Ten Years at the Calif. Energy Commission & White Roofs to Cool your Building, your City and (this is new !) Cool the World

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Presentation available at www.ArtRosenfeld.org
Energy Intensity (E/GDP)

If US intensity dropped at pre-1973 levels of 0.4% per year

OPEC Embargo

Oil Price Collapse

Actual 1972 - 2007 Intensity drops at 2% per year

United States

Russia (E/GDP) in PPP

If US intensity dropped at pre-1973 levels of 0.4% per year

Actual 1972 - 2007 Intensity drops at 2% per year

$1.2 Trillion = 15% of GDP in 2007

$2.1 Trillion = 15% of GDP in 2007

$14 Trillion = 2007 GDP ($2007)
CA vs US Energy Consumption Per Capita

million Btu Per Person set to 1970 levels

[Chart showing the energy consumption per capita comparison between California (CA) and the US without California (US w/o CA) from 1970 to 2005.]

- CA: Yellow line
- US w/o CA: Red line
CA vs US Electricity Consumption Per Capita

kWh per Person


- CA
- US w/o CA
California has avoided building Forty 500 MW power plants.

Utility Programs and Market Effects
Title 24 Building Standards
Title 20 Appliance Standards

~19% of Residential and Commercial Electricity Use in California in 2006

Source: Art Rosenfeld, California Energy Commission
Projections of California Peak Power Demand

Planned in 1974 vs. Actual to 1984

(Goldstein and Rosenfeld, at Calif. Energy Commission, Dec. 1975)
Annual Energy Use, Volume and Real Price of New Refrigerators

Sources: AHAM Factbooks, Rosenfeld 1999 and Bureau of Labor Statistics

- 1978 CA Standard
- 1980 CA Standard
- 1987 CA Standard
- 1990 NAECA Standard
- 1993 DOE Standard
- 2001 DOE Standard
- 2014 Consensus Proposal
  Designs in Research /Demonstration in 2011

50-year Declining Real Price Trend
Refrigerator Adjusted Volume

Energy Use (kWh/yr) or Real Price in (2009$)

Adjusted Volume (cu ft)

Year shipped
Impact of Standards on Efficiency of 3 Appliances

Air Conditioning Energy Use in Single Family Homes in PG&E
The effect of AC Standards (SEER) and Title 24 standards

If only increases in house size -- no efficiency gains
Change due to SEER improvements
SEER plus Title 24
Annual generation from China’s Three Gorges Dam compared to annual savings in 2020, from 20 years of sales of refrigerators and ACs with increasing energy efficiency

Appliance efficiency savings are calculated on the basis of annual savings in 2020. “Post-05” standards accounts for China’s periodic standards revision schedule of 4 to 5 years.

Source: LBNL China Energy End-Use Model, David Fridley and Nina Zheng, 2010
Annual generation from China’s Three Gorges Dam compared to annual savings in 2020, from 20 years of sales of equipment subject to China’s energy efficiency standards

*Other products include: clothes washer, TV, fans, stand-by power, electric water heater, electric cooktop, fluorescent lamp ballasts, rice cooker, microwave ovens, laser printers, fax, copiers, computer monitors, HID lamps and ballasts, motors, air compressors, transformers, servers, computers, double-capped fluorescents, heat pump water heater, rangehoods, ventilating fans, external power supply, vending machines, LED lamps, grid lighting, commercial AC chillers, water-cooled chillers, unitary AC

Source: LBNL China Energy End-Use Model, David Fridley and Nina Zheng, 2010
United States Refrigerator Use, repeated, to compare with
Estimated Household Standby Use v. Time

Average Energy Use per Unit Sold (kWh per year)

- Refrigerator Use per Unit
- Estimated Standby Power (per house)
- 1978 Cal Standard
- 1980 Cal Standard
- 1987 Cal Standard
- 1990 Federal Standard
- 1993 Federal Standard
- 2001 Federal Standard
- 2007 STD.
The residential energy consumption due to televisions rapidly increased from 3-4% in 1990s to 8-10% in 2008. Television energy will grow up to 18% by 2023 without regulations. The projected growth does not include the residential energy use by cable boxes, DVD players, internet boxes, Blue Ray, game consoles etc.

California Energy Consumption from TVs  
(Forecast with and without proposed standards)
*Consumers can expect to save between $ 50 - $ 250 over the life of their TV

*A 50 inch plasma can consume as little as 307 kWh/yr and as much as 903 kWh/yr
## General Purpose Lighting – Proposed Regulations (cont.)

### Proposed Table K-8: Standards for State-regulated General Services Incandescent Lamps -Tier I

<table>
<thead>
<tr>
<th>Rated Lumens Range</th>
<th>Maximum rated Wattage</th>
<th>Minimum Rated Life Time</th>
<th>Proposed California Effective Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1490-2600 Lumens</td>
<td>100→72 Watts</td>
<td>1,000 hours</td>
<td>Jan, 1, 2011</td>
</tr>
<tr>
<td>1050-1489 Lumens</td>
<td>75→53 Watts</td>
<td>1,000 hours</td>
<td>Jan 1, 2012</td>
</tr>
<tr>
<td>750-1049 Lumens</td>
<td>60→43 Watts</td>
<td>1,000 hours</td>
<td>Jan 1, 2013</td>
</tr>
<tr>
<td>310-749 Lumens</td>
<td>40→29 Watts</td>
<td>1,000 hours</td>
<td>Jan 1, 2013</td>
</tr>
</tbody>
</table>

### Proposed Table K-9: Standards for State-regulated General Services Lamps -Tier II

<table>
<thead>
<tr>
<th>Lumens Range</th>
<th>Maximum Lamp Efficacy</th>
<th>Minimum Rated Life Time</th>
<th>Proposed California Effective Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>45 lumens per watt</td>
<td>1,000 hours</td>
<td>Jan, 1, 2018</td>
</tr>
</tbody>
</table>
U.S. mid-range abatement curve – 2030

Source: McKinsey analysis
White roofs to cool your buildings, your cities, and *(this is new)* to cool the earth.
Summer in the city

summer urban heat island
The surface of Sacramento, CA is about

- **20% roofs**
- **30% vegetation**
- **40% pavement**

~ 1 km²
Reflective roofs stay cooler in the sun.

![Graph showing temperature rise vs. solar absorptance for various roof materials]
White roofs, cool-colored roofs save money

OLD

flat, white

AC savings ≈ 15%

pitched, white

AC savings ≈ 10%

NEW

pitched, cool & colored

AC savings ≈ 5%
Chicago Heat Wave 1995, 739 Deaths

Virtually all of the deaths occurred on the top floors of buildings with black roofs
European Heat Wave 2003, 30,000 Deaths
Moscow-Centered Heat Wave 2010, 15,000 Deaths
White roofs around the world
...in Santorini, Greece
...in Hyderabad, India

...and widely in the state of Gujarat, India.
Walmart store in northern California
Congratulations to UC Davis
White roofs are popular in Tucson, AZ
Washington, DC (Federal) has problems with historical buildings
Pentagon
Cooling our planet
Solar-reflective surfaces cool the globe via “negative radiative forcing”

Source: Intergovernmental Panel on Climate Change (IPCC)
GLOBAL COOLING: making 100 m² (1000 ft²) of gray roofing white offsets the emission of 10 t of CO₂
How much CO$_2$ equivalent is offset if we whiten all eligible urban flat roofs worldwide? (i/ii)

- Answer: **24 Gigatonnes (Gt)**
  - $2/3$ of a year’s worldwide emission
  - Gigatonne = billion metric tons

- If implemented over 20 years (the life of a roof or a program) this is $\approx 1.2$ Gt/year.
How much CO$_2$ equivalent is offset if we whiten all eligible urban flat roofs world-wide? (ii/ii)

- Offset is equivalent to **taking 300 million cars off the road for 20 years**.
  - There are about 600 million passenger cars world wide, and they each emit $\approx 4$ t CO$_2$/year.
In terms of avoided power plants

Full white roof potential avoids 500 medium-sized coal fired power plants or 1,000 medium-sized gas fired power plants.

The whole global power system emits ~15 Gt(CO2 annually), equivalent to the output of 6000 typical midsized power plants (2/3 coal, 1/3 gas).
Cool Cities, Cool Planet

What to do now
Progress in energy efficiency standards

- In 2005, California’s “Title 24” energy efficiency standards prescribed white surfaces for low-sloped roofs on commercial buildings. Several hot states are following.
- In 2008, California prescribed “cool colored” surfaces for steep residential roofs in its 5 hottest climate zones.
- Other U.S. states & all countries with hot summers should follow.
Recent cool roof progress (2005 – 2012)

• **2005**
  – California Title 24 – “Flat roofs shall be white” (15 out of 16 climate zones). Walmart adopts white roofs for ALL stores.
  – EPA ENERGY STAR lists Cool Roof Materials

• **2010**
  – June 1st, 2010 – Memo from U.S. Energy Secretary Steven Chu calls for all DOE Buildings to have white roofs, if cost-effective
  – June 16th, 2010 – Marine Corp follows suit, Pentagon following slowly
  – June 19th, 2010 – *RetroFIT Philly* announces winner of “coolest block” contest to white-coat black roofs of row houses.

• **2011**
  – 100 Cool Cities launched – see [www.WhiteRoofsAlliance.org](http://www.WhiteRoofsAlliance.org)
  – Spring 2011 – US will launch, at G20 Energy Ministers meeting, a voluntary Cool Roofs initiative and may even offer technical assistance to developing countries who join early.
To come 2013...

• Model codes will be modified to prescribe “flat roofs shall be white”
  – ASHRAE for commercial buildings
  – EECC for residential buildings
• But states and cities have to adopt model codes
Global Cool Cities Alliance could unite many initiatives and trade associations
Resources on the web

- Art Rosenfeld’s website
  - ArtRosenfeld.org
- Cool Colors Project
  - CoolColors.LBL.gov
- Heat Island Group
  - HeatIsland.LBL.gov
- Cool California
  - CoolCalifornia.org
- Global Cool Cities Alliance
  - GlobalCoolCities.org
- Cool Roof Rating Council
  - CoolRoofs.org
- EPA Heat Islands
  - epa.gov/heatisland
- Energy Star Cool Roofs
  - EnergyStar.gov