Inclusion of Solar Reflectance and Thermal Emittance Prescriptive Requirements for Steep-Sloped Roofs in Nonresidential Title 24

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Cooling roofs by increasing solar reflectance

- A conventional dark roof absorbs most sunlight
- Increasing **solar reflectance**
  - reduces solar heat gain
  - lowers roof temperature
- High **thermal emittance**
  - facilitates radiative cooling
  - helps keep roof temperature low
- Lowering roof temperature can reduce
  - building cooling electricity use
  - peak power demand
  - ambient air temperature

Environmental impacts of cooling roofs

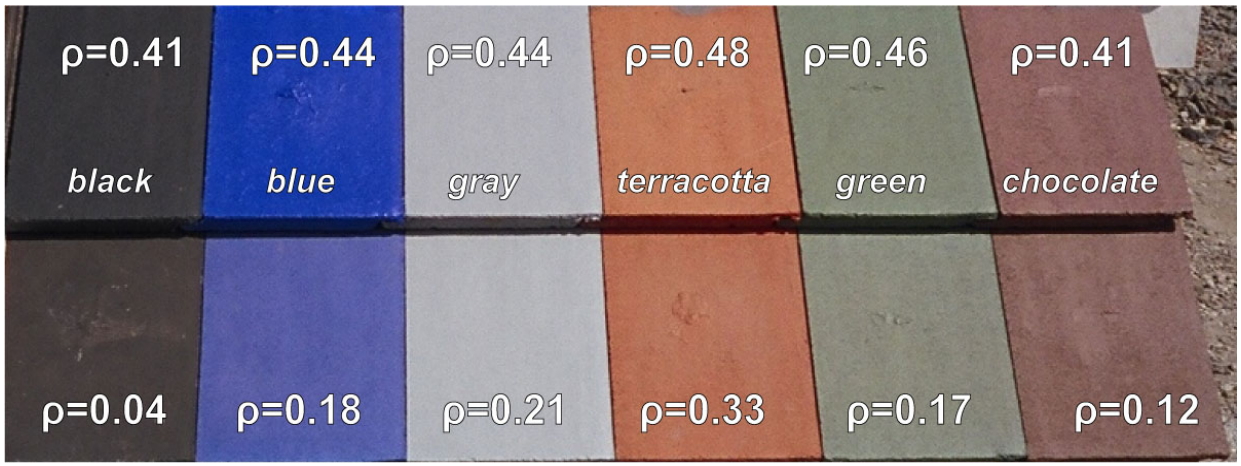
- Benefits
  - increased human comfort
  - slowed smog formation
  - mitigation of urban heat islands in summer
  - decreased waste from disposal of roofs
- Penalties
  - slightly higher wintertime heating energy use
  - degraded wintertime urban air quality

“Cool” products for steep-sloped roofs

- Limited but growing material availability
  - clay tile
  - concrete tile coating
  - metal
  - fiberglass asphalt shingles
- Products are rated by the Cool Roof Rating Council (CRRC)
  - labels solar reflectance, thermal emittance
  - website: www.coolroofs.org

Increasing solar reflectance of concrete tiles: American Rooftile Coatings

Courtesy American Rooftile Coatings



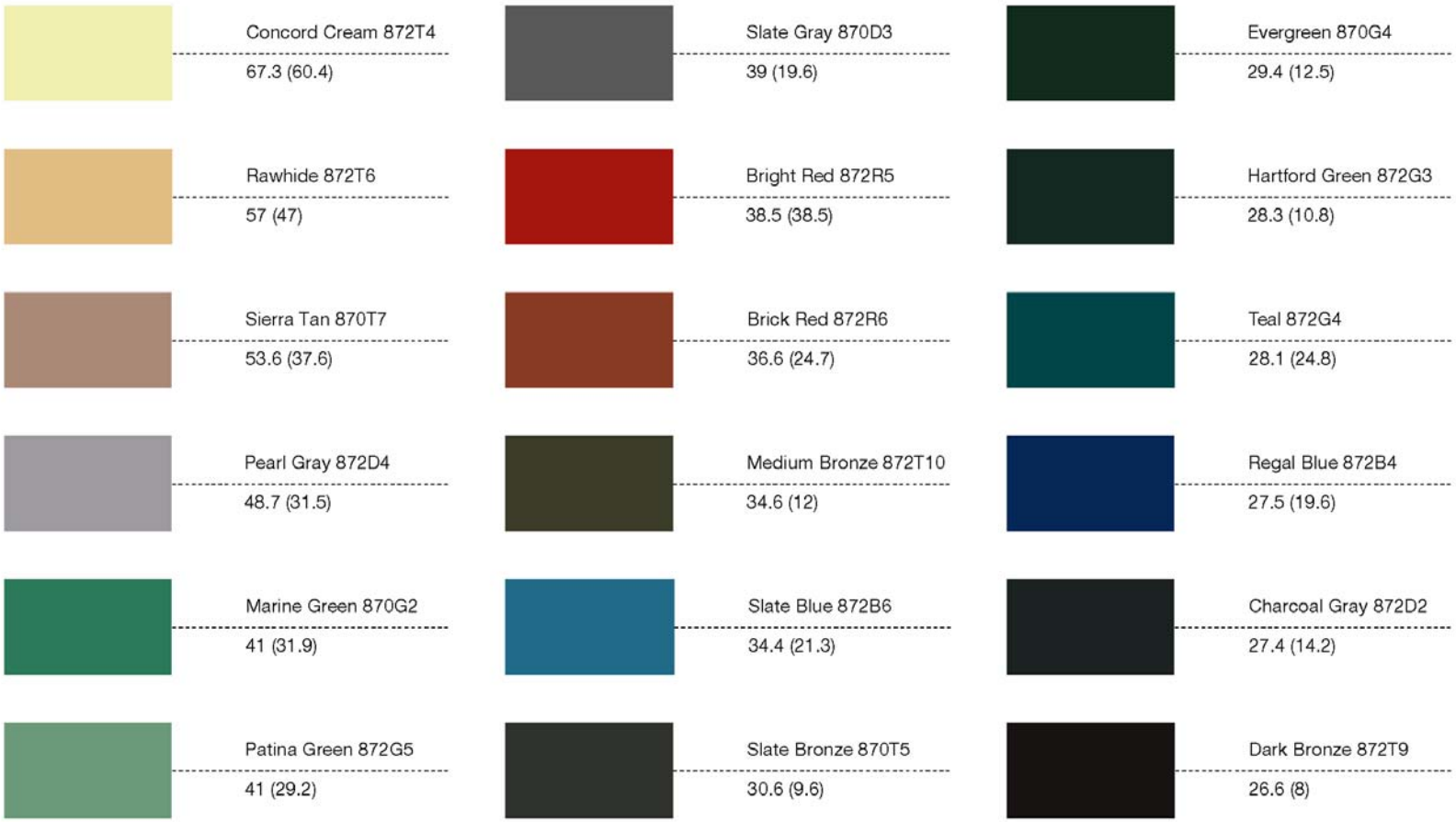
cooler

warmer

Δρ=0.37 **Δρ=0.26** **Δρ=0.23** **Δρ=0.15** **Δρ=0.29** **Δρ=0.29**

- Can increase solar reflectance **ρ** by up to 0.50
- Gain greatest for dark colors

Increasing solar reflectance of metal roofing: BASF Ultra-Cool® metal roof coatings



Courtesy BASF Industrial Coatings

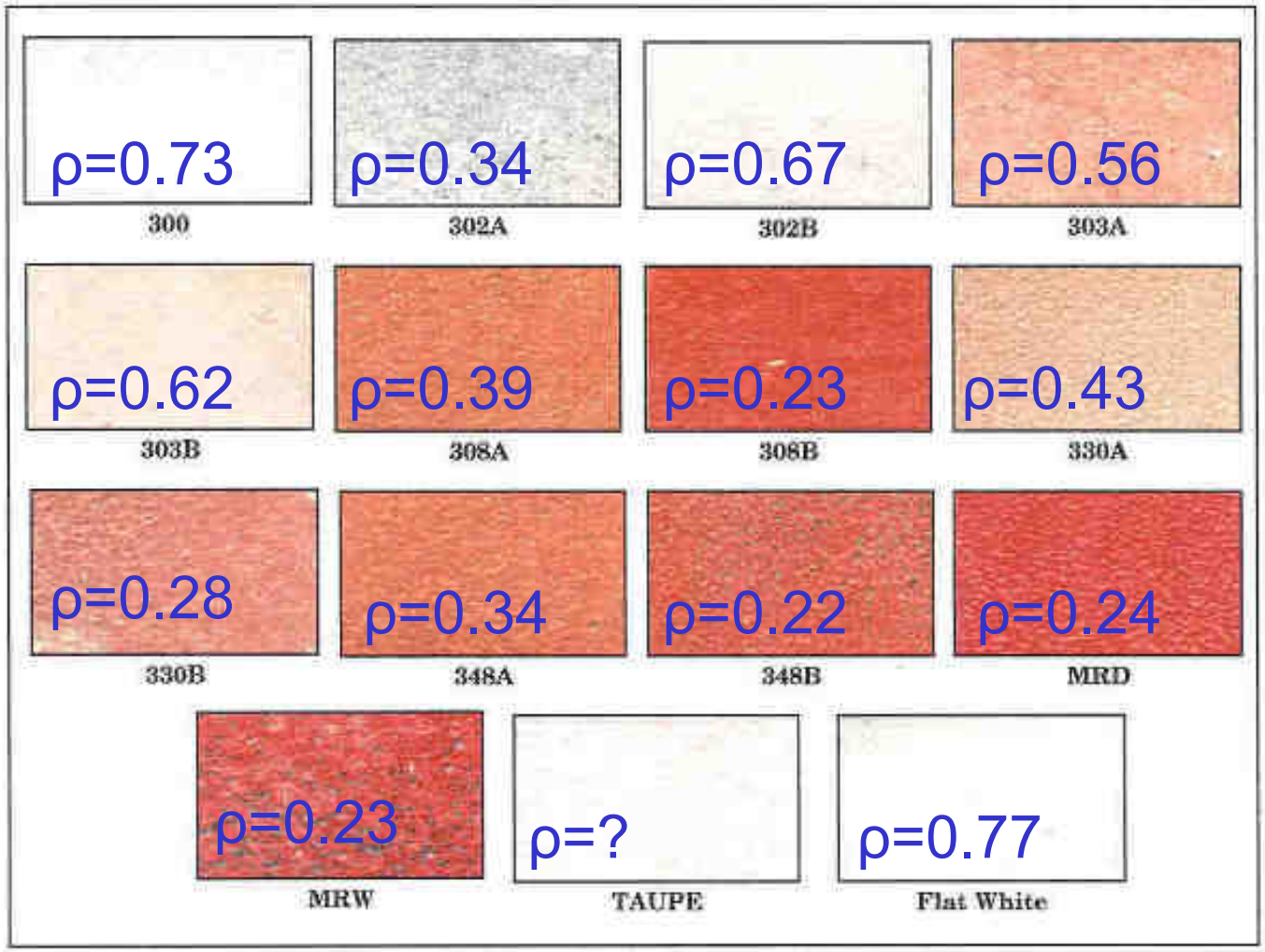
numbers denote solar reflectances: cooler (warmer)

Increasing solar reflectance of clay tiles: MCA Clay Tile cool colored tiles

Model	Color	Initial solar reflectance	Solar reflectance after 3 years
Weathered Green Blend		0.43	0.49
Natural Red		0.43	0.38
Brick Red		0.42	0.40
White Buff		0.68	0.56
Tobacco		0.43	0.41

MonierLifetile concrete tiles

(Source: http://www.fsec.ucf.edu/bldg/pubs/cr670/index.htm#Figure%204)



Increasing solar reflectance of fiberglass asphalt shingles: Elk Prestique® Cool Color Series

3M “cool” granules for fiberglass asphalt shingles

Courtesy 3M

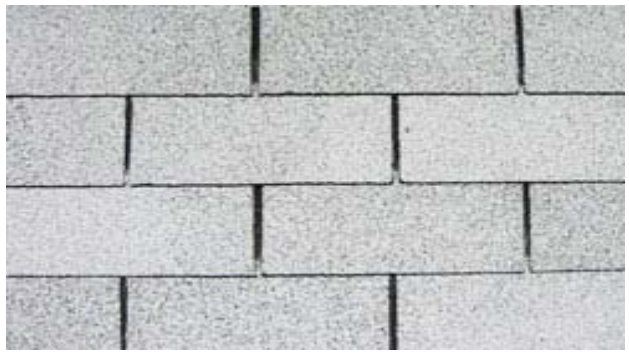
ρ=0.32 ρ=0.25 ρ=0.27 ρ=0.27

ρ = solar reflectance

Increasing solar reflectance of fiberglass asphalt shingles: prototypes

cooler: ρ=0.28

ρ=0.36



ρ=0.37

warmer: ρ=0.23

ρ=0.27

ρ=0.28

ρ = solar reflectance

“Cool” roof requirements in T24: a timeline

Roof → / Building	Low-Slope	Steep-Slope
Residential	2008	2008
Non-Residential	2005	2008

Scope of current study

- Introduce requirements for **steep-sloped roofs** on nonresidential buildings
  - Study proposes minimum aged values of solar reflectance, thermal emittance
  - Based on new building energy analyses
- Update 2005 requirements for **low-sloped roofs** on nonresidential buildings
  - Current code specifies only initial values of solar reflectance, thermal emittance
  - Study proposes minimum aged values of these properties
  - Based on building energy analysis from previous T24 study

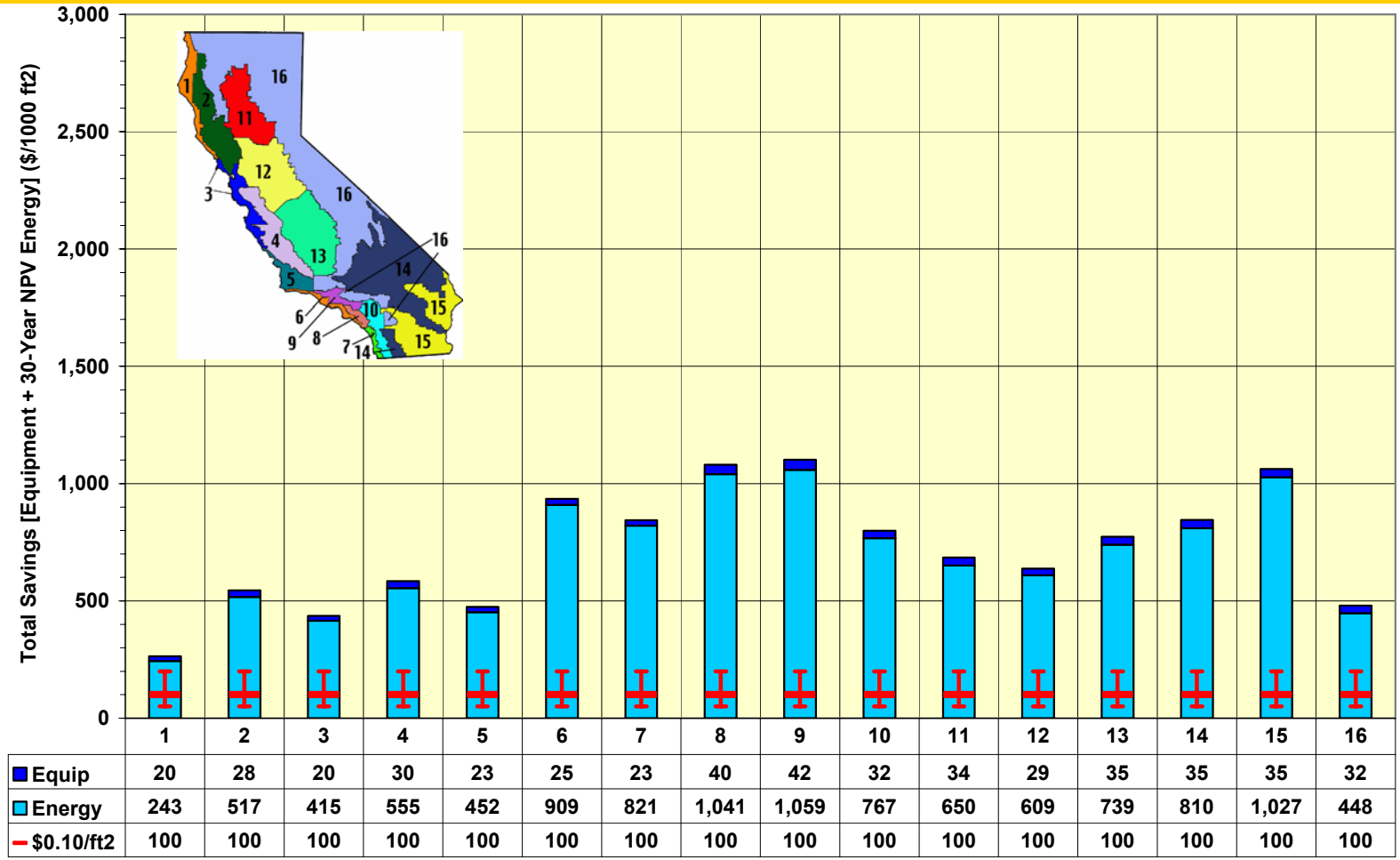
Methodology

- Review measure availability and cost
  - technologies, market share
  - manufacturers, distribution
  - availability, cost premium
  - useful life
- Perform building cost/benefit analysis
  - evaluate measured energy savings
  - simulate cooling and heating energy uses
  - net savings ($) = cooling savings ($) - heating penalty ($)
- Project state-wide savings

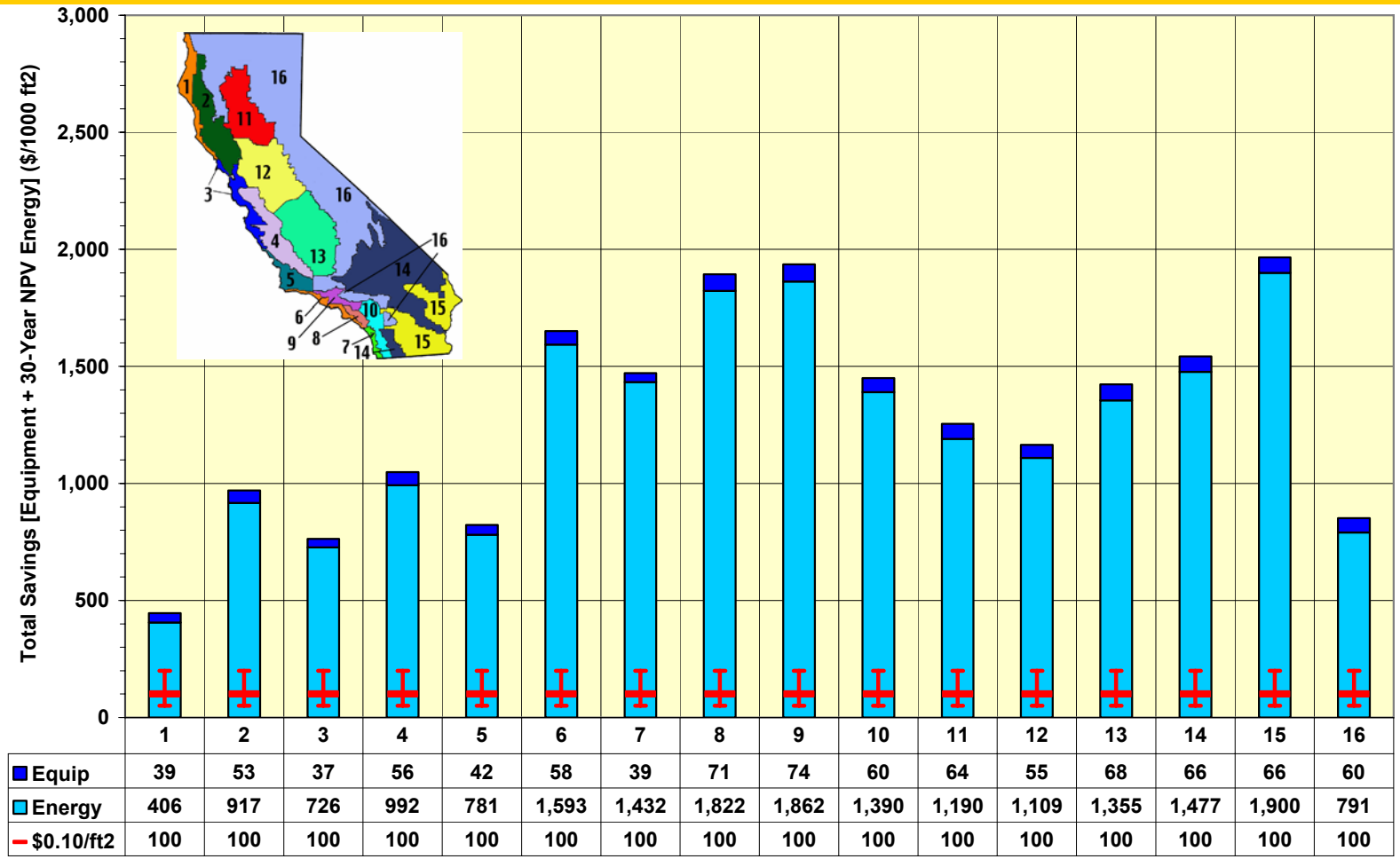
Cost effectiveness of increasing solar reflectance

- Simulated increasing three-year-aged solar reflectance ρ_{aged} of steep-sloped roofing products
  - fiberglass asphalt shingle (increased ρ_{aged} to 0.25 from 0.10)
  - concrete tile (increased ρ_{aged} to 0.40 from 0.10)
  - metal (increased ρ_{aged} to 0.40 from 0.10)
- Cost premium for higher-reflectance roofing
  - about $0.20 per square foot of roof area
- All simulated increases were cost effective
  - 30-year net present value of TDV energy savings ≥ $0.20/ft^2 in all California climate zones

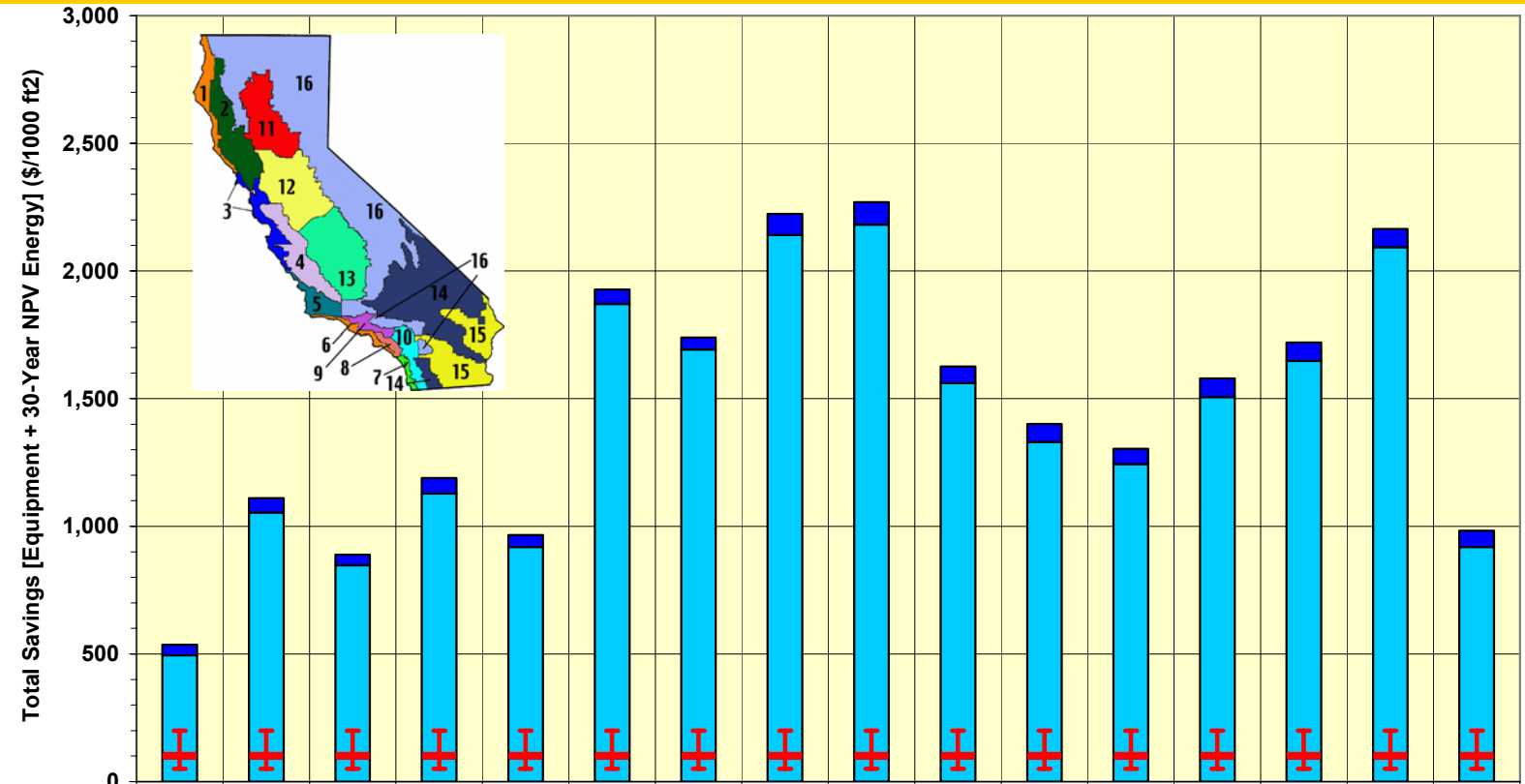
30-year net present value of savings ($/1000 ft^2): **shingle roofs**



30-year net present value of savings ($/1000 ft^2): **concrete tile roofs**



30-year net present value of savings ($/1000 ft^2): **metal roofs**



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Equip	41	57	41	61	47	57	48	83	88	65	71	60	73	72	71	65
Energy	495	1,053	847	1,128	919	1,870	1,692	2,141	2,181	1,561	1,330	1,243	1,507	1,648	2,093	918
$0.10/ft2	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

California Climate Zone

Projected annual statewide savings: **new construction**

- Increase in NR roof area.....78 Mft^2
- Increase in AC steep-sloped NR roof area.....14 Mft^2
- Electricity TDV savings.....15 GWh
- Natural gas TDV deficit.....4.2 GBTU
- Net source energy TDV savings..... 46 GBTU
- Peak power demand savings.....1.4 MW
- Equipment savings……$0.4M
- TDV NPV savings.....$10M

Projected annual statewide savings: **new construction + reroofing**

- Applicable AC steep-sloped NR roof area.....70 Mft^2
- Electricity TDV savings.....69 GWh
- Natural gas TDV deficit.....20 GBTU
- Net source energy TDV savings..... 210 GBTU
- Peak power demand savings.....6.3 MW
- Equipment savings……..$1.9M
- TDV NPV savings.....$48M

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Proposed requirements for three-year-aged values of solar reflectance (ρ_{aged}), thermal emittance (ε_{aged})

- Fiberglass asphalt shingle with $\varepsilon_{aged} \geq 0.75$:

  $\rho_{aged} \geq 0.25$

- All other products with $\varepsilon_{aged} \geq 0.75$:

  $\rho_{aged} \geq 0.40$

- All products with $\varepsilon_{aged} < 0.75$:

  $\rho_{aged} \geq 0.40 + 0.31 * (0.75 - \varepsilon_{aged})$

Determining three-year-aged values of solar reflectance, thermal emittance

- Use CRRC aged values ρ_{aged} , ε_{aged} if labeled
- If CRRC labels only initial values $\rho_{initial}$, $\varepsilon_{initial}$, we estimate ρ_{aged} and ε_{aged} :
  - $\rho_{aged} = 0.20 + 0.70 \times (\rho_{initial} - 0.20)$
  - $\varepsilon_{aged} = \varepsilon_{initial}$
- If the product does not have a CRRC label, default values are
  - $\rho_{aged} = 0.10$
  - $\varepsilon_{aged} = 0.75$

Sections of T24 standards to be modified

- Section 101 - Definitions And Rules Of Construction
- Section 118(f) - Mandatory Requirements for Insulation and Cool Roofs
- Section 143 - Prescriptive Requirement for Building Envelopes
  - Section 143(a) - Envelope Component Approach
  - Section 143(b) - Overall Envelope Approach
- Section 149 –Addition, Alteration, and Repairs to Existing Buildings
- Alternative Calculation Manual (ACM)

Proposed requirements for 3-year-aged values of Solar Reflectance Index (SRI)

- **Prescriptive requirements can be simpler**
- Fiberglass asphalt shingle: SRI ≥ 23
- All other products: SRI ≥ 43