Cool Benefits of Solar-Reflective Surfaces for Shopping-Center Owners and Society

Energy-Efficient Pavement Creates Savings and Customer Appeal

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Abstract: *This article discusses how solar-reflective surfaces save energy, reduce heat and carbon dioxide, and improve the health, safety and security of the property. An additional benefit of this technology is to preserve and protect asphalt parking lots from destructive and costly effects of ultraviolet rays and water penetration.*

Understanding the Parking Lot Metropolis

Over 400 billion square feet (sf) of black asphalt exist on parking lots in the United States today, more than the total sf of roads in the nation.[1] Asphalt now comprises 60% of city surfaces in parking lots and on roofs. These surfaces, visible from the sky, surround airports, sports venues, corporations, hotels and schools. They represent *the* man-made cause of "urban heat islands."[2] Shopping-center parking lots, an indelible element of the modern urban/suburban landscape, are included among these heat islands in every city.

In some cities, such as Orlando and Los Angeles, parking lots are estimated to cover at least one-third of the land area.[3] All of this space poses a problem for planners and developers considering how to mitigate the environmental and social impact.

The difficulty traces, in no small part, to asphalt. Parking-lot asphalt surfaces can average 70 degrees Fahrenheit more than ambient air temperatures on peak heat days because asphalt is made from "black" crude oil that absorbs heat. What is even worse is that when the sun goes down, asphalt re-releases this thermal energy and heats up the nighttime air again.

The Environmental Protection Agency (EPA) points to several negative effects of urban heat islands, particularly during summer: 1) increased energy consumption, 2) elevated emissions of air pollutants and greenhouse gases; 3) compromised human health and comfort; and 4) impaired water quality.[4]

Given these impacts, shopping-center parking lots, for example, loom as difficult financial, operational, environmental, and regulatory challenges. Yet they also represent opportunities to become models of sustainability that will improve landlords' bottom lines and enhance customers' appreciation of centers.

Rethinking the Design and Culture of Parking

The challenges and opportunities present in shopping-center parking lots derive from a common source: their inevitable use as public spaces. With cars and pedestrians by necessity coexisting there, the design and use of these spaces may need to be rethought.

This is the view of Eran Ben-Joseph, a professor of urban planning at the Massachusetts Institute of Technology. He calls for a redefinition of the meaning of "parking lot." He believes parking lots can "contribute as

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[1] Figure derived from author personal communication with Professor Mikhail Chester of Arizona State University; an in-depth analysis of issues involved with deriving such numbers can be found in Mikhail Chester, Arpad Horvath and Samer Madanat, "Parking Infrastructure: Energy, Emissions, and Automobile Life-Cycle Environmental Accounting," *Environmental Research Letters*, Vol. 5 (July 29, 2010), retrieved April 4, 2012.

[2] This term refers to "built up areas that are hotter than nearby rural areas." In a center of 1 million people or more, the annual mean air temperature can be 1.8-5.4 degrees Fahrenheit warmer than its surroundings. See United States Environmental Protection Agency, "Heat Island Effect," retrieved May 22, 2012.

[3] Eran Ben-Joseph, "When a Parking Lot Is So Much More," *New York Times*, March 26, 2012, p. A27, retrieved April 5, 2012.

[4] United States Environmental Protection Agency, "Heat Island Effect: Basic Information," retrieved May 22, 2012.

much to their communities as great boulevards, parks or plazas," while establishing a unique aesthetic and architectural tone for the center.

Central to Dr. Ben-Joseph's argument is how the careful design of the parking lot can mitigate its environmental impact. Solar canopies, for instance, can produce energy while shading the surface to lower the heat. Solar-reflective coating materials and more trees can offset carbon emissions and clean contaminated asphalt runoff.[5]

Cooling Heat Domes

The need for these and other heat-reduction measures at parking lots has become increasingly apparent. The last two years represented some of the highest temperatures recorded in more than a century.[6] The midsummer "heat dome" of high-pressure, high-temperature conditions enveloping most of the United States in 2011 ended up setting more than 200 heat records.[7]

In 2012, the 11-year cycle of sun activity which reached a "solar maximum" was expected to bring more frequent and higher levels of solar flares, as well as more heat.[8] The cost of air conditioning will spike during these months. The National Air and Space Administration anticipates heat and electromagnetic activity could also affect the power grid because a 1-degree Fahrenheit temperature rise increases power demand on the grid by as much as 2%.[9]

The Role of "Cool Pavements" in Retail Sustainability

Many new and advanced materials have emerged that can reduce heat and offset the toxic effects of carbon dioxide (CO_2) as well as other pollutants in smog associated with this heat. The term *cool pavements*, coined by the EPA, mainly refers to reflective surfaces that lower temperatures and reduce heat absorbed into the pavement. (See Figures X-1 and X-1 for before-and-after shots of a parking lot with cool pavement.)

Figures X-1 and X-2
Cool Pavement Design Layout: Before and After

Source: Emerald Cities USA

Cool pavements include light-colored materials such as chip seal, solar-reflective cool coatings and solar-reflective sealers applied directly on existing black asphalt. By lowering surface temperatures, they cool stormwater and reduce the damage to local watersheds.[10] *Permeable pavements*, which hold water causing cooling through evaporation, are also included.

Retailers who implement cool pavements, trees and other "smart parking lot" solutions will save on power costs and also help reduce the load on the grid. (See Figure X-3.)

Re-Inventing America's Shopping Centers

U.S. Secretary of Energy Stephen Chu, former Director of the Lawrence Berkeley National Lab of the Department of Energy (DOE), has championed the idea of reflective surface colors in 100 of the world's largest cities, which, he calculated, could save the equivalent of 44 billion tons of carbon dioxide.[11]

Changing roof and pavement color to be more reflective can help mall managers cool their property by as much as 20 degrees Fahrenheit, save on monthly electric bills, reduce carbon footprint, increase parking-lot safety and enhance customer appeal. Successfully changing this color involves selecting strong sustainable

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5 Ben-Joseph, *op. cit*.

6 The year 2010 ranked as the hottest since 1880, while 2011 placed among the nine warmest over that time span. See "NASA: 2011 Among Top-Nine Warmest Years Since 1880," *Voice of America*, January 20, 2012, retrieved May 23, 2012.

7 John Hudson, "What's a 'Heat Dome' Anyway?", *The Atlantic Wire*, July 22, 2011, retrieved May 23, 2012.

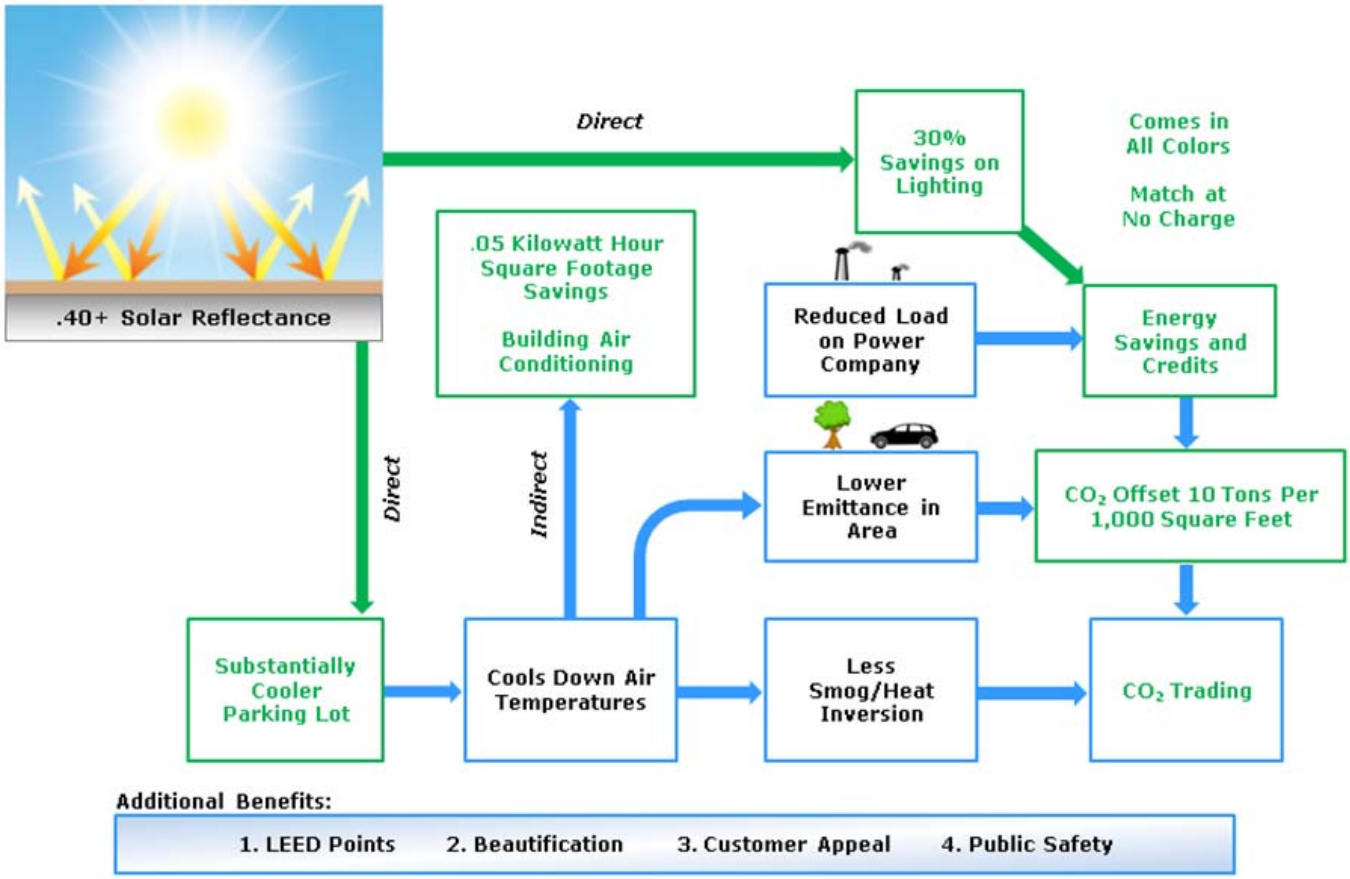
8 "Solar maximums" are periods of minimum-to-maximum-to-minimum cycles that usually last 11 years. In this current cycle, solar activity began to pick up in 2010 and should peak in 2014. Ultraviolent radiation emission comes with this greater solar activity, producing more solar flares—coronal mass ejections—that are absorbed in the atmosphere. The increased infrared emission that comes with the warmer atmosphere, in turn, will increase the cost of air conditioning. See "NASA Measures Impact of Huge Solar Flare on Earth's Atmosphere," March 23, 2012, retrieved July 3, 2012.

9 United States Environmental Protection Agency, "Heat Island Effect: Heat Island Impacts," last updated June 21, 2012, retrieved July 3, 2012.

10 Lawrence Berkeley National Laboratory, Heat Island Group, "Cool Science: Cool Pavements," retrieved July 2, 2012.

11 "In The News: Chu Suggests Painting World White to Fight Global Warming," press release of Reply Re-Roofing (undated).

Figure X-3
Energy-Efficient Cool Pavement



Source: Emerald Cities USA

materials. Products now coming onto the market should be viewed for their durability and maintenance features.

The Shopping-Center Contribution to Energy

Shopping-center landlords can contribute much to reducing the heat problem in North American cities—and their own operational expenses—simply by changing the parking-lot asphalt with solar-reflective color coatings. In particular, an examination of the square-footage totals of examples drawn from the top 100 chain stores in America reveals some startling potential for energy savings and carbon offsetting.

Wal-Mart and Target supercenters typically range from 180,000 to 250,000 sf, but their parking lots are larger than the stores themselves. Many other big-box stores—including Home Depot, Lowe's, Office Depot, and Bed Bath & Beyond—range from 60,000 to 140,000 sf, again with parking lots that equal or exceed store size. Most supermarkets, such as Safeway, Albertsons, Ralphs, and Krogers, range from 25,000 to 45,000 sf; free-standing drugstores operated by Walgreens, Rite Aid and CVS are generally 11,000 to 15,000 sf, with the parking lot typically 20,000 to 30,000 sf in size.[12]

Table X-1 lists general calculations for CO_2 reduction and kilowatt (kWh) energy savings for parking lots of major retail chains in the United States. Calculations of the savings are shown in Box X-1.

Cool Pavement Illumination Savings

Parking-lot lighting represents a significant operating cost for centers—not unsurprisingly, since the types most commonly used, metal halide, high pressure sodium or T-12 fluorescent, typically run 24 hours a day, seven days a week, or 8,760 hours a year. The addition of a solar-reflective, pavement-coated surface can mean 30%

[12] Sizes of big-box stores are compared in the graph "How Big Are Big-Box Stores?", New Rules Project, Institute for Local Self-Reliance, February 12, 2006, retrieved July 24, 2012. More recently, chains such as Wal-Mart, Target and Kohl's have been experimenting with smaller formats. See, for instance, Jack Neff, "Size Matters in Retail -- But Just What Size?" *Advertising Age*, March 19, 2012, retrieved July 24, 2012.

Table X-1
Potential CO_2 Parking-Lot Offsetting and Energy Savings, Major U.S. Chains

Chain Store Name	Number of Stores	Store Parking Lot SF*	Store Asphalt Total SF*	Store Reduction (Tons CO_2**) Cool Pavement
Wal-Mart	4,358	200,000	871,600,000	8,716,000
Kroger	3,609	40,000	144,360,000	1,443,600
Target	1,750	150,000	262,500,000	2,625,000
Walgreen	7,456	15,000	111,840,000	1,118,400
The Home Depot	1,966	125,000	245,750,000	2,457,500
Costco	412	150,000	61,800,000	618,000
CVS Caremark	7,217	15,000	108,255,000	1,082,550
Lowe's	1,723	100,000	172,300,000	1,723,000
Best Buy	1,312	37,000	48,544,000	485,440
Sears Holdings	3,484	130,000	452,920,000	4,529,200
Safeway	1,475	40,000	59,000,000	590,000
SUPERVALU	2,436	70,000	170,730,000	1,707,300
Rite Aid	4,750	15,000	71,250,000	712,500
Publix	1,173	50,000	58,650,000	586,500
Macy's	852	120,000	102,240,000	1,022,400
McDonald's	14,027	10,000	140,270,000	1,402,700
Kohl's	1,083	80,000	86,640,000	866,400
J.C. Penney	1,099	60,000	65,940,000	659,400
Taco Bell	6,446	4,000	25,784,000	257,840
Kentucky Fried Chicken	11,000	10,000	110,000,000	1,100,000
Pizza Hut	6,000	10,000	60,000,000	600,000
True Value	4,701	25,000	117,525,000	1,175,250
ShopRite	273	40,000	10,920,000	109,200
Wendy's / Arby's	9,406	10,000	94,060,000	940,600
Staples	1,575	30,000	47,250,000	472,500
Ace Hardware	4,047	10,000	40,470,000	404,700
Toys "R" Us	1,486	100,000	148,600,000	1,486,000
Whole Foods	288	30,000	8,640,000	86,400
Bed Bath & Beyond	1,114	80,000	89,120,000	891,200
7-Eleven	6,586	4,000	26,344,000	263,440
Burger King	7,258	3,000	21,774,000	217,740
Ross Stores	1,054	150,000	158,100,000	1,581,000
Office Depot	1,125	30,000	33,750,000	337,500
Trader Joe's	359	15,000	5,385,000	53,850
AutoZone	4,364	10,000	43,640,000	436,400
Applebee's	3,000	5,000	15,000,000	150,000
Advance Auto Parts	3,537	6,000	21,222,000	212,220
Barnes & Noble	1,343	40,000	53,720,000	537,200
OfficeMax	904	8,000	7,232,000	72,320
O'Reilly Automotive	3,570	20,000	71,400,000	714,000
Big Lots	1,398	80,000	111,840,000	1,118,400
Pet Smart	1,118	20,000	22,360,000	223,600
RadioShack	5,602	6,000	33,612,000	336,120
Albertsons	221	40,000	8,840,000	88,400
Sherwin-Williams	3,279	5,000	16,395,000	163,950
Sports Authority	464	40,000	18,560,000	185,600
Outback Steakhouse	968	6,000	5,808,000	58,080
Chili's Restaurants	1,337	5,000	6,685,000	66,850

Source: Emerald Cities USA

* SF = square feet; ** CO_2 = carbon dioxide

Box X-1
Calculating the CO_2 Reduced and Kilowatts of Energy Saved

Number of Stores: Taken from "2011 Top 100 Retailers," *Stores* Magazine, July 2011
Store SF of Parking Lot: Minimum sizes of parking lots have been calculated based upon average store sf, except where actual parking-lot sizes are published.
Total SF Store Asphalt: Number of stores multiplied by the minimum average size of the parking lot = total sf of asphalt each retailer owns/operates. This calculation, based on number of stores, does not deduct for in-store operations, whereby the company would not have its own parking lot.
Total Store CO_2 Offset: Based on the DOE-Lawrence Berkeley National Laboratory calculation of .4 solar reflectance (40%) = 10 tons CO_2 per/1000 sf. See "White Roofs Cool the World, Directly Offset CO_2 and Delay Global Warming," *Research Highlights*, *LBNL Heat Island Group*, November 10, 2008, retrieved May 24, 2012. Until recently, the solar reflectance of pavement could only be raised on average by about 0.15, offsetting about four tons of CO_2 per 100 sq m. However, with recent breakthroughs in "Cool Pavement" coatings through the use of solar-reflective colors, pavements can now be cooled to the equivalent of roof coatings. These durable, state-of-the-art materials can offset up to 10 tons of CO_2 per 1000 sf.
Estimated kWh Energy Savings: Based upon DOE studies of cool-roof energy savings, Emerald Cities estimates that "indirect" kWh savings to the building from cool-pavement at .4 reflectance is 0.05 kWh in air-conditioning savings per sf of building on peak heat days.

in direct kWh savings and generate more illumination than ordinary asphalt.[13] This of course converts to dollar savings on electric bills.

Shopping Center Safety with Savings

Poor parking-lot lighting sends a danger signal to customers, who fear that they will be attacked or their cars entered. It also conveys a message about disorder and poor management that can be difficult to reverse. Cool pavements help to counteract these impressions through a glowing surface that increases visibility and customer comfort with the center's environment. In pursuing reduced insurance rates, center managers can point to use of cool pavements as evidence that they are proactive in adopting effective crime-prevention measures.

Cooler—and Smarter—Shopping Centers

The benefits for the shopping-center industry of cool surfaces—parking lots and roofs—from this new solar-reflective technology applied to asphalt, cement and roof tiles—is a winning solution for communities, companies and consumers. Cool-pavement installations allow retailers to reduce consumption of electricity through lower air-conditioning costs, save on parking-lot illumination, increase the safety and comfort of customers and employees, and reduce the carbon footprint of the shopping center.

References

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[13] U.S. Department of Energy, "Demonstration Assessment of Light-Emitting Diode (LED). Parking Lot Lighting, Phase I. Host Site: T.J.Maxx, Manchester, New Hampshire," Tables 2.3 and 2.4, June 2010, retrieved July 5, 2012.

Sheri Roese, a 35-year veteran of the architectural-surface design field, is known for her designs and architectural surface treatments in projects all over the world. In 1991, she was honored with the International Woman in Design Award. Her textile designs have appeared in showrooms across America, and been featured in Harrods London and Lafayette's in Paris.

Sheri has a background in physics and chemistry, as well as bouillon logic and its application in corporate intelligence work.

Her clients have included Martin Marietta, ITT, Loral, Rockwell International, Motorola Defense, McDonnell Douglas (Offset Programs) and many small high-tech firms. Following the invasion of Kuwait, she also worked directly for the Al Sabah Royal Family attorney out of London, helping to bring engineering, construction and technology companies back into Kuwait to assist with reconstruction projects.

During that time, Sheri formed Nations Trust Ltd. to assist smaller clients in accessing the Lloyds and London financial markets for project financing alternatives and political-risk underwriting. In 2008, Nations Trust Ltd. formed Emerald Cities™ International Ltd. specifically to foster master planning of sustainable green communities. In 2009 Emerald Cities™ USA Ltd. was set up to manufacture cool pavement products as part of that master plan. Voluntary Emissions Reductions Transactions will be conducted through CTX London with trading scheduled to begin in 2013.

Collaborating with Lawrence Berkeley National Labs and scientists at Arizona State University (ASU) School of Sustainability, Emerald Cities™ is offering to provide scientific data, studies, solar-reflective materials testing, and access to sustainable solutions such as solar canopies and LED resources, as well as information about the developing variety of "Cool Solutions" to assist retailers in making smart energy-saving choices.

Emerald Cities™ is working with both ASU's Dr. Mikhail Chester and the DOE Lawrence Berkeley National Laboratories test site at University of California at Davis, to define a protocol of kWh energy-savings calculations for cool-pavement installations. This study will provide a data-collection exercise to develop the "cost calculator" for big-box stores to accurately evaluate the indirect electricity and cost savings resulting from cool pavement.

For further information on this article, or on how to participate in the "ASU/EC Cool Pavement Study," please contact Sheri Roese directly at sheri@emeraldcitiesusa.com.