SMART SURFACES COALITION

Achieving urban cooling, enhanced public health and equity, and lower climate risk in hot dry climates through Smart Surfaces:

An indicative case study of Stockton, California

This broad, transformative strategy allows cities to become cooler, reduce contribution to climate change, advance equity, protect their economy, and become healthier and more livable.

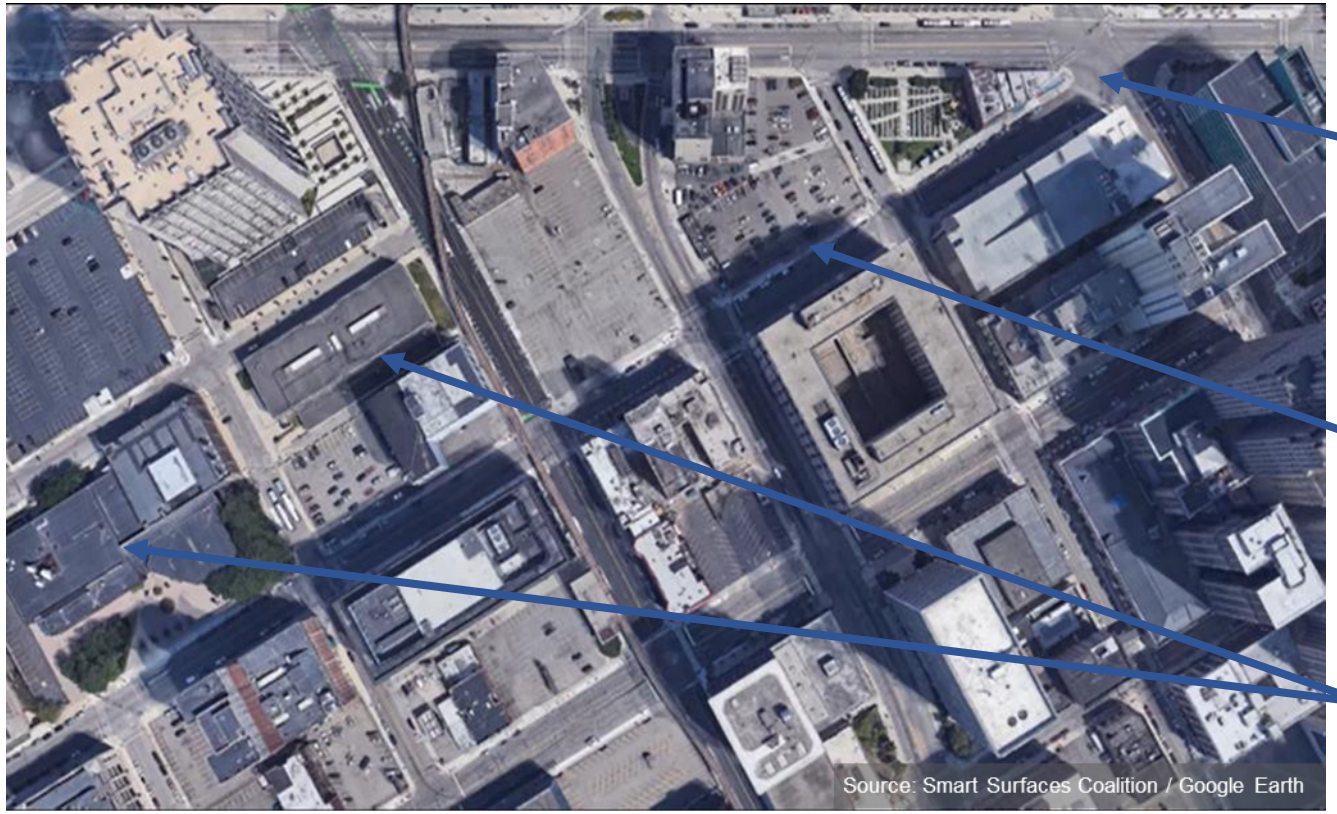
www.smartsurfacescoalition.org

Overview

- This report focuses on Smart Surfaces potential for hot- and mixed-dry climates. General findings apply to many cities and towns across California and the globe in similar climate zones. We chose Stockton because it is representative of a diverse, mid-sized Californian city in a hot- and mixed-dry climate with substantial heat, climate, and equity challenges.
- Funded by the The Institute for Governance and Sustainable Development (IGSD), the Smart Surfaces Coalition conducted a preliminary analysis of the costs and benefits of city-wide adoption of Smart Surfaces for Stockton. This report uses a modest set of Smart Surfaces adoption targets (see slide 12).
- A customized Stockton-specific online analytic engine was developed for Stockton to adjust adoption targets and the timeframe and to test, compare, and optimize Smart Surfaces adoption scenarios to select the most effective Smart Surfaces strategies.
- 2.92°F downtown cooling, 6.9:1 benefit-cost ratio, 817 good paying, full-time jobs created, 4.58 million tonnes of CO2 equivalent emissions reduced over 30 years, $777 million net present value (roughly $2,490 per resident over the 30-year analysis period)
- The largest cooling, air quality, and health benefits of Smart Surfaces accrue in low-income and minority neighborhoods where there is typically less tree canopy and green space, and more dark, impervious surfaces.
- Many benefits not quantified due to limited scope—e.g., reduced heat deaths, lower AC bills, increased exercise enabled by cooler, less polluted greener outdoor spaces, reduced crime, increased mobility, etc.—these would substantially increase the benefits, esp. from non-solar Smart Surfaces

The Current City Norm:

Dark, impervious hot surfaces with few trees and little green space
Current solution: More air conditioners > Hotter Cities > More Air Conditioners > Hotter Cities



Dark and impervious roads:
- Absorbs and re-radiates heat
- Low reflection causes global warming
- Rain runoff and flooding
- No shade

Dark and impervious parking lots:
- Increases heat of city
- Increases smog

Dark roofs:
- Heats up building, increasing electricity for air conditioning
- Heats up the city

Future Smart Surface City Norm:

Covered in light-colored/reflective, porous, and green surfaces, trees, and rooftop solar PV → a cost-effective solution for more livable cities.

Light-colored, reflective roads:
- Reduced heat absorption, reduces ambient temperature
- Porous parking lanes manage stormwater and reduce runoff

Porous, reflective parking lots with trees:
- Increased thermal comfort
- Shading and stormwater management

Reflective, green and PV roofs:
- Reduced building and city temperature
- Reduced runoff
- Generating clean renewable energy

Changing City Surfacing Decisions:

Today

Governments and foundations spend hundreds of millions of dollars to pilot and promote single solutions such as urban trees or porous or reflective surfaces.

But…cities are *still* getting hotter and more polluted, and are losing tree canopy…why?

City infrastructure decisions are made by **city departments** that **lack the expertise, authority or tools to quantify and understand most benefits** including city heat, air and water pollution and quality, human health, equity, employment, livability, city bond rating and climate impact

With Smart Surfaces

For cities to adopt reflective, porous and green surfaces and trees at scale requires that overall costs and benefits be fully quantified and included in design decisions.

How does the Smart Surfaces Coalition do this?

- ☑ Organize surface solutions in a single framework to enable city-wide analysis and adoption
- ☑ Build tools for cities to quantify the full costs and benefits of all surface options, model city adoption scenarios, and make fully-informed surface design decisions
- ☑ Directly support cities through integrated training, guidance, and analysis through a Coalition of leading organizations that cities already trust

Smart Surfaces allow cities to better manage sun and rain to cut costs and increase livability.

Reflective roofs are light colored and reflect most light and heat, much of which exits the atmosphere, slowing global warming.

Green roofs provide shading, reduce building energy use, clean the air, and absorb and clean water.

Porous pavements allow rain to recharge ground-water - and reduce pollution, storm water runoff, and flood risk.

Click here to watch a brief video on Smart Surfaces adoption.

Solar PV converts sunshine into electricity and provides shading for buildings, sidewalks, and other public areas.

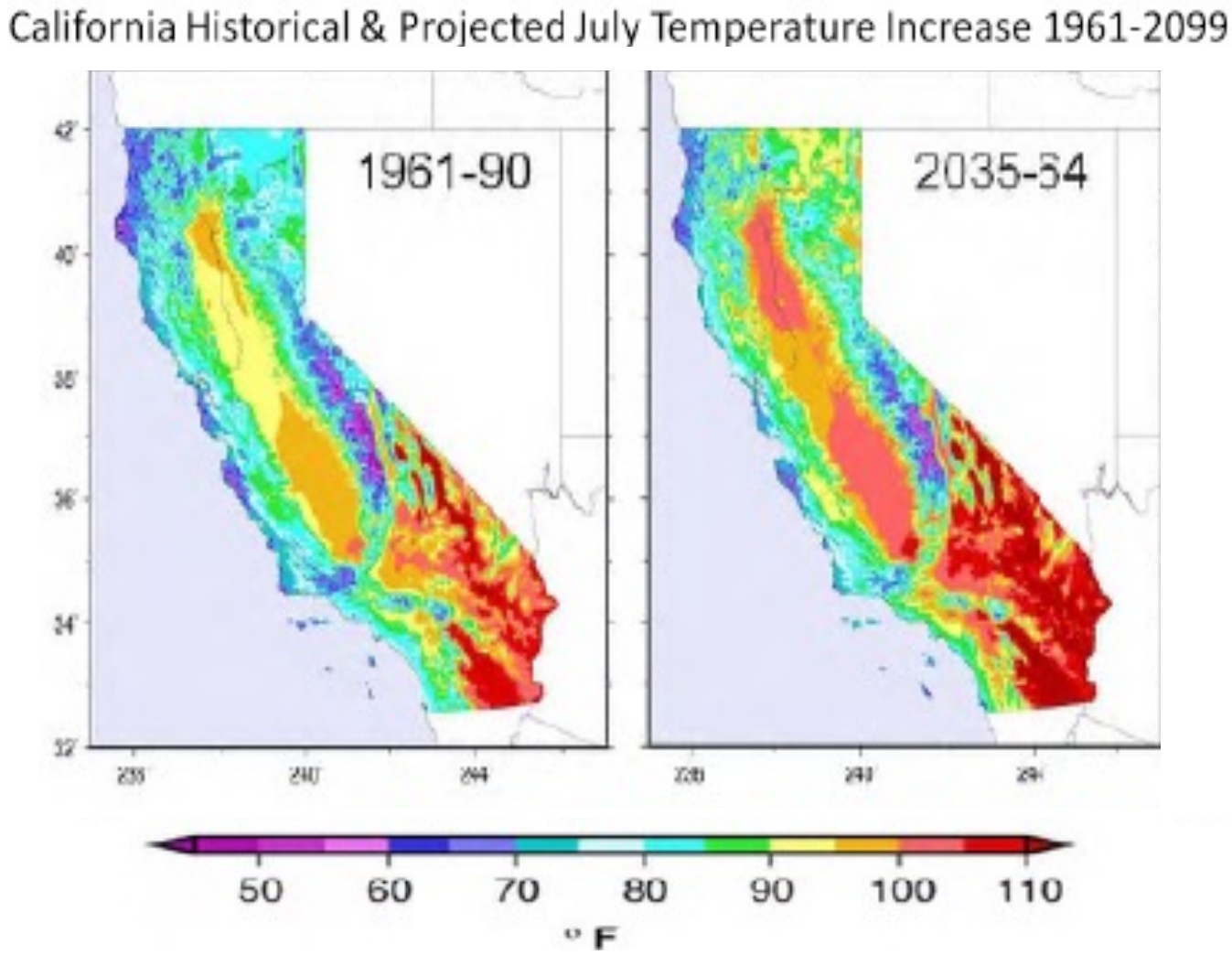
Trees reduce temperature by providing shade, clean air of pollutants, reduce flooding risk, and sequester carbon.

Reflective roads and highways cut global warming, reduce pollution and city air temperature, address environmental justice issues cost effectively and are job creative.

Combined Solutions such as:

- Solar PV on green roofs to manage both sun and rain, shade buildings and generate clean power
- Sequestration of carbon in roads and sidewalks.

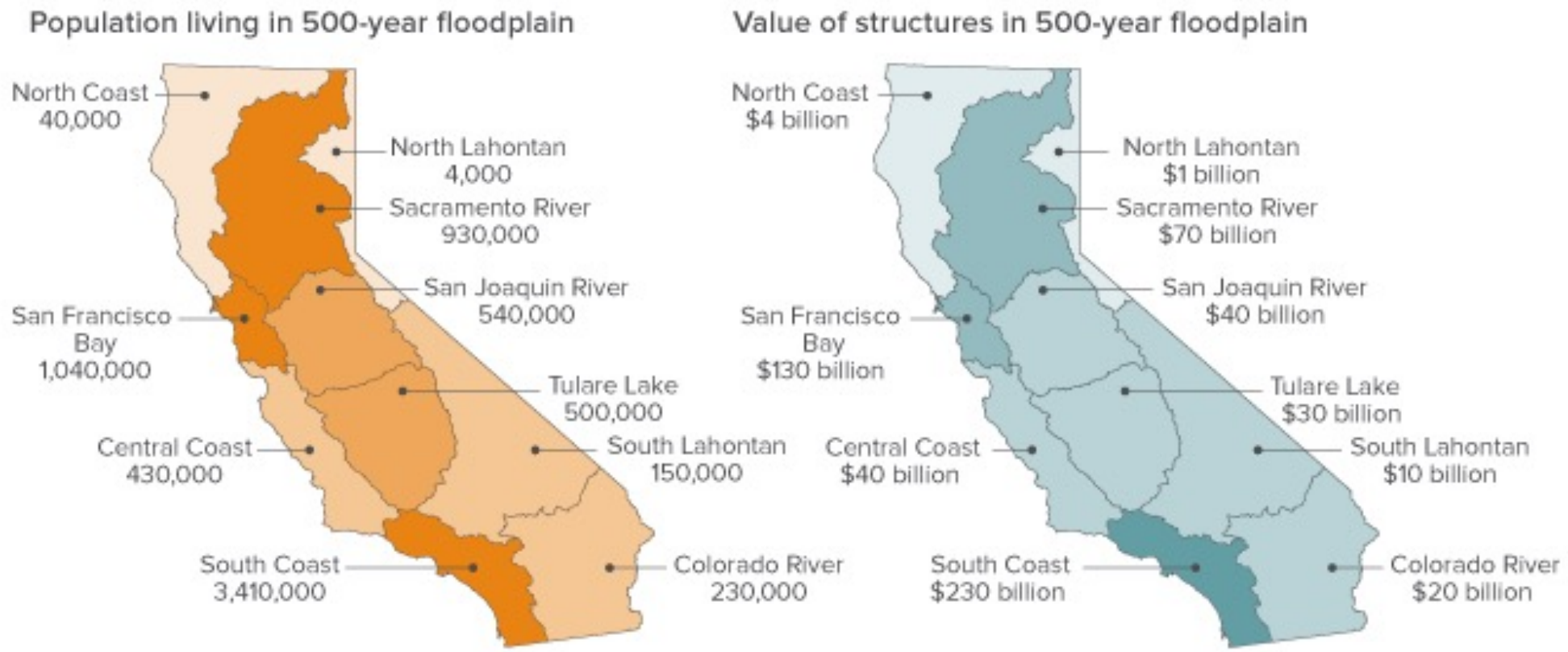
Like many cities in California, Stockton is becoming hotter, & less livable — particularly in low-income areas.



- Dark urban surfaces absorb, rather than reflect, most of the sun's heat—heating cities and the planet
- Dark surfaces make cities ~9℉ (~5℃) degrees warmer in the summer on average, and even hotter in lower-income neighborhoods that have less vegetation and more dark, impervious surfaces
- State-wide projections show that extreme summer temperatures in California will be markedly higher in coming years

Image courtesy of Dan Cayan, Sierra Club: https://blogs.sierraclub.org/sierradaily/2012/11/california-forecast-hot-and-ugly.html

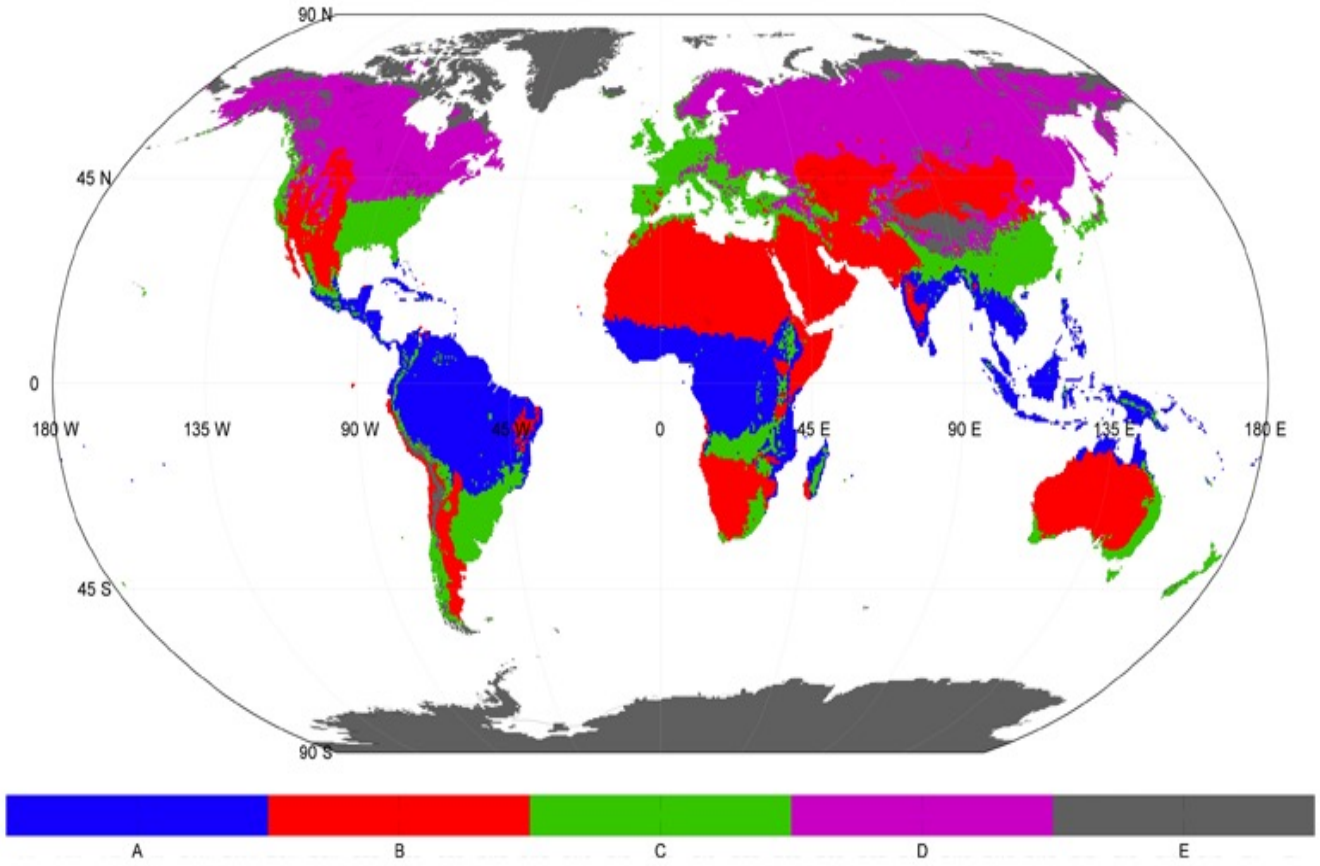
California's climate is changing, and if measures are not taken to address flood risk, there could be devastating infrastructure, health, and societal costs.



- Impervious surfaces increase flooding, mold, and water pollution, leading to costly infrastructure repairs and public health risks
- California's climate is changing—with larger winter storms, more precipitation falling as rain rather than snow, and rising sea levels, current flood management systems are obsolete—requiring major investments to reduce flood risk.
- Though the Stockton report did not quantify many Smart Surfaces that are effective in addressing flood mitigation like porous pavements, bioswales, and green roofs, these solutions can be quantified in future reports to enable Californian cities to better prepare for increased rainfall and flooding.

Applicability of Smart Surfaces Across the Globe

- Stockton's climate falls in the major Köppen type "c", which experiences similar environmental conditions as places in South America, much of Europe, India, Southeast Asia, Africa, and Australia.
- Stockton is mid-sized, diverse city in a hot- and mixed-dry climate that suffers from socioeconomic inequality and climate related challenges like extreme heat and flooding.
- Stockton's health, equity, heat, and flooding challenges parallel many other cities globally such as Kolkata or New Delhi in India or Santiago in Chile for example.
- By adopting Smart Surfaces at scale, cities around the world can simultaneously cool themselves, advance equity, improve public health, reduce flooding, and both adapt to and mitigate the effects of climate change.

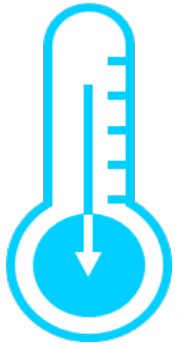


Major Köppen climate classifications

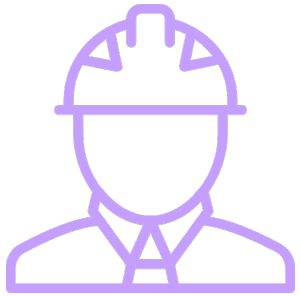
Stockton Benefits From Modest Adoption of Smart Surfaces

$777 million net present value from adoption of Smart Surfaces*

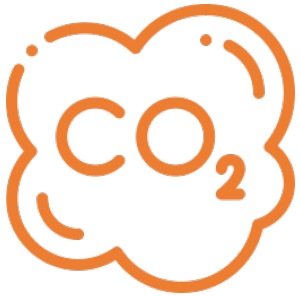
7x more benefits than costs required to implement and maintain this strategy†



2.92°F peak summer temperature reduction in hottest areas of the city. With **1.88°F** peak summer temperature reduction on average city-wide¶



817 full-time, new jobs created (**16,347 job years** created over 30 years). §



4.58 million tonnes carbon equivalent emissions reduced ‡

NOTES:
* In 2021 dollars, at 2% real discount rate over 30 years, many surface impacts are not quantified due to lack of rigorous data and/or research
† dollar value of total benefits and total costs over 30 years, in 2021 dollars
‡ in metric tonnes over 30-years. Avoided CO2 from Solar PV generation, and CO2 equivalent from radiative forcing effect of increasing reflectivity. A 3% annual reduction in grid emissions intensity is assumed for business-as-usual baseline/comparison
§ jobs include installation, O&M, and direct materials. One job year equals one full-time job for one year.
¶ ambient air temperature from reflective surfaces and radiative shading effect from trees, not including evapotranspiration cooling and reduced A/C heat ejection so actual temperature reduction is likely higher

Importance of Scaling Smart Surfaces in California

Georges Benjamin, MD Executive Director, American Public Health Association

“Climate change is the greatest public health crisis of our lifetime and is an especially grave and immediate threat to urban communities, particularly lower income communities, which are at a higher risk of heat related injury. The Smart Surfaces Coalition offers a transformative and cost-effective way to slow global warming and make cities cooler and healthier. Smart Surfaces are also an important strategy to mitigate the health risk from extreme heat in a cost-effective way—it must be adequately funded, rapidly implemented and brought to scale.”

Greg Spotts, Chief Sustainability Officer and Assistant Director, StreetsLA, City of Los Angeles

“We have off-the-shelf solutions for urban heat, and we can drive down the cost of these solutions by taking them to scale. I believe every major city in California needs a heat action plan that focuses efforts on improving health and quality of life in historically underserved neighborhoods. The Stockton Report is a great step to guide policy makers to take action.”

William H. Lamar IV, Pastor of Metropolitan African Methodist Episcopal Church

“I became angry that my community was hotter because of specific policies that invested in wealthy neighborhoods but failed to invest in Black and lower-income neighborhoods. It angered me that the choice to exercise and be outdoors that was afforded to wealthy communities was denied to my own. By making almost all surfaces reflective, porous and/or green, we can make communities—including those in which I have served as pastor—far cooler, healthier and more livable, allowing people to be outdoors in the summer and to thrive, regardless of where they live.

Smart Surfaces for Stockton Adoption: Modest Target Scenario

20-year adoption period, analysis extends 10 years beyond adoption period

Roof Targets		
Surface Type	Low-Slope	Steep-slope
Cool roof	60%	10%
Solar PV	20%	5%
Adoption Timeframe	20 years	20 years

*PV can be put on any roof (e.g., PV can go on a regular roof, green roofs, or reflective/cool roofs, and standard roofs).
**Note: Target % = percent of existing surfaces available (e.g., % of low slope roofs, or % of roads)

Pavement Targets	
Surface Type	Reflective
Parking	50%
Streets	5%
Adoption Timeframe	20 years

Urban Tree Canopy Targets	
Surface Kind	Tree Canopy
Urban trees	20% (10% absolute increase)
Adoption Timeframe	20 years

Limitations of the Study

- With limited funding, SSC conducted a comprehensive and detailed first order assessment of the surface options available to Stockton that would provide value to the city's residents, businesses, and government.
- Benefits not quantified due to limited scope include reduced heat deaths, reduced hospital visits, increased exercise enabled by cooler, less polluted, and greener outdoor spaces, reduced crime, increased mobility, and more.
- Full city-wide analysis of Smart Surfaces would include training for city officials and local NGOs, a customized analytic model for specific neighborhoods, Stockton specific impact data, alternate adoption scenarios for different timelines, prevented summer tourism loss, other surface options like urban meadows, and more. These can be quantified in future reports.

Managing Sun: Reflective Surfaces Overview

OBJECTIVE:

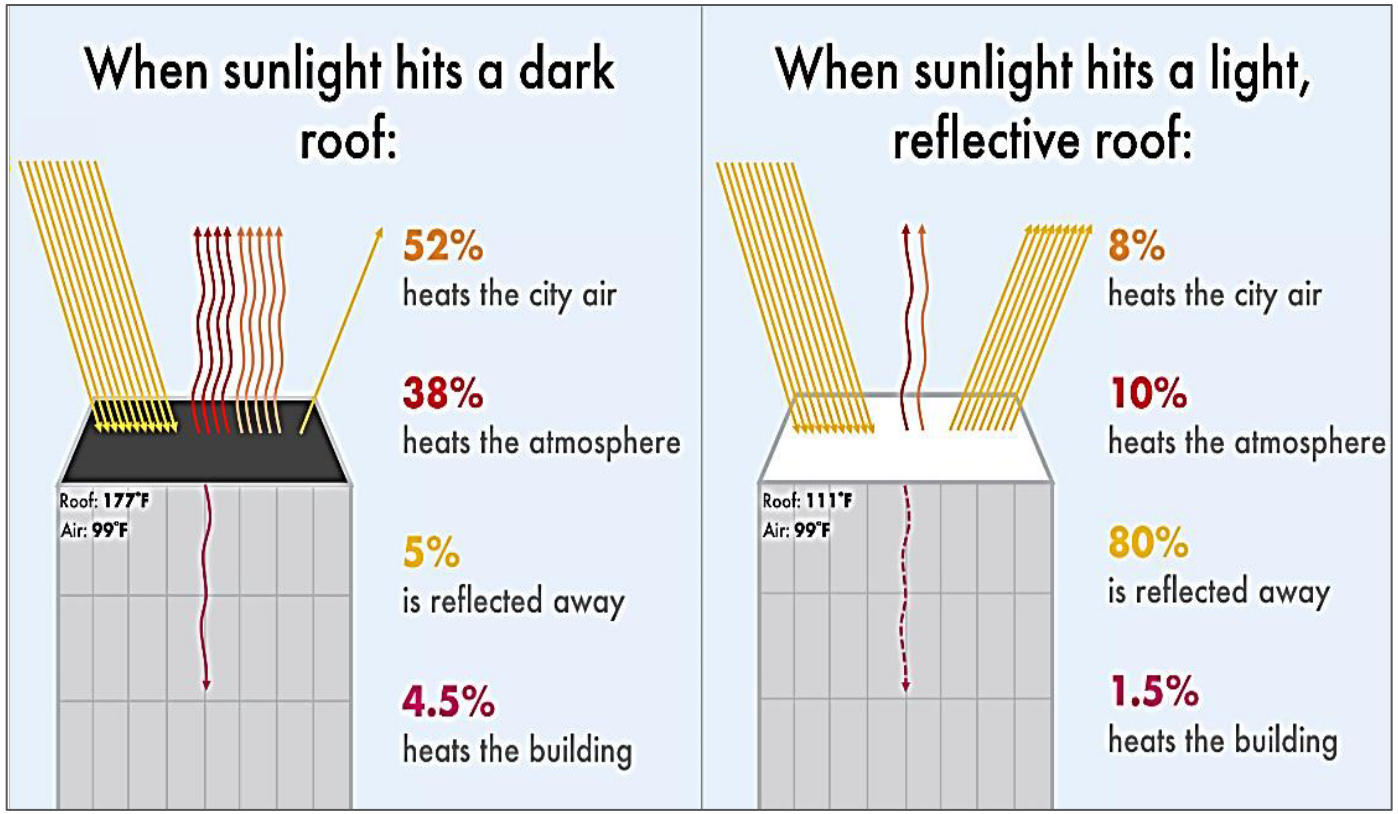
- Increase reflectivity of roofs, roads, and parking lots to reflect most incoming light and heat back into space – cooling cities and slowing global warming
- Reflective surfaces also cool the building below (if roof) or nearby (if pavement) resulting in less A/C and lower energy bills, further reducing temperature by reducing A/C heat ejection into city air

MAIN BENEFITS:

- Reduced ambient city air temperature
- Reduced building electricity use
- Extension of surface life
- Reduced Ozone and PM2.5
- Reduced global warming

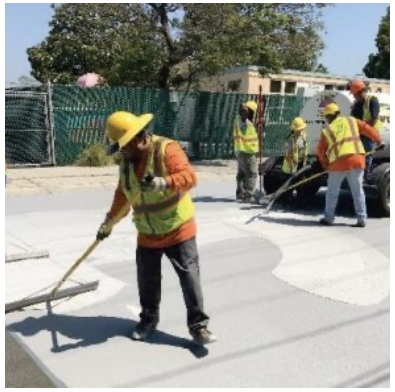
ADOPTION INFO:

- Easy installation, proven technologies
- Very cost-effective (incremental costs fully recouped from surface life extension: reflective surfaces expand and contract less and last longer)



Managing Sun: Reflective Surfaces Impacts in Stockton

Cool / Reflective Roof



Reflective Road

Reflective Parking

Reflective Surface:	Adoption Target (over 20 years)	Cost (millions) (2020$)	Benefit (millions) (2020$)	NPV (2% discount rate, millions) (2020$)***	Benefit Cost Ratio	Job Years Created**	Temperature Reduction Contribution*
Roofs	60% low-slope	$13	$215	$198	17:1	440	1.39°F
	10% steep-slope	$17	$16	$1***	0.9:1	-	-
Roads	5% of road area	$2	$6	$4	2.9:1	4	0.04°F
Parking	50% of lot area	$16	$38	$21	2.3:1	179	0.4°F

* Contribution to peak summer (1-4pm) temperature reduction in some of the hottest areas of city (e.g., parts of downtown/central areas of city)
** Job years for steep slope cool roofs and low slope roofs are combined, meaning that there are 440 job years between both.
***The NPV for steep-slope cool roofs is a small, but negative number. This report does not quantify AC load reduction, ambient air temperature reduction, and reduced heat-related illnesses and hospital visits. When these metrics are factored in, the benefits far outweigh the costs. Since these benefits are not calculated in the report due to complexity, a lack of effective studies, etc., this estimate is conservative.

Managing Sun: Solar PV Impacts in Stockton

MAIN BENEFITS:

- Reduces CO2 emissions from electricity generation
- Generates electricity for use by building owner or sold into the grid
- Shades roof, decreasing summer cooling requirement
- Zero-dollar upfront financing options are readily available

ADOPTION INFO:

- Can be installed on flat and steep-slope regular roofs as well as on top of cool and green roofs
- Costs continue to decline as efficiency is increasing (e.g., more electricity from same array area)

Solar PV* Surface (roof type)	**Adoption Target** (over 20 years)	**Cost** (millions) (2020$)	**Benefit** (millions) (2020$)	**NPV** (2% discount rate, millions) (2020$)	**Benefit Cost Ratio**	**Job Years Created****
Low-slope	20%	$10	$282	$267	29.5:1	14,730
Steep-slope	5%	$5	$184	$175	35.6:1	-

*Assumes Solar PV is third-party financed, with electricity savings accruing to financier during first 10 years
**Job years created for solar PV on low- and steep-slope roofs are combined, meaning there are almost 15,000 jobs for both types of roof in total.

Managing Sun & Rain: Urban Trees Overview

Main benefits:

- Ambient cooling and reduced energy use due to lower need for building cooling
- Reduced greenhouse gas emissions and global cooling
- Improved air quality and reduced heat-related mortality
- Reduced stormwater runoff

Source: TreeBaltimore.org

Surface Type	Adoption Target (over 20 years)	Cost (millions) (2020$)	Benefit (millions) (2020$)	NPV (millions) (2020$)	Benefit Cost Ratio	Job Years Created	Temperature Reduction Contribution
Urban Tree Canopy	20% of city area*	$71	$187	$113	2.6:1	994	1.1°F **

* Full 20% canopy coverage will occur approximately 10 years after year 20 of adoption assuming O&M continues
** Temperature reduction is due to radiative shading effect of trees and does not include effect of evapotranspiration

Stockton Results Overview: 20-year Adoption Scenario

30-year analysis period (ongoing costs and benefits extend 10 years beyond adoption period)

Smart Surfaces for Stockton 20-Year Adoption Scenario Impacts								
Smart Surface	Target	Albedo target	Costs (2020$)	Benefits (2020$)	NPV (2020$, 2% Real Discount Rate)****	Benefit:Cost Ratio (from 2020$)	Employment (job yrs)**	Peak Period Summer Temp Reduction Estimate***
Reflective (Cool) Roofs	Low-slope roof area: 60%	0.75	$12,596,418.93	$214,732,248.83	$198,172,382.26	17:1	440	1.39 °F
	Steep-slope roof area: 10%	0.4	$16,721,760.63	$15,524,313.28	($1,173,968.00)	0.9:1	-	
Solar PV (3rd party financed)*	Low-slope roof area: 20%	-	$9,578,288.71	$282,169,676.53	$267,246,458.65	29.5:1	14,730	not included
	Steep-slope roof area: 5%	-	$5,150,165.15	$183,455,192.19	$174,808,850.03	35.6:1	-	not included
Reflective Parking	Parking area: 50%	0.4	$16,282,939.97	$37,993,526.59	$21,284,888.84	2.3:1	179	0.4 °F
Reflective Roads	Road area: 5%	0.35	$1,913,476.23	$5,561,040.31	$3,576,043.21	2.9:1	4	0.04 °F
Trees	City land area: 20% (10% absolute increase)	-	$70,996,581.13	$186,498,481.77	$113,237,157.49	2.6:1	994	1.1 °F
TOTAL			**$133,239,631**	**$925,934,479.50**	**$777,151,812.49**	**6.9:1**	**16,347 job years (817 full time jobs created)**	**2.92 °F reduced in downtown Stockton**

Note: numbers may not add correctly due to rounding

*Assumes Solar PV is third-party financed, with electricity savings accruing to financier during first 10 years

**Job years created for solar PV on low- and steep-slope roofs as well as reflective (cool) roofs on low- and steep-slope roofs are not separated

***Temperature reduction data comes from Baltimore, using Stockton surface coverage and albedo change.

****The NPV for steep-slope cool roofs is a small, but negative number. This report does not quantify AC load reduction, ambient air temperature reduction, and reduced heat-related illnesses and hospital visits. When these metrics are factored in, the benefits far outweigh the costs. Since these benefits are not calculated in the report due to complexity, a lack of effective studies, etc., this estimate is conservative.

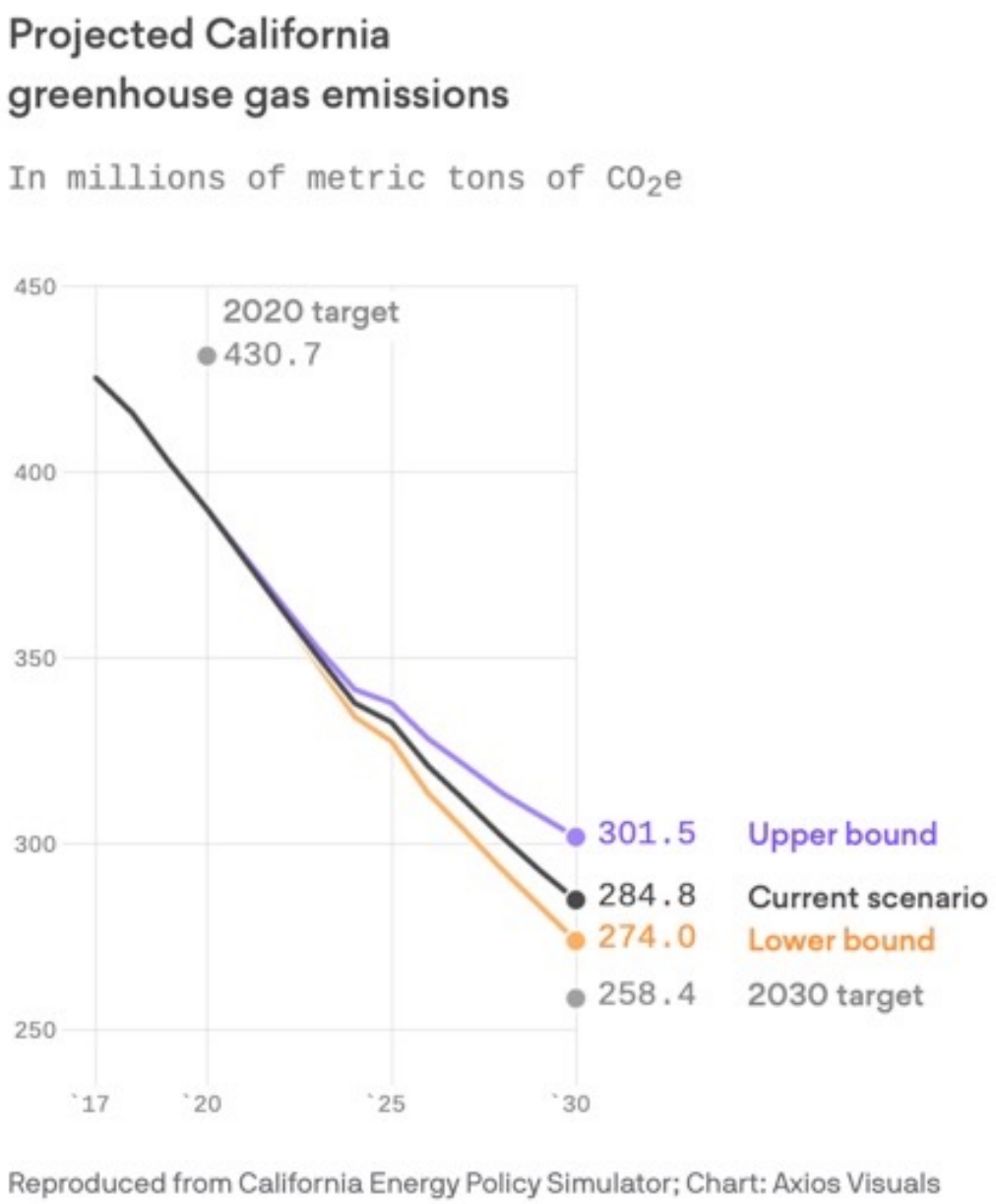
California: A Global Climate Leader

California has the 5th largest economy in the world, a robust clean tech sector, and the most ambitious climate targets out of any state in the country

- Climate programs
  - Cap and Trade Program, Green Building Standard, GHG Emission Inventory, Advanced Clean Cars Program, Low Carbon Fuel Standard, Renewable Portfolio Standard of 60% by 2030, Transformative Climate Communities Program, and more
- An abundance of climate regulators
  - California Energy Commission, Air Resources Board, State Transportation Agency, Department of Recycling and Recovery, Governor's Office of Planning and Research, Strategic Growth Council, CalRecylce, and more
- Statewide support
  - So far, 49 cities and counting in California have adopted building codes that reduce their reliance on gas and support energy efficient design
  - California organized the Global Climate Action Summit in 2018 to gather leaders of all expertise for a call to climate action
- Ambitious climate legislation
  - AB 32 Global Warming Solutions Act of 2006 → Required California to reduce GHG emissions to 1990 levels by 2020, which was achieved in 2016, 4 years ahead of schedule
  - SB 32 The California Global Warming Solutions Act of 2006 → extended this bill to reduce emissions 40% below 1990 targets by 2030
  - AB 585 Extreme Heat and Community Resilience Program → Provides statewide coordination so that local governments and vulnerable communities can better protect themselves from the dangers of extreme heat
  - *AB 1500 Safe Drinking Water, Wildlife Prevention, Drought Preparation, Flood Protection, Extreme Heat Mitigation, and Workforce Development Bond Act of 2022*
  - *SB 100 The 100% Clean Energy* Act of 2018 → sets a 2045 goal of powering all retail electricity sold in state agency electricity needs with zero-carbon sources (Updates the state's RPS to include 60% renewables by 2030)
  - AB 617 Community Air Protection → air quality legislation that increases requirements and penalties for polluters who exceed limitations in vulnerable communities
  - SB 535 Disadvantaged Community Benefits → Requires the state to direct at least 25% of state cap-and-trade revenues to go to projects that benefit disadvantaged communities

What does this demonstrate for California?

- California already has ambitious climate targets, effective programs for increasing resilience, an abundance of climate regulators, and support from cities and towns across the state…so why does California need Smart Surfaces?
- Retaining its position as a global climate leader means California must move faster to electrify buildings and decarbonize large industry than other states.
- The State will fall short of meeting the 2030 goal of a 40% reduction in greenhouse gas emissions from 1990 levels by 2030 “unless emissions reductions occur at a faster pace.”
- By adopting Smart Surfaces state-wide, California can continue to be a leader in decarbonization, meet their climate objectives on time, improve air quality and public health, stabilize the grid, and advance equity…all at the same time.



Guiding the Coalition:

Steering Committee (strategy decisions)

- **Greg Kats (co-chair)** – Author of Greening Our Built World: Costs Benefits and Strategies
- **Vivian Loftness (co-chair)** – Former Head of School of Architecture at Carnegie Mellon
- **Lynn Goldman** – Dean, School of Public Health at The George Washington University
- **Rashad Kaldany** – former COO of the International Finance Corporation
- **Julie T. Katzman** – former COO of the Inter-American Development Bank
- **Georges Benjamin, MD** – Executive Director of the American Public Health Association
- **Pastor William Lamar IV** – Pastor, Metropolitan African Methodist Episcopal Church
- **Jennifer Roberts** – Former Mayor of Charlotte
- **Durwood Zaelke** – President of the Institute for Governance and Sustainable Development
- **Greg Spotts** – Chief Sustainability Officer, StreetsLA, City of Los Angeles
- **Chris Leinberger** – President of Locus, also at GWU and Brookings
- **Cooper Martin** – Director, Sustainable Cities Institute, National League of Cities
- **Cynthia Koehler** – Executive Director, WaterNow Alliance
- **Kurt Shickman** – CEO, Global Cool City Alliance
- **Brendan Shane –** Climate Director, Trust for Public Lands, former C-40 Regional Director for North America
- **Ian Riley** – CEO, World Cement Association and Partner, WhitewaterTx
- **Dr. Radhika Khosla** – Research Director of the Oxford India Centre for Sustainable Development
- **Mark Conway –** Executive VP at Chesapeake Conservancy and Baltimore City Councilmember

Board of Directors (fiduciary oversight)

- **Frank Loy (chair)** – former Under Secretary of State for Global Affairs, former board chair of
- **Carolina Barco** – former Foreign Minister for Colombia, Ambassador to the U.S., & IADB Consultant
- **Tracy Wolstencroft** – former President of National Geographic Society, former partner at Goldman Sachs
- **Greg Kats** – former Managing Director, Good Energies, Inc.

Additional Resources on Smart Surfaces

- Smart Surfaces Coalition website
- 3-part Series in Risk & Insurance: How Smart Surfaces protect city credit rating
- City-wide Smart Surfaces cost-benefit mapping for/with Philadelphia, El Paso, and Washington D.C.
- 5-minute video on how Smart Surfaces work
- 14-minute video of Smart Surfaces Coalition CEO speaking at the Harvard Graduate School of Design about Smart Surfaces potential
- Detailed cost-benefit analysis on Smart Surfaces for Baltimore report
- Twitter & LinkedIn for social media engagement

To contact Smart Surfaces Coalition, email:
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