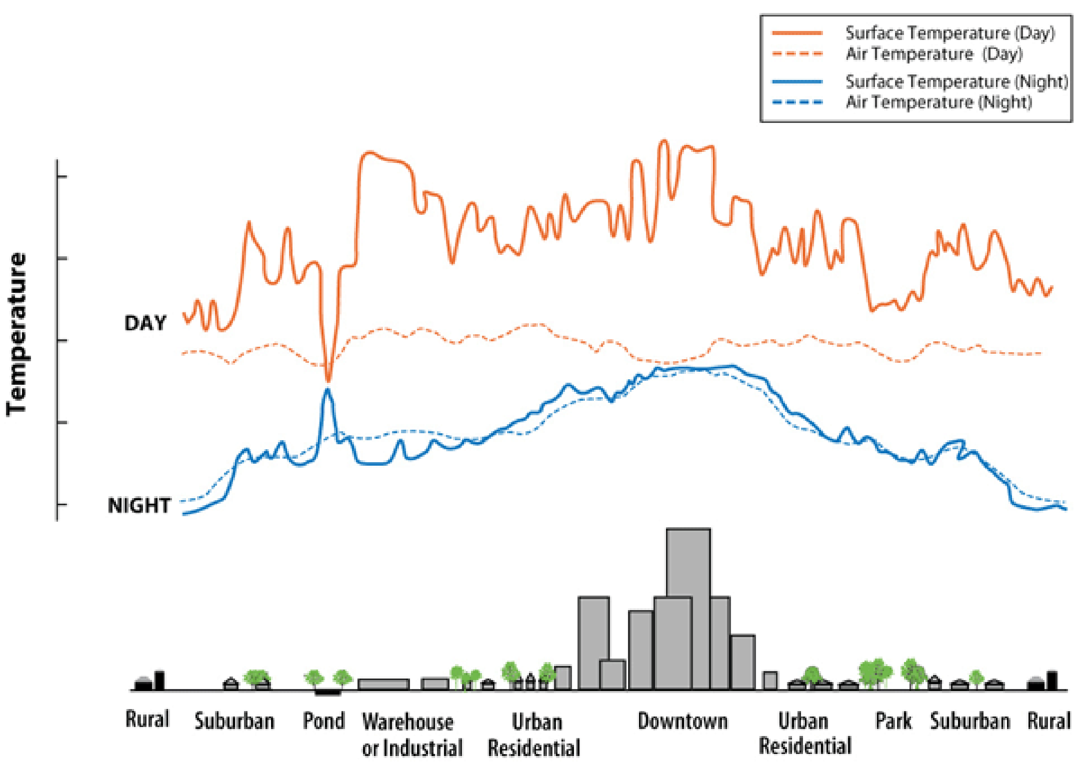
What wildly underfunded climate solution can achieve all of these goals simultaneously:

- Slow global warming by increasing the reflectivity of the Earth (geo-engineering)
- Reduce local temperatures in the hottest cities (adaptation)
- Reduce fossil CO2 emissions (mitigation)
- Save U.S. consumers and businesses billions of dollars in energy costs
- DReduce urban smog and hence cardio-pulmonary disease
- Create more than 100,000 jobs in two years?

The answer is a major effort to make roofs (and pavements) whiter and/or more reflective, which should be coupled with a major urban tree-planting effort. **This " urban heat island" (UHIM) may well be the single most cost-effective energy and climate strategy**.



[*This figure is from EPA's excellet heat island website, showing how urban areas are relatively hotter where vegetation has been removed and replaced with dark, heat-absorbing roofs and pavements.*]

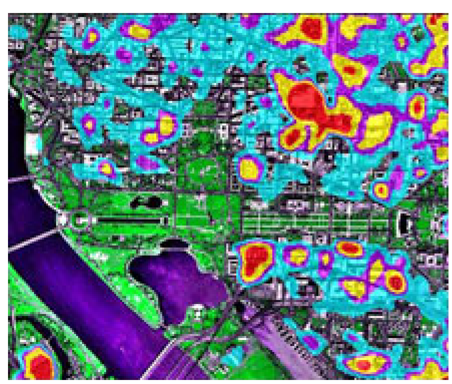
UHIM will be the subject of a multipart series. Part 2 will look at a new analysis of **the multi-trillion-dollar direct climatic/geo-engineering benefits of a global "cool roofs" initiative** [and, no, I am still not a fan of what is commonly called geo-engineering]

Part 3 will present a specific new proposal to use the economic stimulus package to jump-start the UHIM effort. **A key benefit of a UHIM stimulus is that it does not require either highly-skilled labor or expensive, uncommon material**. Thus, unlike many proposed elements of the stimulus package (green or otherwise), this one can be ramped up quickly.

The rest of this post is an introduction to heat islands, excerpted from a *Technology Review* article I coauthored, "Paint the Town White – and Green" ":

On a summer afternoon, central Los Angeles registers temperatures typically 5°F higher than the surrounding suburban and rural areas. Hot roofs and pavements, baked by the sun, warm the air blowing over them. The resulting urban "heat island" causes discomfort, raises air-conditioning bills, and accelerates the formation of smog.

Heat islands are found in many large cities, including Chicago, Washington, and Atlanta. The effect is particularly well recognized in cities that quote two airport temperatures on the weather report. Thus Chicago-Midway airport is typically a few degrees hotter than suburban O'Hare, and the same difference applies between Washington's Reagan National airport and Dulles.



[*Hot spots in Washington show up as red areas in this satellite image. The presence of such heat islands increases energy use and raises smog levels. The largest red patch is at the site of a convention center. The coolest areas (green) are those covered by grass and trees.*]

Heat islands do not arise mainly from heat leaking out of cars, buildings, and factories. Rather, dark horizontal surfaces absorb most of the sunlight falling on them. Consequently, dark surfaces run hotter than light ones. The choice of dark colors has caused the problem; wiser choices can reverse it.

The country is now paying dearly for this extra heat. One sixth of the electricity consumed in the United States goes to cool buildings, at an annual power cost of $40 billion. Moreover, a 5°F heat island greatly raises the rate at which pollutants-nitrogen oxides and volatile organic compounds emanating from cars and smokestacks-"cook" into ozone, a highly oxidizing and irritating gas that is the main ingredient of smog. In Los Angeles, for example, ozone rises from an acceptable concentration at 70°F to unacceptable at 90°F. The Los Angeles heat island raises ozone levels 10-15 percent and contributes to hundreds of millions of dollars in annual health-related expenses. (In winter, we have plenty of smog precursors but, because it is cool, little smog.)

Fortunately, we can go a long way toward dissipating urban heat islands with modest measures. One solution is to use lighter colors for roofs and pavement. The other is to plant lots of trees, which have a two-fold benefit. First, they provide cooling shade. Second, trees, like most plants, soak up groundwater. The water then "evapotranspires" from the leaves, thus cooling the leaves and, indirectly, the surrounding air. A single properly watered tree can evapotranspirate 40 gallons of water in a day-offsetting the heat equivalent to that produced by one hundred 100-watt lamps, burning eight hours per day.

Increases in temperature do not have to follow from an influx of population. The Los Angeles basin in 1880 was still relatively barren, and yearly highs ran about 102°F. Then settlers introduced irrigation, the fruit trees cooled the air, and, within 50 years, summer temperatures dropped 5°F. But as Los Angeles began to urbanize in the 1940s, cool orchards gave way to hot roofs and asphalt pavements. Over the next 50 years, summer highs climbed back to their 1880 values and are still rising at 1°F per decade, with no end in sight.

But with white (or reflective) roofs, concrete-colored pavements, and about 10 million new shade trees, Los Angeles could be cooler than the semidesert that surrounds it, instead of hotter. Such measures would be in keeping with approaches that have been taken for centuries. As civilization developed in warm climates, humans learned to whitewash their dwellings. Even today, building owners in hot cities like Haifa and Tel Aviv are required to whitewash their roofs each spring, after the rains stop.

In the United States, dwellings tended to be built with white roofs through the 1960s. Then, as air conditioning became widespread, cheap, and taken for granted, priorities shifted. It became popular to use darker roofing shingles, which more resembled wooden shingles and better concealed dirt and mold. The colored granules on typical "white" shingles made today are coated with only one-sixth as much white pigment as in the 1960s. Under the summer sun, modern shingles become 20°F hotter than the old-style ones.

In discussing a "cool communities" strategy, the focus will be Los Angeles-the smog capital of the United States-though its elements could be applied in most other cities as well.

SIMULATING A COOLER LOS ANGELES

Urbanized Los Angeles covers 10,000 square kilometers and includes about 1,250 square kilometers of roof and another 1,250 square kilometers of pavement. Obviously, we cannot instantly replace these with cooler-colored materials. Nor can we quickly plant the 10 million shade trees that would make a difference. We can, however, simulate these actions using computer models. A simulation performed by Lawrence Berkeley National Laboratory raised the city's albedo (the reflected fraction of incident solar heat) by a modest 7.5 percent, and covered 5 percent of its area with 10 million trees.

The models indicate that such a "cool community" strategy could lower the average summer afternoon temperature in the Los Angeles heat island by 5°F with a lucrative benefit/cost ratio. The use of white roofs and shade trees in Los Angeles would lower the need for air conditioning by 18 percent, or one billion kilowatt-hours, for the buildings directly affected by the roofs and shaded by the trees. If we assume a price of peak electricity of 10 cents per kilowatt-hour-not uncommon-this translates into savings of $100 million per year.

For a 1,000-square-foot roof, the cost premium of cooler shingles is less than $25. If lighter shingles or tiles raise the albedo 35 percentage points, the additional investment pays for itself in less than one summer's worth of lowered air-conditioning bills.

There is also a large indirect benefit. If an entire community drops a degree or so in temperature, thanks to lighter roofs and pavement and to the evapotranspiration from trees, then everyone's air-conditioning load goes down, even those buildings that are not directly shaded or that still have dark roofs. These indirect annual savings would total an additional 12 percent-0.7 billion kilowatt-hours, or $70 million. Overall, implementing these cool community measures would lower the need for peak electrical generating capacity by about 1,500 megawatts, which is equivalent to two or three large power plants.

The cooler temperature would lower smog, too. Smog "exceedance"–the amount by which ozone levels top the California standard of 90 parts per billion-would drop 12 percent. Ozone can irritate the eyes, inflame the lungs, trigger asthma attacks, and lower the respiratory system's ability to fight off infection. While other components of air pollution also exact a toll on health-especially particulates and sulfur dioxide-ozone is figured to be responsible for about $3 billion in health-related costs every year in the Los Angeles basin. Thus a 12 percent reduction in ozone exceedance could save $360 million.

The benefits of light surfaces and shade trees extend beyond Los Angeles. The 18 percent direct savings of air conditioning attained by shading and lightening individual buildings do not depend on the size of the city, only on its climate; Atlanta, for example, would enjoy the same percentage reduction as Los Angeles.

The indirect savings, on the other hand, will be significant only in large cities with significant heat islands. Since about half the U.S. population lives in heat islands, the annual direct plus indirect U.S. air-conditioning energy savings, after 20 years, might be 10 percent. Peak air-conditioning demand would probably drop by 5 percent.

THE BENEFITS OF URBAN TREES

One of the remedies for urban heat islands has an even greater benefit. Carbon dioxide mitigation strategies focus on two strategies: cutting the use of fossil fuels; and planting trees, which sequester carbon dioxide in their wood. The planting of trees in cities does both of these, and is far more effective than planting trees in forests.

Any tree-whether in the forest or the city-removes CO_2 from the air through photosynthesis. Typically, a tree sequesters a few kilograms of carbon per year in its wood. For a forest tree, that is the total benefit of the tree’s existence, from the standpoint of cutting CO_2 levels. But a tree planted in a city also lowers fossil-fuel usage, by cooling the city and thus reducing the amount of electricity consumed in air conditioning. A tree in Los Angeles, for example, will save an additional 3 kilograms of carbon per year by lowering the city’s overall need for air conditioning, plus 15 kilograms more if it directly shades a building.

Thus, any group concerned with greenhouse warming enough to plant trees in forests ought to consider working with utilities in cities with growing air-conditioning demand to start shade-tree/cool-surfaces programs. Such programs would not only save more CO_2 per tree than would forest trees, but would mitigate smog problems as well.

Not all trees are equally beneficial. It is better to plant deciduous trees, for example, which give shade in summer but do not block the warmth in winter. Also, some types of trees emit large amounts of the volatile organic hydrocarbons (VOCs) that combine with oxides of nitrogen to form smog. Ash and maple are among the more VOC-free trees, emitting only about 1 VOC unit (defined as one microgram per hour per gram of dry leaf). Eucalyptus trees, on the other hand, are a problem. They were introduced a century ago, are thriving, and emit 32 units; perhaps they should be replaced with more suitable native trees. Weeping willows top the emissions list, releasing a whopping 230 VOC units.

Measures to reduce L.A.'s heat island could reduce air-conditioning bills by $175 million per year and alleviate $360 million per year of smog-related expenses. Similar measures can achieve benefits nearly as remarkable in many of the major cities in this country.