BUILDINGENERGY BOSTON

Making Ourselves Heard: The Building Sector as Leaders in Carbon Neutrality

Vivian Loftness (Carnegie Mellon University)

Northeast Sustainable Energy Association (NESEA)
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The CMU Intelligent Workplace CBPD Zoelly BCJ

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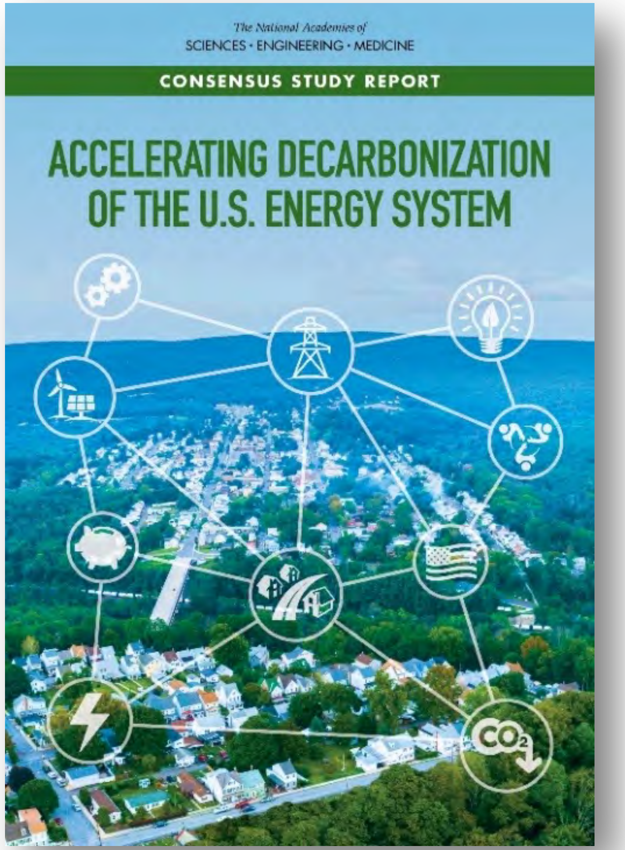

nap.edu/decarbonization

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 Tech

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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

Sandy Fazeli, NASEO

Adrienne Hollis, Union of Concerned Scientists

Carlos Martin, Urban Institute & Harvard

Michael Mendez, UC Irvine

Keith Paulson, Colorado State

Patricia Romero-Lankao, NREL

Devashree Saha, WRI

Reed Walker, UC Berkeley

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.

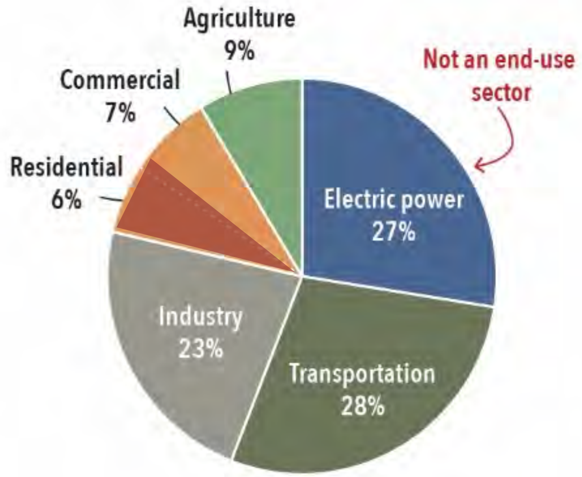
Support communities, businesses, and workers

Proactively support those directly and adversely affected by the transition

Maximize cost-effectiveness

Electric Power is not an End-use Sector.

CO_2 and GHG charts must be corrected to clearly reveal that 38% of the environmental challenge is in building construction and operations, and then add in the impact of planning on transportation GHG.



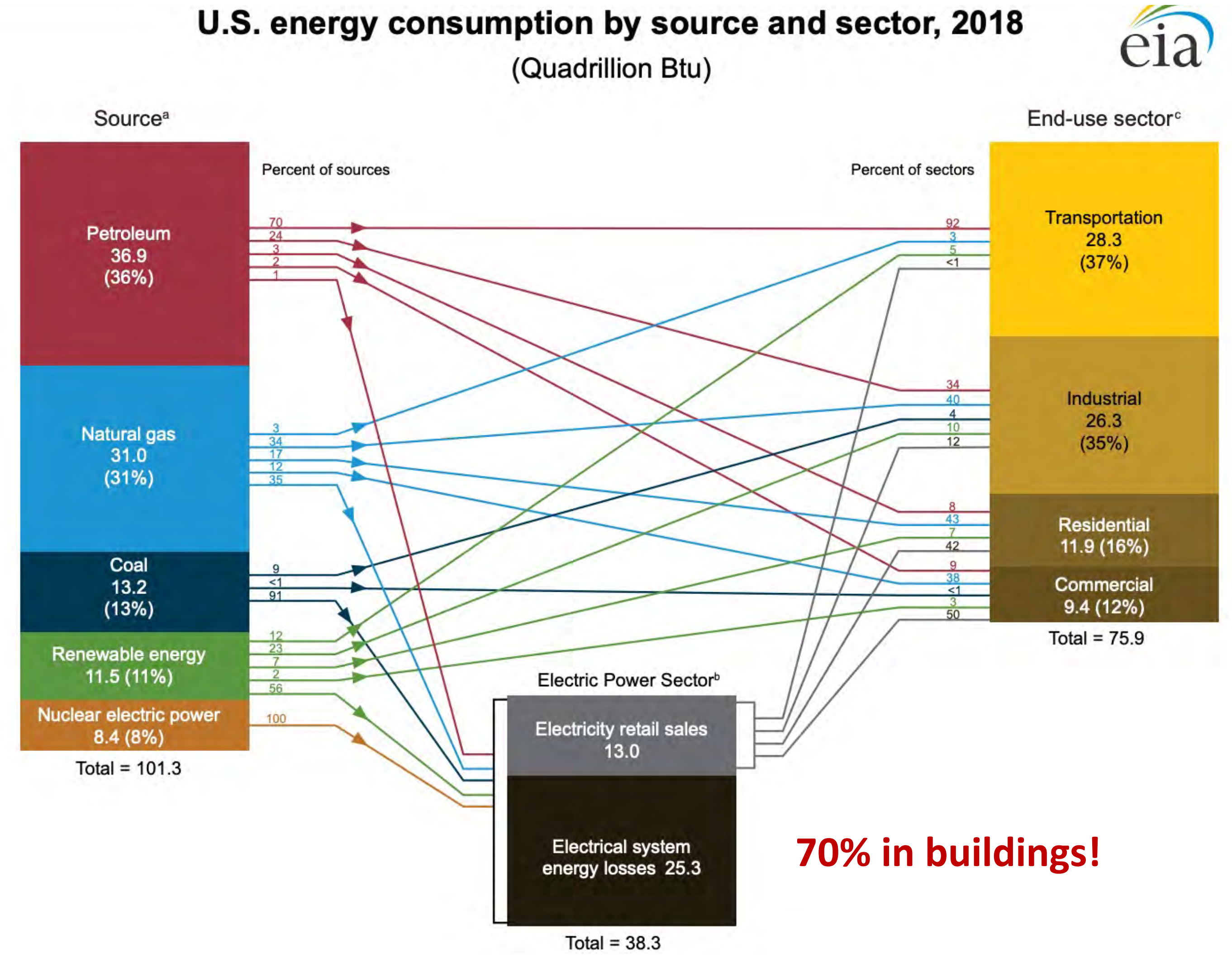
U.S. GHG emissions with electricity as an end-use sector

Fully Assigning GHG Emissions to I

Created 2020 by Carnegie Mellon Center for Building Performance and I
Emissions and Sinks 1990-2018, US EPA; Röck at al., 2020

Electric Power is not an End-use Sector.

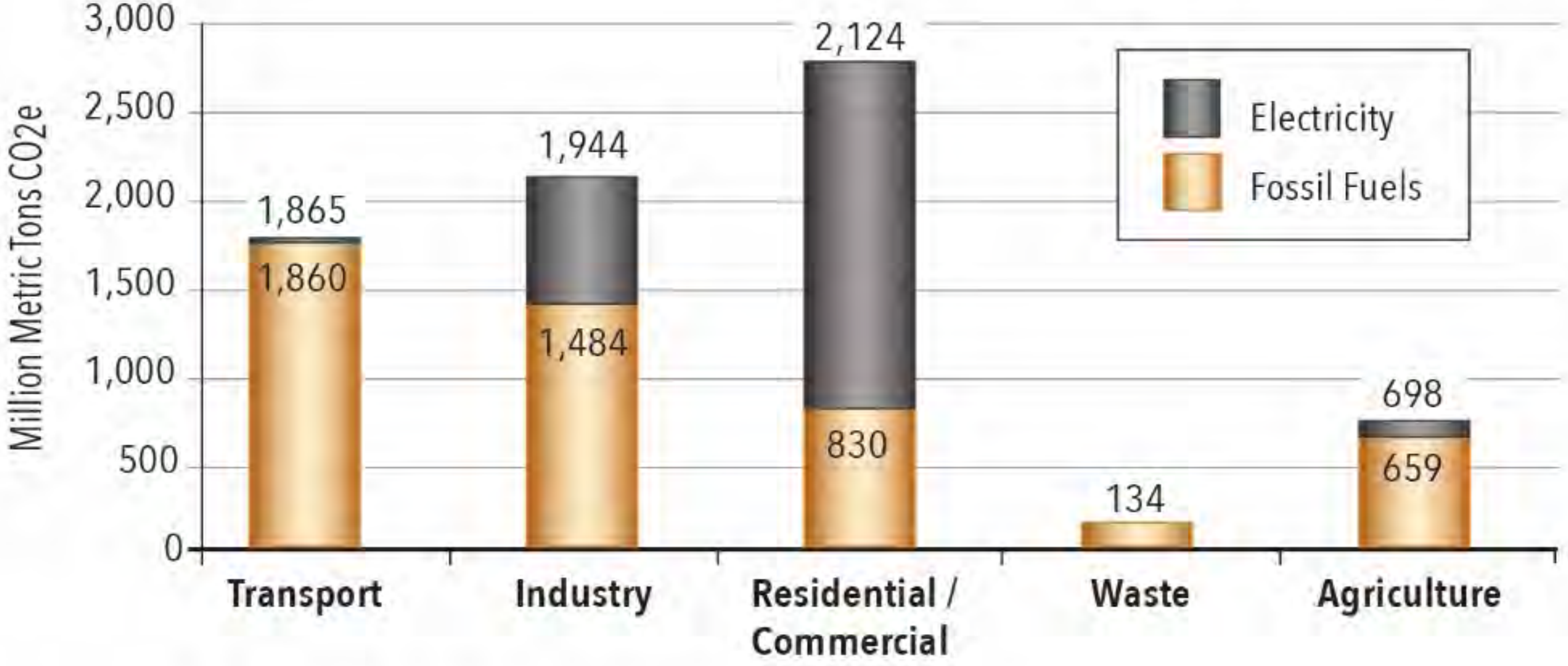
EIA updates its U.S. energy consumption by source and sector chart in 2019!



direct use of
fossil fuel dominates

70% in buildings!

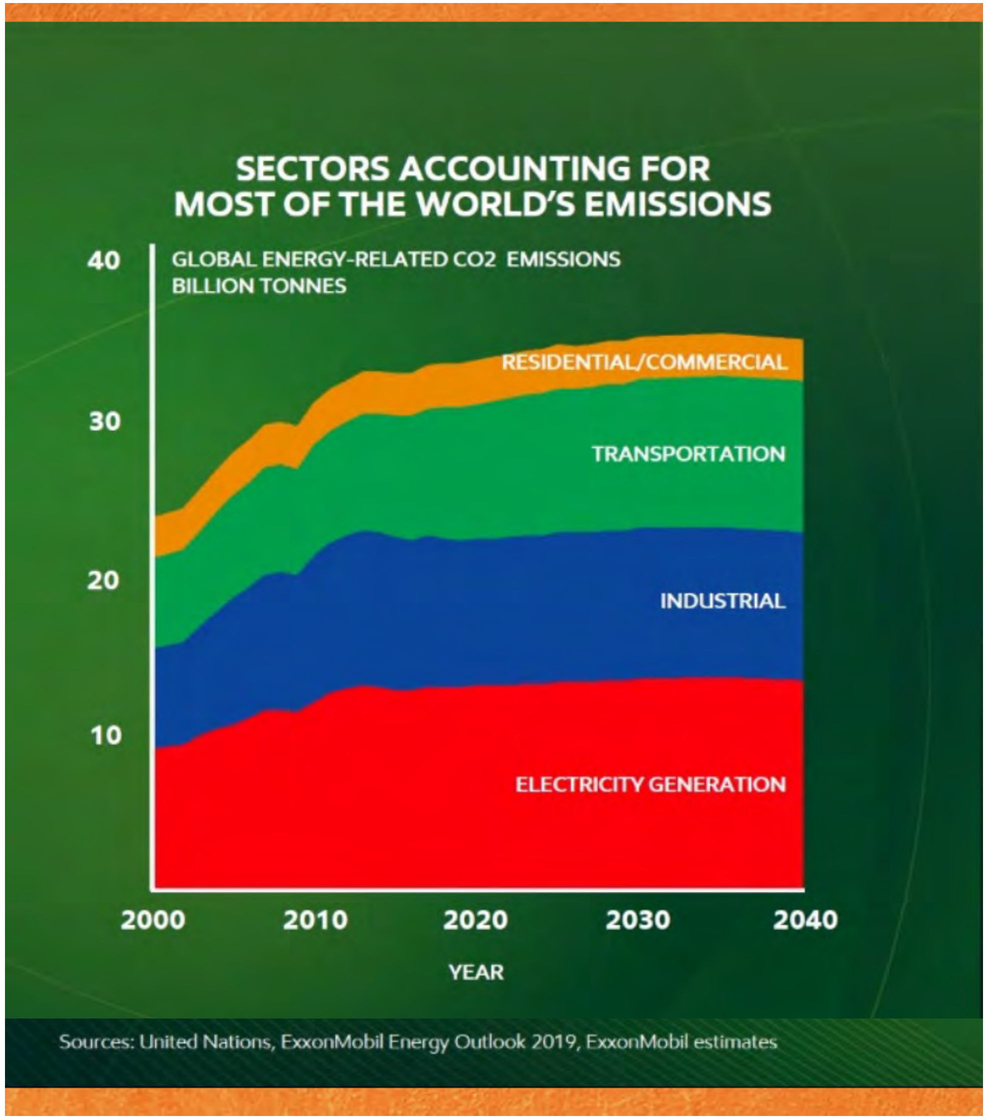
Both Electricity and Fossil Fuels Contribute to Greenhouse Gas Emissions.

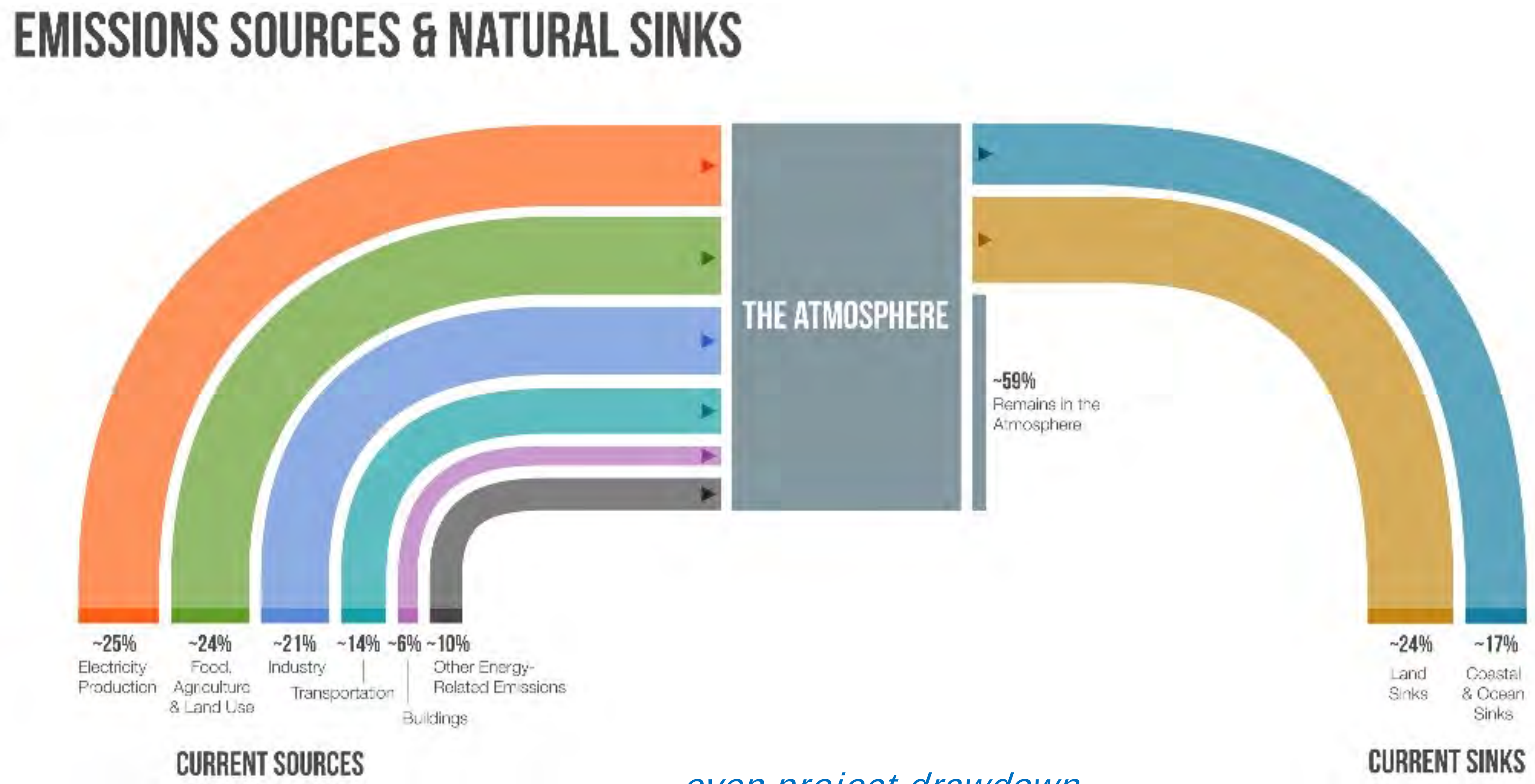


U.S. 2018 GHG Emissions by Sector

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

Electric Power is not an End-use Sector.





even project drawdown …

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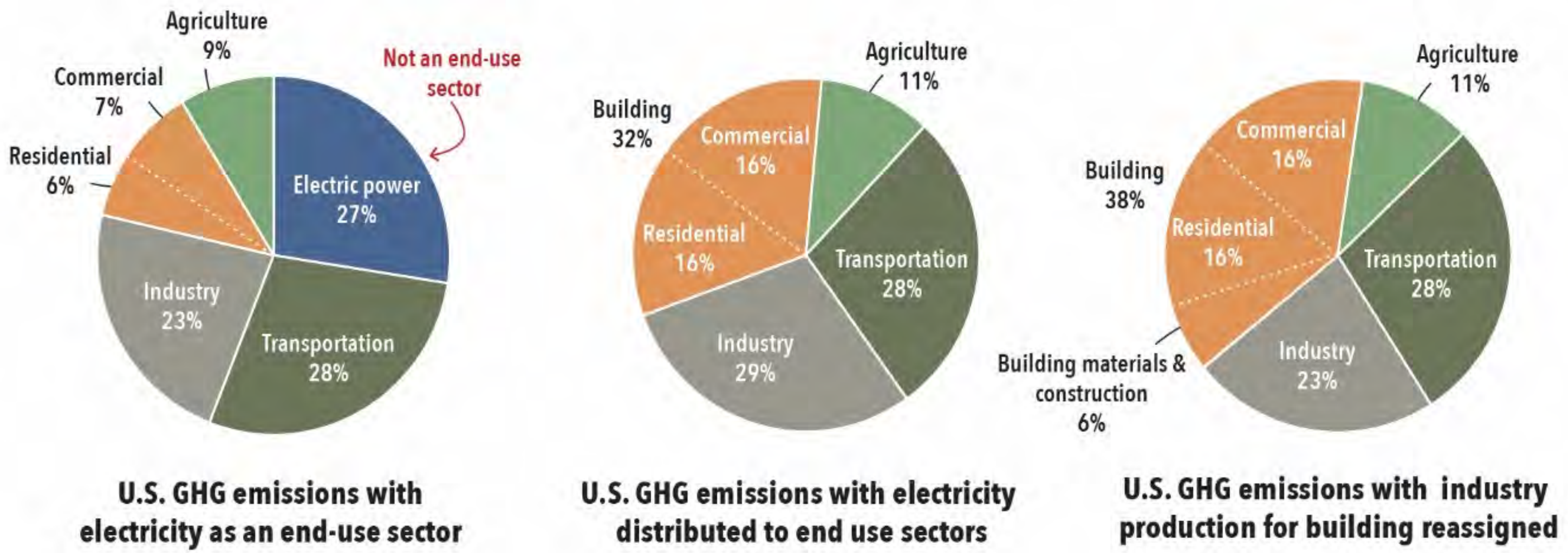
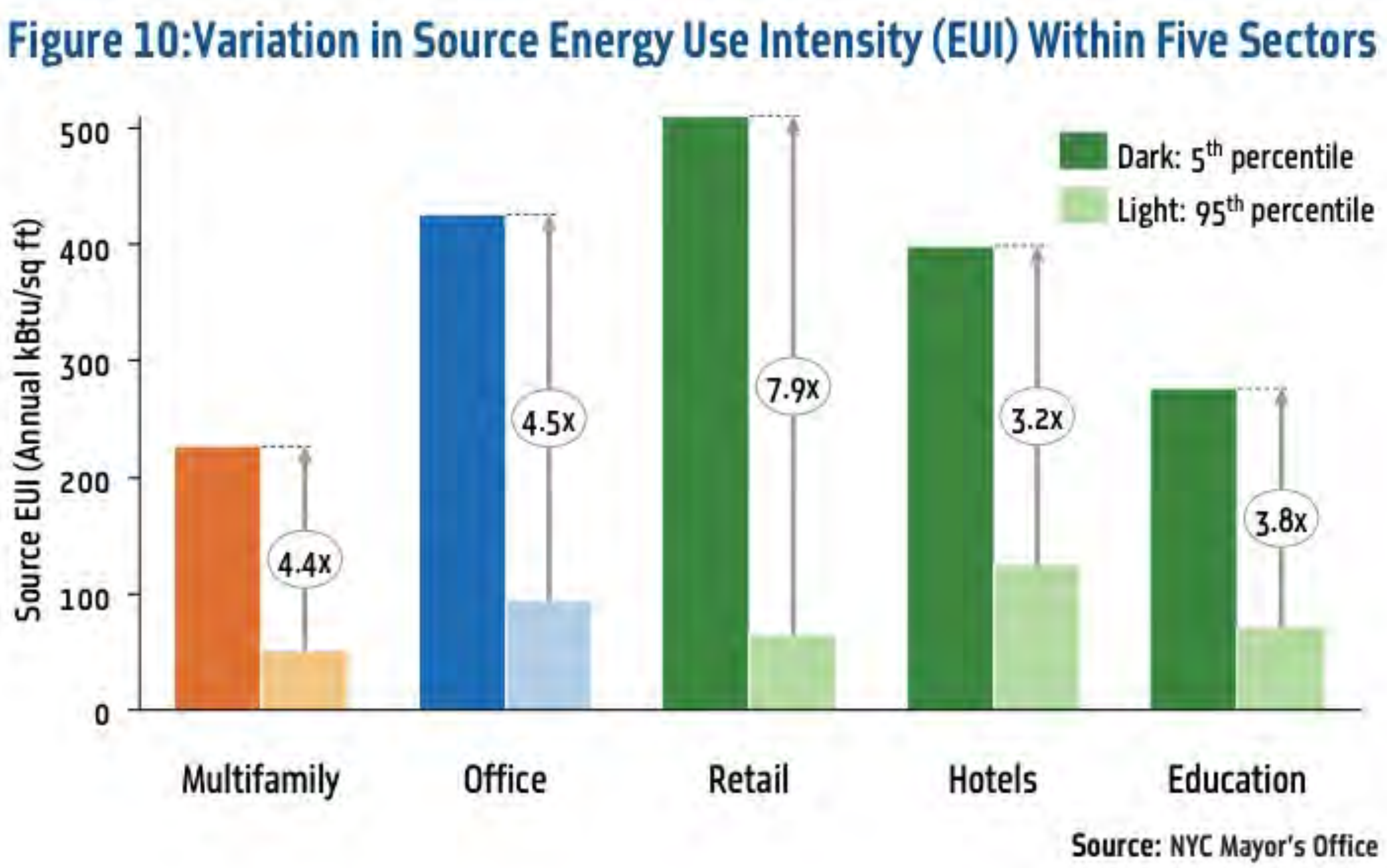


Fully Assigning GHG Emissions to End Use Sectors for Decarbonization Policy & Action

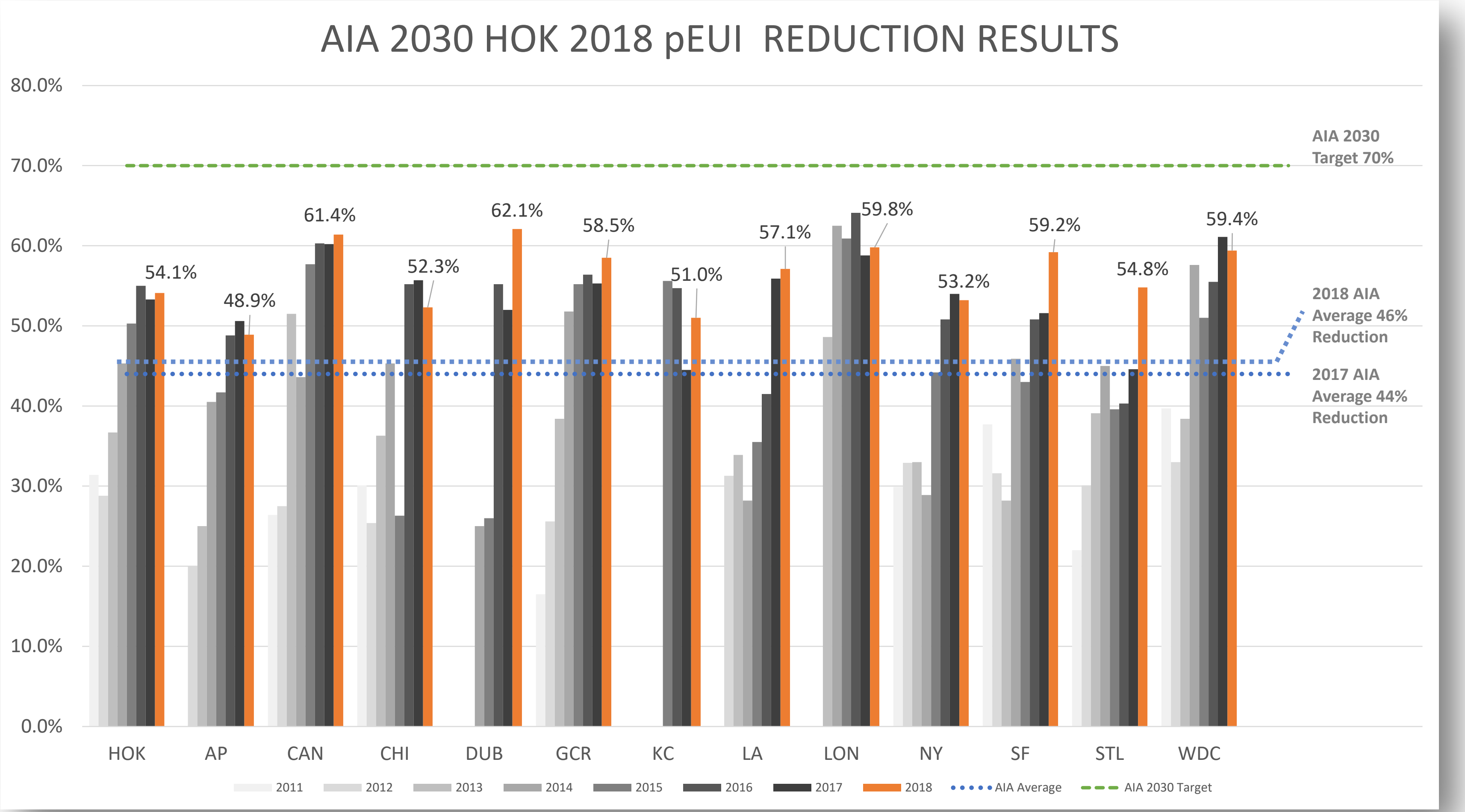
Created 2020 by Carnegie Mellon Center for Building Performance and Diagnostics, based on Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2018, US EPA; Röck at al., 2020

Buildings are the sloppiest use of fossil fuel and electricity.

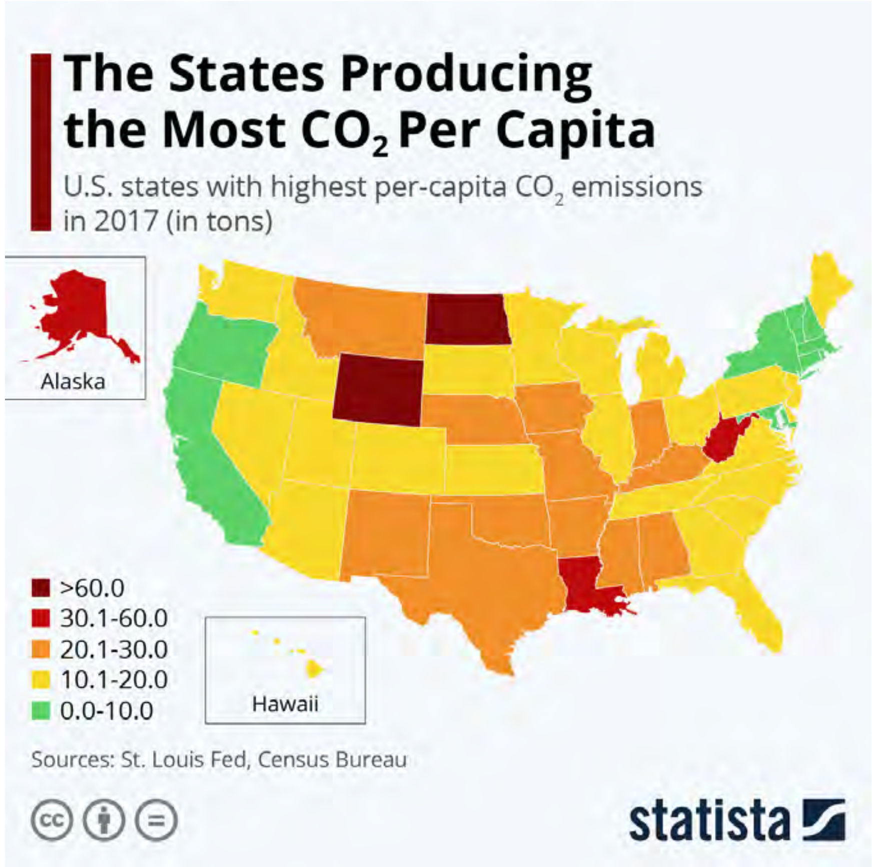
with demand reductions of 40% easily achievable by 2030 and 80% reductions in building energy use demand (EUI) achievable by 2050, combining new and retrofit construction.

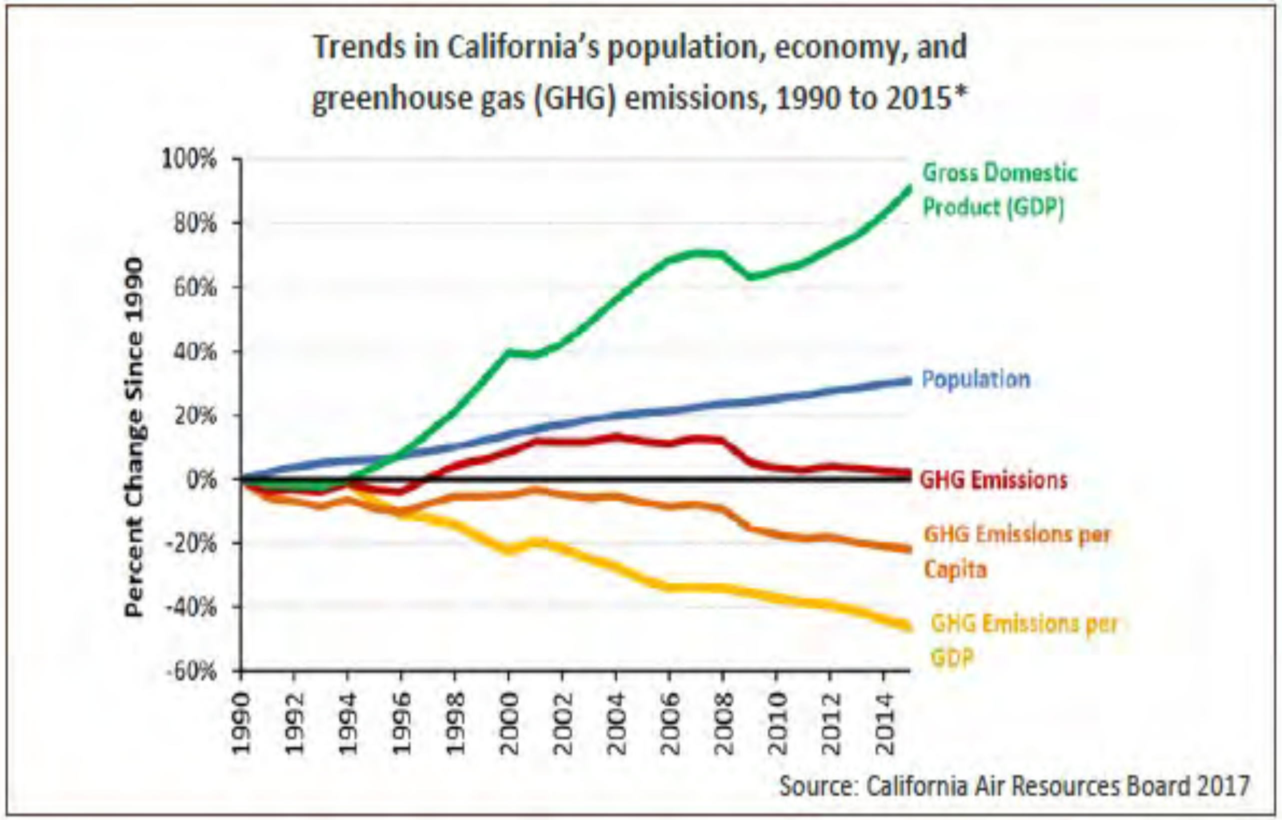


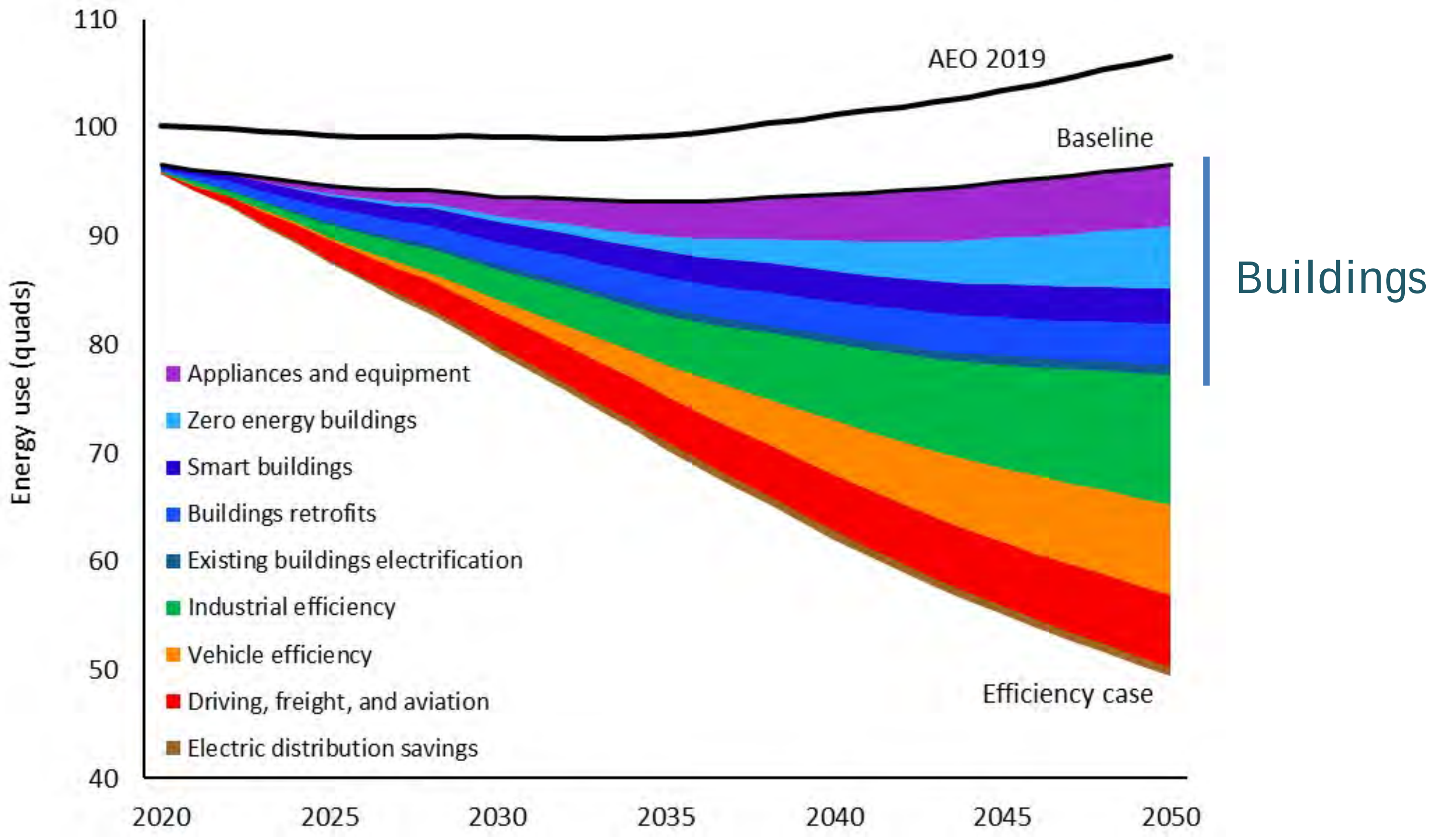
The building sector has demonstrated 60 -70% reductions in new and major retrofit large buildings worldwide.



Policy Matters – the market will not take care of building energy and environmental investments.







Energy and carbon goals can only be met through strategic building investments.

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

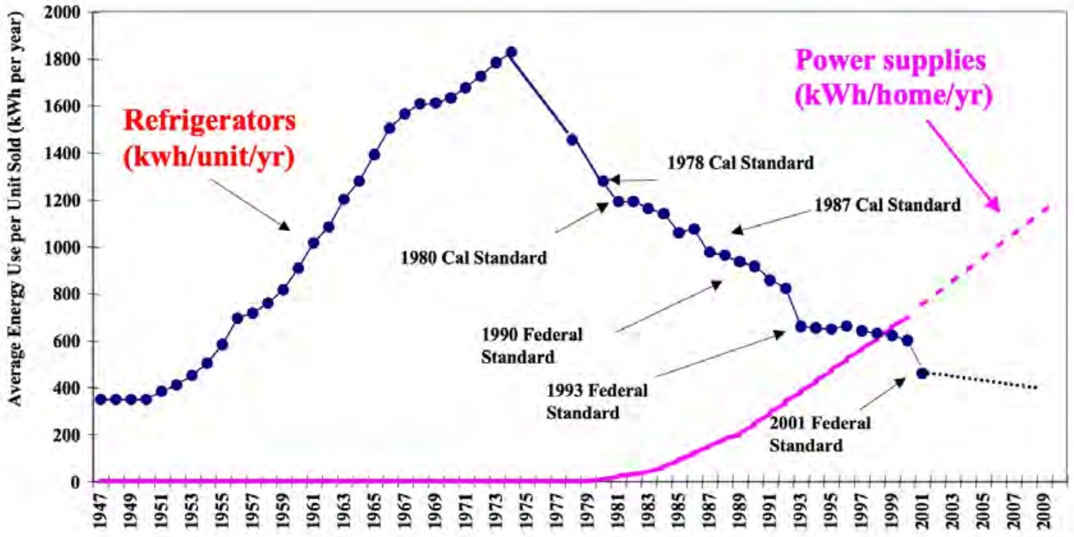
(with US mix a quadrillion BTU = 2600 Million $MTCO^2$)

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

Appliance and Equipment Efficiency

(Innovation, Energy Star Standards and Low-Income Replacements)

5.6 Quads, 210 M MtCO2 reductions (1.64 trillion kWh)



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

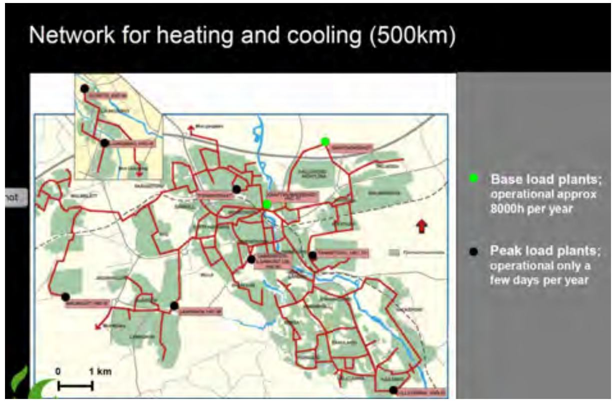
2030 to 2050 Performance Standards

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.

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

4 Quads, 150 mTCO2/year



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

Envelope Retrofits for Existing Homes and Commercial Buildings

‘ARRA’ Investments for Equitable Housing for Low-Income with local employment

3.8 Quads, 125 M MtCO2 reductions

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

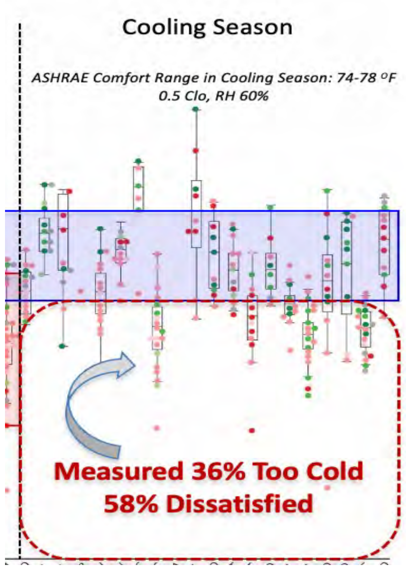
Photos courtesy of Energiesprong (left) and Rocky Mountain Institute (right)

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).

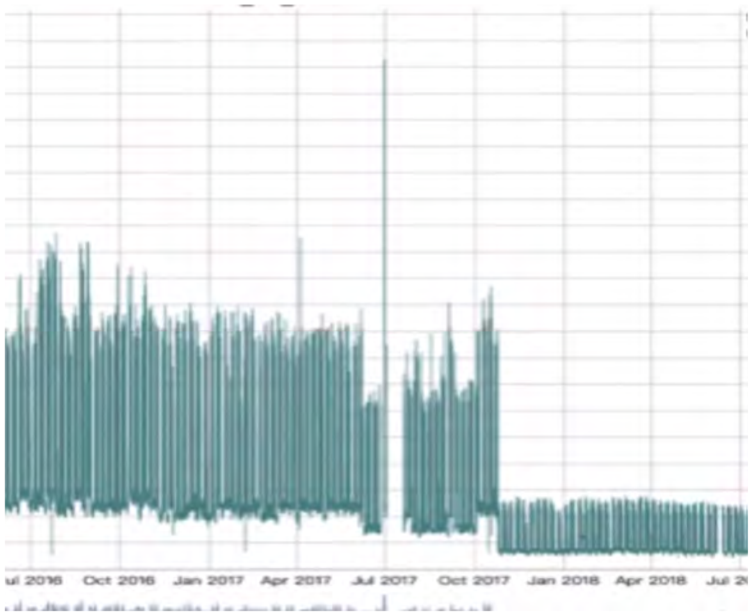
Smart Homes & Commercial Buildings – New and Existing

WPA Installation Program and FM Education

3.2 Quads, 125 M $MtCO_2$ reductions

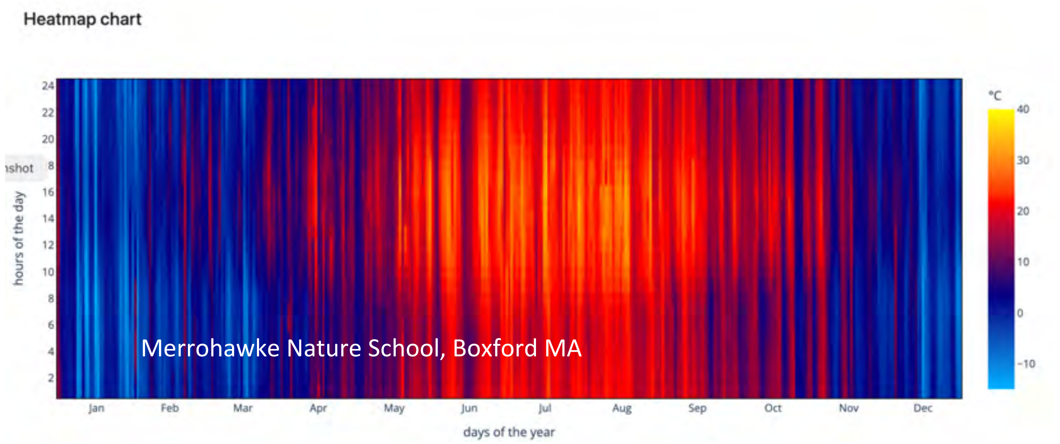


environmental surfing!



Information and communications technology (ICT), access to real-time information, smart algorithms to help optimize energy-using systems (Elliott, Molina, and Trombley 2012) for residential and commercial BAS. A simple example is a learning thermostat that monitors home temperature and occupancy, weather, and other parameters to improve heating and cooling system operation after learning a household's patterns.

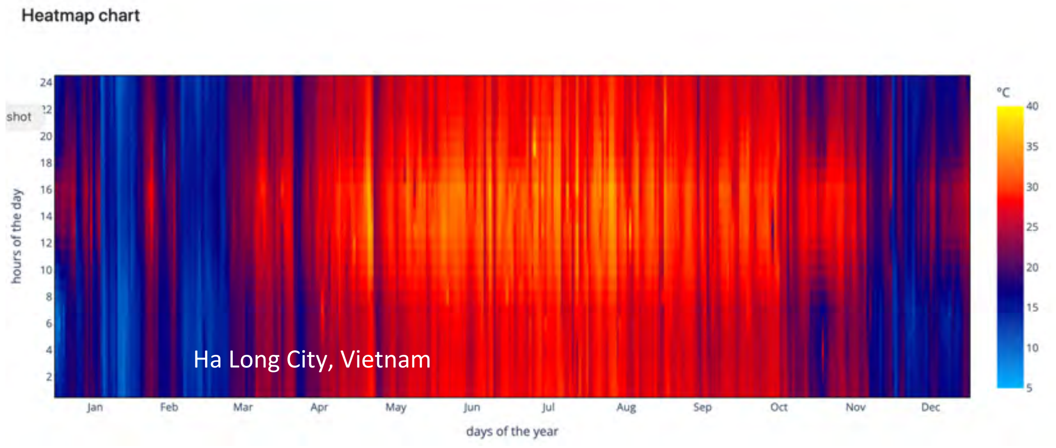
Smart Buildings Put Nature and Humans in the Loop: Environmental Surfing!



for every hour possible
of every day

daylight
passive solar heat
natural ventilation breathing
natural ventilation cooling
night ventilation cooling
time lag conditioning
externalizing program

ensuring that 'obese' buildings
become illegal for resiliency and health



Montessori in Vietnam - HGAA Architects
https://www.archdaily.com/941551/mmg-nil-my-montessori-garden-preschool-hgaa/5ee26053b357655b9e00024d-mmg-nil-my-montessori-garden-preschool-hgaa-concept?next_project=no

Design for Environmental Surfing!

natural conditioning
for every hour possible of every day

daylight
passive solar heating
natural ventilation breathing
natural ventilation cooling
night ventilation cooling
time lag conditioning
externalizing program

ensuring that 'obese' buildings
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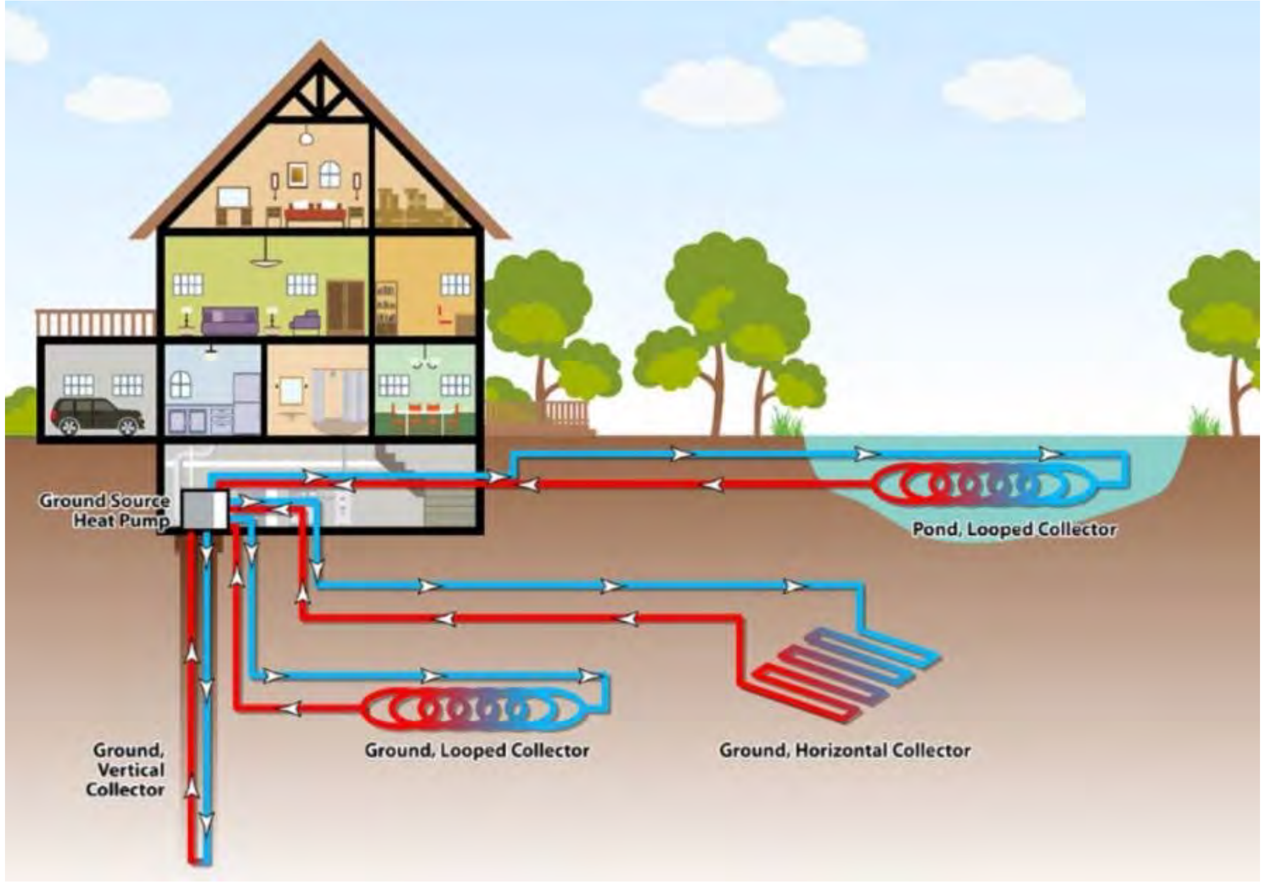
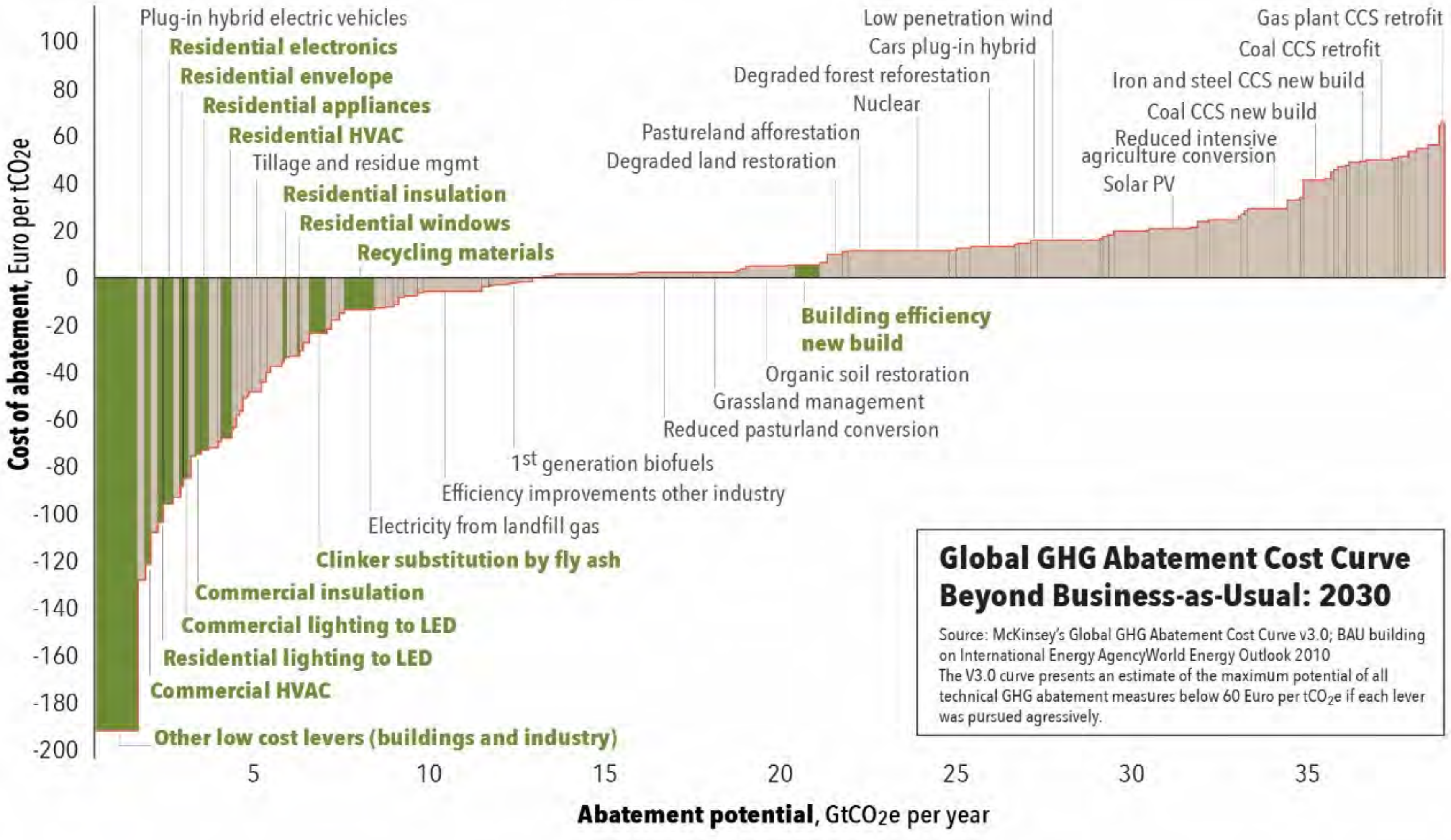
Deeply Efficient Electrification of Space Heating and Water Heating in Existing Homes & Commercial Buildings (in combination with renewables)

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 that an existing air conditioner, furnace, or boiler needs to be replaced will save operational costs, but costs need to be incentivized for a transition to an all-electric future.

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



(http://www.mckinsey.com)

Electrification of the built environment and grid integration will be key to full decarbonization.

GSA, ACEEE, NBI, RMI are fighting to position buildings in the electrification dialogue.

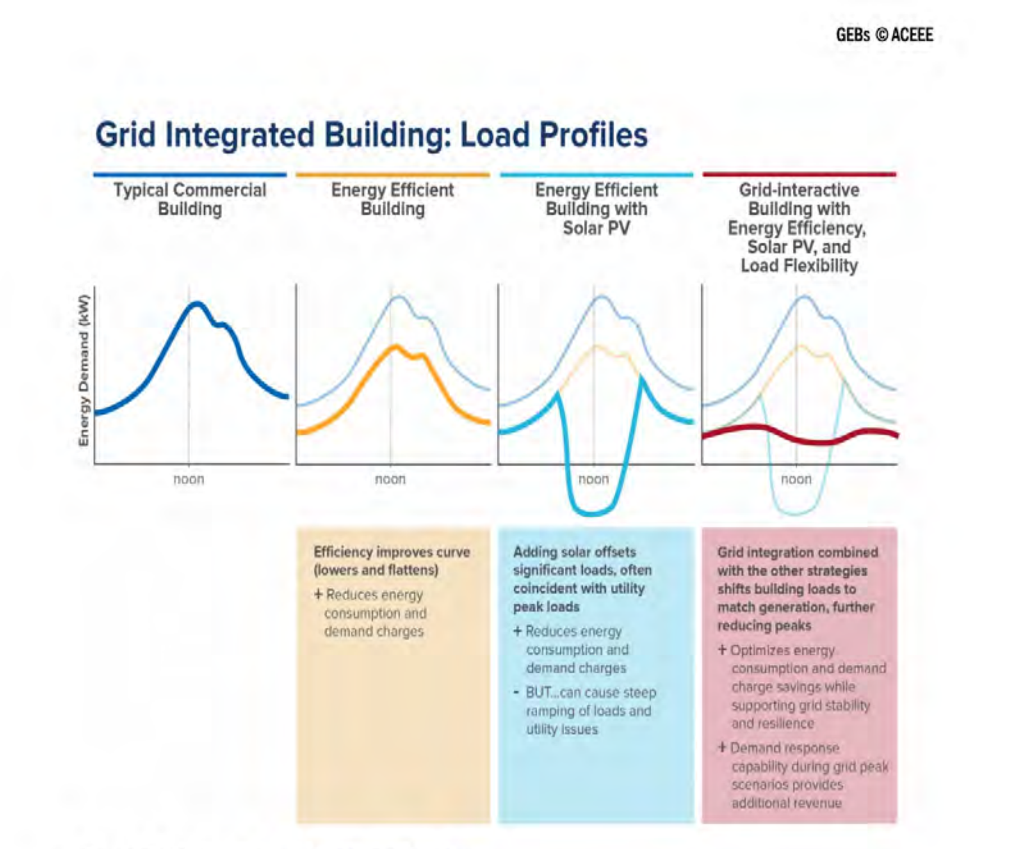
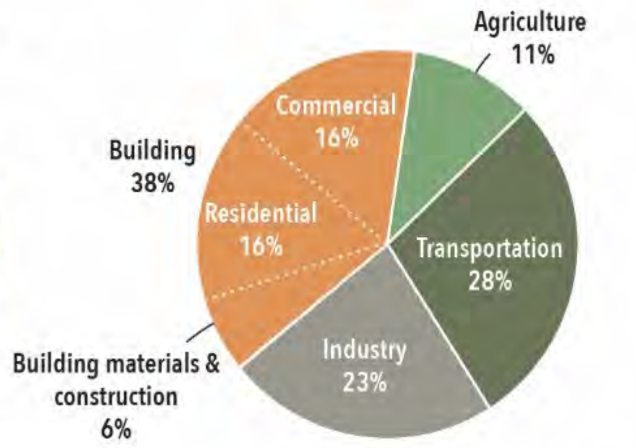


Figure 3. Flexible demand. *Source:* Carmichael et al. 2019.

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

As buildings become more efficient, the embodied carbon in building materials becomes as critical as operational carbon.



U.S. GHG emissions with industry production for building reassigned

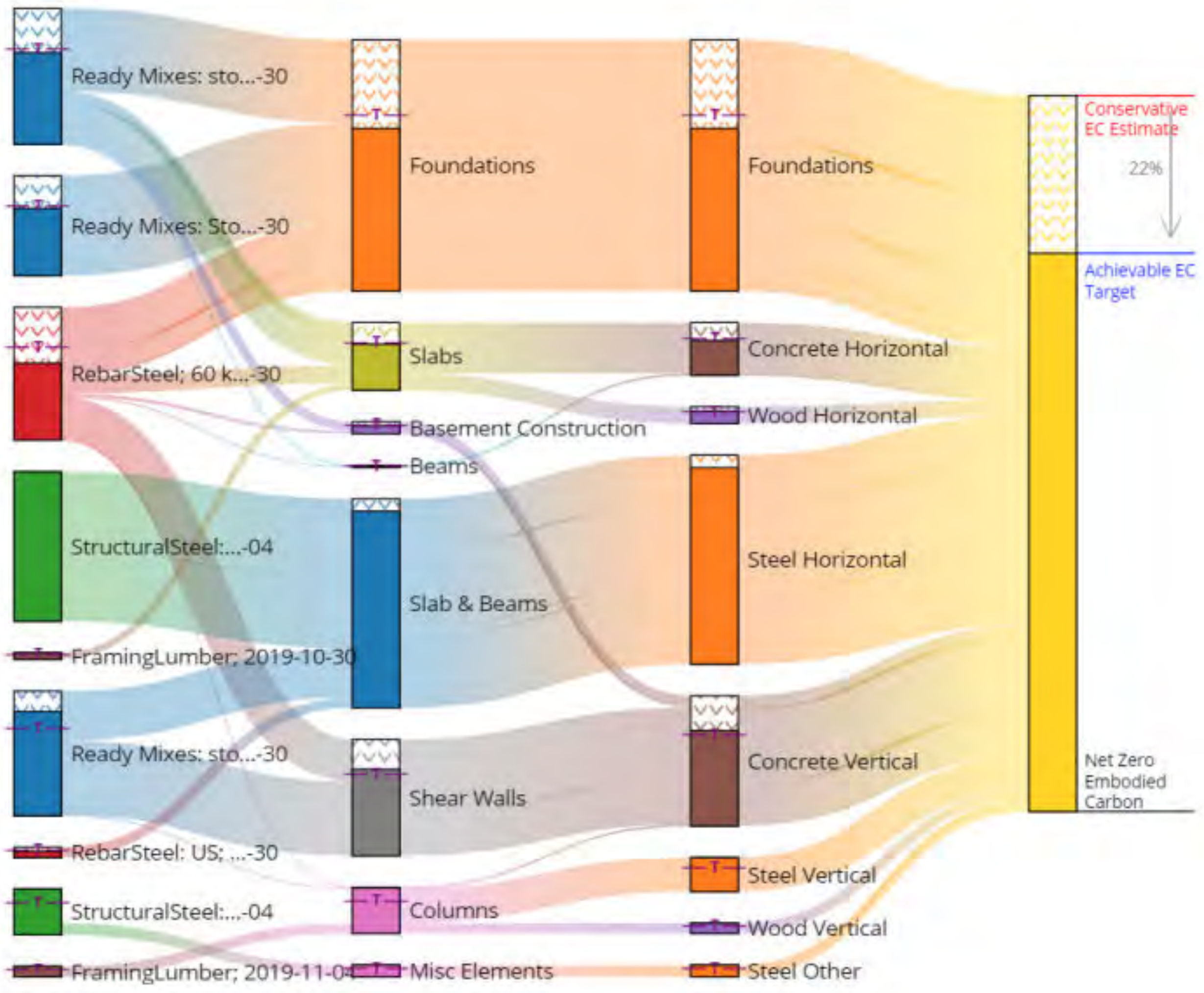


Figure 4: EC3 Tool Sankey Diagram of Carbon within a Reference Building

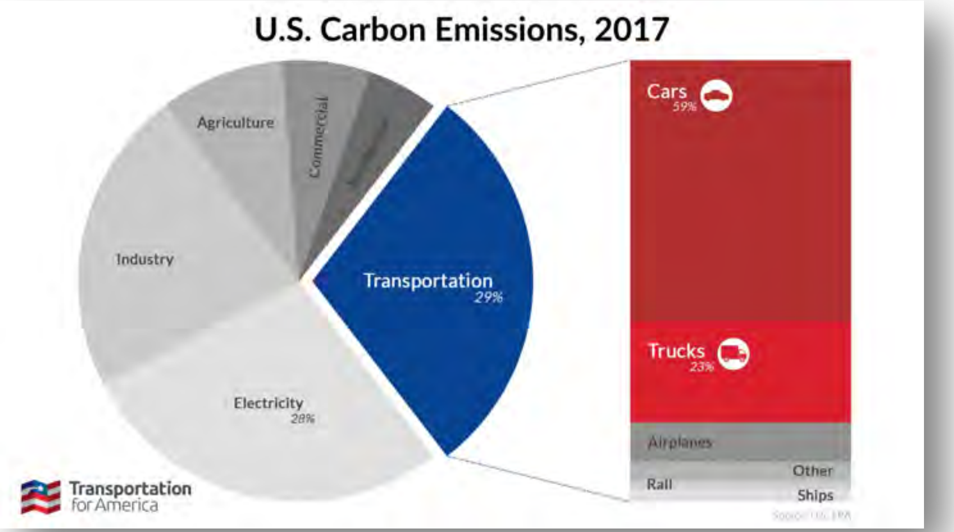
Big Six:
Concrete
Steel
Aluminum
Insulation
Plastics

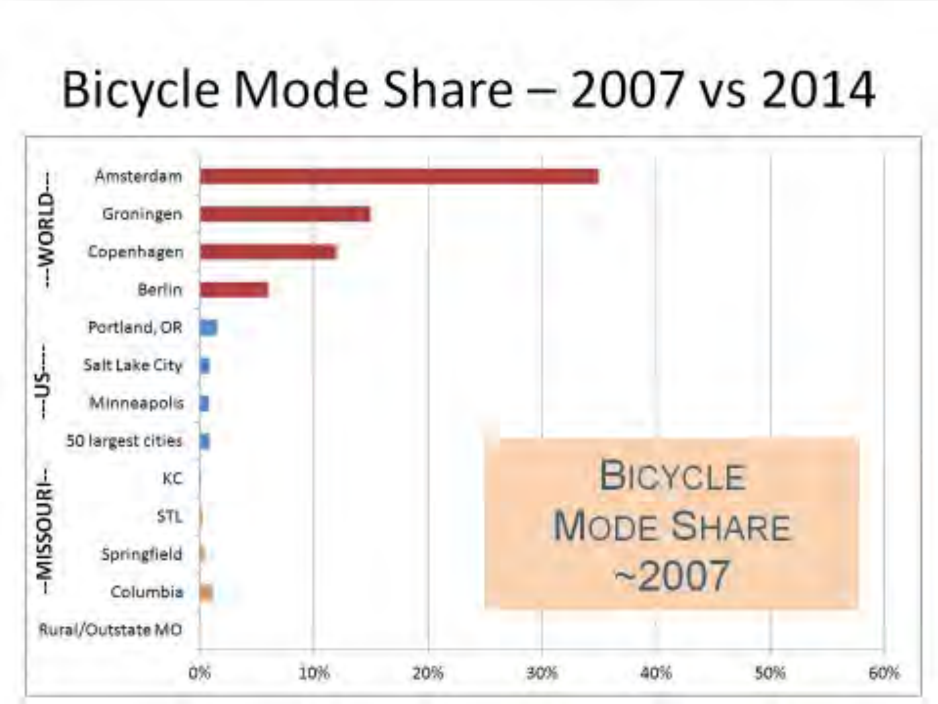
Carbon Leadership Forum EC3 Tool
Materials Petal
EPD & Declare
AIA Materials Pledge

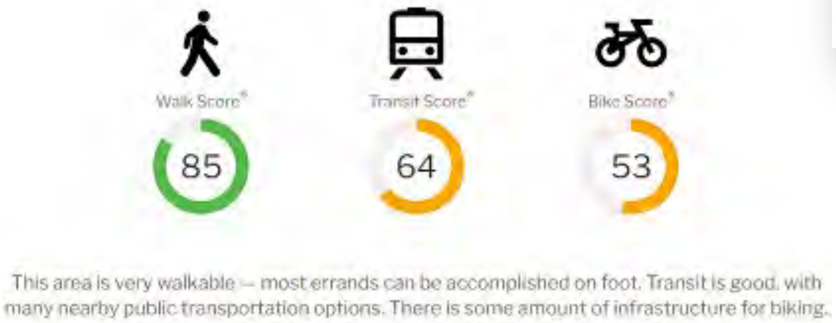
Buildings also have a critical role in carbon sequestration.

https://golab.us

Finally, planning our built environment is key to mobility and transportation energy, to securing regenerative agriculture and forestry, and ensuring resiliency.

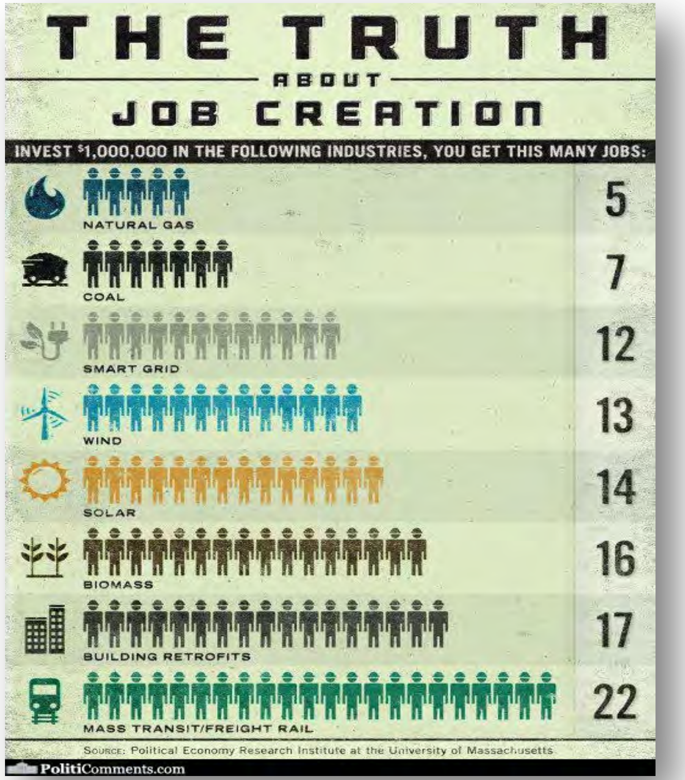


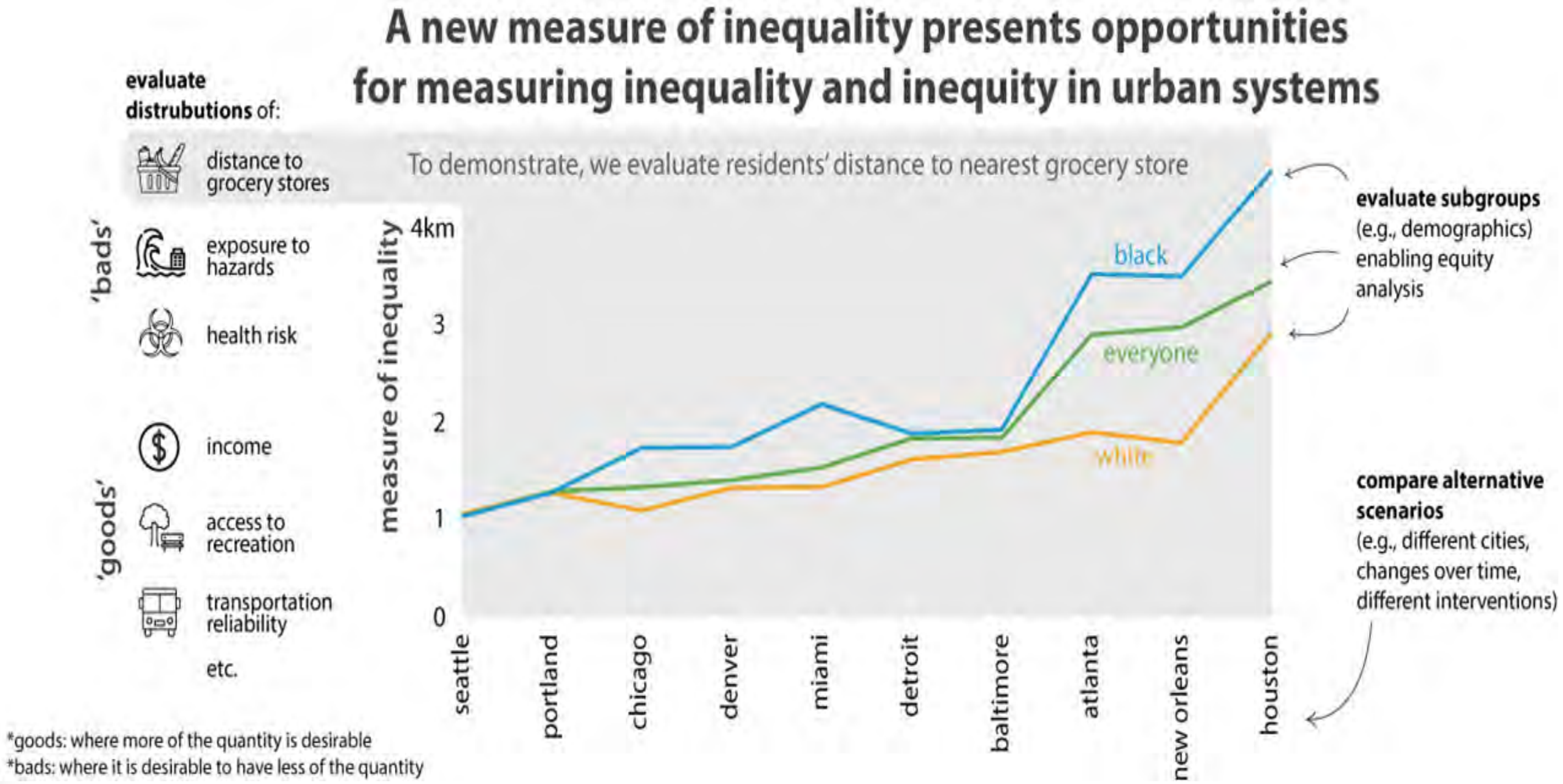




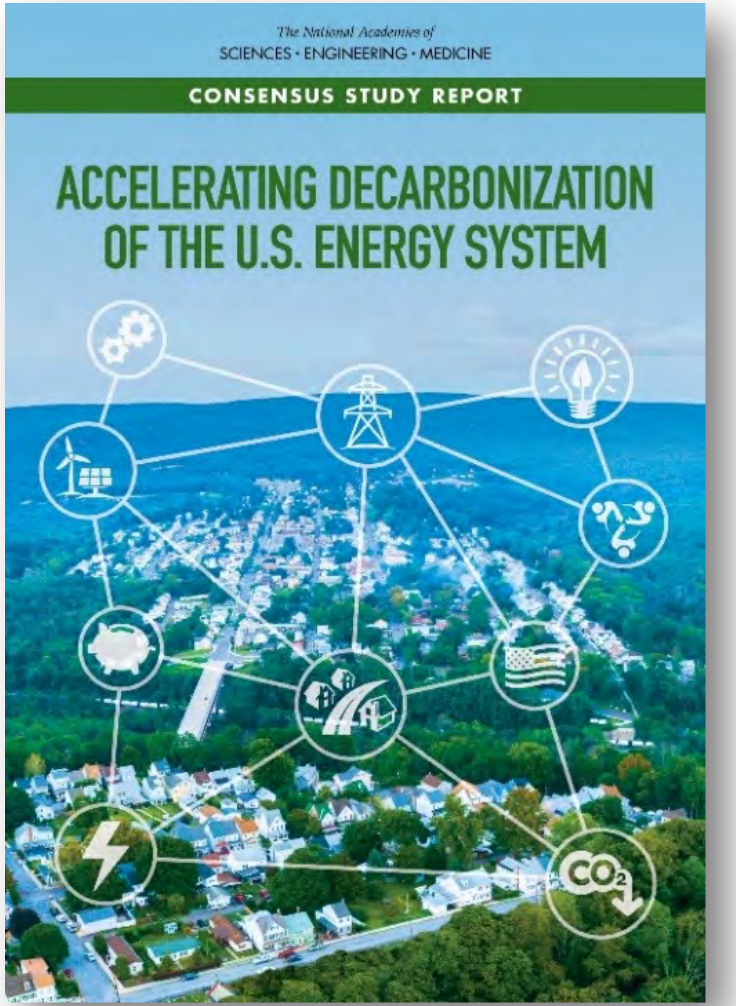
Walkability
Urban Growth Boundaries
Preserving Land

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





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.



Policies Recommended

$40/tCO2 value on carbon, rising 5% per year to 2030

Green jobs $20 billion/year

Green Bank capitalized with $30 billion, plus $3 billion/yr

DOE clean energy RD&D tripled to $20 billion/yr

GI Bill education program in clean energy $5 billion/yr

Energy efficiency block grants of $1 billion/ yr

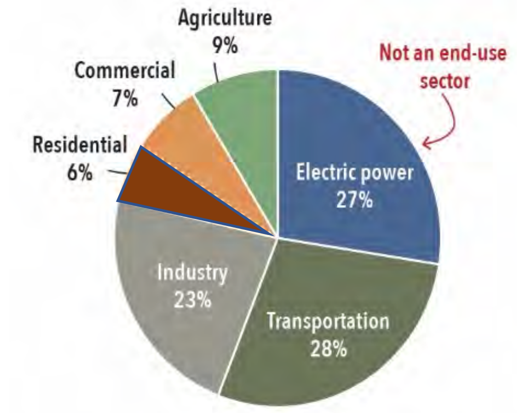
Weatherization tripled to $1.2 billion/ yr

Download the report and policy table at
nap.edu/decarbonization

Join the conversation on twitter with **#USDecarb**

Data to convince National Leadership about the role of the built environment in Decarbonization

1. **Buildings are are critical 40% of the solution – compile the list of quantified actions in order.**
2. Investments in buildings – new and existing are strong economically (per mTCO2) and logistically.
3. Investments in the built environment is key to addressing environmental inequity and employment.
4. Buildings and communities are key to renewable power generation (DER) and load matching.
5. Buildings and land use can sequester carbon as well as direct air capture (DAC) or deep mine CCS.



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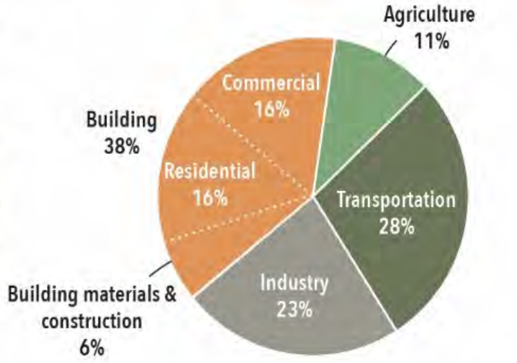

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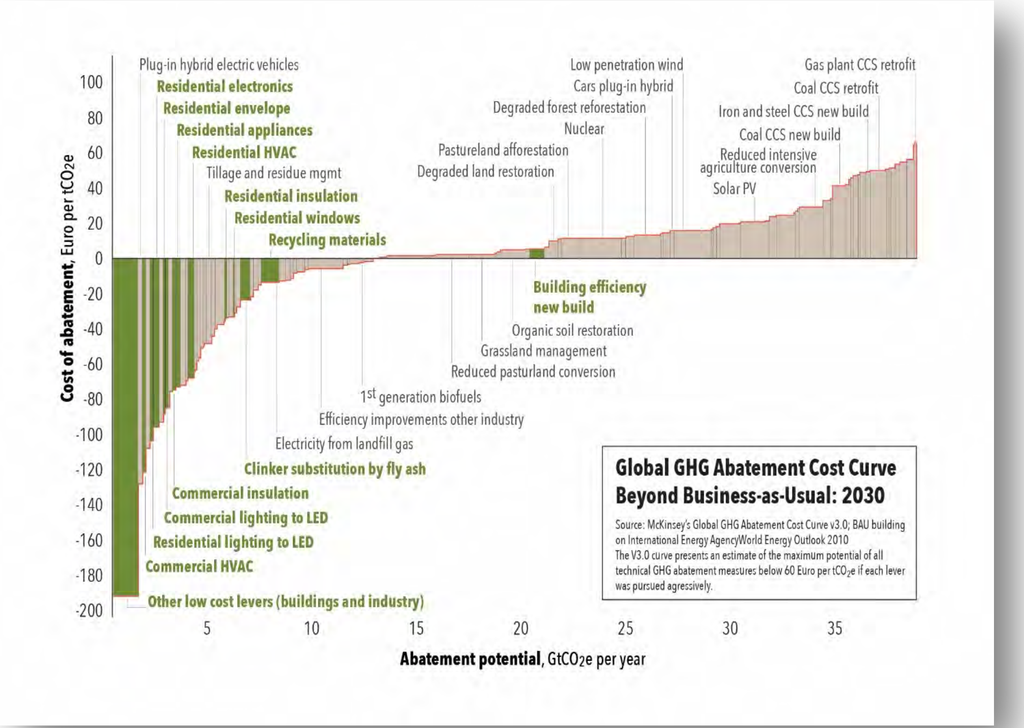

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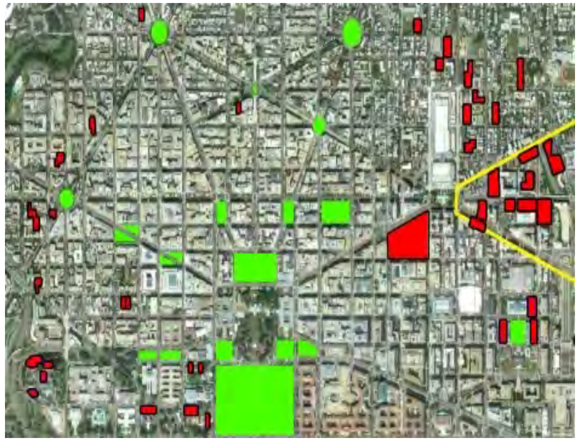
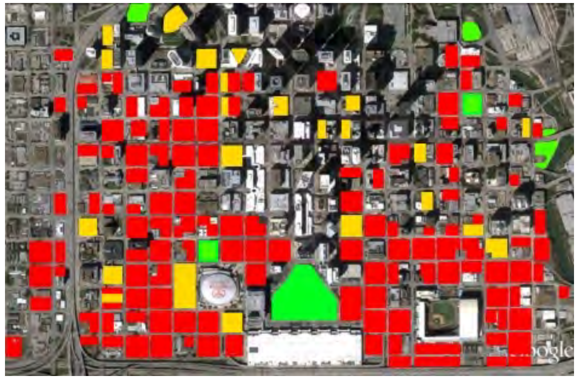


Total area for roads plus surface parking: 44.4%



Total area for roads plus surface parking: 64.7%

And maybe a % of transportation carbon

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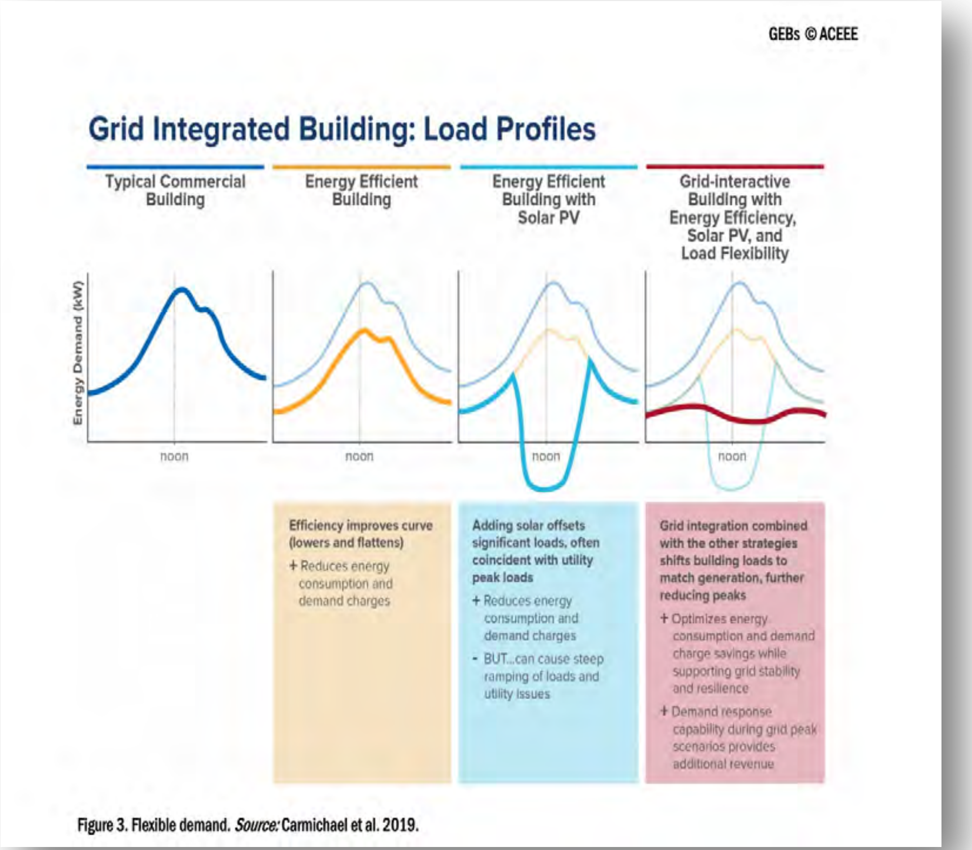

Figure 3. Flexible demand. *Source:* Carmichael et al. 2019.

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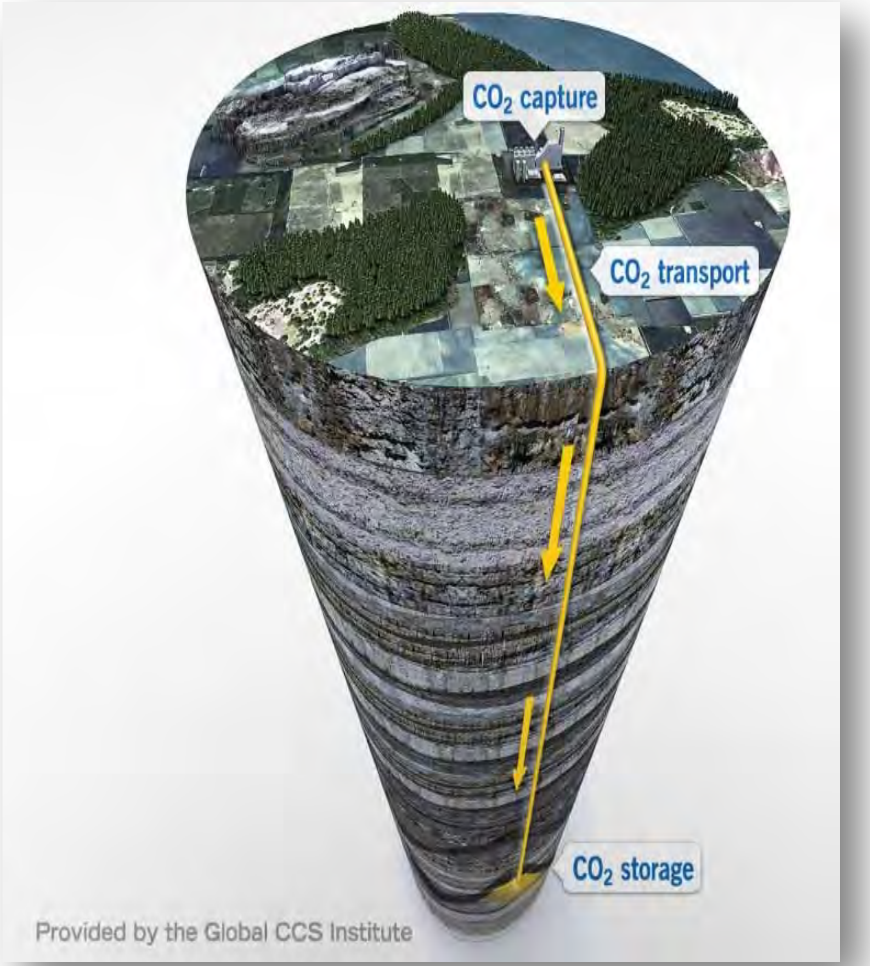

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