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

St. Petersburg Polytechnical University
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California Energy Commission.

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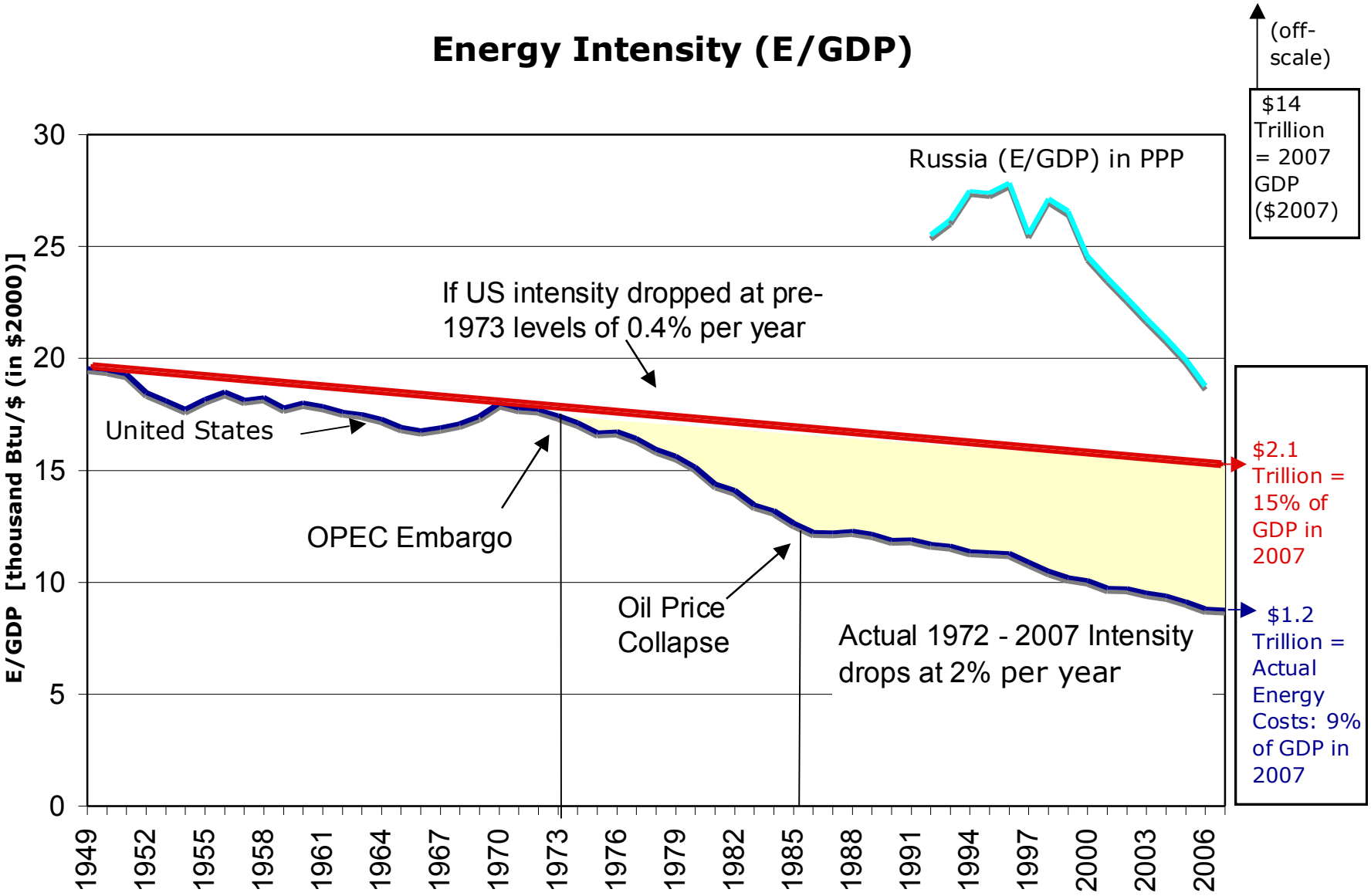
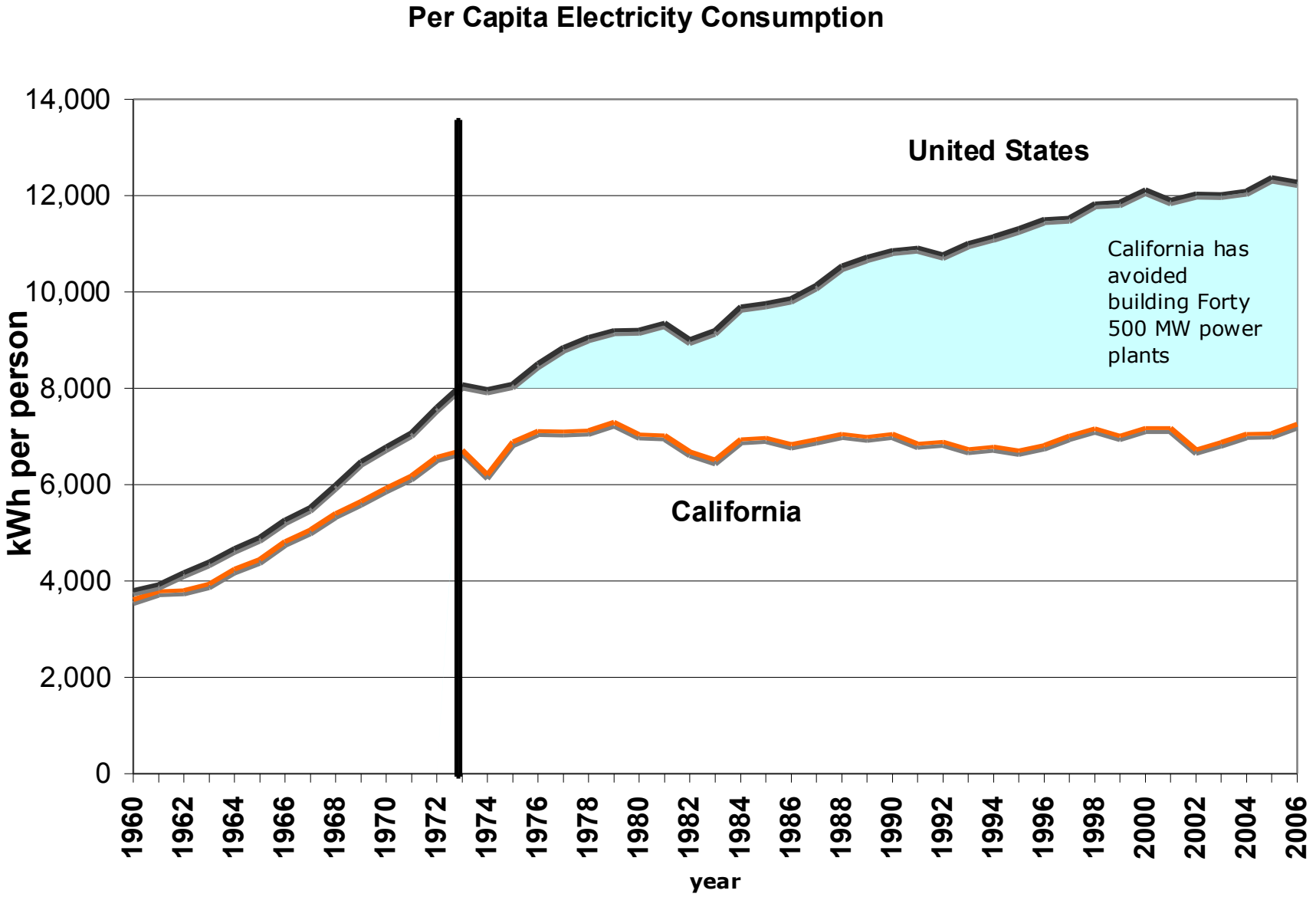
Presentation available at www.ArtRosenfeld.org

Filename Russian Talk 6-5-11 + DR from EE Summit Sactp. . Path DinnerTalk Life at CEC. ARPA-E

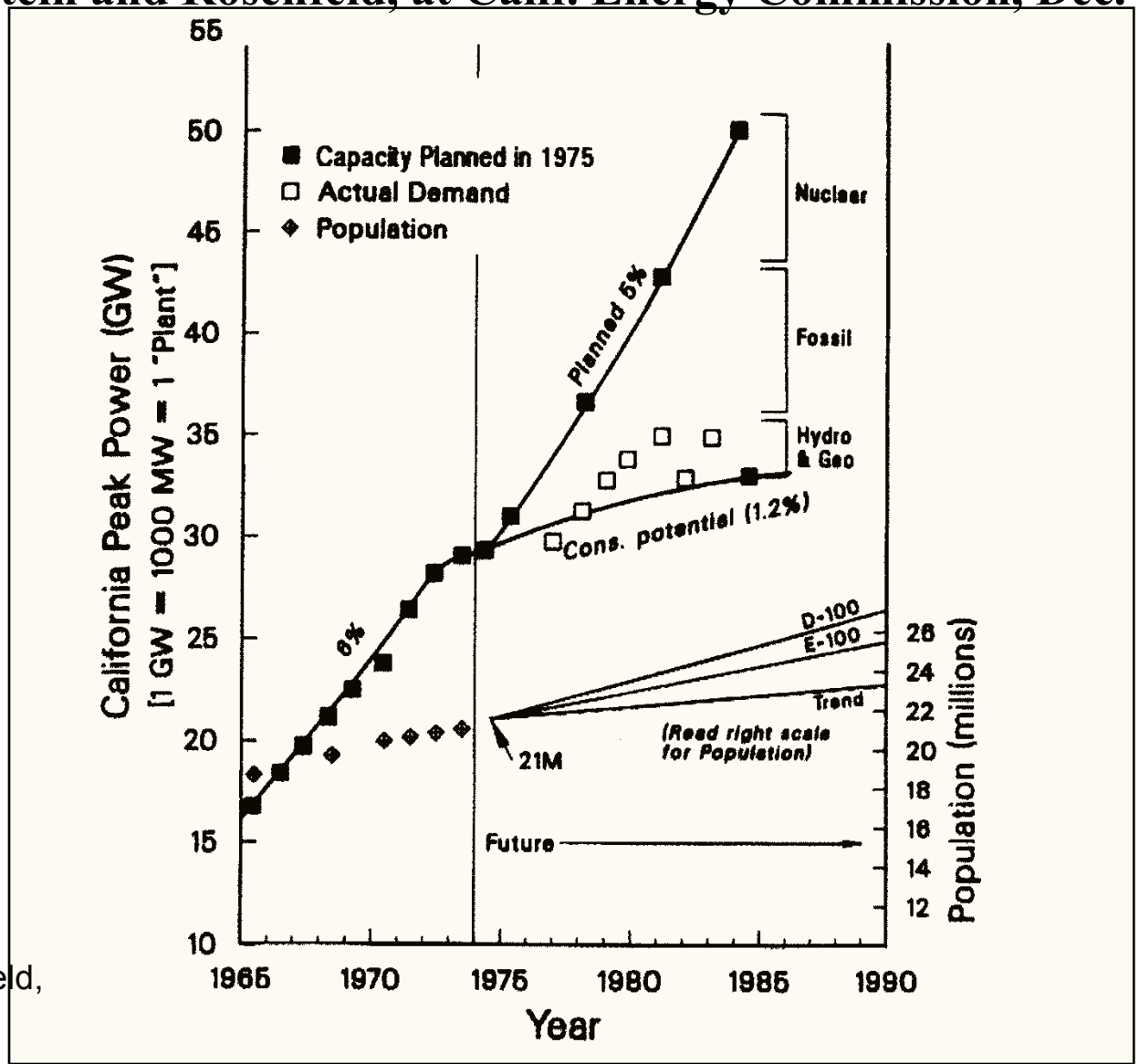

Energy Intensity (E/GDP)
E/GDP [thousand Btu/$ (in $2000)]
30
25
20
15
10
5
0
1949
1952
1955
1958
1961
1964
1967
1970
1973
1976
1979
1982
1985
1988
1991
1994
1997
2000
2003
2006
Russia (E/GDP) in PPP
(off-scale)
$14 Trillion = 2007 GDP ($2007)
If US intensity dropped at pre-1973 levels of 0.4% per year
United States
OPEC Embargo
Oil Price Collapse
Actual 1972 - 2007 Intensity drops at 2% per year
$2.1 Trillion = 15% of GDP in 2007
$1.2 Trillion = Actual Energy Costs: 9% of GDP in 2007


Per Capita Electricity Consumption
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
kWh per person
United States
California has avoided building Forty 500 MW power plants
California
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
year

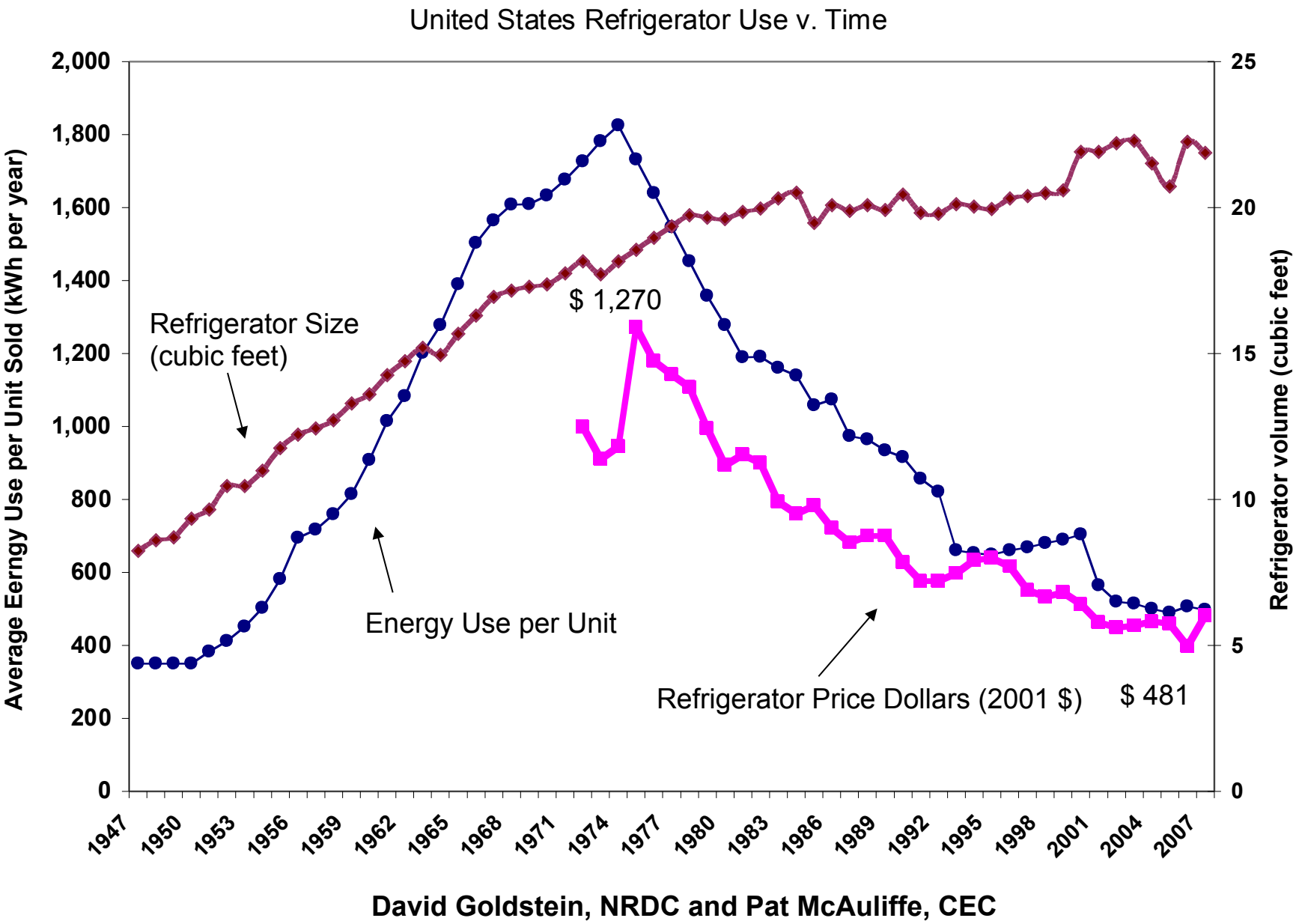
Projections of California Peak Power Demand

Planned in 1974 vs. Actual to 1984

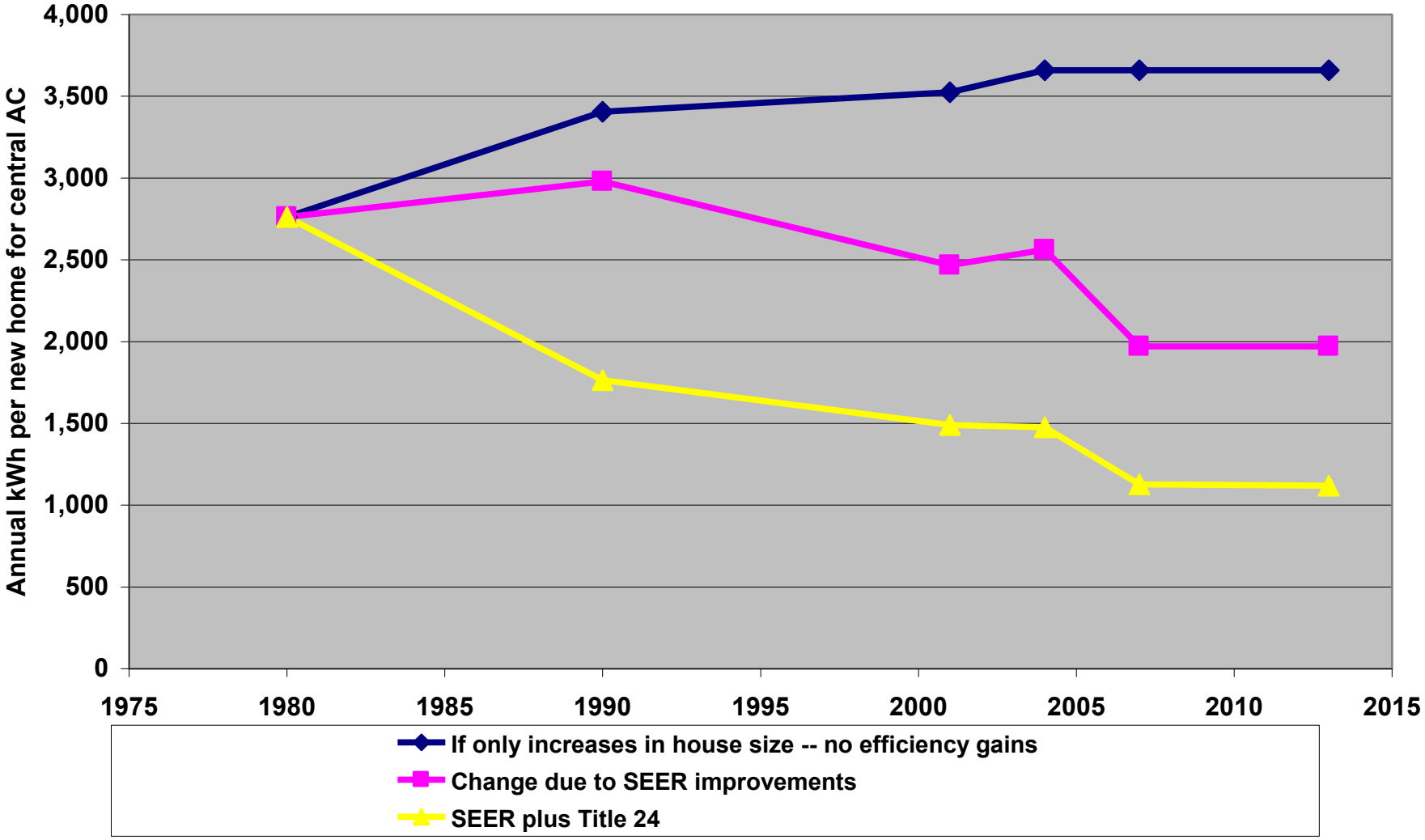
(Goldstein and Rosenfeld, at Calif. Energy Commission, Dec. 1975)



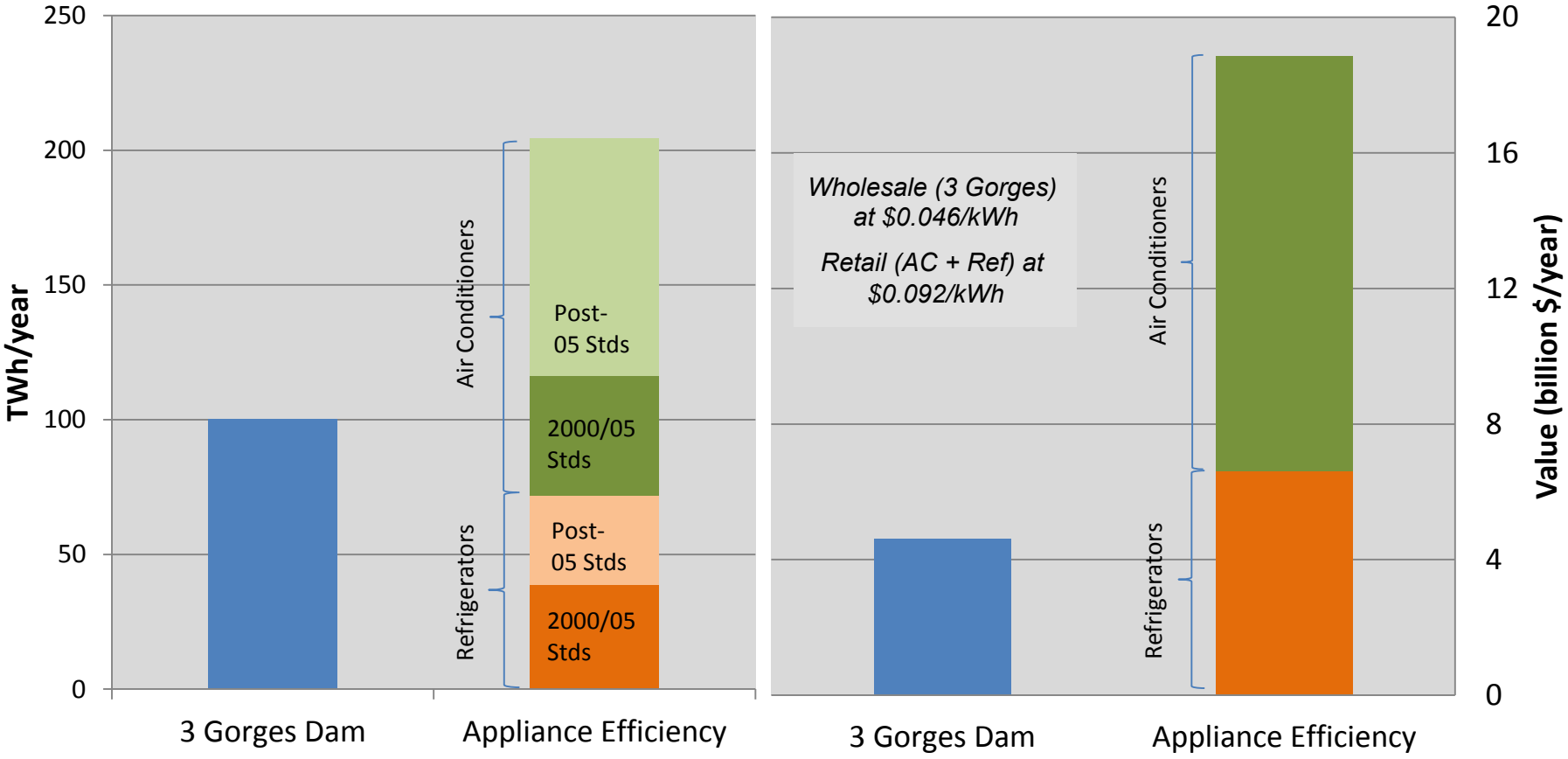
Arthur Rosenfeld,


United States Refrigerator Use v. Time
Average Eerngy Use per Unit Sold (kWh per year)
Refrigerator volume (cubic feet)
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
25
20
15
10
5
0
1947
1950
1953
1956
1959
1962
1965
1968
1971
1974
1977
1980
1983
1986
1989
1992
1995
1998
2001
2004
2007
Refrigerator Size
(cubic feet)
Energy Use per Unit
$ 1,270
Refrigerator Price Dollars (2001 $)
$ 481
David Goldstein, NRDC and Pat McAuliffe, CEC

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



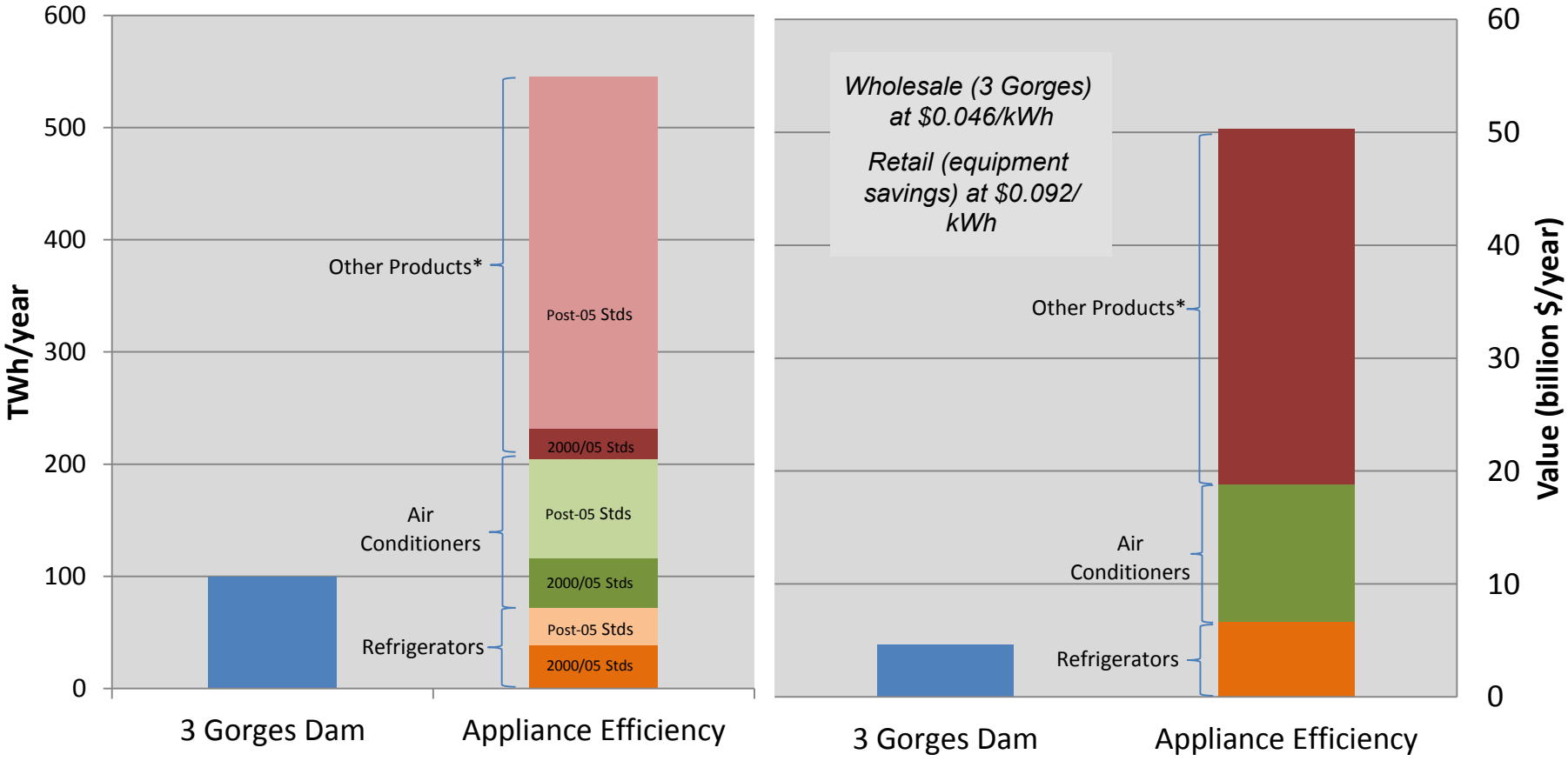
Annual generation from China's Three Gorges Dam compared to annual savings in 2020, from 20 years of sales of refrigerators and ACs with increasing energy efficiency



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

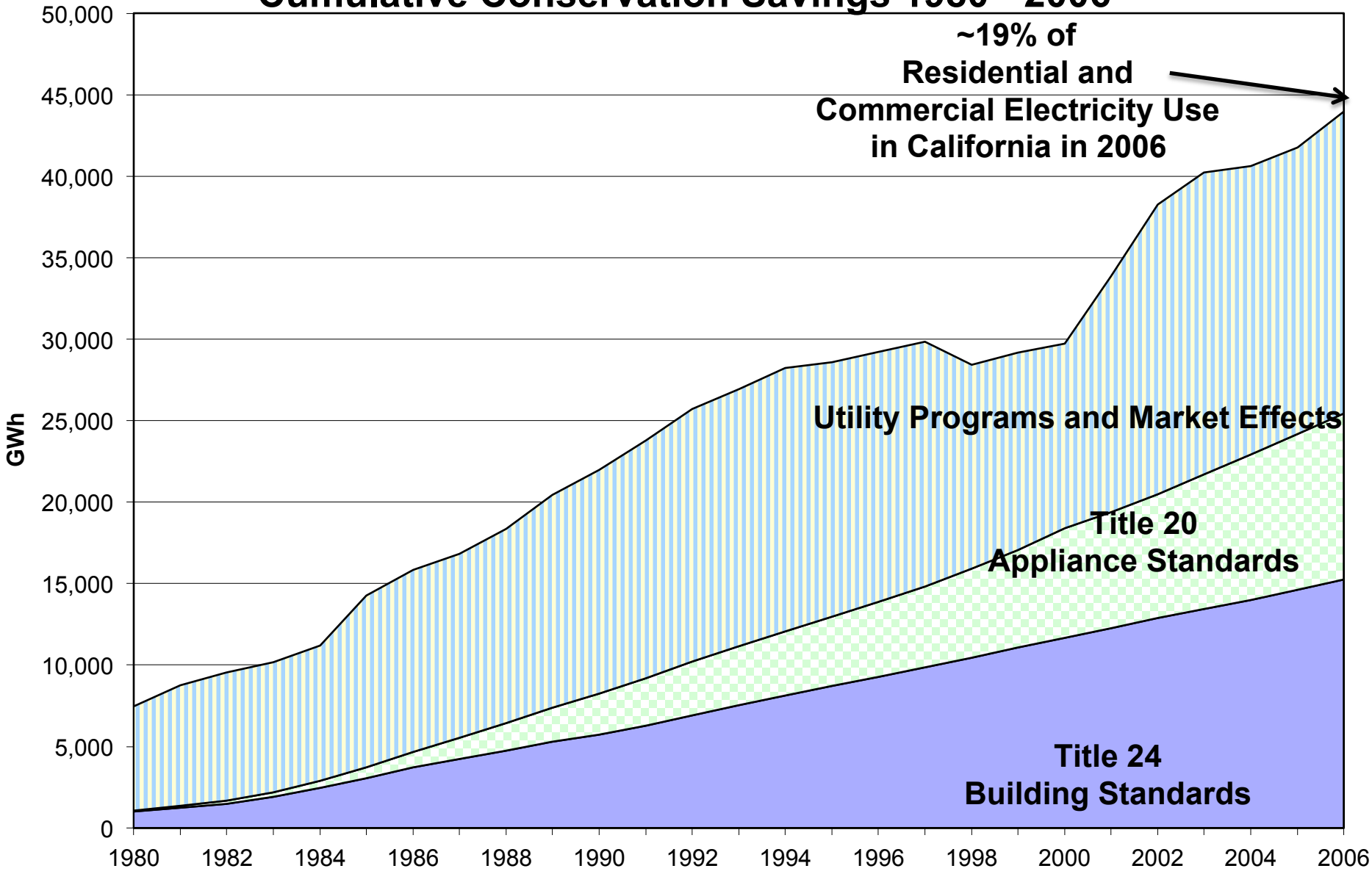
Annual generation from China's Three Gorges Dam compared to annual savings in 2020, from 20 years of sales of equipment subject to China's energy efficiency standards



***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**

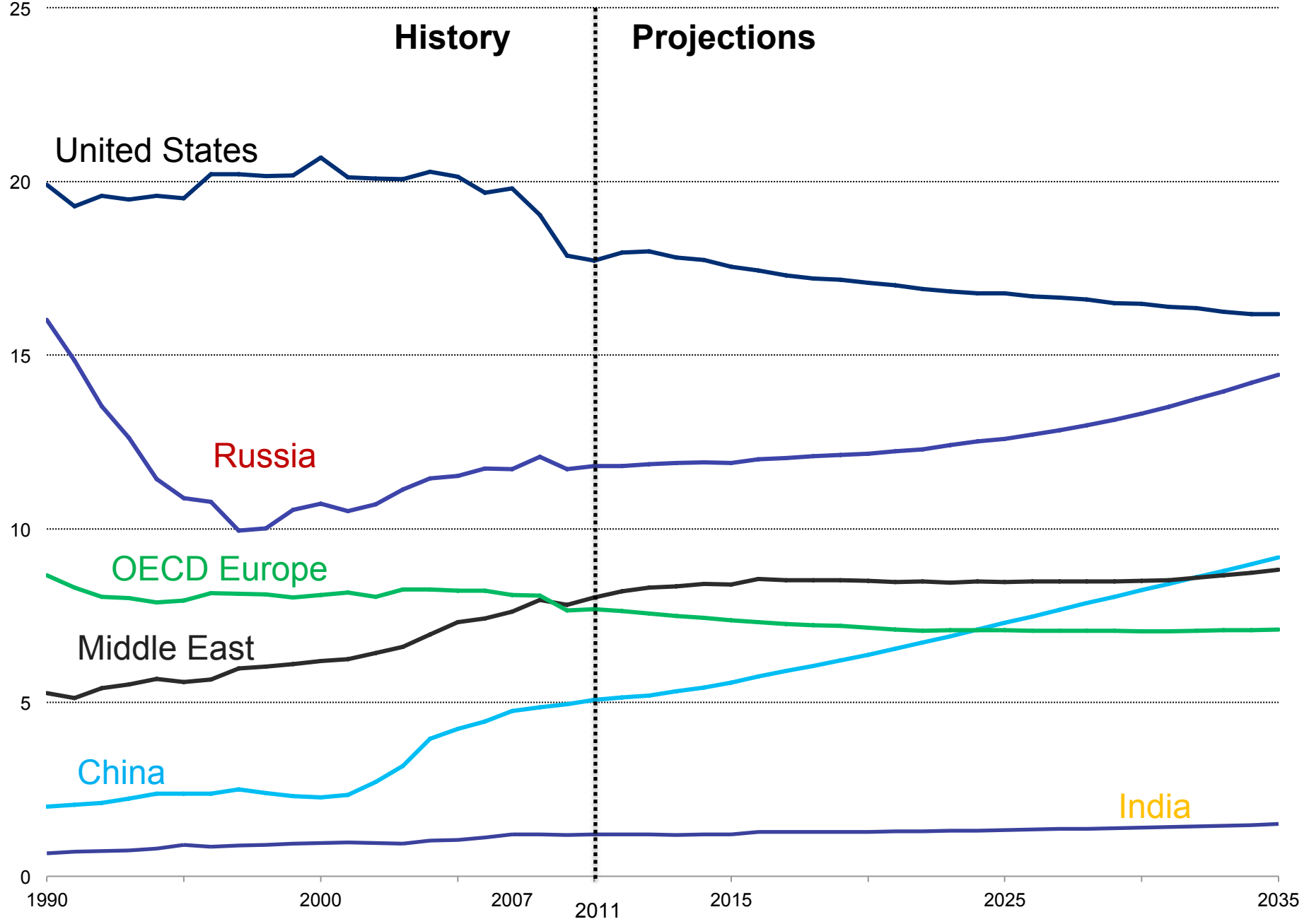
Source: LBNL China Energy End-Use Model, David Fridley and Nina Zheng, 2010

Residential and Commercial Cumulative Conservation Savings 1980 - 2006

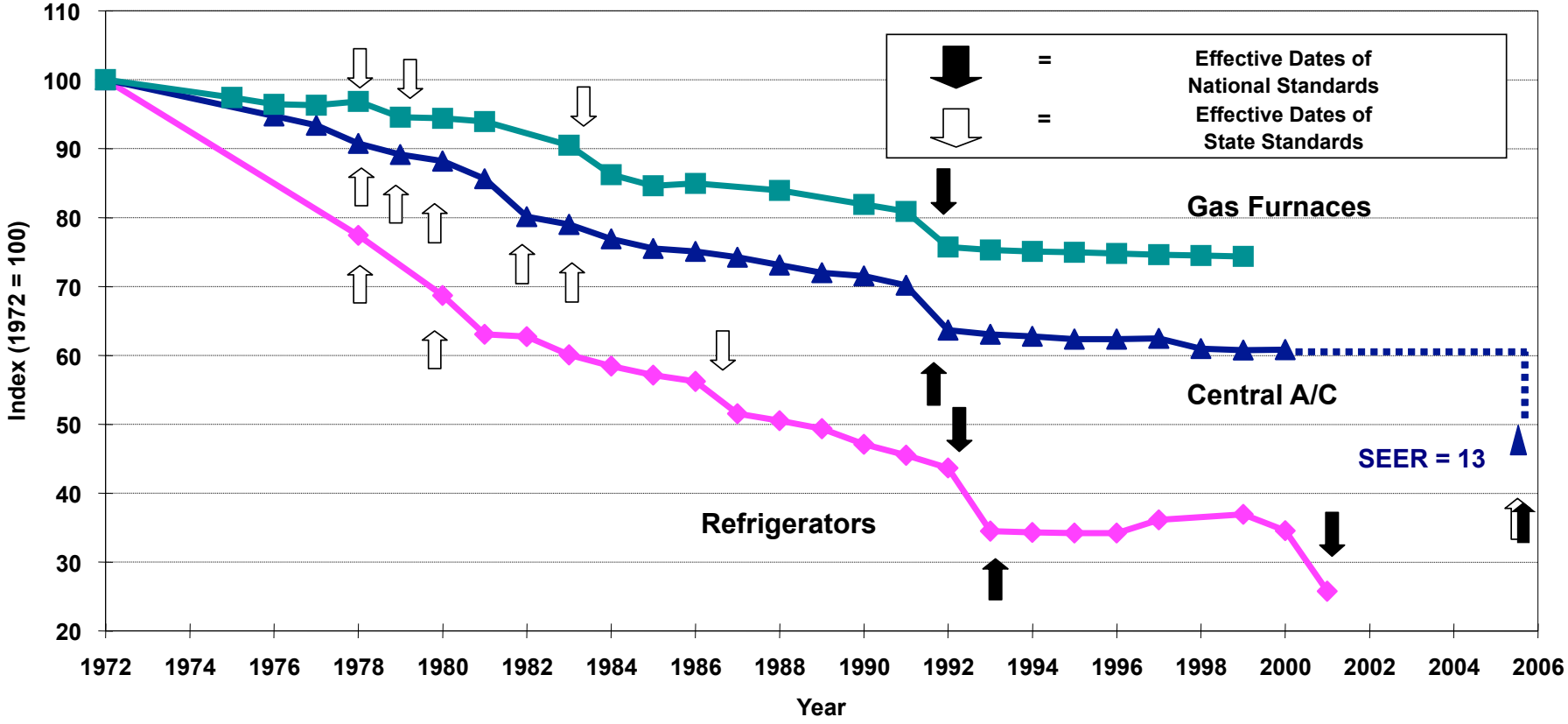


Source: Art Rosenfeld, California Energy Commission

Figure 113. CO2 emissions per capita by selected country and region, 1990-2035
(metric tons per person)



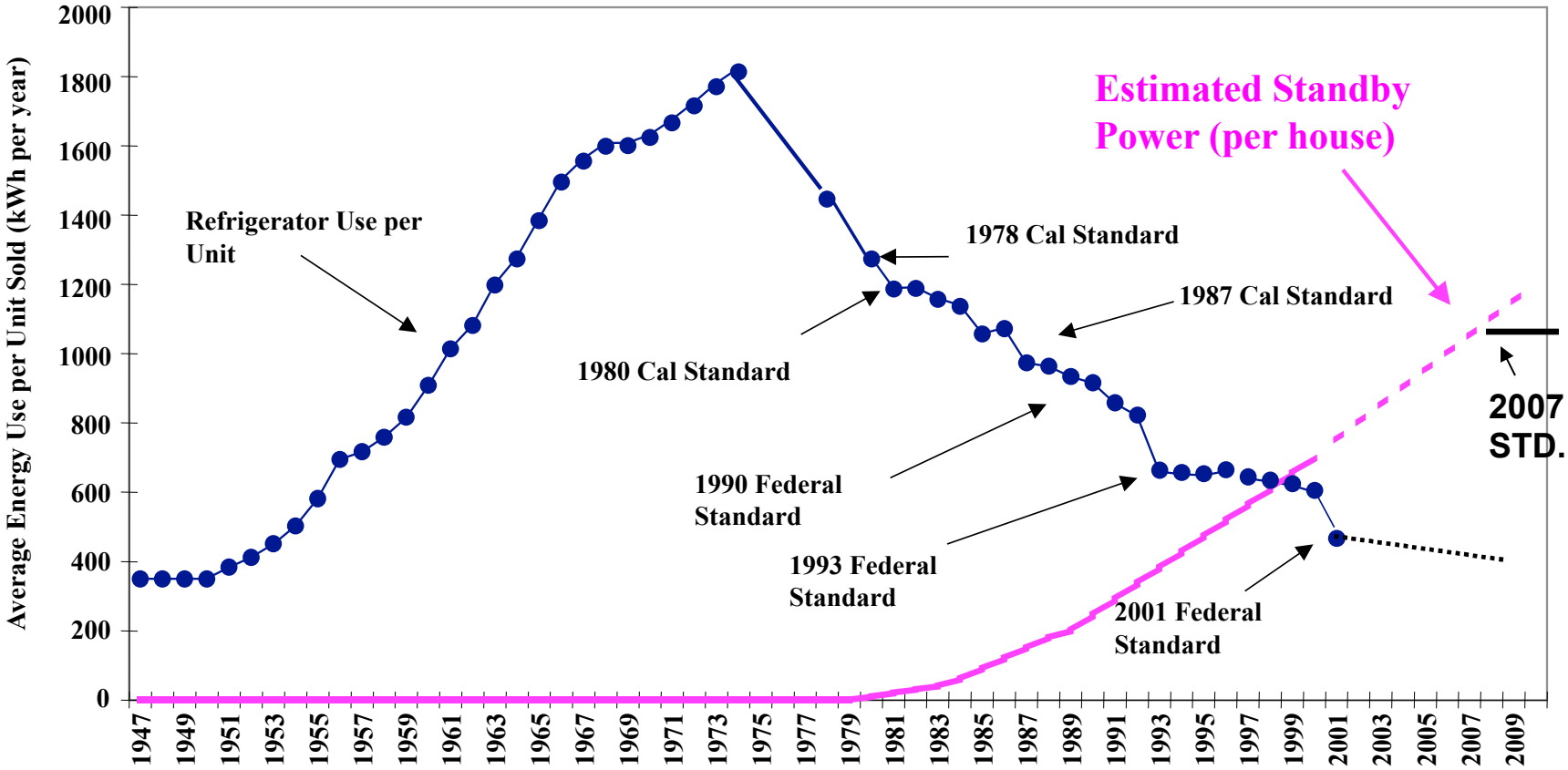
Impact of Standards on Efficiency of 3 Appliances



Source: S. Nadel, ACEEE,

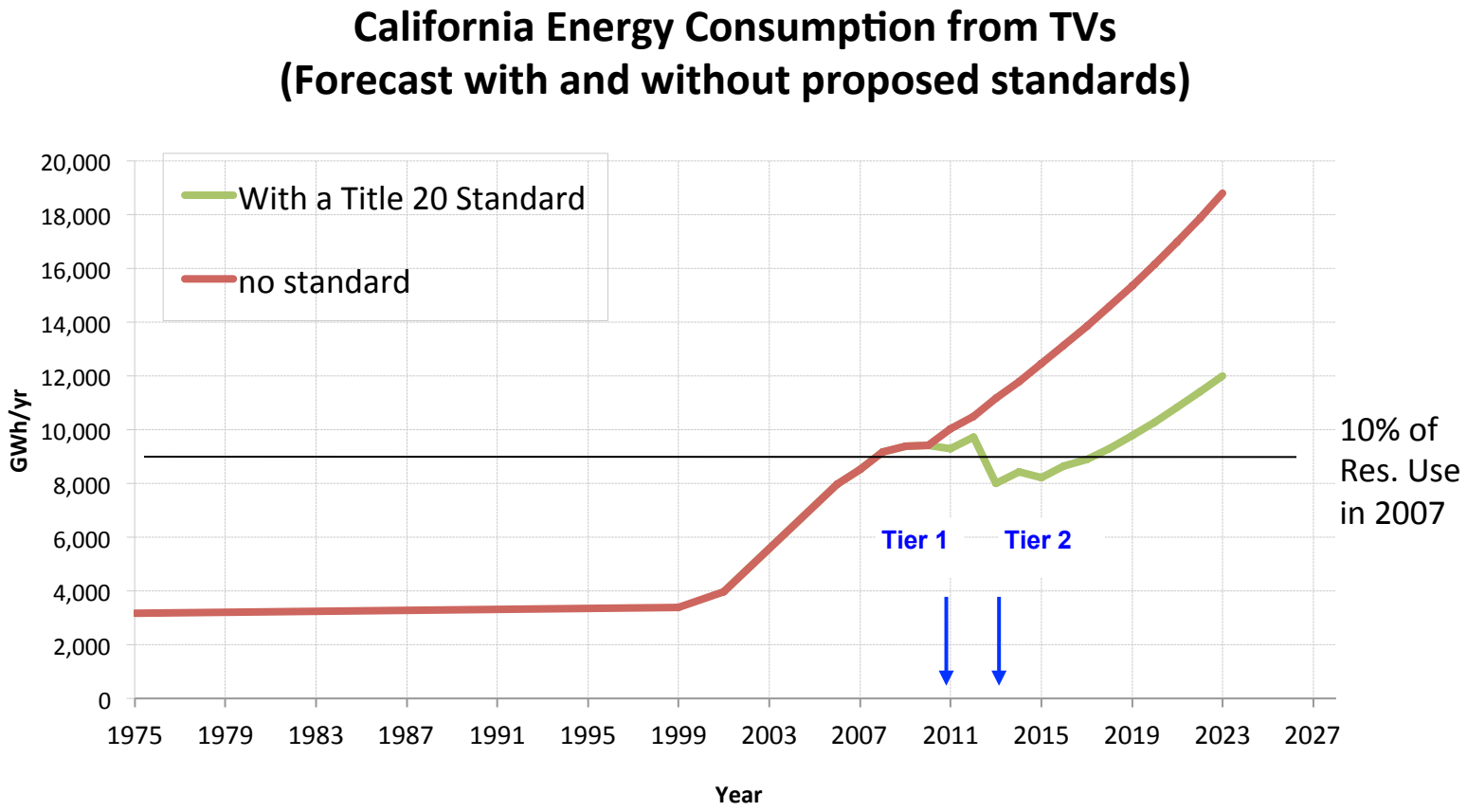
in ECEEE 2003 Summer Study, www.eceee.org

United States Refrigerator Use, repeated, to compare with Estimated Household Standby Use v. Time

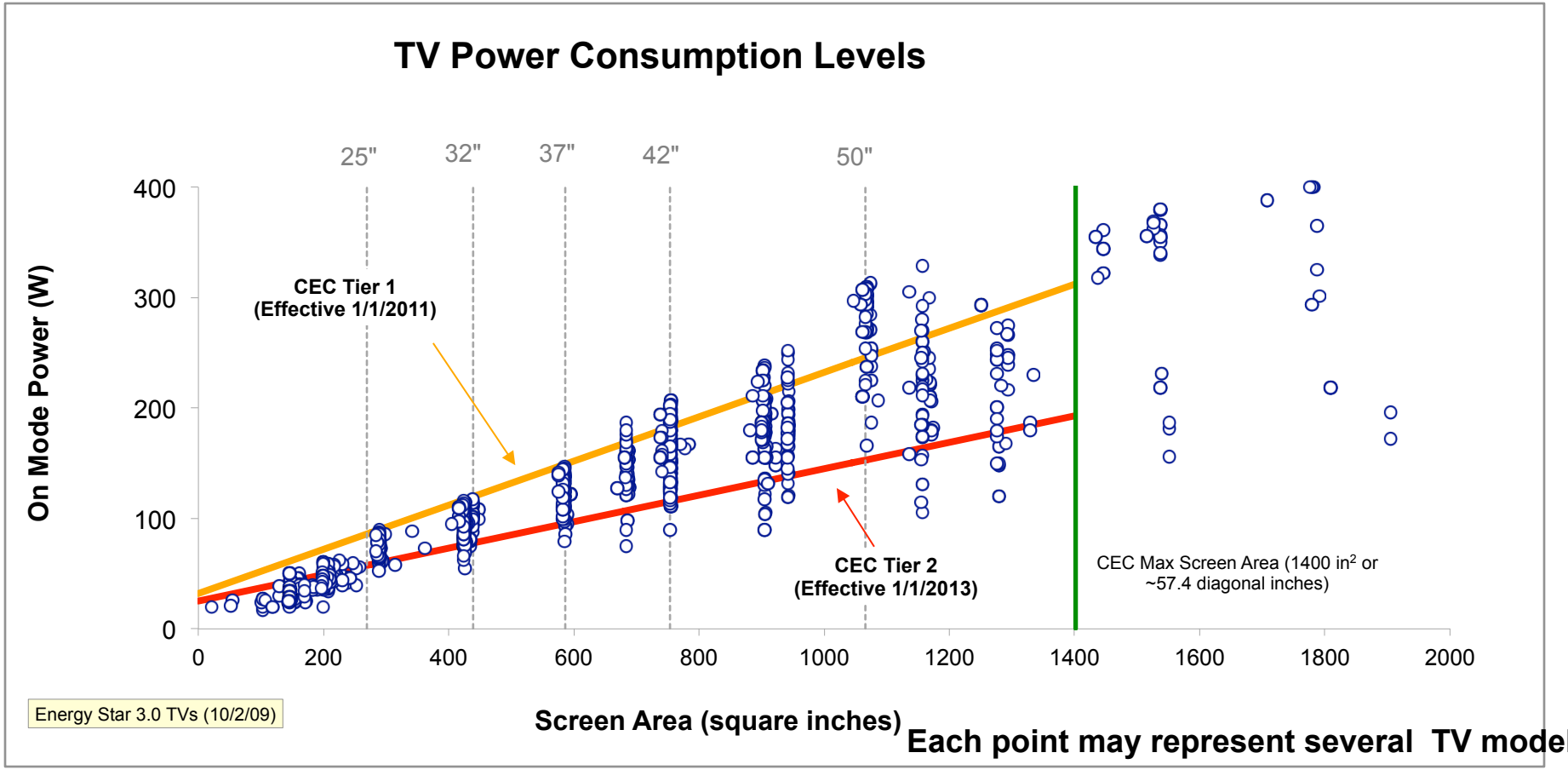


Televisions Represent Significant Energy Use

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.



Technically Feasible 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

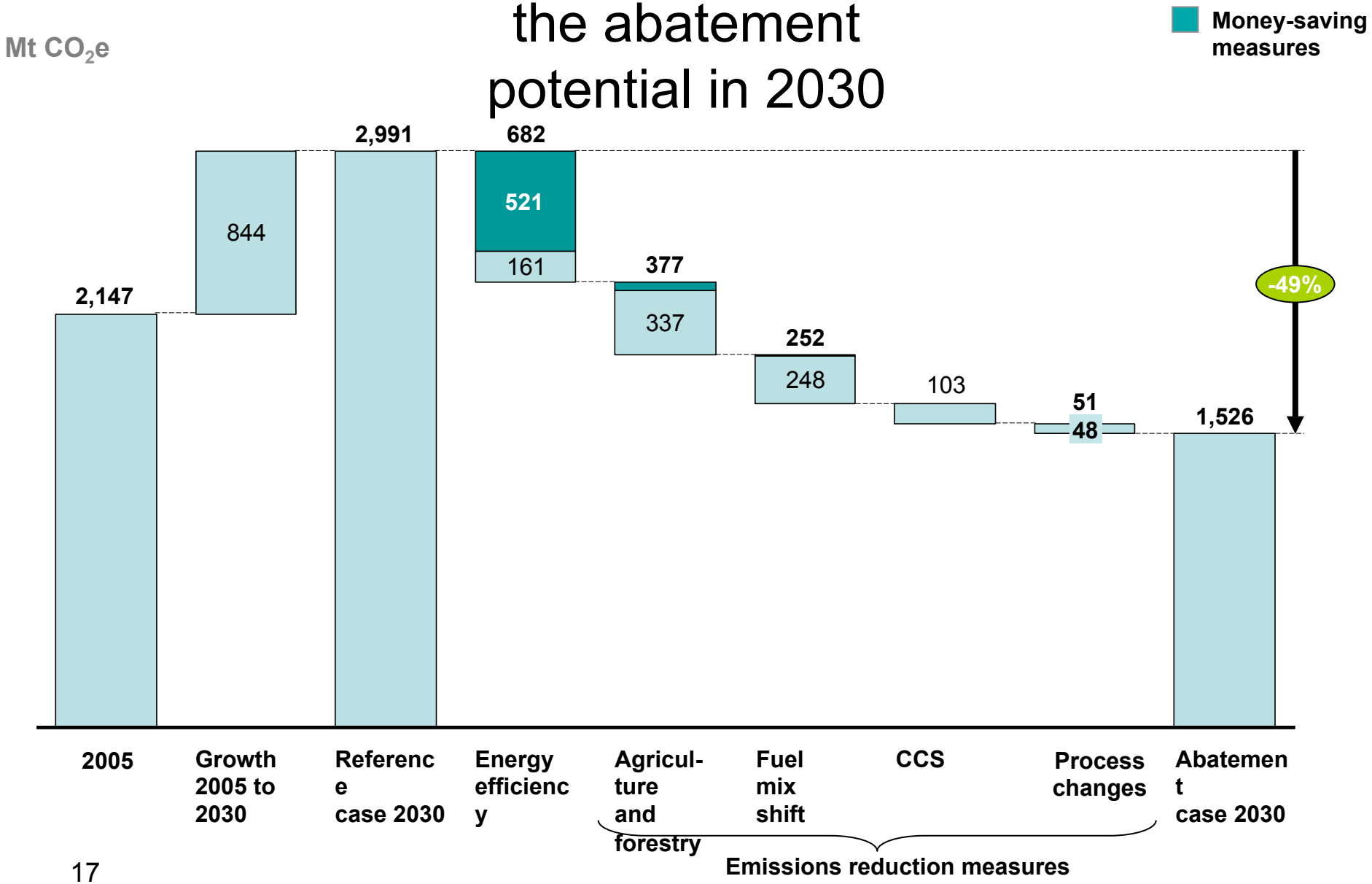
Rated Lumens Range	Maximum rated Wattage	Minimum Rated Life Time	Proposed California Effective Date
1490-2600 Lumens	100→72 Watts	1,000 hours	Jan, 1, 2011
1050-1489Lumens	75→53 Watts	1,000 hours	Jan 1, 2012
750-1049 Lumens	60→43 Watts	1,000 hours	Jan 1, 2013
310-749 Lumens	40→29 Watts	1,000 hours	Jan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

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

Lumens Range	Maximum Lamp Efficacy	Minimum Rated Life Time	Proposed California Effective Date
All	45 lumens per watt	1,000 hours	Jan, 1, 2018

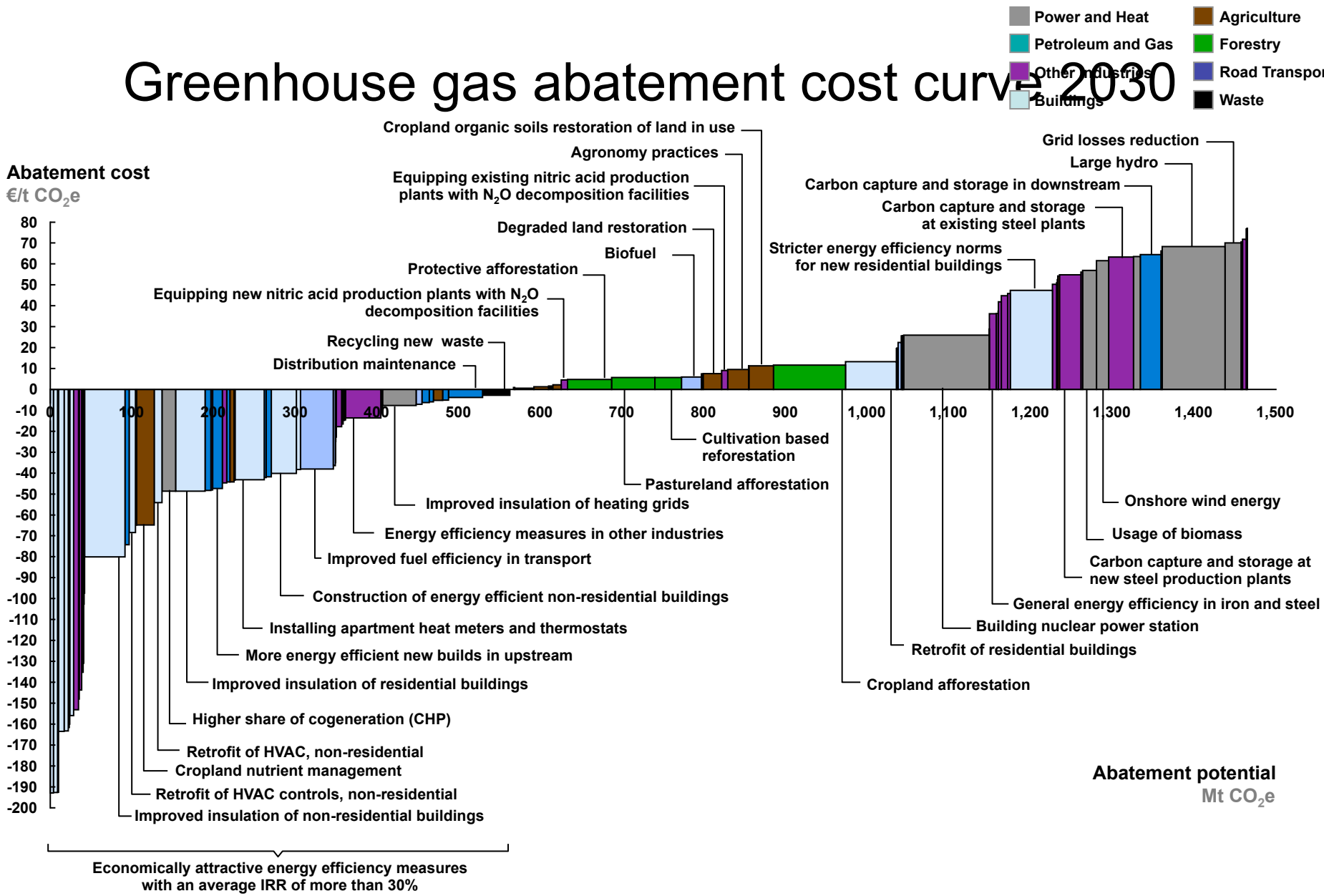
- McKinsey Russian Report:
- C02 abatement through EE

Russia's baseline greenhouse gas emissions and the abatement potential in 2030



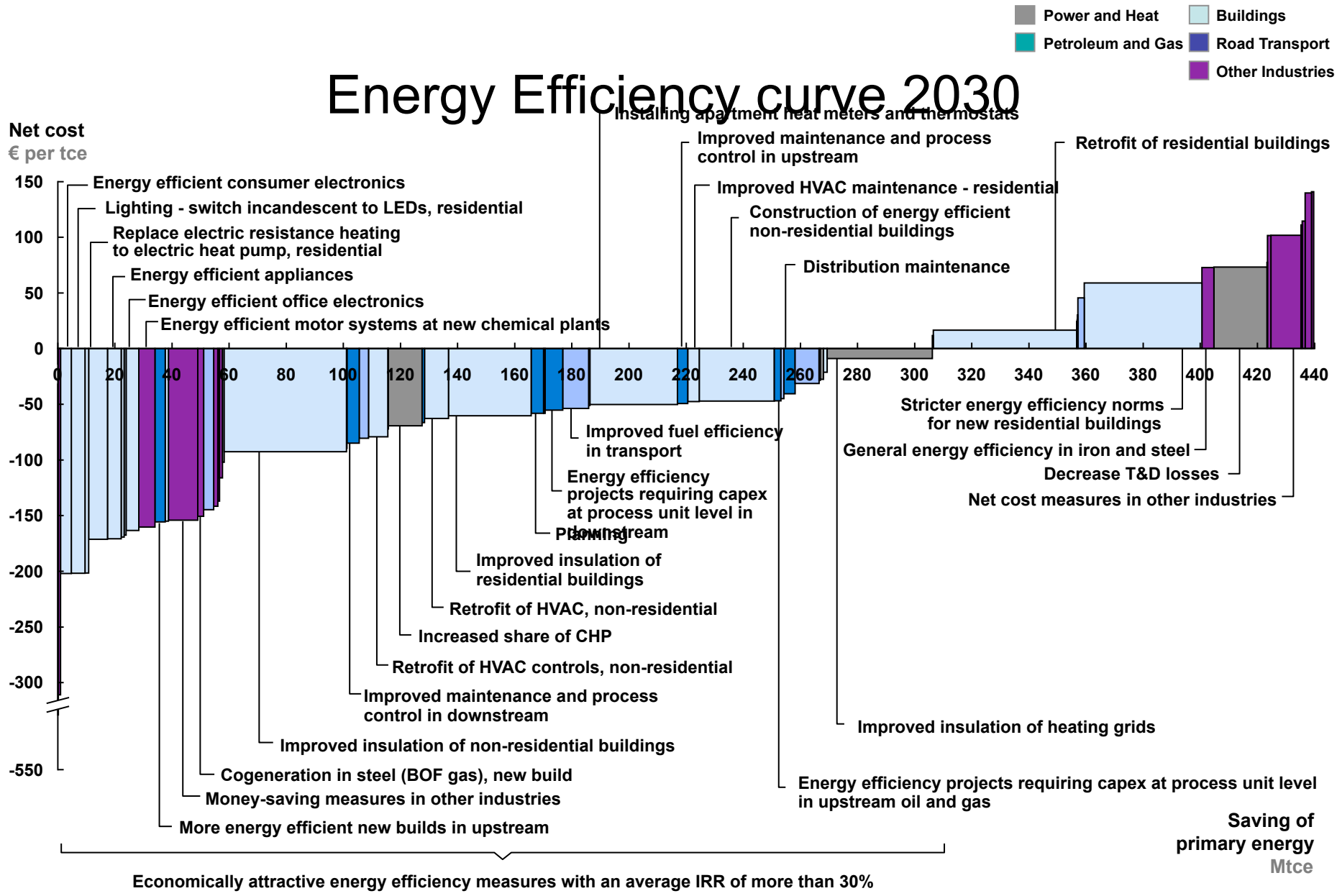
SOURCE: McKinsey

Greenhouse gas abatement cost curve 2030

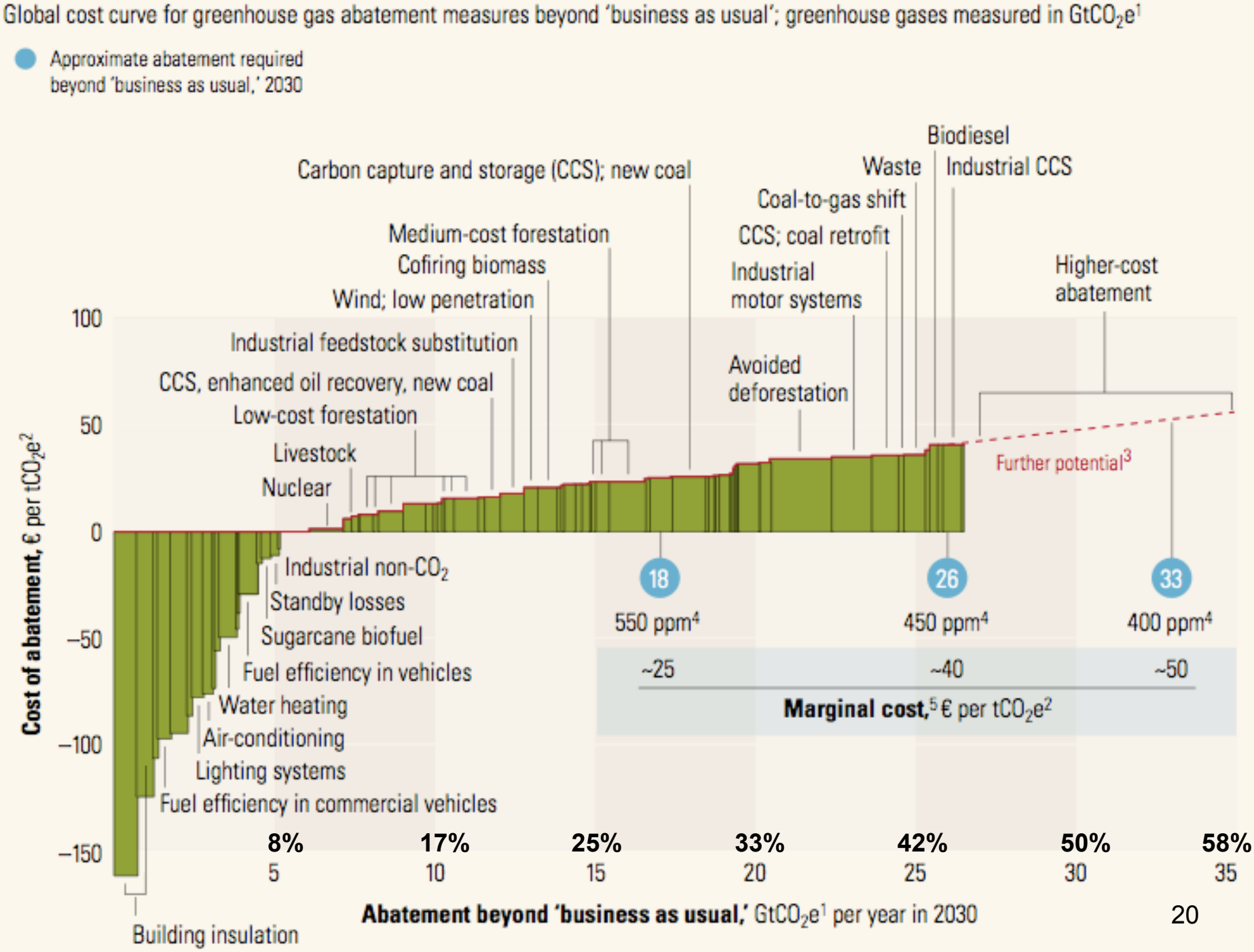


SOURCE: McKinsey

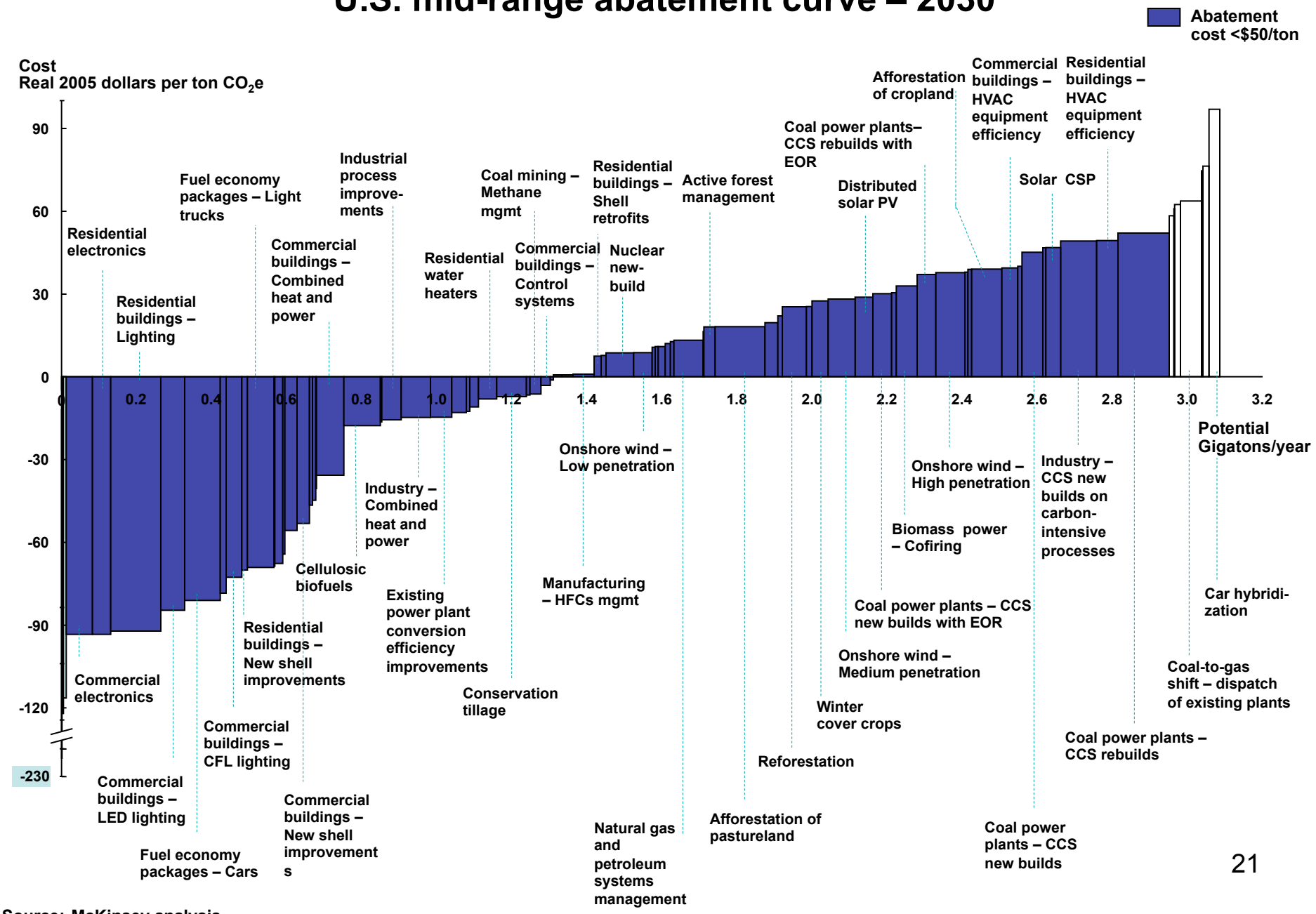
Energy Efficiency curve 2030



SOURCE: McKinsey


Global cost curve for greenhouse gas abatement measures beyond 'business as usual'; greenhouse gases measured in GtCO2e1
Approximate abatement required beyond 'business as usual,' 2030
Biodiesel
Waste
Industrial CCS
Carbon capture and storage (CCS); new coal
Coal-to-gas shift
Medium-cost forestation
CCS; coal retrofit
Cofiring biomass
Industrial motor systems
Higher-cost abatement
Wind; low penetration
Industrial feedstock substitution
Avoided deforestation
CCS, enhanced oil recovery, new coal
Low-cost forestation
Livestock
Nuclear
Further potential3
Industrial non-CO2
Standby losses
Sugarcane biofuel
Fuel efficiency in vehicles
Water heating
Air-conditioning
Lighting systems
Fuel efficiency in commercial vehicles
Building insulation
100
50
0
−50
−100
−150
Cost of abatement, € per tCO2e2
18
26
33
550 ppm4
450 ppm4
400 ppm4
~25
~40
~50
Marginal cost,5 € per tCO2e2
8%
17%
25%
33%
42%
50%
58%
5
10
15
20
25
30
35
Abatement beyond 'business as usual,' GtCO2e1 per year in 2030

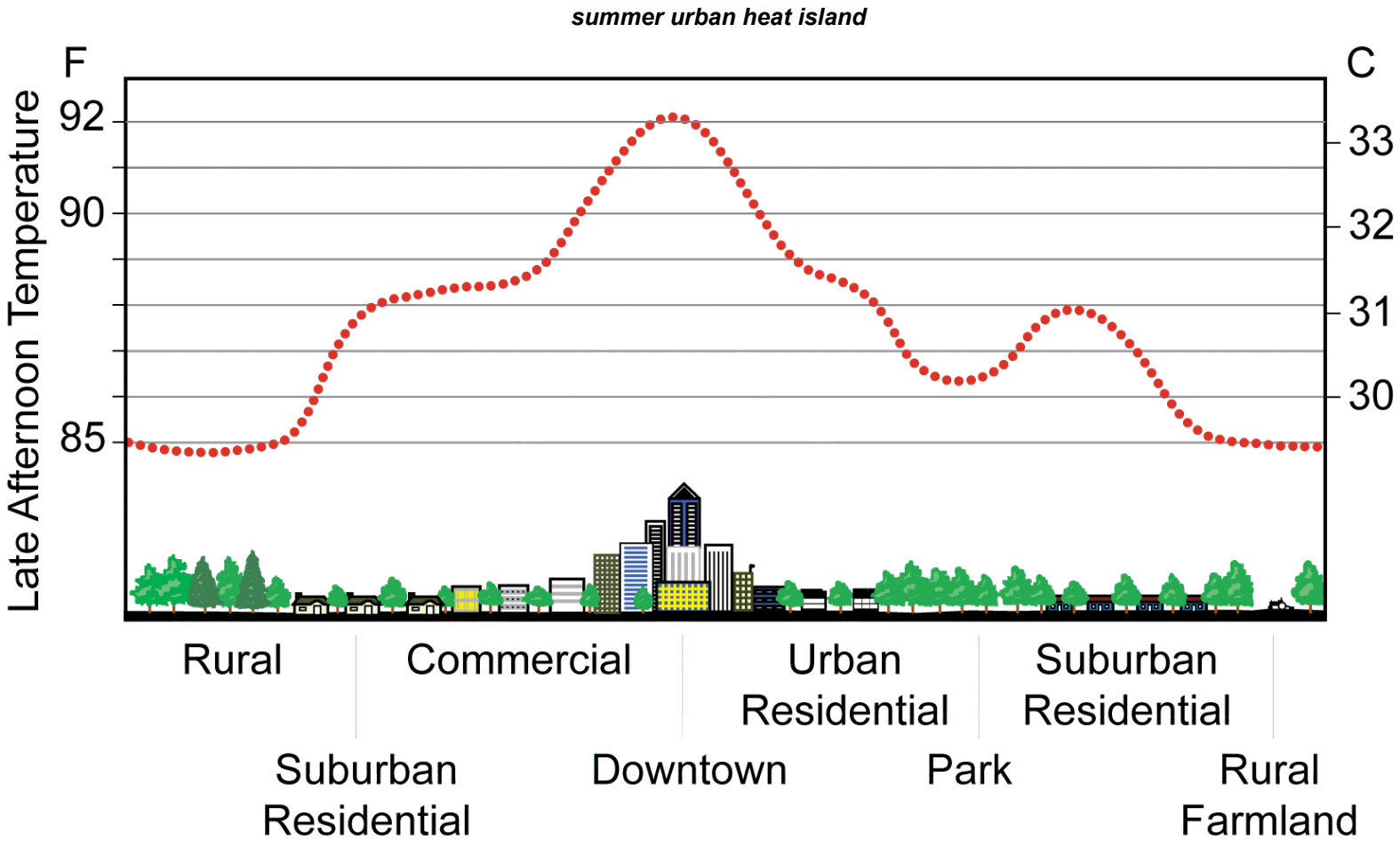
U.S. mid-range abatement curve – 2030



Source: McKinsey analysis

White roofs to cool your buildings, your cities, and (this is new) to cool the earth.

Summer in the city



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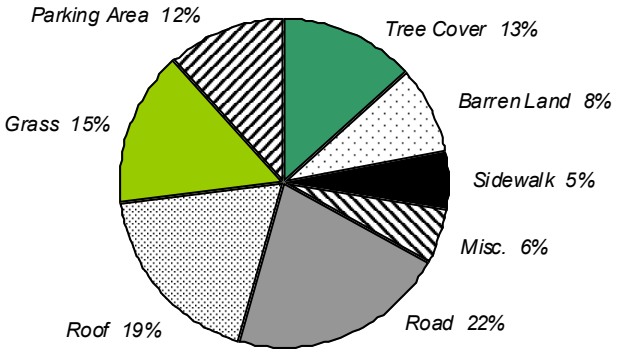
Bird's eye view of urban land use

~ 1 km^2

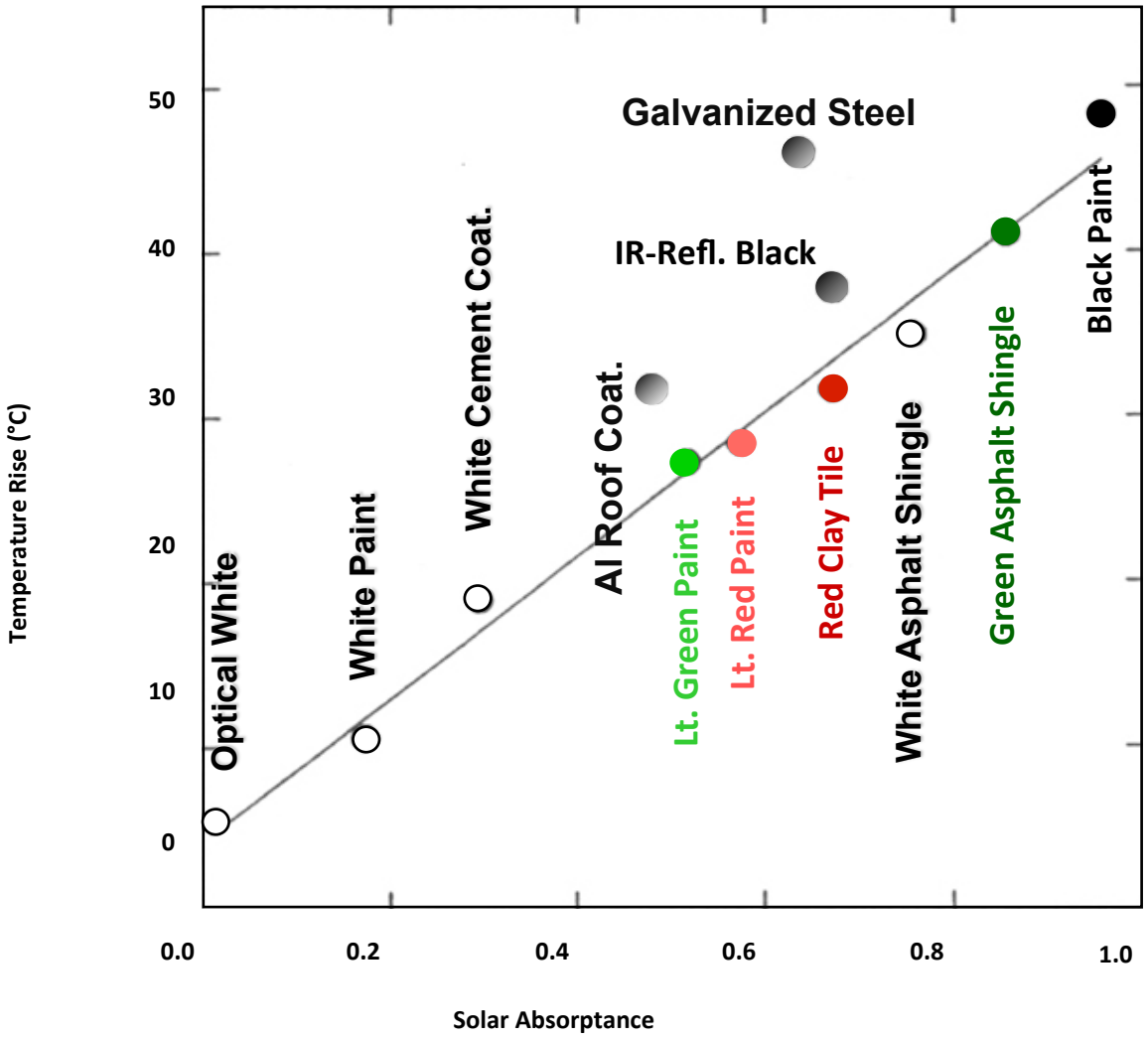
The surface of Sacramento, CA is about

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



Area by Land-Cover Category Above the Canopy

Reflective roofs stay cooler in the sun



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White roofs, cool-colored roofs save money

OLD

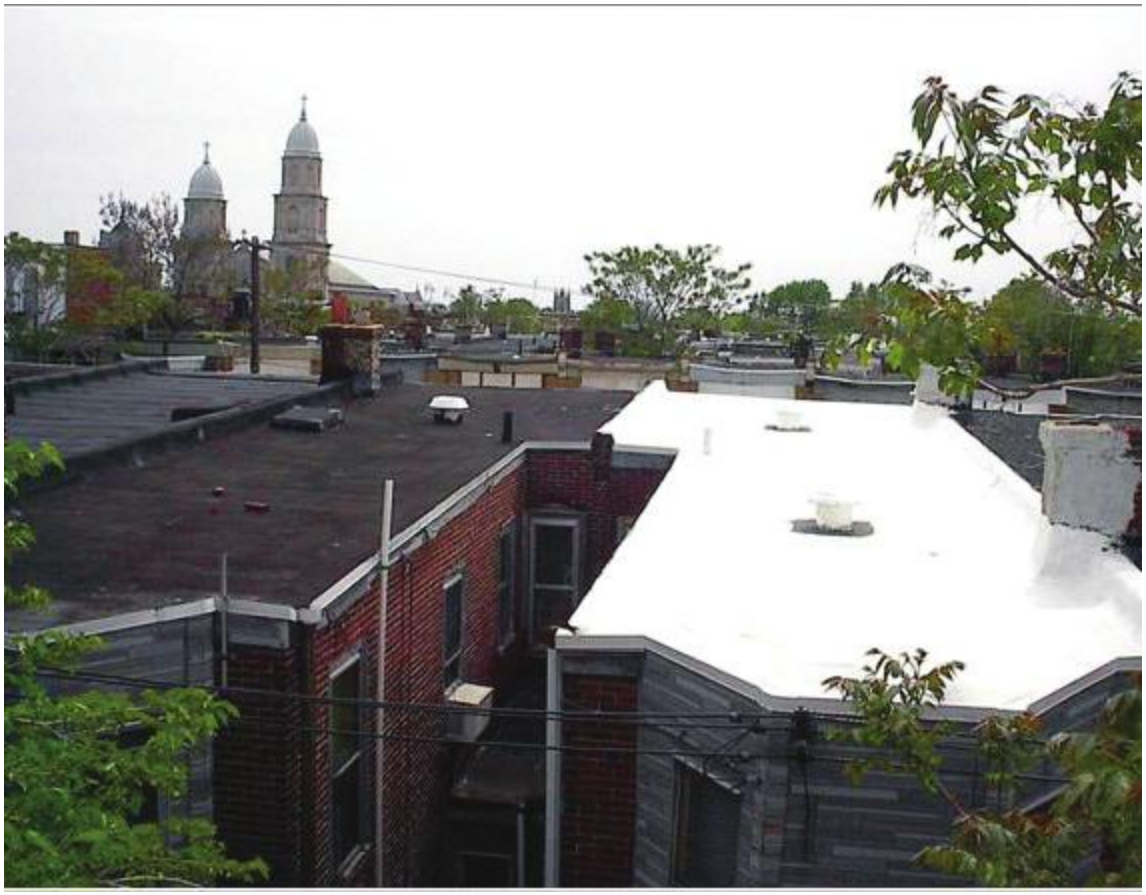
flat, white

pitched, white

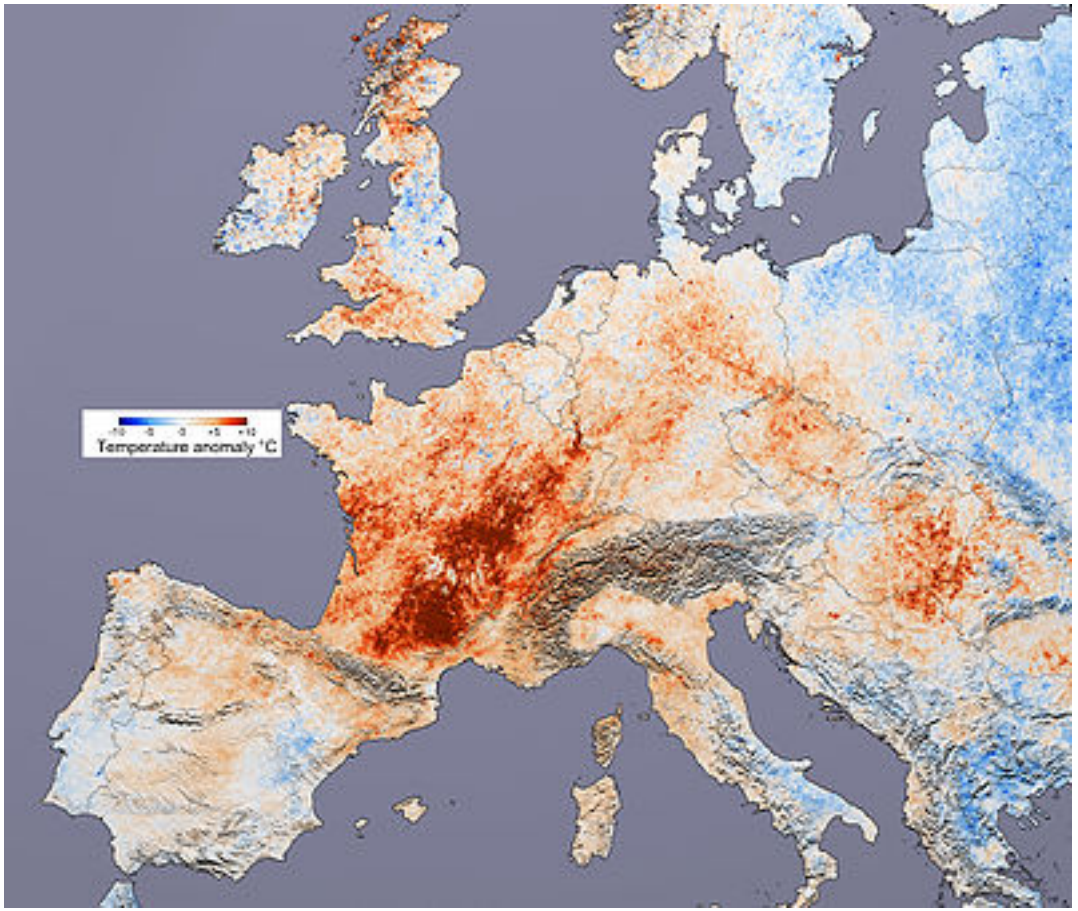
NEW

pitched, cool & colored

Chicago Heat Wave 1995, 739 Deaths
The most lethal floor was the top floor of a building with a black roof



European Heat Wave 2003, 30,000 Deaths
Moscow-Centered Heat Wave 2010,15,000 Deaths



White roofs around the world

…in Santorini, Greece

30

…in Hyderabad, India

…and widely in the state of Gujarat, India.

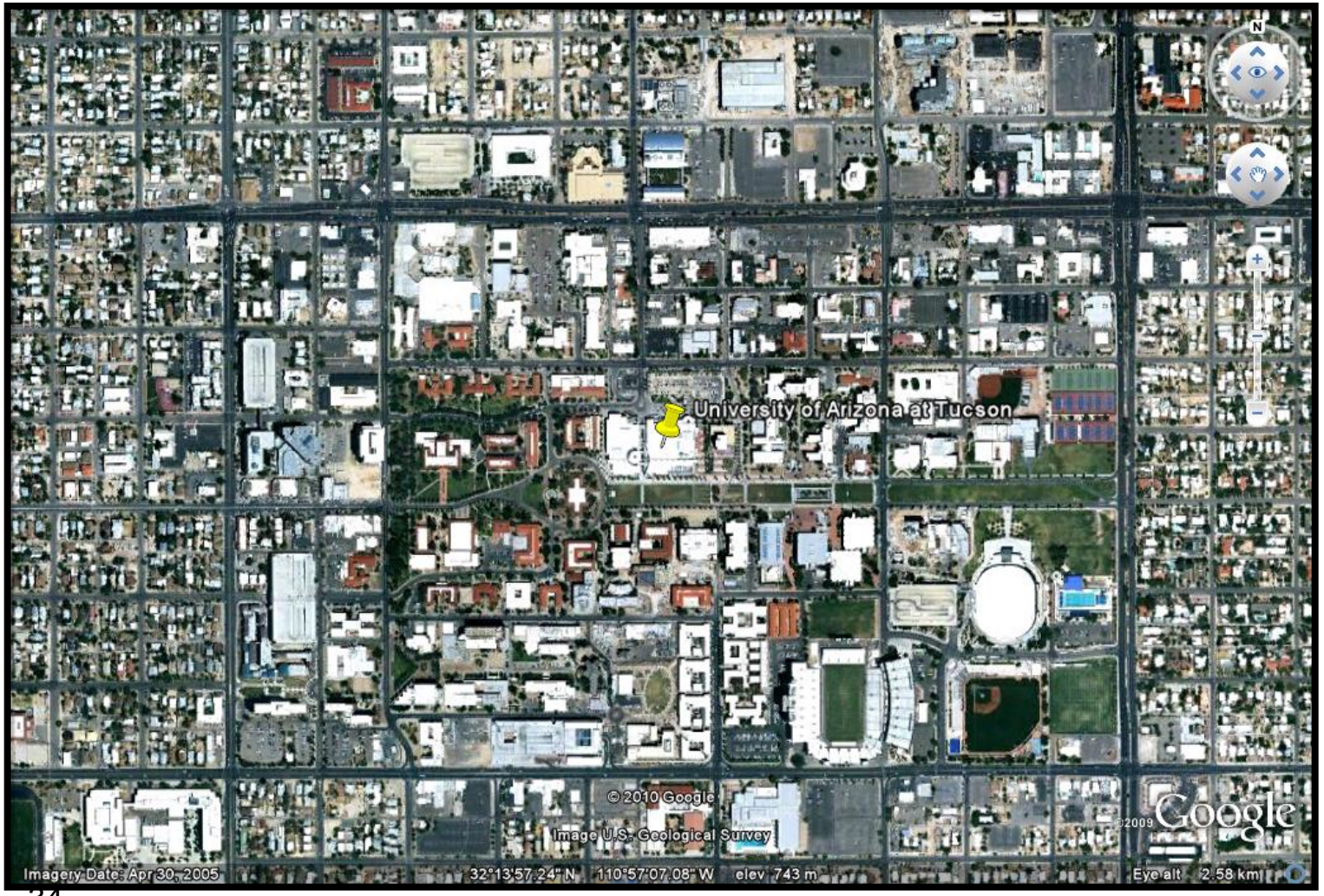
Walmart store in northern California

32

Congratulations to UC Davis

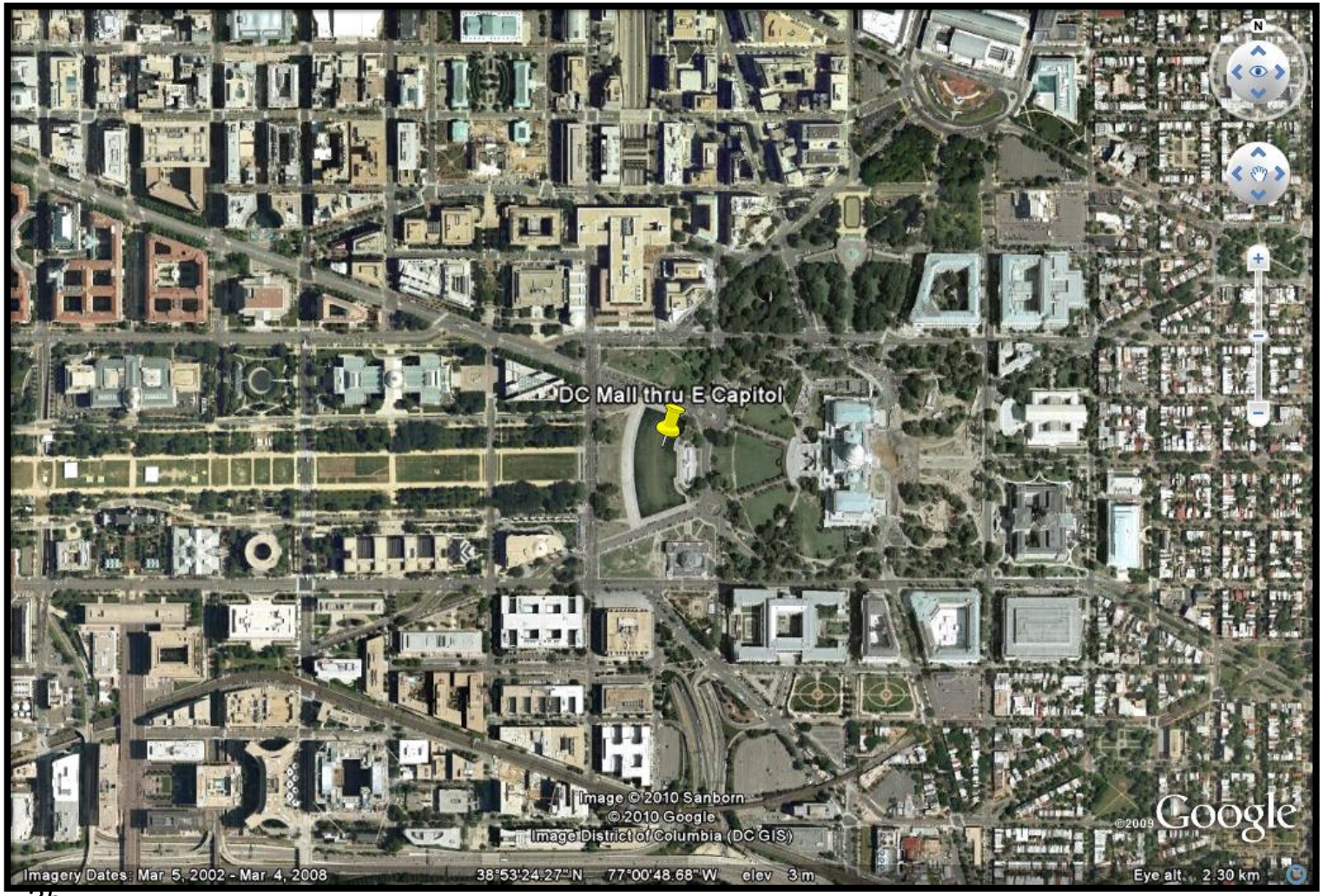
33

White roofs are popular in Tucson, AZ



34

Washington, DC (Federal) has problems



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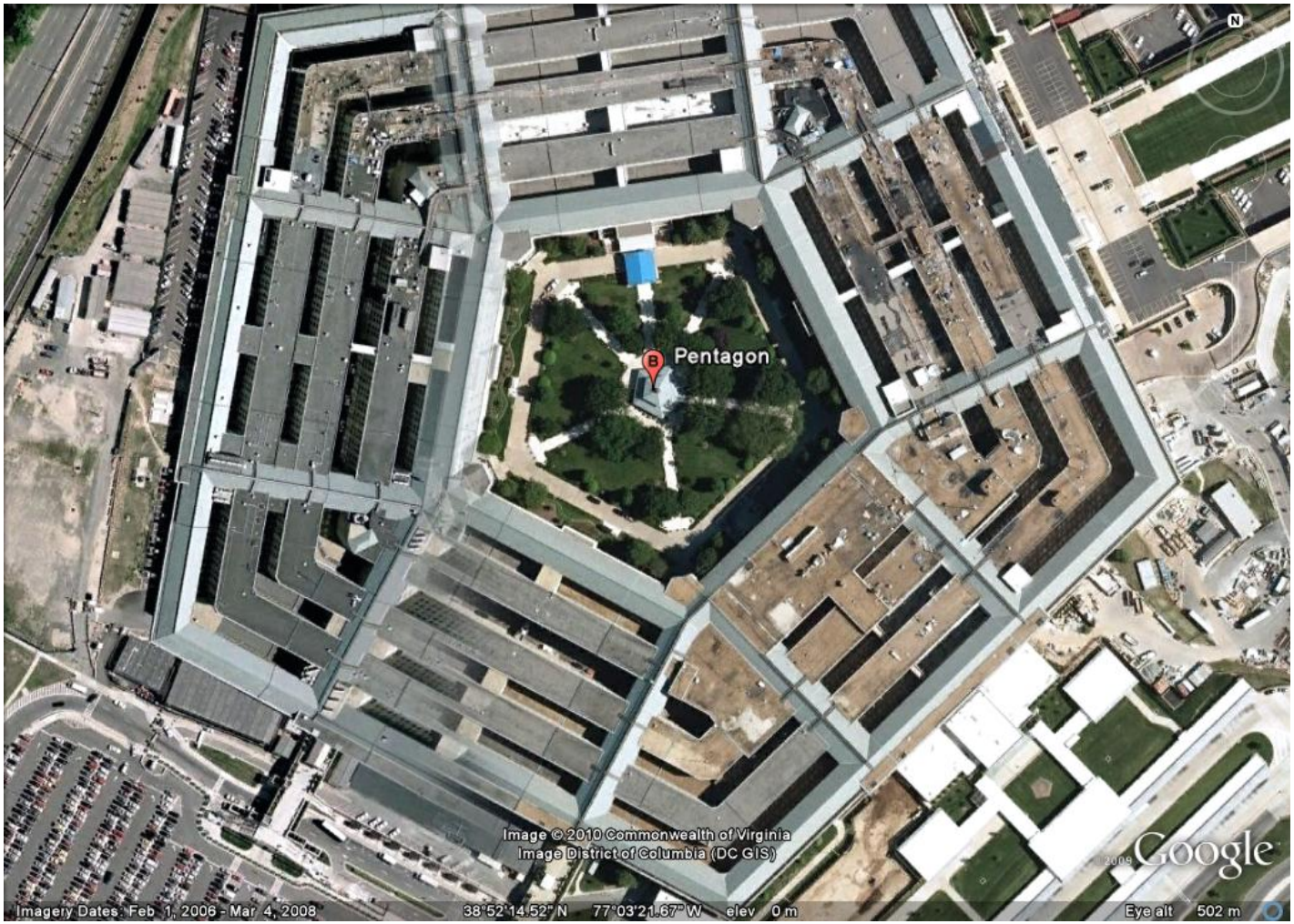
Pentagon

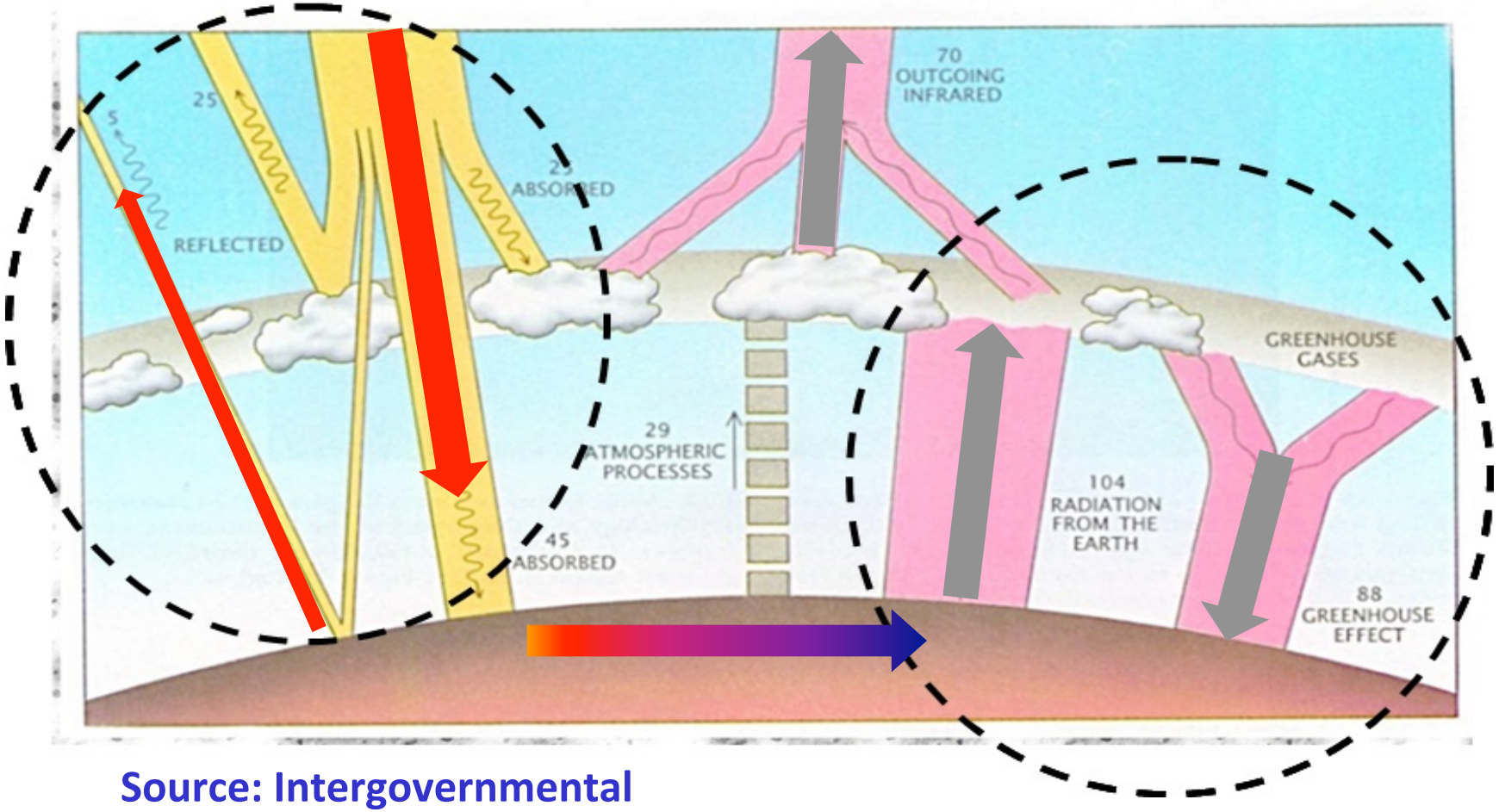

Pentagon
Image © 2010 Commonwealth of Virginia
Image District of Columbia (DC GIS)
Imagery Dates: Feb 1, 2006 - Mar 4, 2008
38°52'14.52" N 77°03'21.67" W elev 0 m
Eye alt 502 m
Google

Rostov on Don, white roofs

Baku, dark roofs

Cooling our planet

Solar-reflective surfaces cool the globe via “negative radiative forcing”



Source: Intergovernmental Panel on Climate Change (IPCC)

40

GLOBAL COOLING: making 100 m^2 (1000 ft^2) of gray roofing white offsets the **emission** of 10 t of CO_2

41

How much CO_2 equivalent is offset if we whiten all eligible urban flat roofs world-wide? (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 ≈ 4 t CO_2/ year.

In terms of avoided power plants

Full white roof potential can ***offset*** **the emissions from 500 medium-sized coal fired power plants or 1,000 medium-sized gas fired power plants**.

That is just the albedo effect – if the building is air conditioned, it will avoid comparable *real* CO2 back at the power plant.

LAWRENCE BERKELEY NATIONAL LABORATORY PRESENTS:
SCIENCE AT THE THEATER

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.**

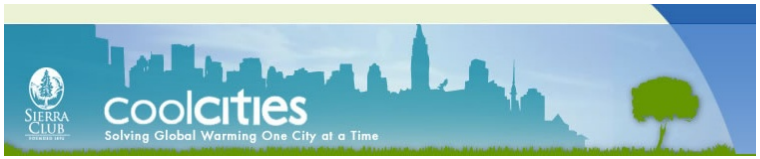
Recent cool roof progress (2005 – 2011)

- 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
  - 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



EMERALD CITIES COLLABORATIVE
GREEN • FAIR • DEMOCRATIC

American Council for an Energy-Efficient Economy

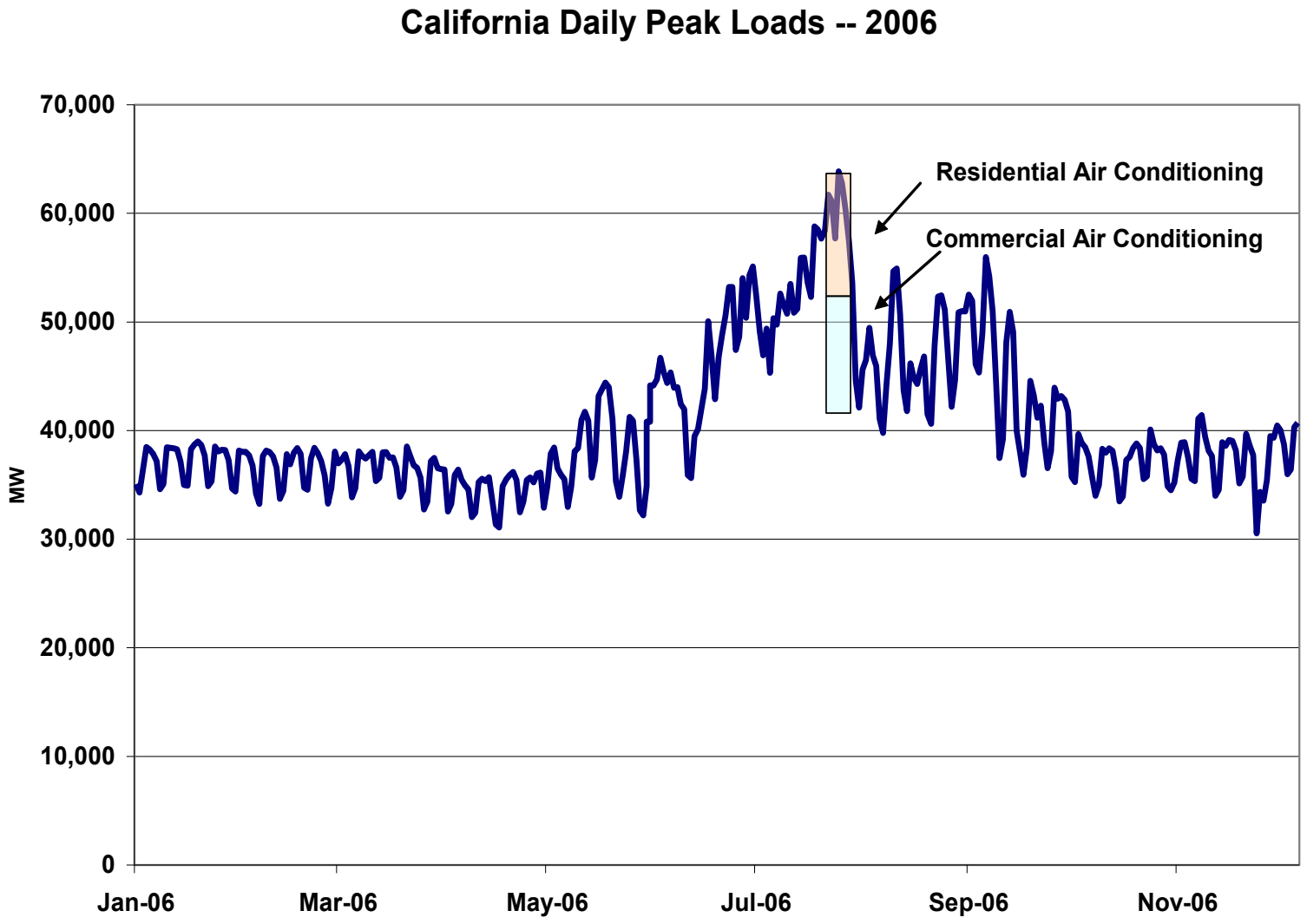
THE CLIMATE GROUP

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

Demand Response

California is a Summer Peaking Area

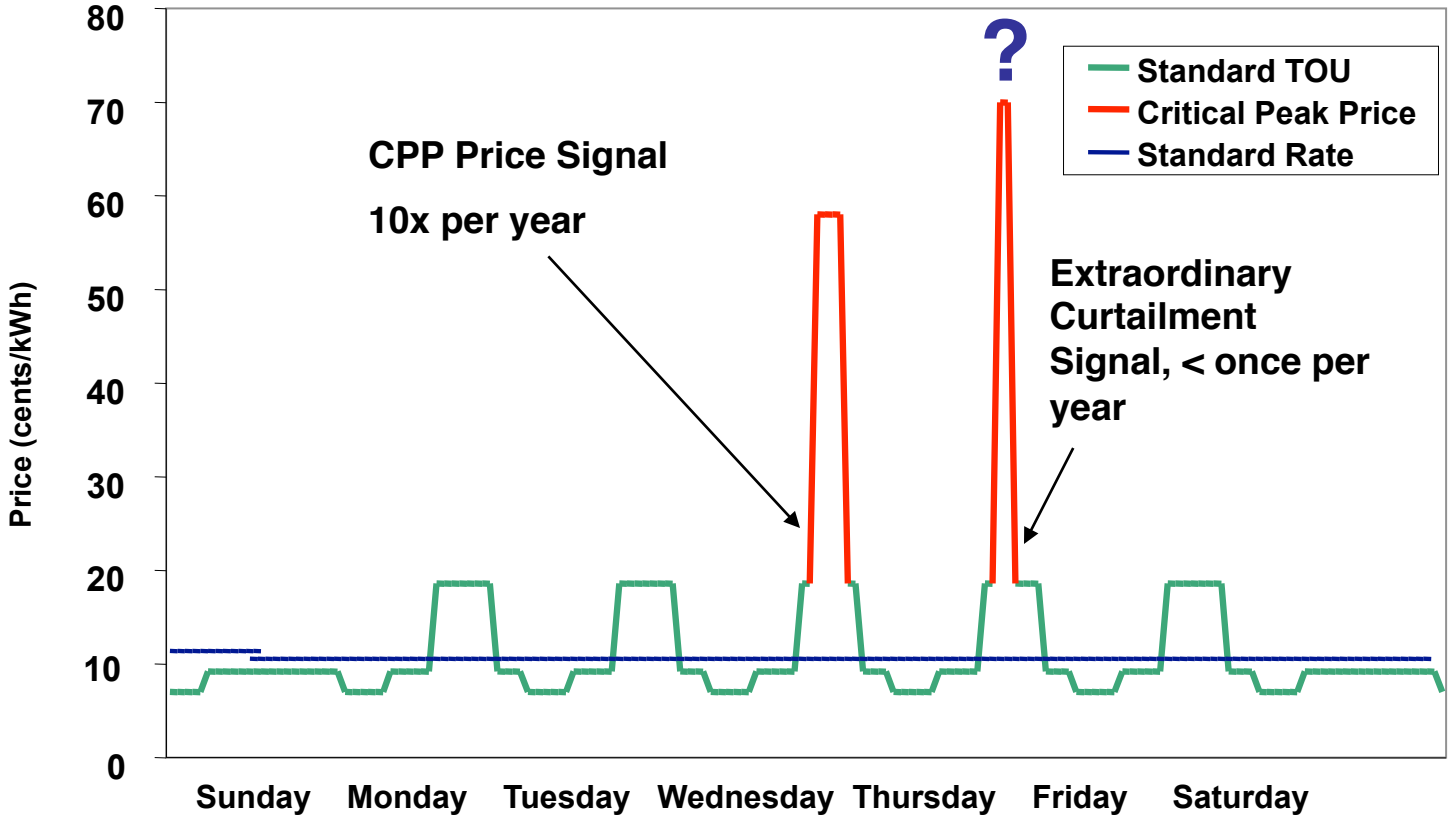


Three Necessary Components for Demand Response (The low-tech half of the smart grid; no Gee Whiz reliability)

- Advanced Metering Infrastructure--recorded hourly
  - Digital meters with communication; readings available in near-real time
- Dynamic Tariffs
  - Enable customers to be able to respond to hourly prices
  - The structure of these tariffs is critically important as customers are hoping to reduce total energy costs
- Automated Response Technology at customer locations
  - Enable residential and small commercial customers to respond to price **automatically**
  - Larger customers with energy management systems linked to pricing signals over the internet or through other communication channels
- And, when coupled with energy efficiency programs and policies the result can be reduction in total consumption as well as peak period consumption

Critical Peak Pricing (CPP) with Time of Use (TOU)

Direct customer savings comes mainly be response to TOU. Customer response to CPP is mainly civic pride but avoids utility investment and expensive peak infrastructure.

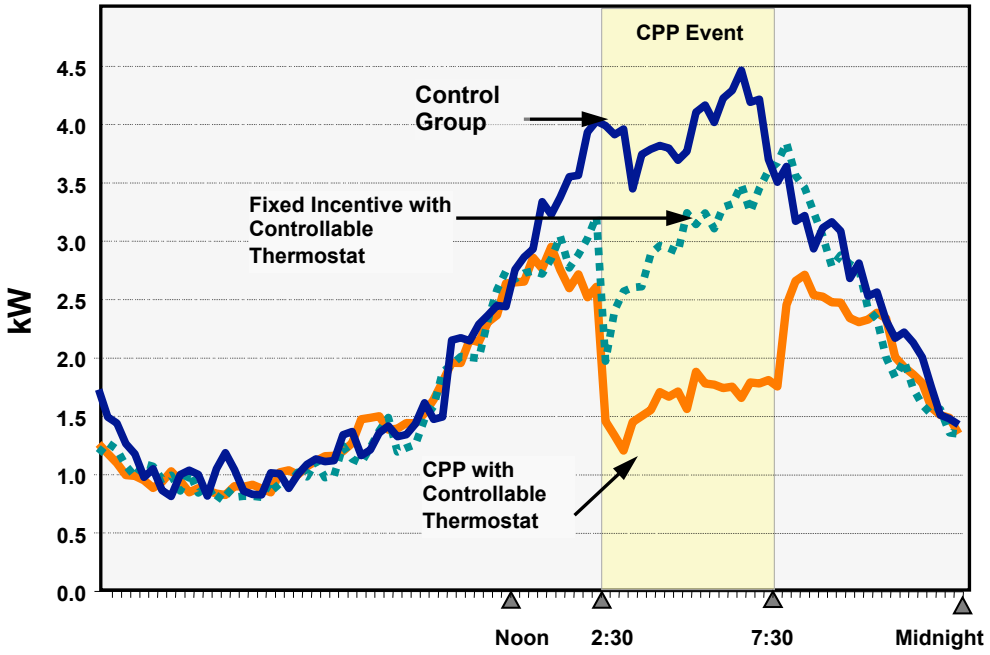


Prices are designed such that the average non-responder sees no bill change.

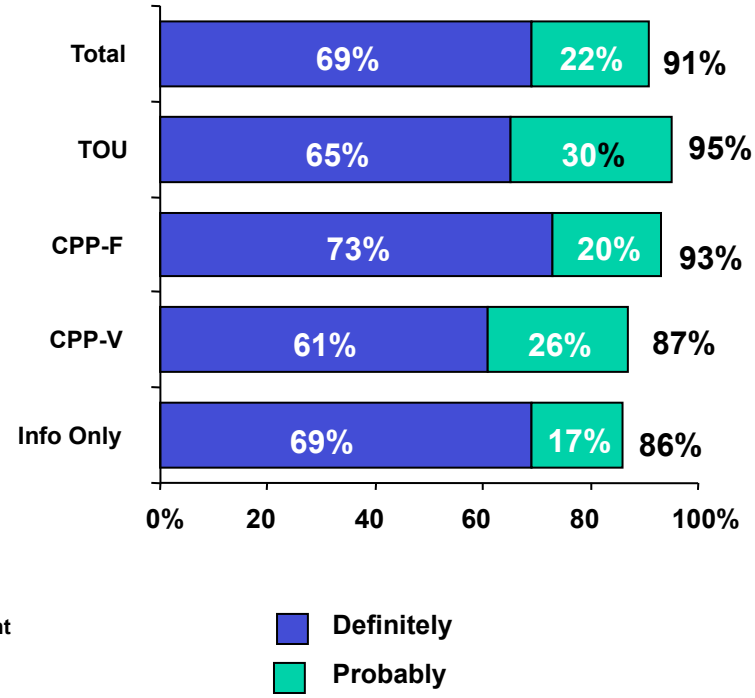
Key Results from Residential Pilot

- 12% average load reduction for CPP rate alone
- Up to 40% with rate + enabling tech
- Most participants preferred the pilot rates

Average Residential Response to Critical Peak Pricing

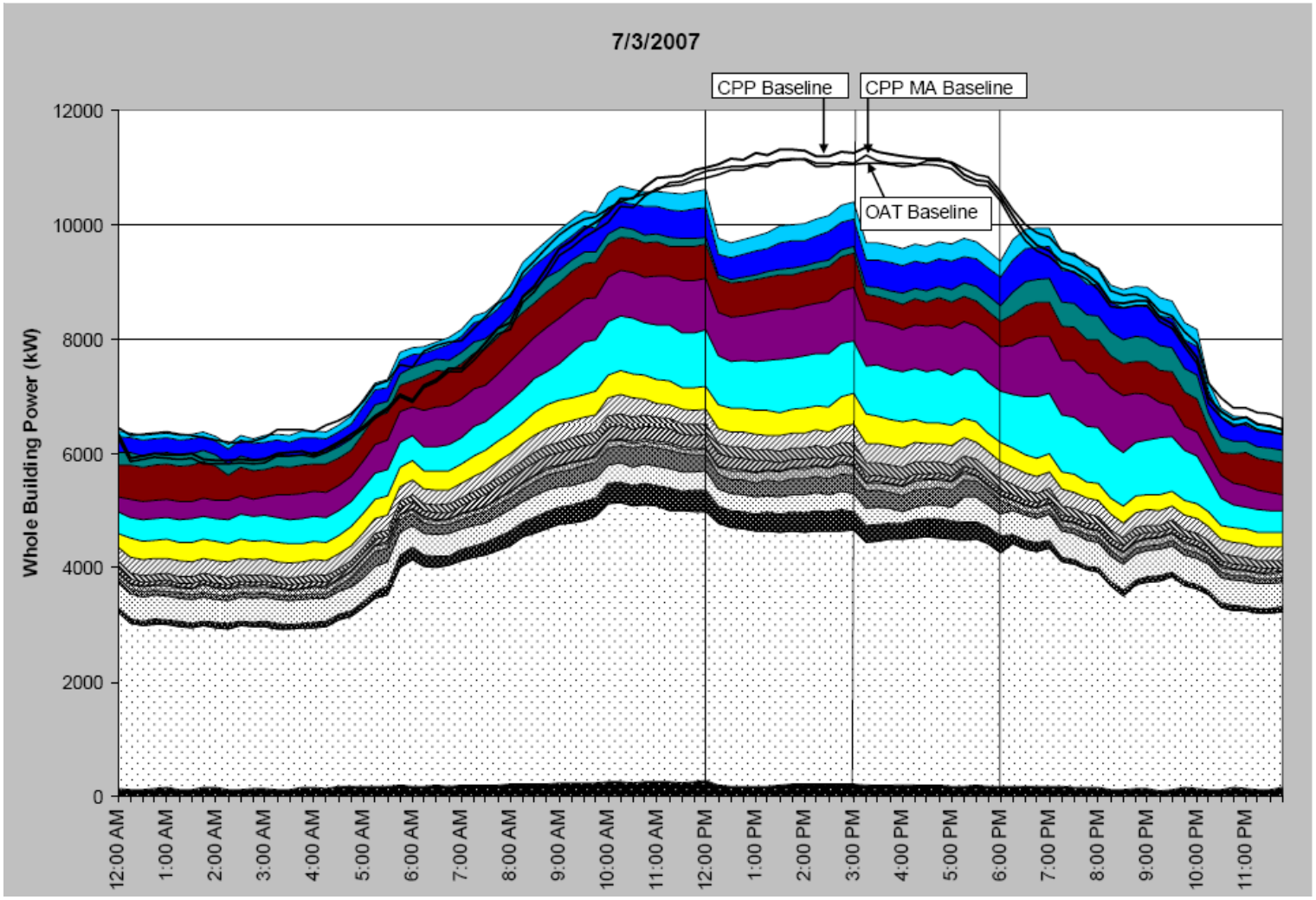


Should dynamic rates be offered to all customers?



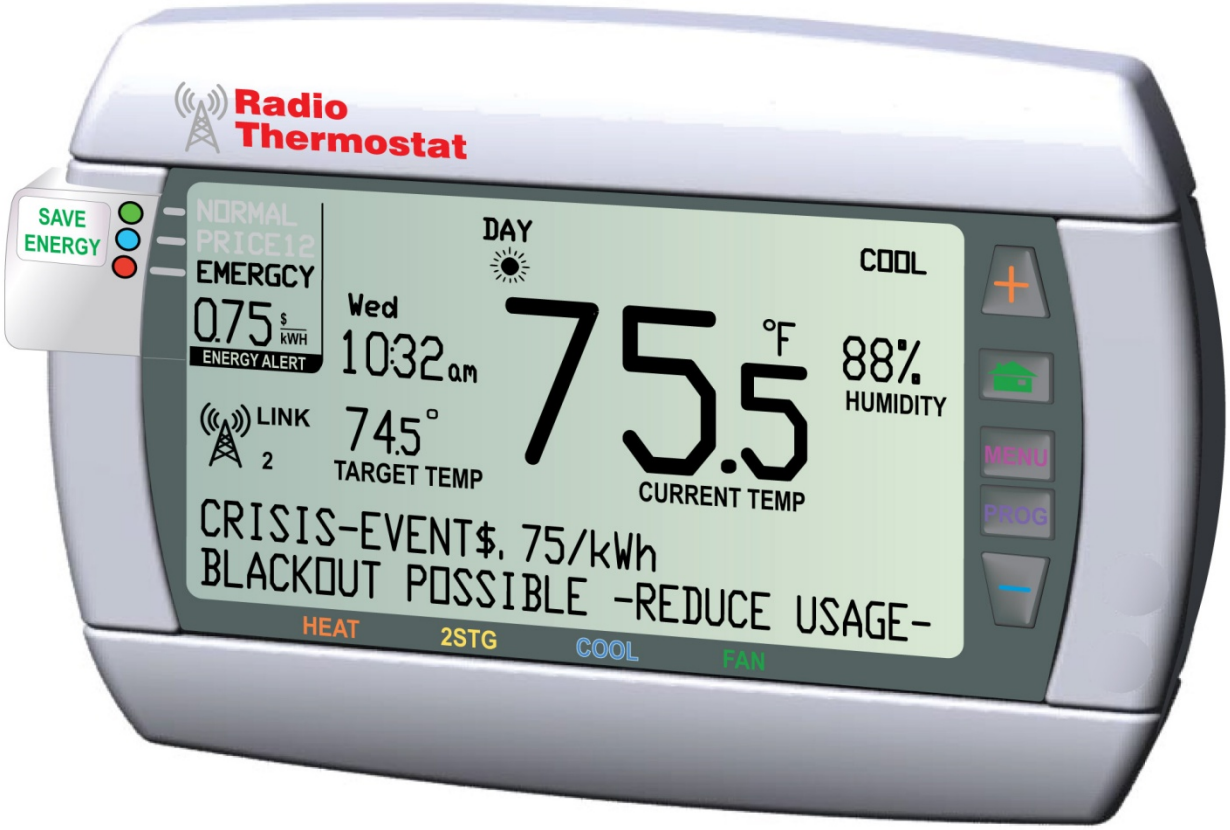
Automated Demand Response

Commercial Customers



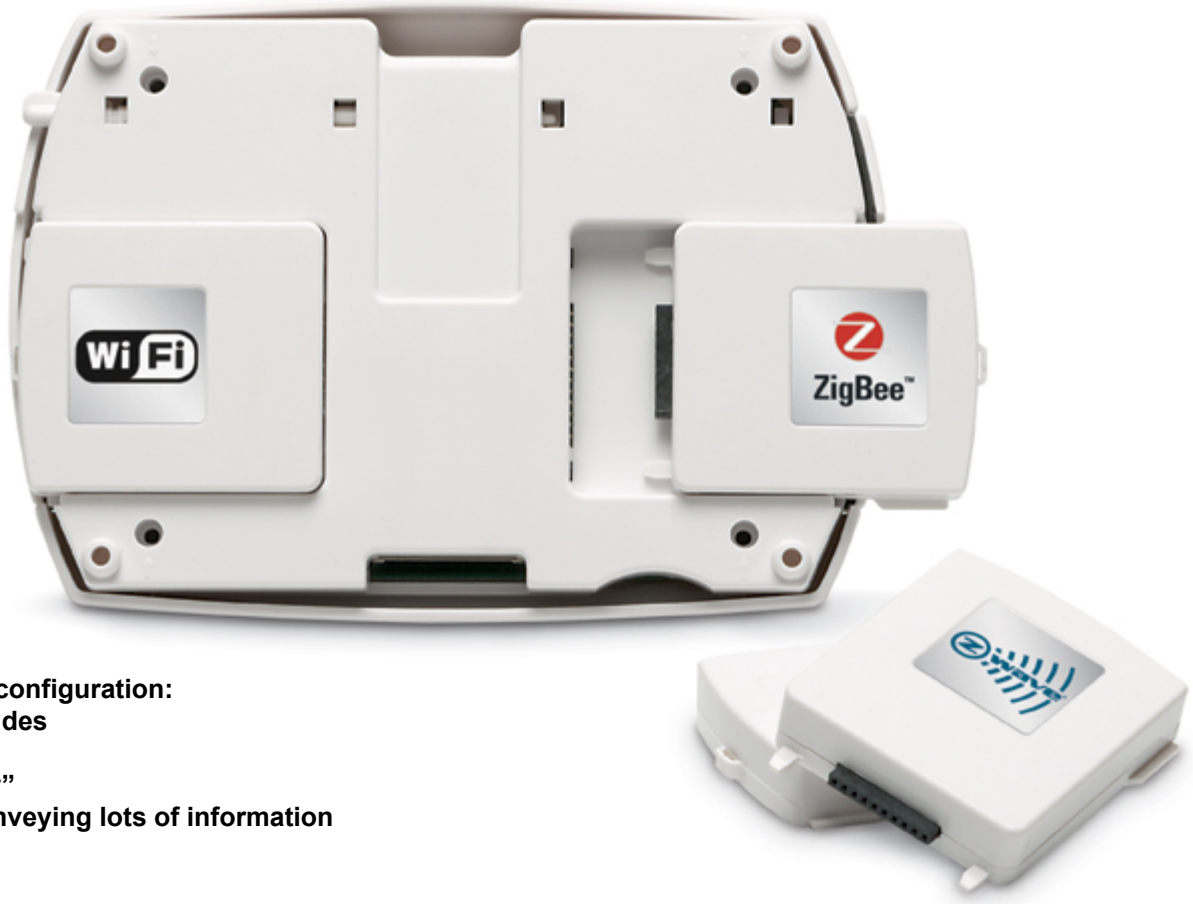
*Source: Demand Response Research Center, Global Energy Partners

Smart thermostat with universal communications interface at rear



Source: Tim Simons, Golden Power

Smart thermostat with U-SNAP Interface



Advantages of this configuration:

1. **Customer decides**
2. **Flexible**
3. **“plug and play”**
4. **Capable of conveying lots of information**

Source: Tim Simons, Golden Power