# Adjusting for New Abnormals: Adapting Buildings to Extreme Heat and Power Outages *

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**Dec. 14, 2018**


'Unprecedented' early heat wave sets new records. Fire danger is high. July 6, 2018.

Over 12,000 still without power in L.A. after 3 days of record heat and record power demand. July 9, 2018.

* *This information is for research and education purposes only; its commercial use is prohibited.*

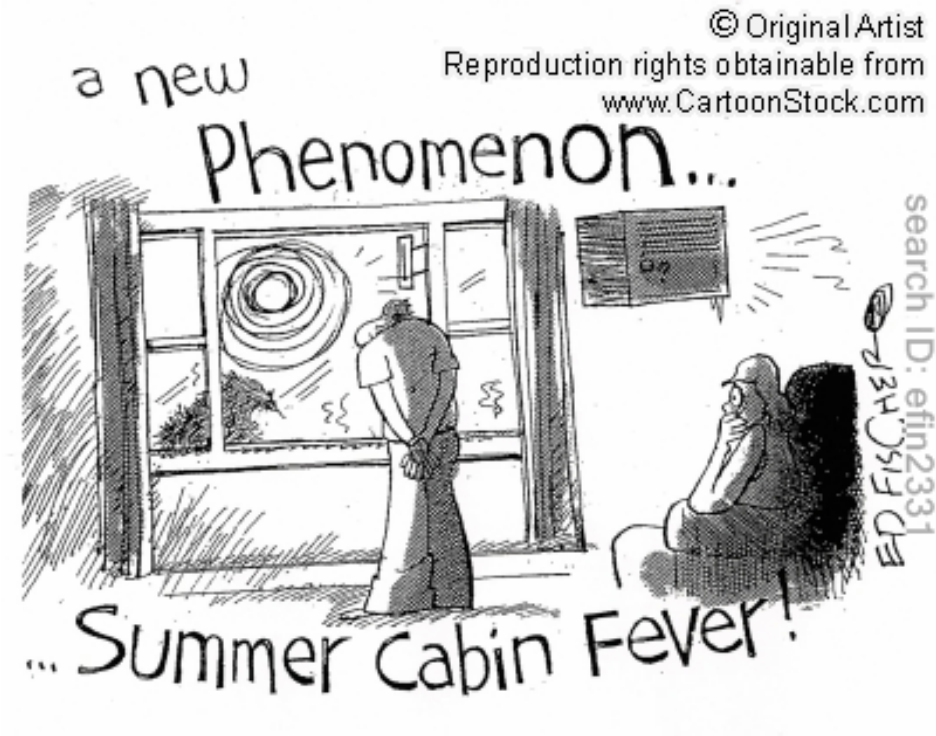
Image: adapted from Mike Luckovich, 2012.
http://www.gocomics.com/mikeluckovich/2012/07/06/.

# Climate Change and IEQ

**SoCal heat wave leaves thousands without power**
**27,000+ at SCE, 15,000 at LADWP, June 2010**

**Los Angeles Heat Wave Bakes At Record 113 Degrees**
**Power out for 30,000+ at SCE, 5400 at LADWP, September 2010**

***Climate change: High risk of permafrost thaw***
**Nature, November 2011**




# What Do I Tell My Children and Grandchildren When They Ask Me:

## *What Did You Do About Climate Change ?*

A. Told them to play inside

B. Said it was too expensive

C. Thought it was not urgent

D. Partied like it was 2099

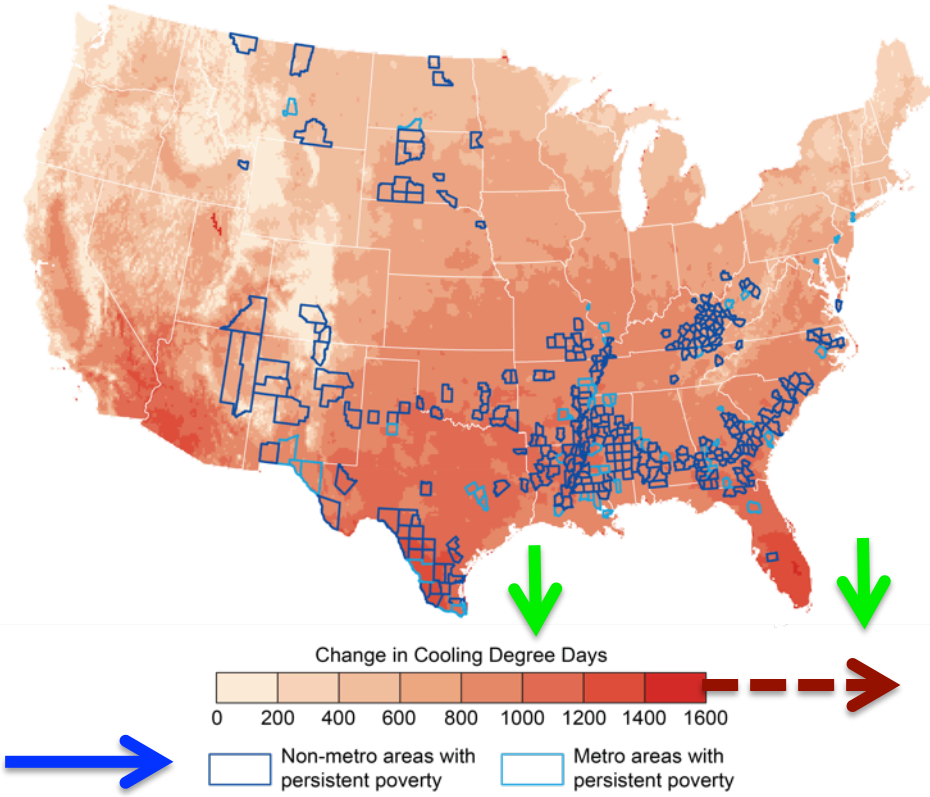
E. Acted to help future generations


Image Source: Daly V, 2012. Active indoor activities for kids during a heat wave. http://cutemonster.com/2012/06/active-indoor-activities-for-kids-during-heat-wave/.

# Climate Change Impacts: Cooling Demand

- **Increased cooling demand (Cooling Degree Days/year) [1]**
  - **Mid-century: + > 1,000 CDD in many regions**
  - **Late century: + > 2,000 CDD in many areas [2]**
  - **Energy poverty and/or AC lacking in many areas (blue boxes)**
- **Major impacts on energy costs, grid demand, grid outages, and health**

***CDD Increase by Mid-Century, RCP 8.5 [1]***



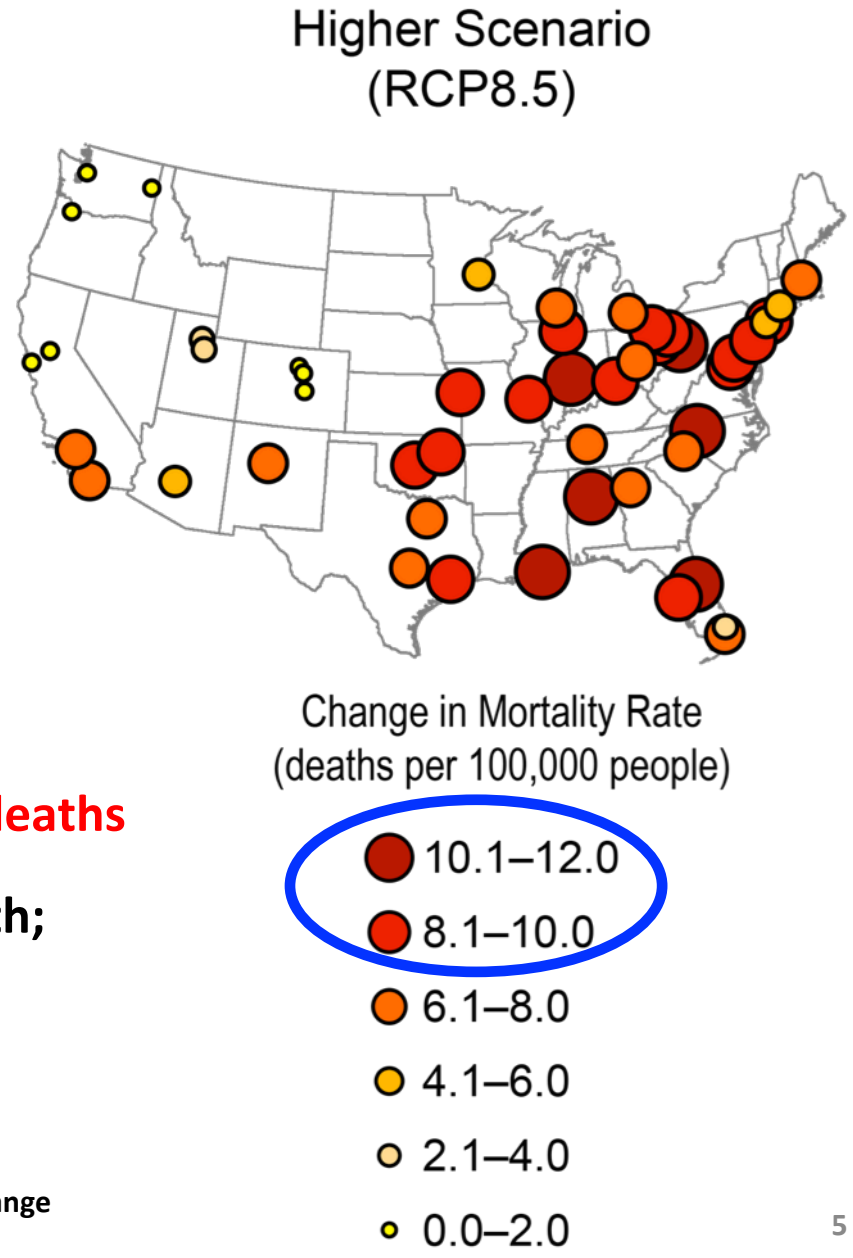


1. USGCRP, 2018. Fourth National Climate Assessment, Vol. 2. Fig. 14 and 19. https://nca2018.globalchange.gov/chapter/front-matter-about/.
2. Petri & Caldeira, 2015. https://www.nature.com/articles/srep12427.

# Climate Change Impacts: Mortality

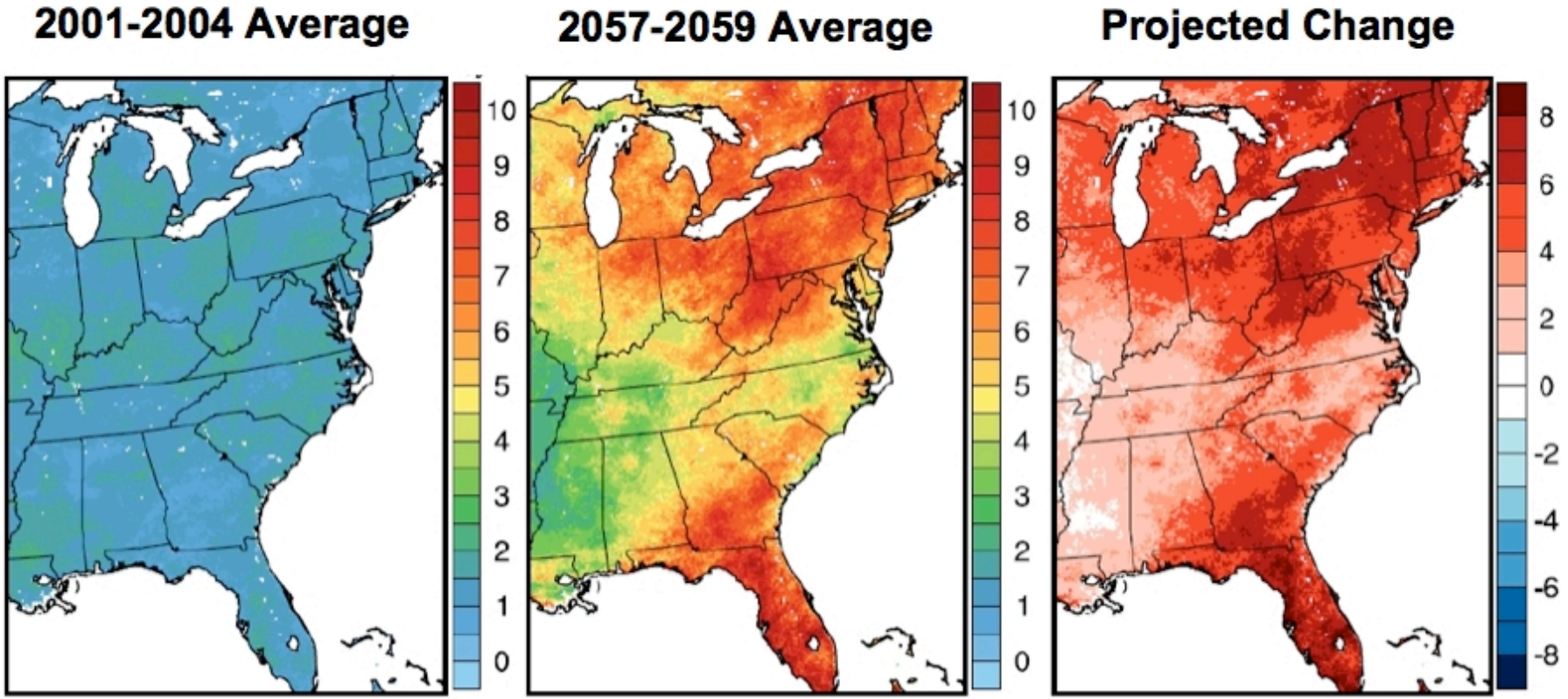
- **Increased U.S. mortality from extreme heat & cold [1]**
  - Late century: up to 9,300 deaths/year across 49 cities (1/3 of US population)
  - Very high risk in many cities: ≥ 10 per 100,000 risk ($10^{-4}$ risk)
  - $140 billion/year (in 2015 dollars)
  - RCP 8.5, no adaptation

- **California heat-related mortality [2]**
  - 650 deaths in 2006 heat wave
  - Late century, seniors: 4,700 – 8,800 deaths per year (9 urban metro areas; medium growth; 5 models; no adaptation)





1. USGCRP, Nov. 2018. Fourth National Climate Assessment, Vol. 2. Figs. 14.4 and 19.22 . https://nca2018.globalchange.gov/chapter/front-matter-about/.
2. Sheridan et al., 2011. A spatial synoptic classification approach to projected heat vulnerability in California under future climate change scenarios. CARB Seminar, Final Report, and journal articles.




## Heat Waves per Year

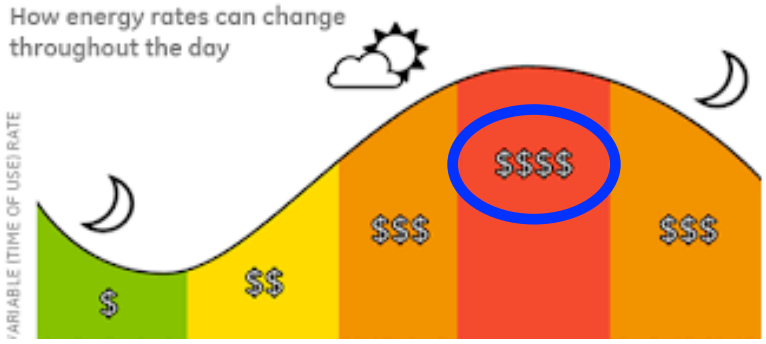
**By mid-century, there are expected to be more heat wave days in the Northeast and eastern Midwest than in the Southeast, according to new modeling.**

Source: University of Tennessee, 2012.
https://www.sciencedaily.com/releases/2012/12/121217121732.htm.
Gao et al., 2012. DOI: 10.1088/1748-9326/7/4/044025.

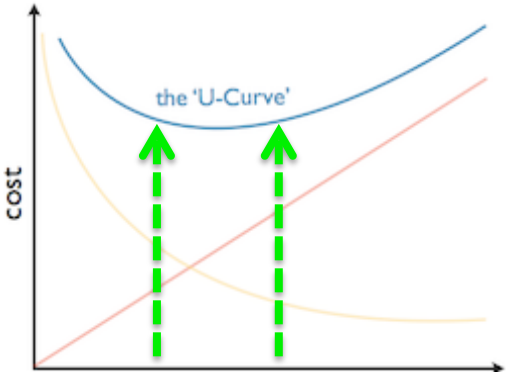
# Methods (2)

- **Overheating** Metrics
  - Discomfort Index (DI)
  - Wet Bulb Global Temperature (WBGT)

- **Time Dependent Value** Energy (TDV) and Total Energy Use
  - CBECC-Residential model for CA building standards




- **Building Optimization**
  - Optimize for TDV, cooling energy, and carbon emissions
  - BeOpt model (NREL, free tool)




TDV image: Time of Use utility rates. GE, in CPUC, Residential Rate Reform Through 2019.
U Curve image: Donald Peterson at Fabok, 2013. https://zsoltfabok.com/blog/2013/03/the-optimal-batch-size/.

# Overheating: Metrics

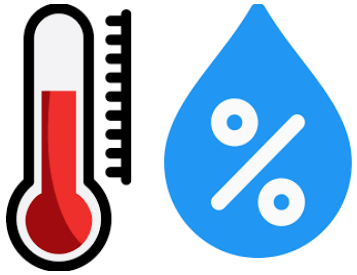
- **Discomfort Index (DI)**

  *DI = (0.5 * T dry bulb) + (0.5 * T wet bulb)* [1]

  **Targets:** ≥ 22 °C (71.6 °F) Mild [2]

  ≥ 24 °C (75.2 °F) Moderate [2]

  ≥ 28 °C (82.4 °F) Severe [2]



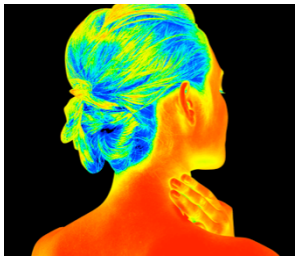
- **Wet-Bulb Globe Temperature (WBGT)**

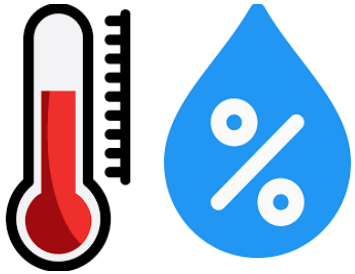
  *WBGT = (0.2 * T black globe) + (0.1 T dry bulb)+ (0.7 * T wet bulb)* [3]

  **Targets:** ≥ 26 °C (78.8 °F)

  ≥ 28 °C (82.4 °F) [3]

  ≥ 31 °C (87.8 °F) [3]

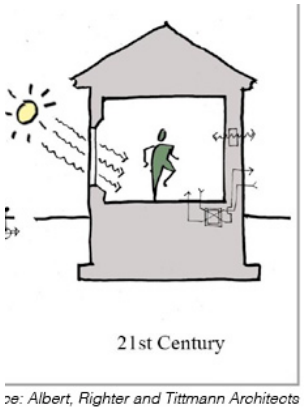




*Black Globe T = Radiant T*


1. Baniassadi and Sailor (2018).
2. Epstein and Moran (2006).
3. Holmes, Phillips, and Wilson (2016).
4. Radiant Temperature image: Science News for Students, Aug. 6, 2018.

# Overheating Standards and Guidelines: *International*

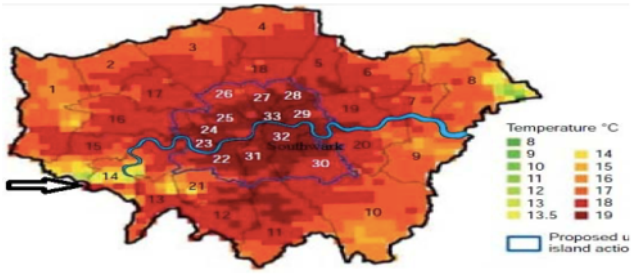


*ɔe: Albert, Righter and Tittmann Architects*

- **Passive House Program:**
  **≤ 10% (h/y) > 25 C, and moisture limit** [1]

- **CIBSE TM 59 Overheating Design Guide (UK):**
  **1-3 % (h/y) overheating limits by room type;**
  **future climate scenarios recommended.** [2,3]

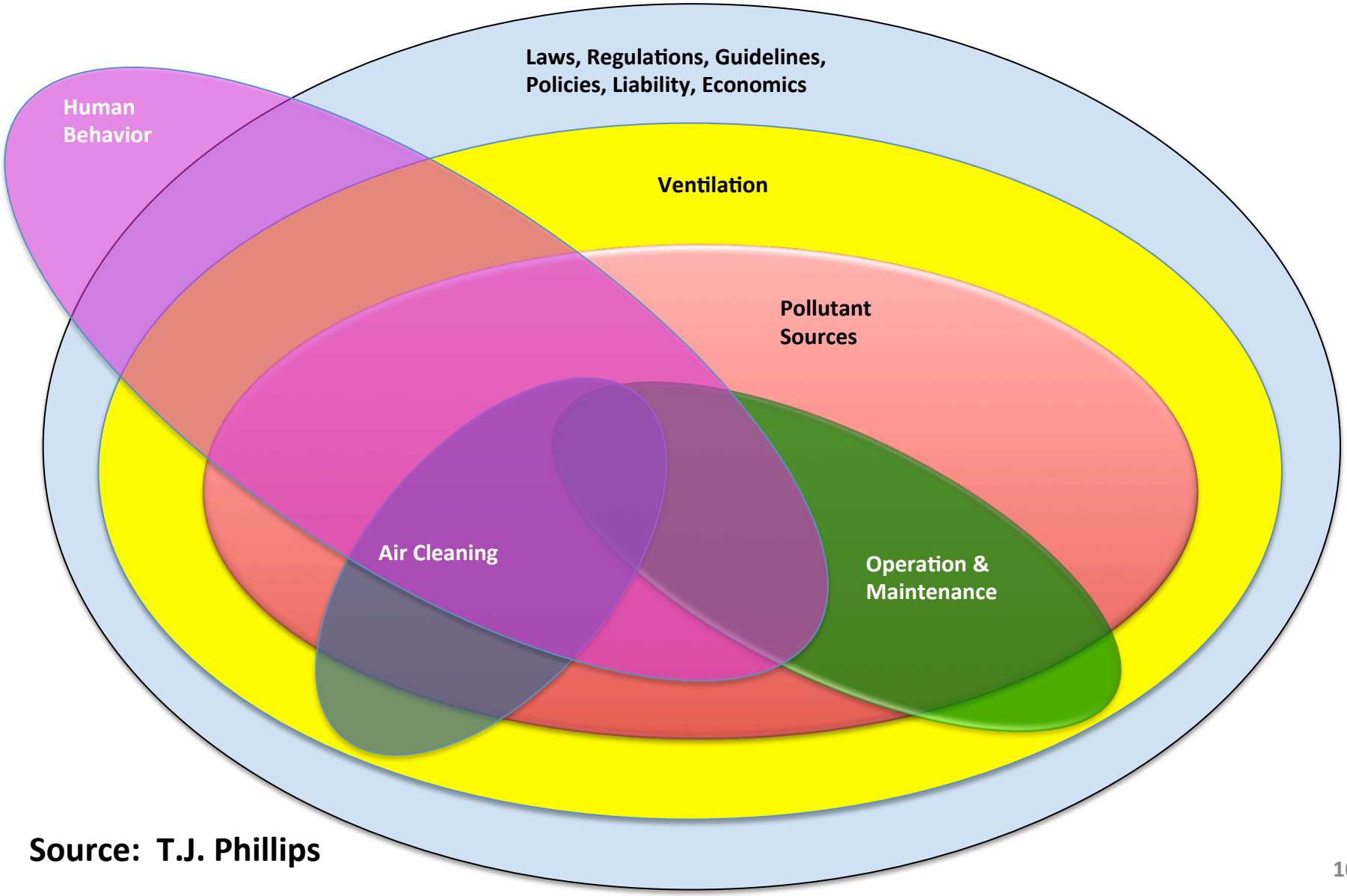

- **CIBSE TM 49 Urban Heat Island Design Guide (UK and London Plan):**
  **Overheating risk assessment for urban heat zones.** [4]




Average outdoor air temperature in London during August 2013

1. Passive House Institute, 2016. Criteria for the Passive House, EnerPHit and PHI Low Energy Building Standard.
2. CIBSE, 2017: TM 59, Design methodology for the assessment of overheating in homes.
3. Diamond, S., May 22, 2017. TM 59 webinar. Inking Associates.
4. CIBSE, 2014. TM49 Design Summer Years for London. See also: ARCC Network, 2017. Designing for Future Climate.

# Behavior Cuts Across All IEQ Determinants



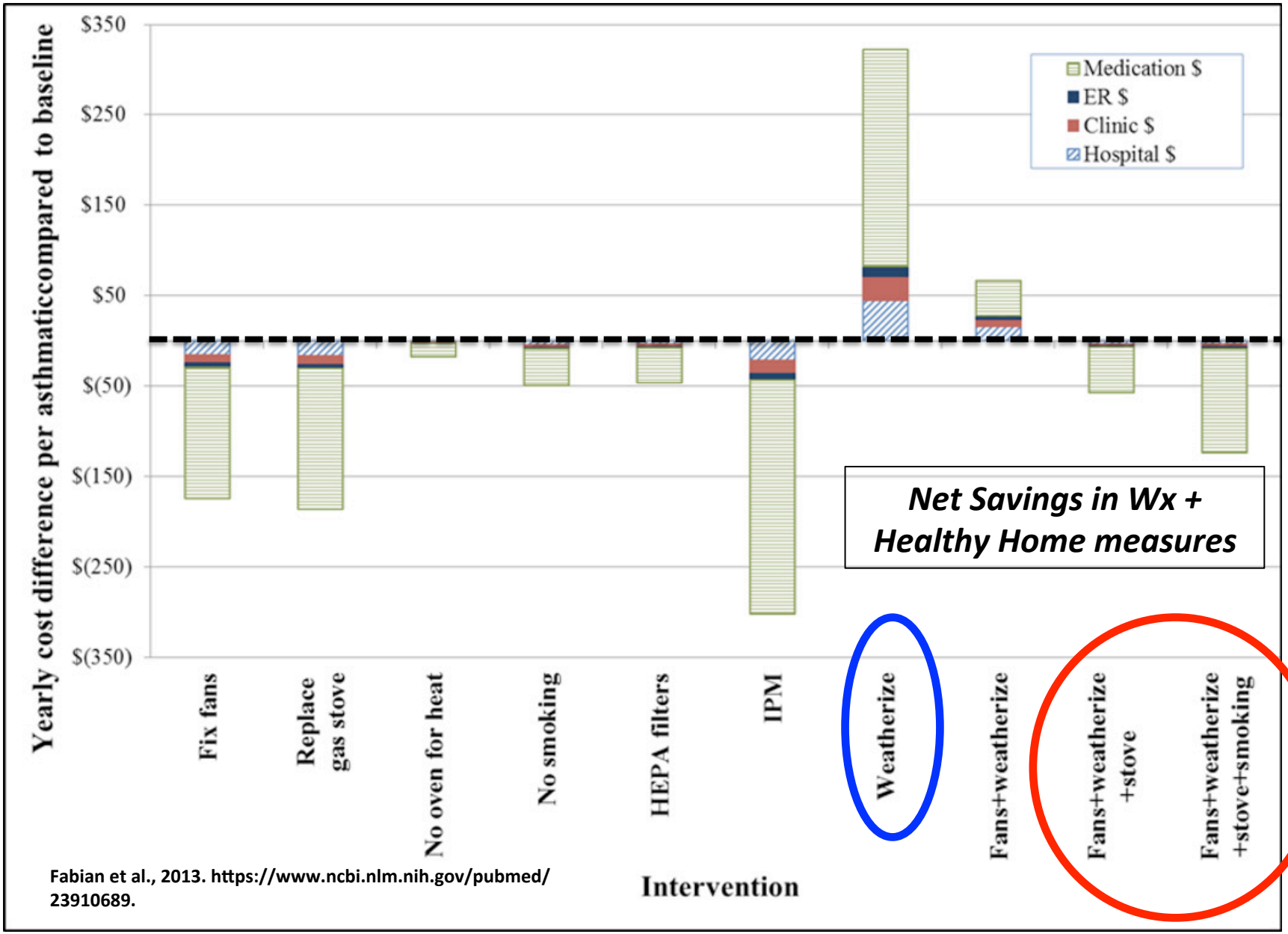

**Source: T.J. Phillips**

# QA Requires Worker Training

**Source: simpsons,wikia.com**

# Weatherization and Asthma Home Intervention Impacts:

## *Modeled Annual Cost Changes per Asthmatic in Low Income MFam Households*




Fabian et al., 2013. https://www.ncbi.nlm.nih.gov/pubmed/23910689.

# Overheating Standards and Guidelines:
## *North America: Input Needed **

- ✓ **Build It Green (2016): GreenPoint Rated 7.0 (CA Homes)** [1]
- ✓ **LEED/RELi (2018 update) Pilot Credit: Resilient Design 2.0** [2]
- ✸ **Collaborative for High Performance Schools Criteria (U.S.)** [3]
- ✸ **California Title 24 Building Energy Efficiency Standards, and BC's Energy Step Code** [4]
- ✸ **Cal-Adapt climate tools update (CA)** [5]
- ✸ **California PUC to address strategies and guidance for climate adaptation for electric and natural gas utilities** [6]
- ⌘ **Big Boom in research papers on overheating.**

***2018 Update:***
***Dec. 6 webinar;***
***Dec. 10 Comments !***

***2019: Weather files update***
***& future weather files !!***

***Dec. 5 webinar;***
***User input sought !***

***Schedule***
***TBD !***


1. Build It Green, 2017. Version 7.0 Update, Executive Summary.
2. Wilson, A., 2018. The LEED credits are back up.
3. CHPS 2018 draft update and webinar.
4. J. Huang, White Box Technologies. Personal communication, Nov. 21, 2018.
   ACT, Dec. 2018. BC's Energy Step Code. Low Carbon Resilience: Best Practices for Professionals – Final Report. Simon Fraser University.
5. Cal-Adapt. https://cal-adapt.org/blog/2018/webinar-december/.
6. Filings at the CPUC, May 2018. www.cpuc.ca.gov/.../CPUC_Website/.../Filings%20newsletter%202018-05.pdf

# More Information & Resources [1,2]

- ARCC – Adaptation and Resilience in the Context of Change Network, Overheating Projects (UK). http://www.arcc-network.org.uk/overheating/.
- CSIRO – Pathways to Climate Adapted and Healthy Low Income Homes (Australia). http://www.nccarf.edu.au/publications/climate-adapted-low-income-housing.
- AWESOME – Air pollution and WEather-related health impacts (UK). http://awesome.lshtm.ac.uk/objectives/.
- APACHE (UK) – Air PermeAbility: Cities Health Energy (UK companion project). http://www.ucl.ac.uk/sustainable-cities/smallgrants/small-grants-2013-14/mavrogianni.
- SIMMER – System for Integrated Modeling of Metropolitan Extreme Heat Risk (NOAA/ NCAR, US). http://www.ral.ucar.edu/projects/simmer/.
- California Energy Commission – Updated and future climate data (weather files) for building energy standards, in progress. Cal-Adapt (Interactive climate change data), https://cal-adapt.org/.
- Resilient Design Institute – News and Blogs. https://www.resilientdesign.org/.


1. Phillips, May 2013. Bigger, Longer Heat Storms Are Coming Soon: Will Your Building Keep Its Cool? http://www.resilientdesign.org/bigger-longer-heat-storms-are-coming-soon-will-your-building-keep-its-cool/.
2. Phillips, May 2014. Climate Change and Indoor Environmental Quality: *People Get Ready.* National Healthy Home Conference. Nashville, TN.