The CMU Intelligent Workplace CBPD Zoelly BCJ

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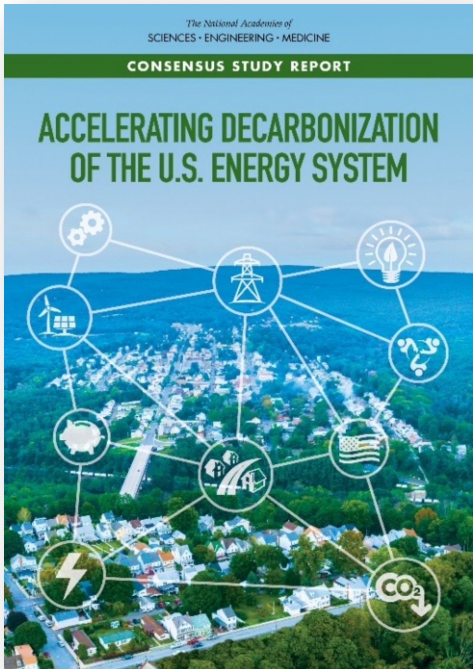


nap.edu/decarbonization

Accelerating Decarbonization NAS Committee

Federal actions over the next ten years to put the US on a **fair and equitable path to net-zero in 2050**.

Sectors considered include **CO_2, transportation, electricity, industry, buildings, and biofuels**.

Not whether the nation should move to net zero, but how to get there. Other GHGs, sinks created by forestry practices, and cropping practices that enhance soil carbon are not discussed in detail.

This report is broadly compatible with recent announcements from the Biden Administration. It was developed by an expert panel without prior consultation with the Administration.

Committee Roster

Stephen W. Pacala, Chair, Princeton University

Colin Cunliff, ITIF

Danielle Deane-Ryan, Libra Foundation

Kelly Sims Gallagher, Tufts University

Julia H. Haggerty, Montana State University

Chris T. Hendrickson, Carnegie Mellon University

Jesse Jenkins, Princeton University

Roxanne Johnson, BlueGreen Alliance

Timothy C. Lieuwen, Georgia Institute of Technology

Vivian E. Loftness, Carnegie Mellon University

Clark A. Miller, Arizona State University

Billy Pizer, Duke University

Varun Rai, University of Texas at Austin

Ed Rightor, Am. Council for an Energy-Efficient Economy

Esther S. Takeuchi, Stony Brook University

Susan F. Tierney, Analysis Group

Jennifer Wilcox, University of Pennsylvania

2030 Technology Goals

Electrify energy services in transportation, buildings, and industry

50% of vehicle sales EV by 2030,
deploying heat pumps in 25% of residences.

Improve energy efficiency and productivity

Total energy use for new buildings should be reduced by 50% by 2030, existing buildings reduced 3% per year from now.
Industrial energy productivity (dollars of economic output per energy consumed) should be increased from 1 to 3% per year.

Produce carbon-free electricity

Double the share of electricity generated by carbon-free sources from 37% to 75%.

Expand the innovation toolkit

Triple federal support for net-zero RD&D.

Plan, permit, and build critical infrastructure

Expand grid capacity and transmission lines by 40% to distribute renewables, establish EV charging network, CO_2 pipeline network.

2030 Socio-Economic Goals

Strengthen the U.S. economy

Use the energy transition to accelerate US innovation, reestablish US manufacturing, increase the nation's global economic competitiveness, and increase the availability of high-quality jobs.

Promote equity and inclusion

Ensure equitable distribution of benefits, risks and costs of the transition to net-zero.
Integrate historically marginalized groups into decision-making.
Ensure entities receiving public funds report on leadership diversity to ensure non-discrimination.

Support communities, businesses, and workers

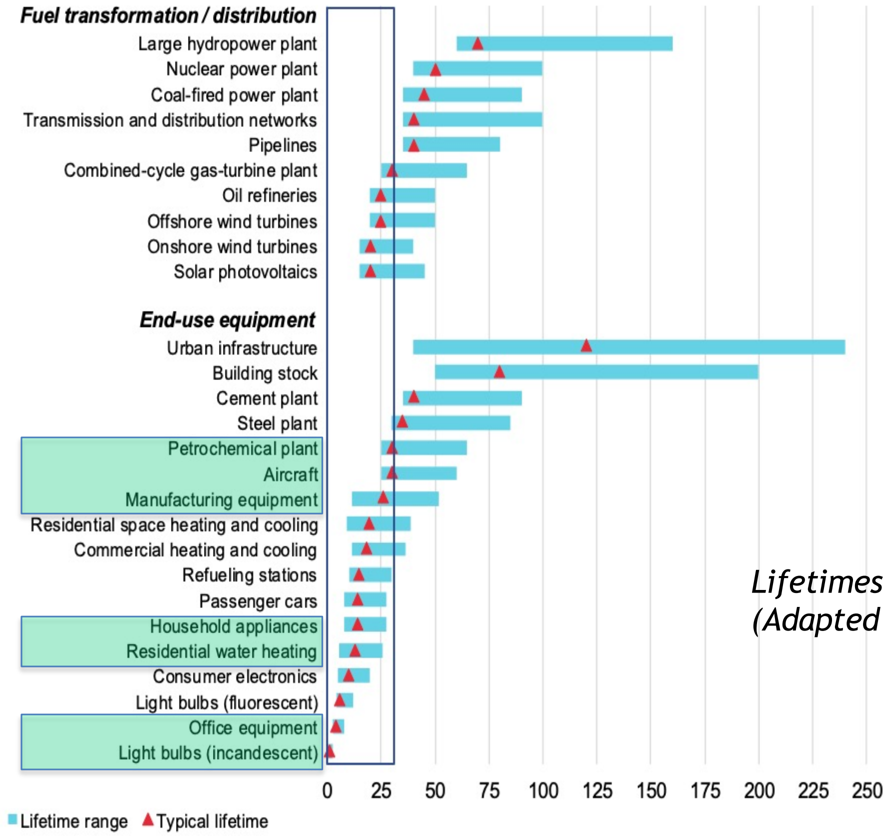
Proactively support those directly and adversely affected by the transition

Maximize cost-effectiveness

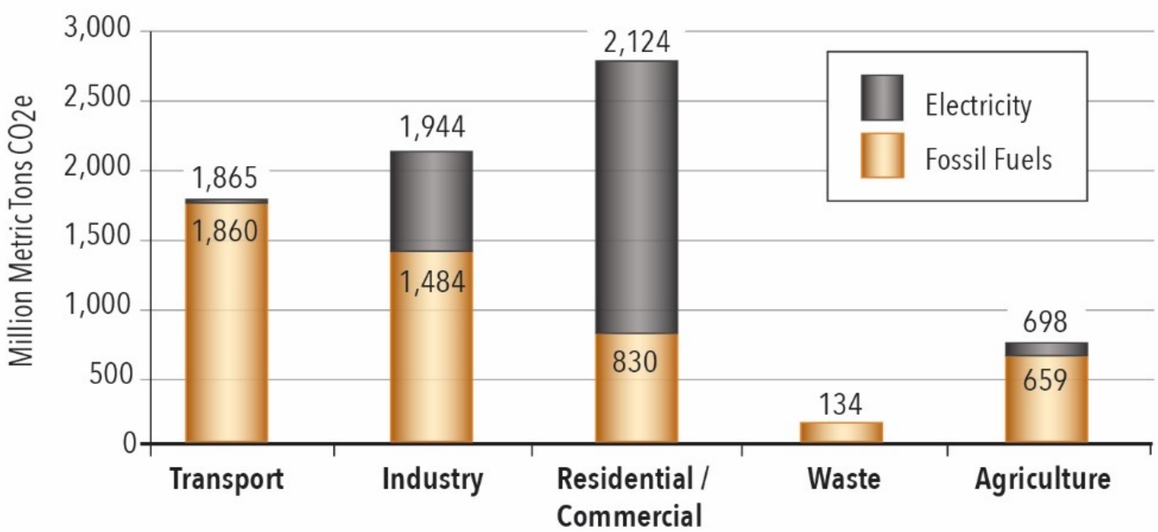
Deep decarbonization requires immediate action

Actions required during the first ten years are robust to the uncertainty about the final make-up of the energy system.

Long-lived assets must be replaced by net-zero alternatives when they reach the end of their life cycle.



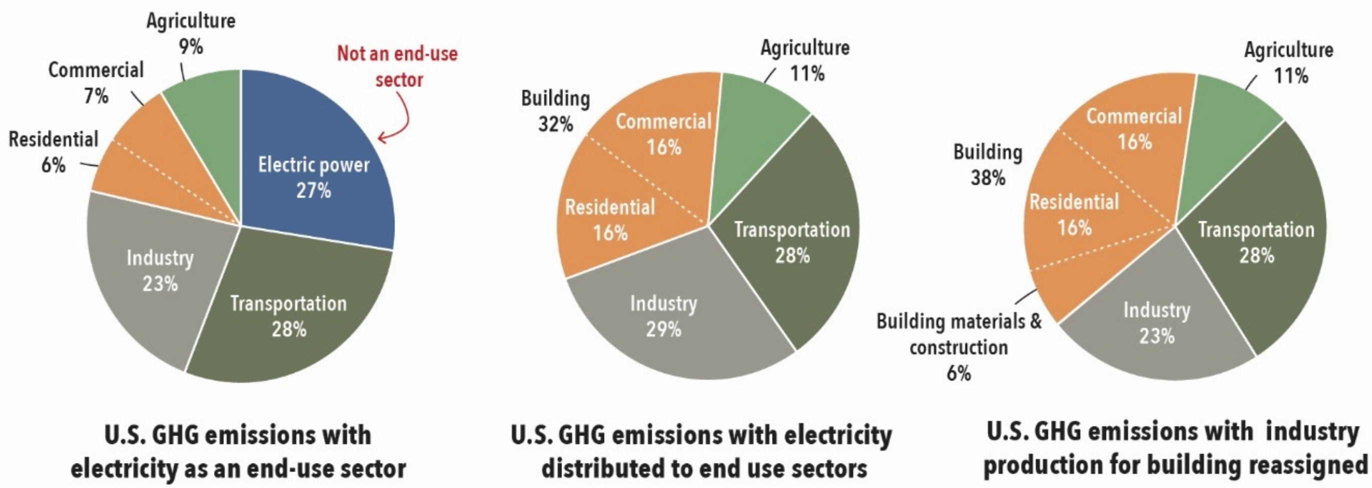
Lifetimes of Energy Assets (Adapted from IEA, 2020a)



U.S. 2018 GHG Emissions by Sector

Created 2020 by Carnegie Mellon Center for Building Performance and Diagnostics, based on US data: https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks March 23, 2020

Both Electricity and Fossil Fuels Contribute to Greenhouse Gas Emissions.

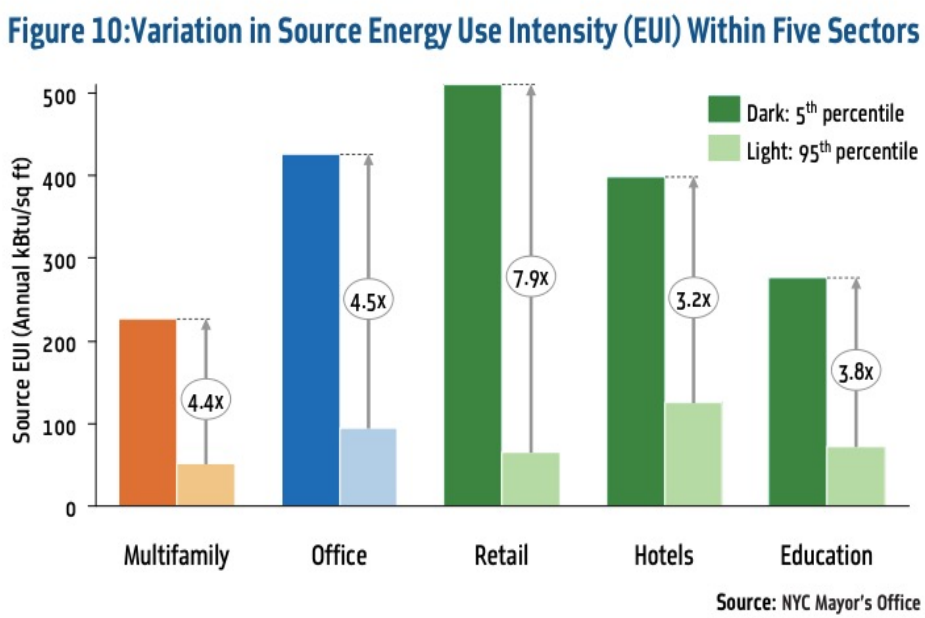


Fully Assigning GHG Emissions to End Use Sectors for Decarbonization Policy & Action

Created 2020 by Carnegie Mellon Center for Building Performance and Diagnostics, based on Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2018, US EPA; Röck at al., 2020

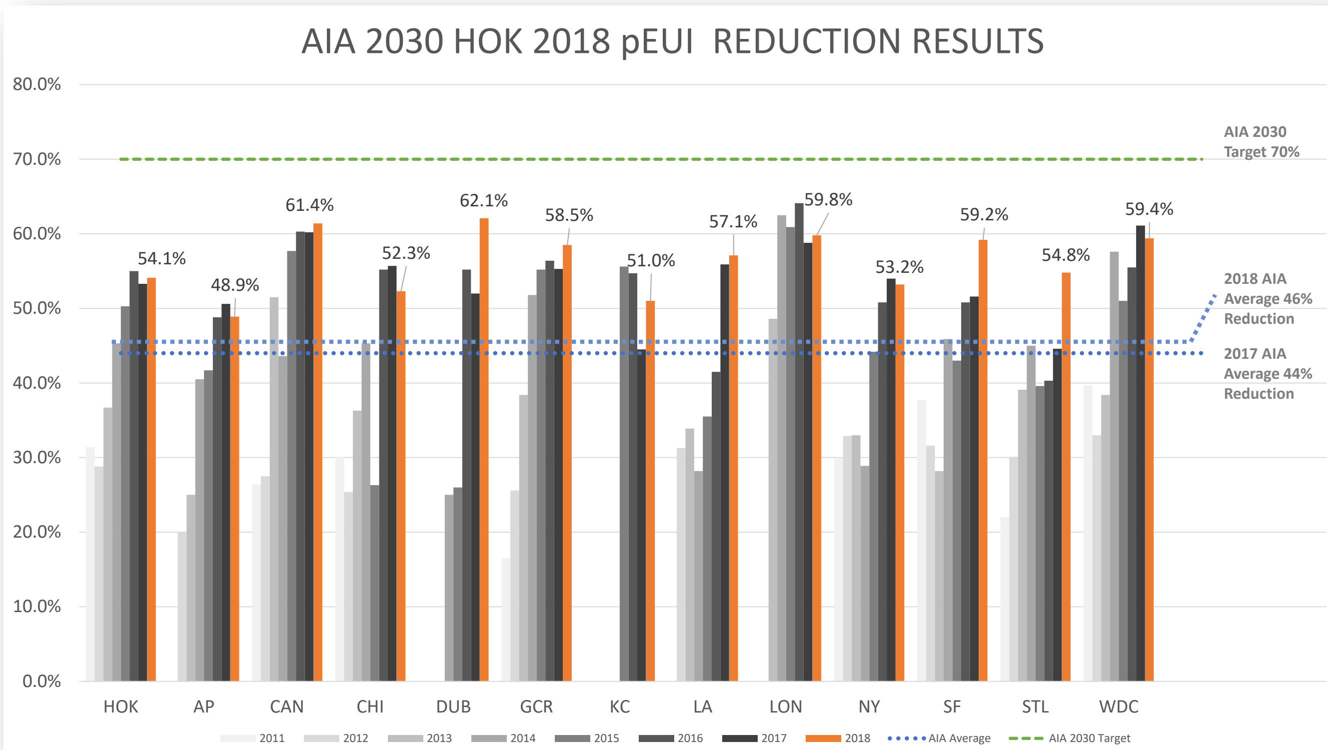
Electric Power is not an End-use Sector.

CO2 and GHG charts must be corrected to clearly reveal that 44% of the environmental challenge is in building construction and operations, and then add in the impact of planning on transportation GHG.

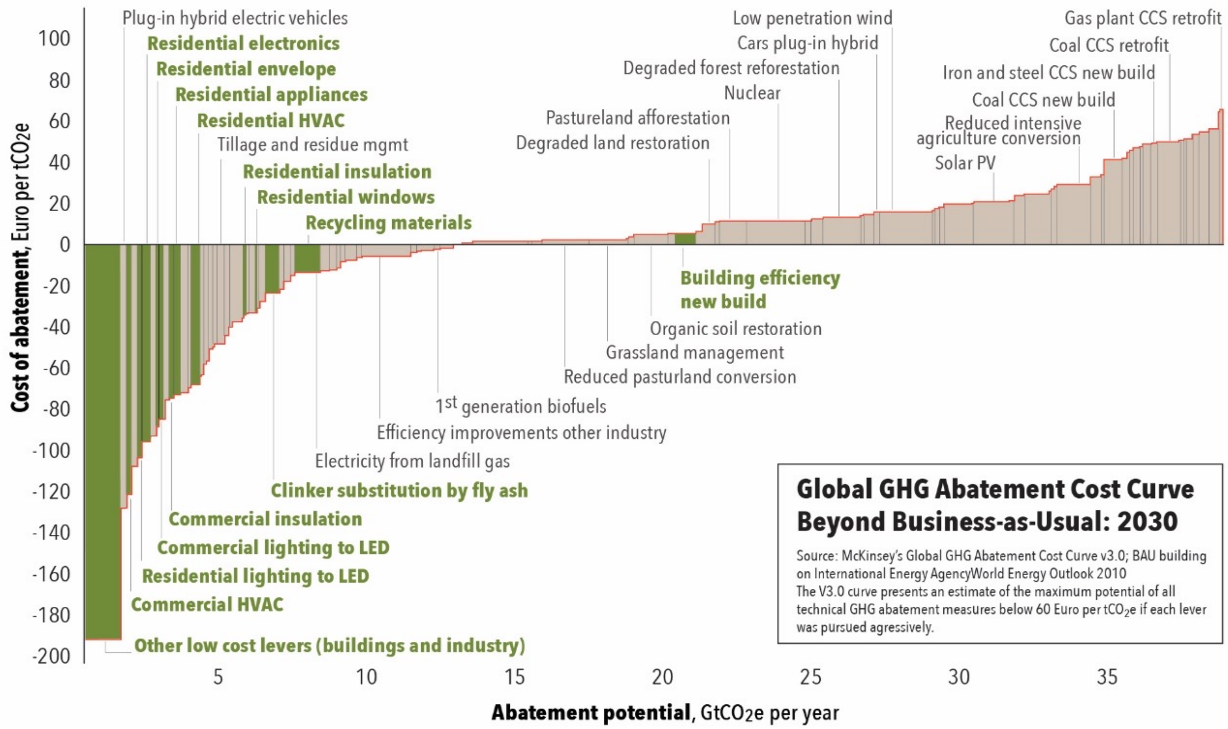


Buildings are the sloppiest use of fossil fuel and electricity.

with demand reductions of 40% easily achievable by 2030 and 80% reductions in building energy use demand (EUI) achievable by 2050, combining new and retrofit construction.

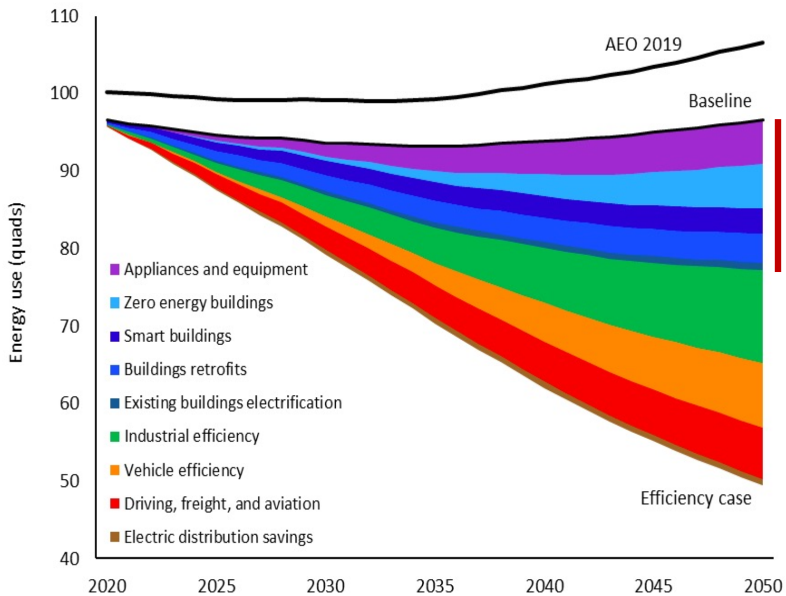


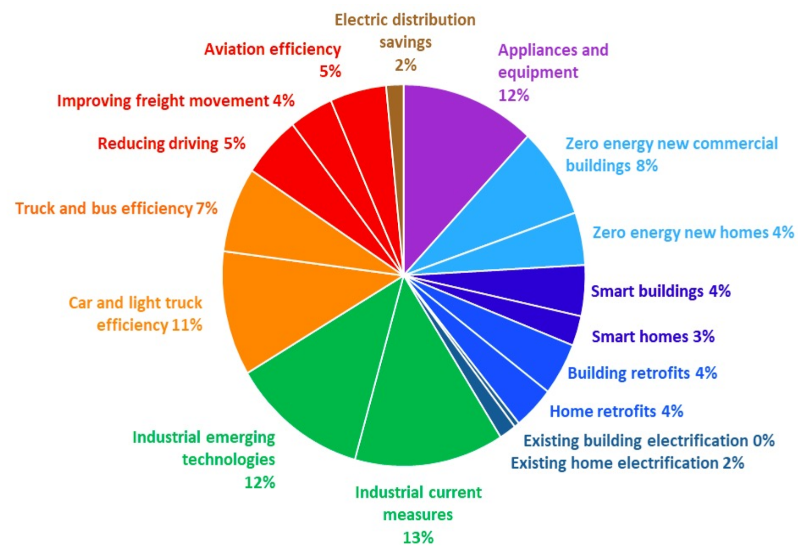
The building sector has demonstrated 60 -70% reductions in new and major retrofit large buildings worldwide.



Carbon reductions through building energy efficiency are the lowest cost per ton with the highest return on investment

(http://www.mckinsey.com)





Building energy and carbon goals can be met in the near term through strategic building investments.

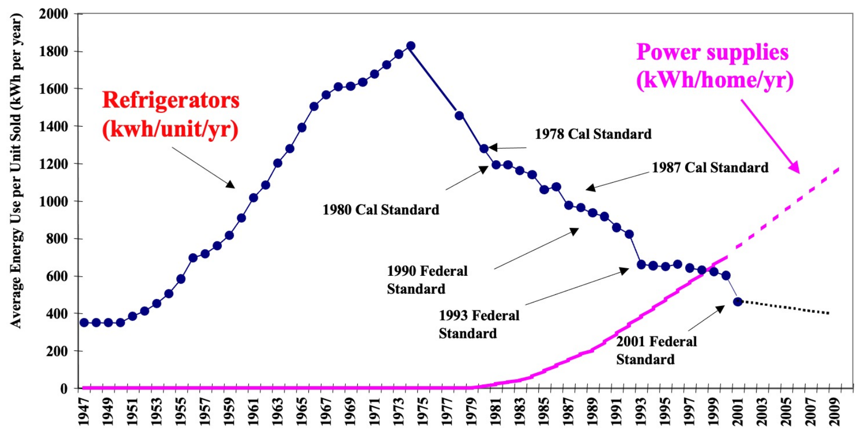
Key number is to get to a demand reduction of 50 Quads per year by 2050

ACEEE 2019 report “Halfway There: Energy Efficiency Can Cut Energy Use and Greenhouse Gas Emissions in Half by 2050

Appliance and Equipment Efficiency

(Energy Star Standards and Low-Income Replacements)

5.6 Quads, 210 M $MtCO_2$ reductions



Next gen Energy Star: 70% of the savings coming from a dozen products: residential water heaters, central air conditioners/heat pumps, showerheads, clothes dryers, refrigerators, faucets, and furnaces, as well as commercial/industrial fans, electric motors, transformers, air compressors, and packaged unitary air conditioners and heat pumps.

Zero Energy New Homes and Commercial Buildings

Standards and ARRA for Low-Income

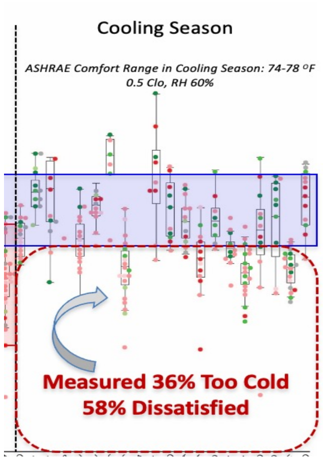
5.7 Quads, 265 M MtCO2 reductions

70% energy savings relative to reference case efficiency levels,
with the remaining 30% coming from a mix of on-site or off-site renewable energy systems.

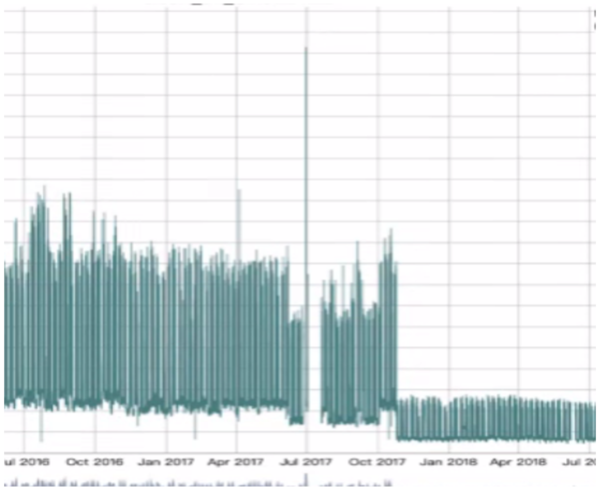
Smart Homes & Commercial Buildings – New and Existing

WPA Installation Program and FM Education

3.2 Quads, 125 M MtCO2 reductions



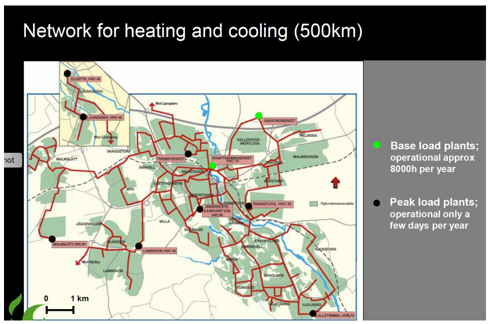
environmental surfing!



information and communications technology (ICT), access to real-time information, and smart algorithms to help optimize energy-using systems (Elliott, Molina, and Trombley 2012) for residential and commercial BAS systems. A simple example of an intelligent efficiency measure is a learning thermostat that monitors home temperature and occupancy, weather, and other parameters and finds ways to improve heating and cooling system operation after learning a household's patterns (e.g., when people are home and which temperatures they like).

District & Combined Heat, Cooling and Power – New and Existing

4 Quads, 150 mTCO2/year



The potential of co- or poly-generation of power, heating, how water and cooling with district energy systems can reduce emissions by 150 million metric tons of CO2 each year by installing new CHP plants with a total capacity of 40 GW by 2020 (Park et al 2019).

Existing Home and Commercial Building Envelope Retrofits

with local employment, equitable homes

3.8 Quads, 125 M MtCO2 reductions

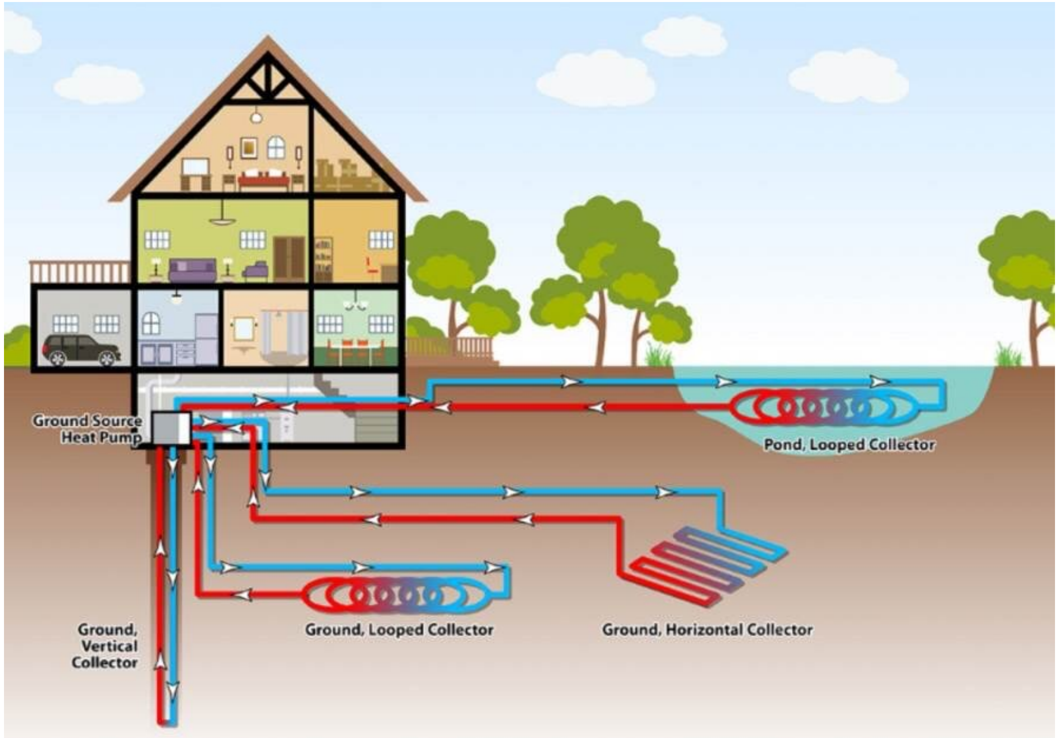
Figure 1. Energiesprong project before (left) and after (right) renovation

Photos courtesy of Energiesprong (left) and Rocky Mountain Institute (right)

Retrofits that improve air tightness, envelope insulation, and window quality such as Home Performance with ENERGY STAR can reduce energy use by 20–30% (Belzer et al. 2007; Liaukus 2014). A study on 10 deep energy retrofits of federal buildings found average savings of 38%, with savings in individual projects ranging from 18–100% (Shonder 2014).8

Deeply Efficient Electrification of Space Heating and Water Heating in Existing Homes & Commercial Buildings (in combination with renewables)

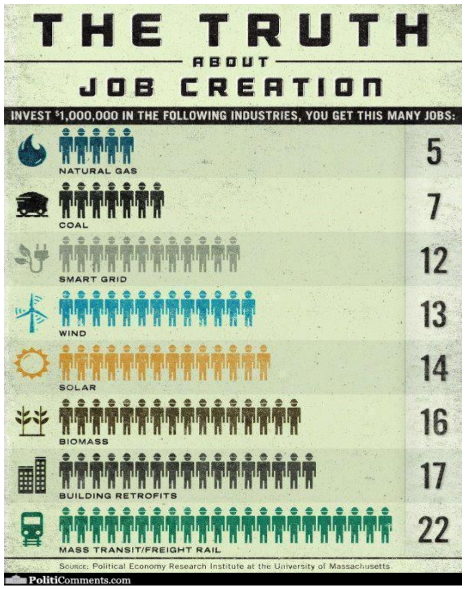
0.9 Quads (after measures above),76 M MtCO2 reductions

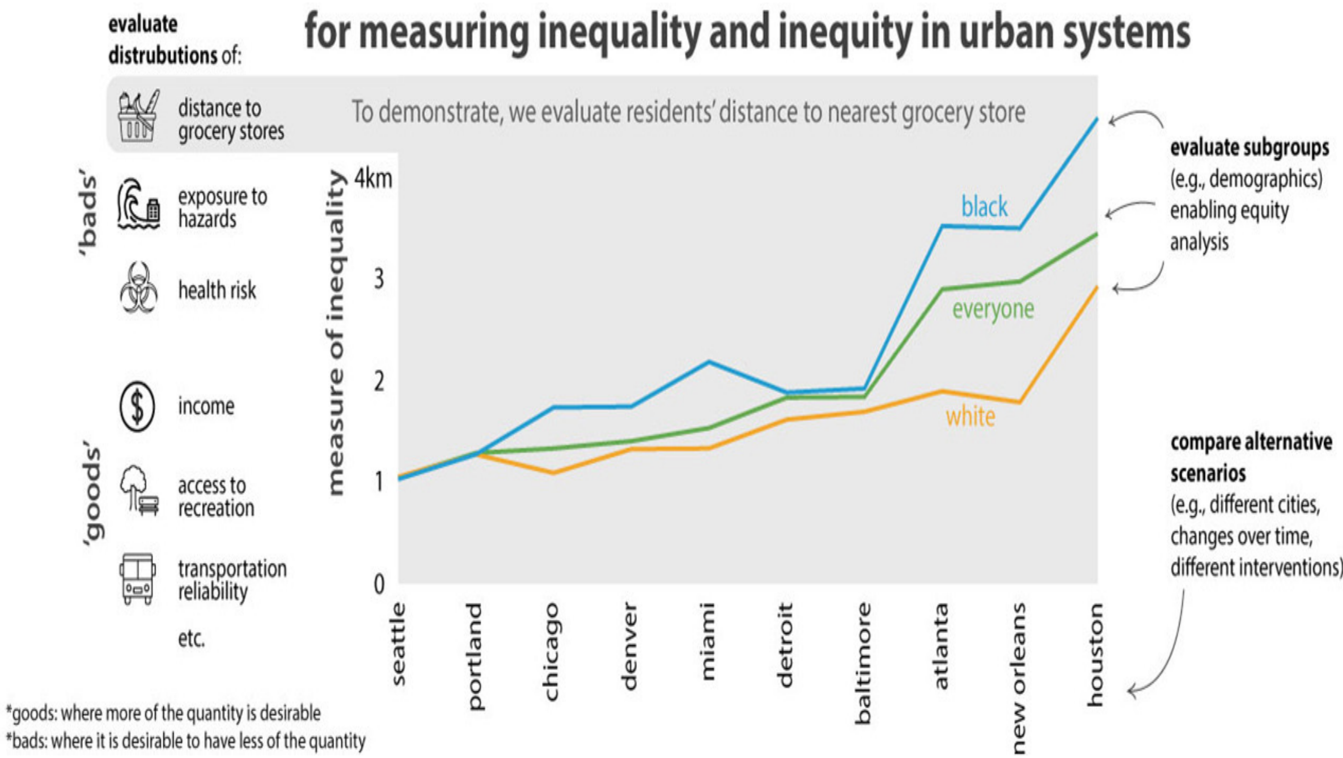


If high-efficiency heat pumps use electricity from low- or no-carbon generation, they can achieve substantial energy savings as well as emissions reductions. Converting to heat pumps at the time an existing air conditioner, furnace, or boiler needs to be replaced will reduce operational costs, but first costs need to be incentivized for a transition to an all-electric future.

Buildings have a critical role in electricity generation, peak load management & storage.

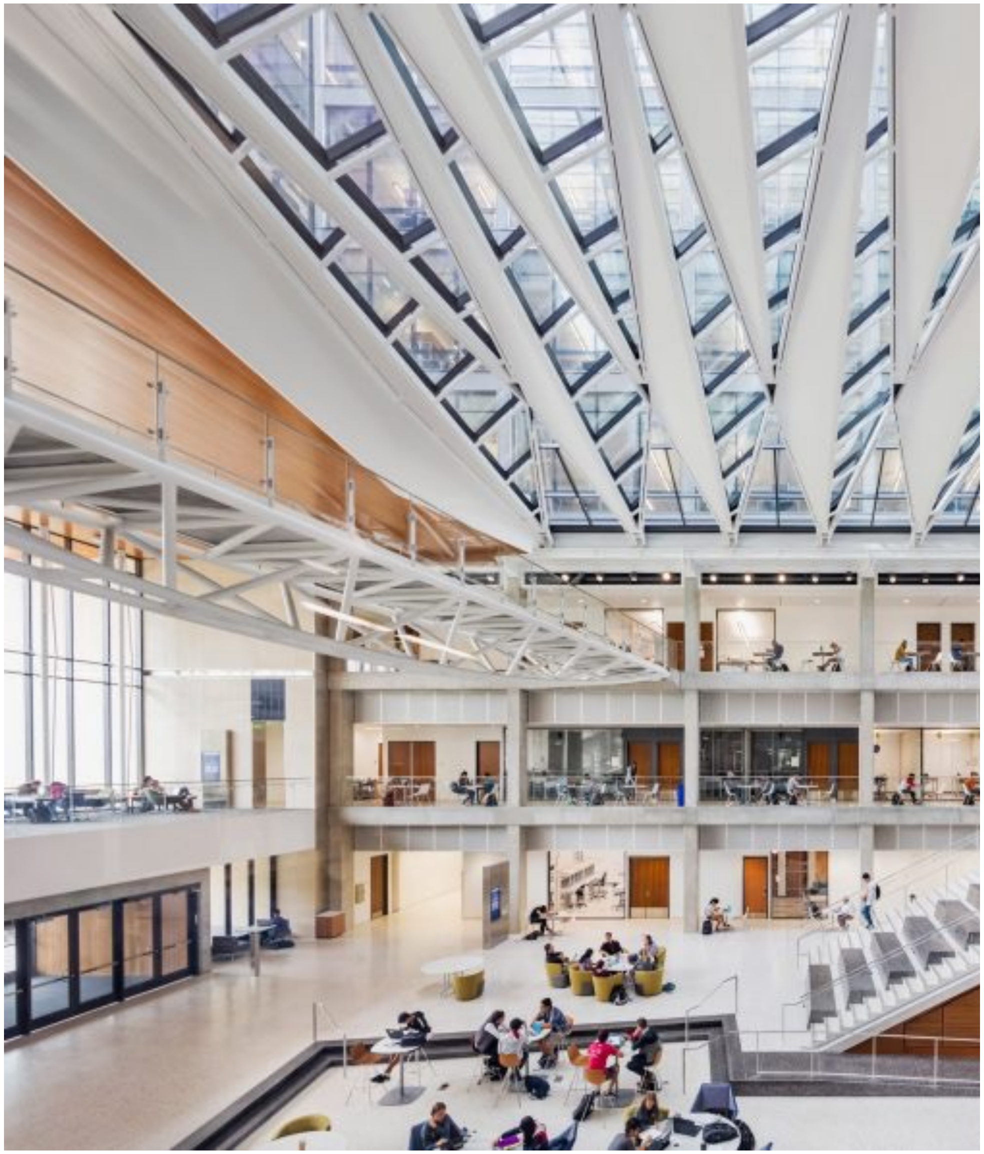
Distributed energy generation, peak load shifting, and heat/coolth/electricity storage





Focused attention on decarbonization of the built environment yields equity, resiliency and health.

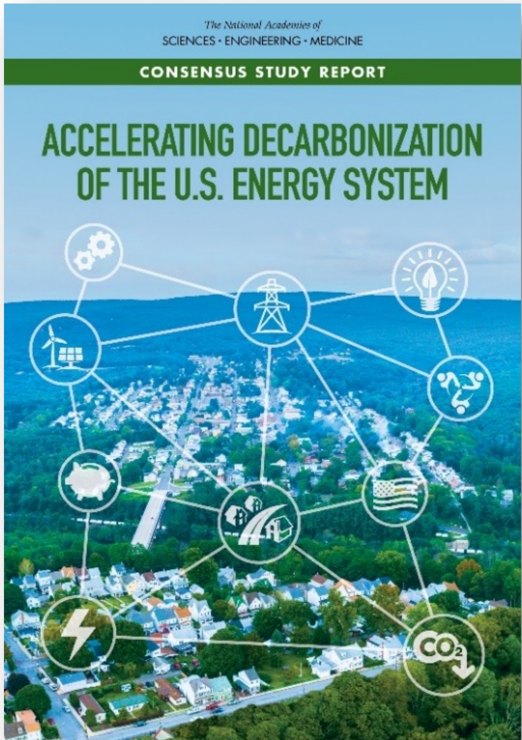
Logan, T., Anderson, M., Williams, T., and Conrow, L. "Measuring Inequality in the built environment: an approach for evaluating the distribution of amenities and burdens". Computers, Environment and Urban Systems.



"The University of Texas at Austin will reduce energy consumption at the building level by an average of 20% per square foot per degree day by August 31, 2020 using 2009 as the base year. "

2% a year over 40 years will get to net zero.

Cockrell Engineering Building
UT Austin
ENNEAD Architects



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