Green Technologies and White Roofs

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Presentation available at www.ArtRosenfeld.org

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

OPEC Embargo

Oil Price Collapse

1207, First Earth Day

Actual 1972 - 2007 Intensity drops at 2% per year

2007 GDP = $14 Trillion ($2007)
15% of GDP in 2007 = $2.1 Trillion
Actual Energy Costs: 9% of GDP in 2007 = $1.2 Trillion

E/GDP = thousand Btu/$ (in $2000)


year

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Per Capita Electricity Sales (not including self-generation) (kWh/person) (2006 to 2008 are forecast data)

United States

California

2005 Differences
= 5,300kWh/yr
= $165/capita

Per Capita Income in Constant 2000 $

<table>
<thead>
<tr>
<th></th>
<th>1975</th>
<th>2005</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>US GDP/capita</td>
<td>16,241</td>
<td>31,442</td>
<td>94%</td>
</tr>
<tr>
<td>Cal GSP/capita</td>
<td>18,760</td>
<td>33,536</td>
<td>79%</td>
</tr>
</tbody>
</table>
Annual Energy Savings from Efficiency Programs and Standards

~15% of Annual Electricity Use in California in 2003

Utility Efficiency Programs at a cost of ~1% of electric bill

Appliance Standards

Building Standards

GWh/year
Comparison of 3 Gorges to Refrigerator and AC Efficiency Improvements

Savings calculated 10 years after standard takes effect. Calculations provided by David Fridley, LBNL
CA vs US Energy Consumption Per Capita

million Btu Per Person set to 1970 levels

CA

US w/o CA
CA vs US Electricity Consumption Per Capita

kWh per Person

0 2,000 4,000 6,000 8,000 10,000 12,000 14,000


CA vs US

CA

US w/o CA
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
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

1978 Cal Standard

1980 Cal Standard

1987 Cal Standard

1990 Federal Standard

1993 Federal Standard

2001 Federal Standard

2007 STD.

Estimated Standby Power (per house)
Televisions Represent Significant Energy Use

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)

- **With a Title 20 Standard**
- **no standard**

10% of Res. Use in 2007
Technically Feasible Standards

![TV Power Consumption Levels](chart)

- **CEC Tier 1** (Effective 1/1/2011)
- **CEC Tier 2** (Effective 1/1/2013)
- **CEC Max Screen Area** (1400 in² or ~57.4 diagonal inches)

* 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

Cost
Real 2005 dollars per ton CO₂-e

-120 -90 -60 -30 0 30 60 90

-230 -120 -90 -60 -30 0 30 60 90

Potential Gigatons/year

Abatement cost <$50/ton

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

Late Afternoon Temperature

Rural | Commercial | Urban Residential | Suburban Residential | Suburban Residential | Rural Farmland
The surface of Sacramento, CA is about

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

Area by Land-Cover Category Above the Canopy

~ 1 km²
Chicago Heat Wave 1995, 739 Deaths

Virtually all of the deaths occurred on the top floors of buildings with black roofs
Reflective roofs stay cooler in the sun
White roofs are popular in Tucson, AZ
Washington, DC (Federal) has problems
Cooling our planet
European Heat Wave 2003, 30,000 Deaths
France July 2010, Few Deaths
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%
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
Solar-reflective surfaces cool the globe via “negative radiative forcing”

Source: Intergovernmental Panel on Climate Change (IPCC)
GLOBAL COOLING: making $100 \text{ m}^2$ ($1000 \text{ ft}^2$) of gray roofing white offsets the emission of 10 t of $\text{CO}_2$
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 ≈ 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.
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 – 2011)

- **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 2012...

• 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 Communities Project
  – CoolCommunities.LBL.gov

• Roof Savings Calculator
  – RoofCalc.com

• Global Cool Cities Alliance
  – GlobalCoolCitiesAlliance.org

• Cool Roof Rating Council
  – CoolRoofs.org

• Cool California
  – CoolCalifornia.org

• EPA Heat Islands
  – epa.gov/heatisland

• Energy Star Cool Roofs
  – EnergyStar.gov