BUILDINGENERGY BOSTON

Decarb Do No Harm:
Applying the Hippocratic Oath to Existing Buildings

Sara Kudra, Architecture Towards Neutral
Ilene Mason, Rethinking Power Management
Rand Lemley, DREAM Collaborative

Curated by Jean Carroon

Northeast Sustainable Energy Association (NESEA) | March 21, 2025

Acknowledgement

Massa-adchu-es-et (Massachusett)

Pawtucket

Naumkeag

We Are:

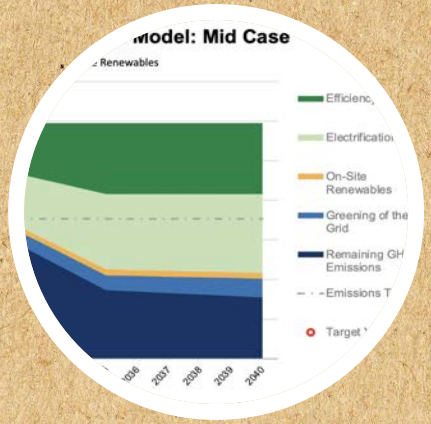
Sara Kudra
Founder/ Principal
Architecture Towards Neutral

Ilene Mason
Founder and CEO
Rethinking Power Management

Rand Lemley
Sustainability Lead
DREAM Collaborative

We Do:

High Performance New Construction



Immediate and Long Term Planning

Existing Building Decarbonization

Why this matters

Why is there an imperative to do this work?
Natural beauty meets human made disaster.

IMAGE: 2014 YOSEMITE WILDFIRE, PALLEY

1975

IMAGE: NESEA

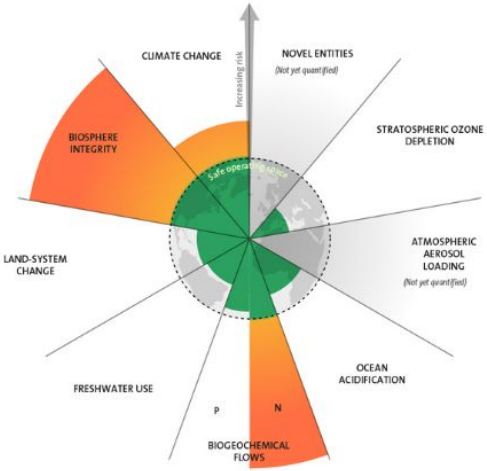
From friend … to foe

When the ocean hits CO2 saturation (predicted year 2025…) we will suddenly be forced to see our true colors

IMAGE: PEXELS

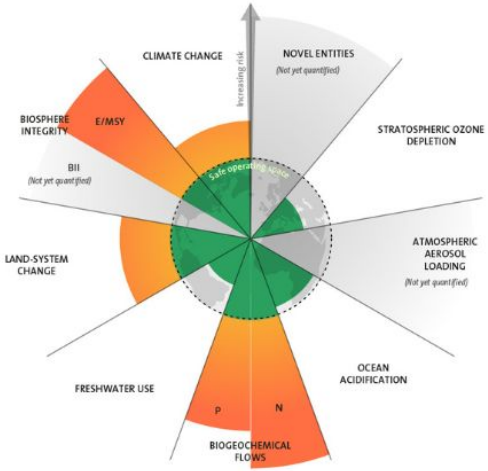
Planetary Boundaries

2009



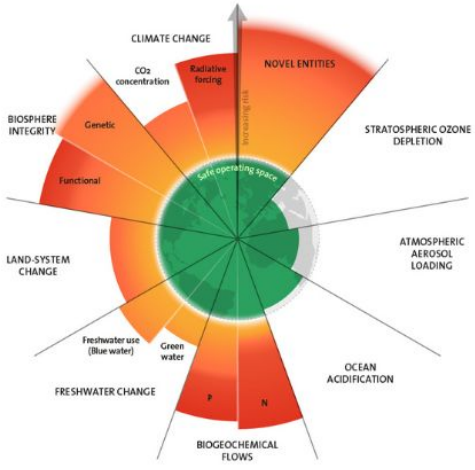
7 boundaries assessed,
3 crossed

2015



7 boundaries assessed,
4 crossed

2023

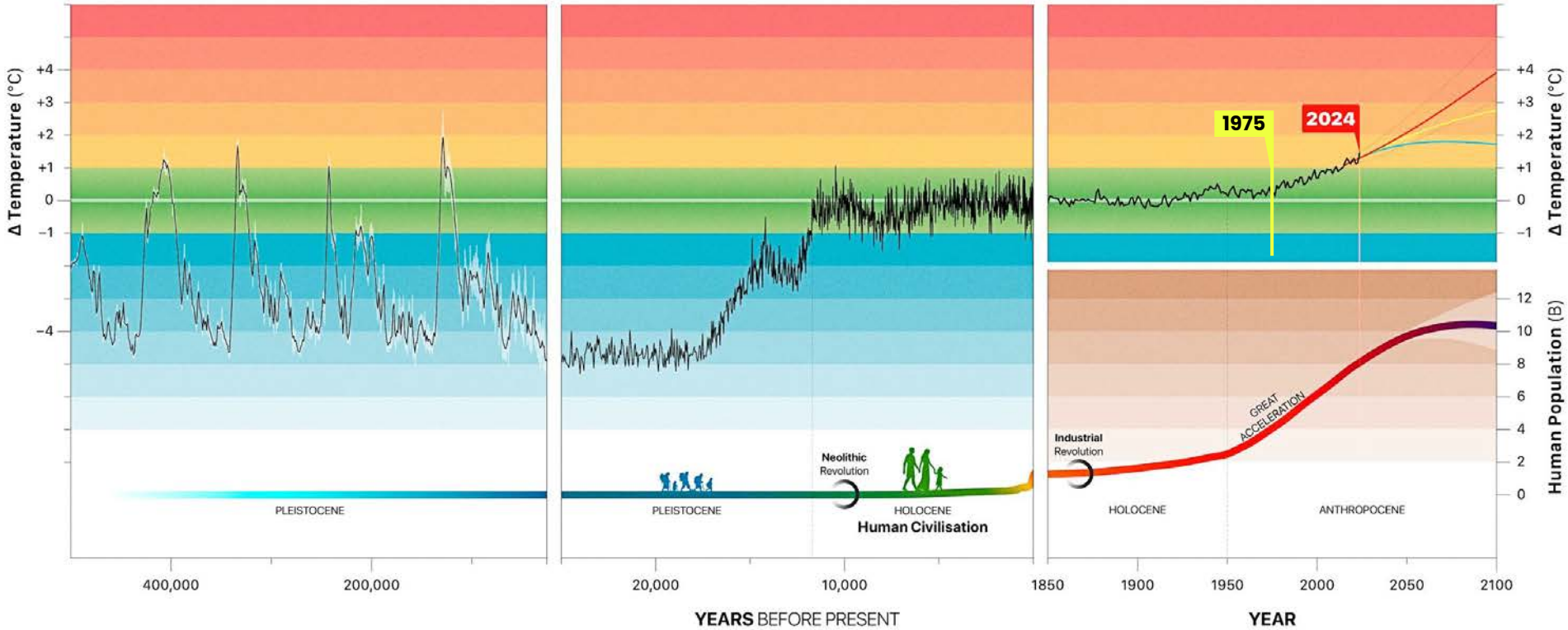


9 boundaries assessed,
6 crossed

IMAGE: STOCKHOLM RESILIENCE CENTRE

Humanity's Journey on Earth

Human Population Size and Global Temperature from 500,000 Years BP Until 2100



Planetary Boundaries Science

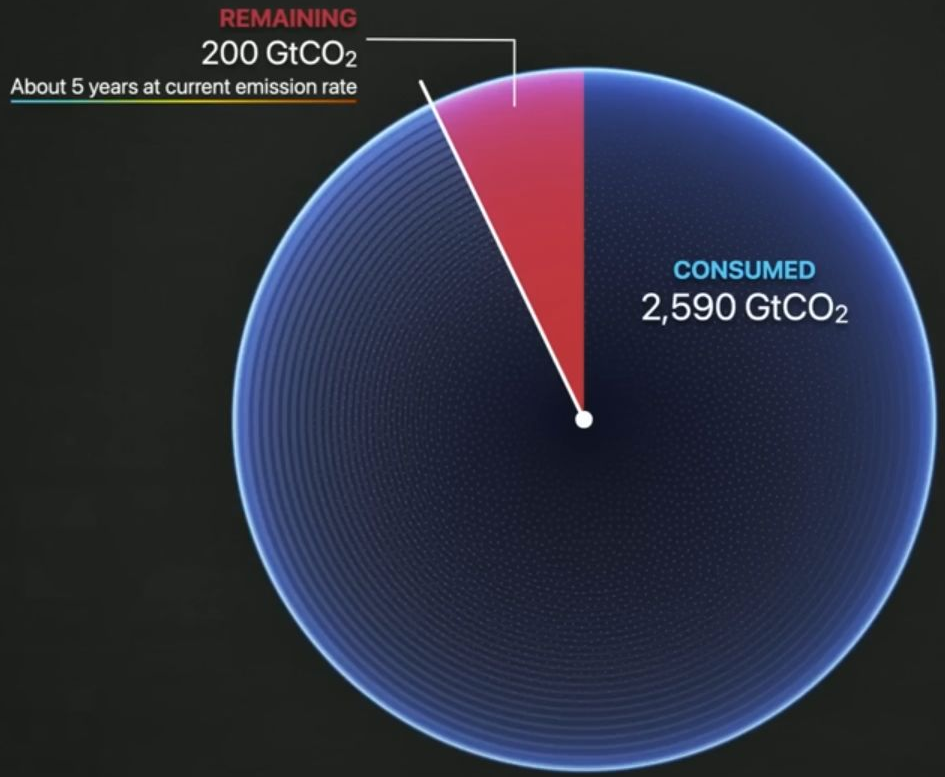
Potsdam Institute for Climate Impact Research

GLOBAÏA

DECARB DO NO HARM

REMAINING CARBON BUDGET

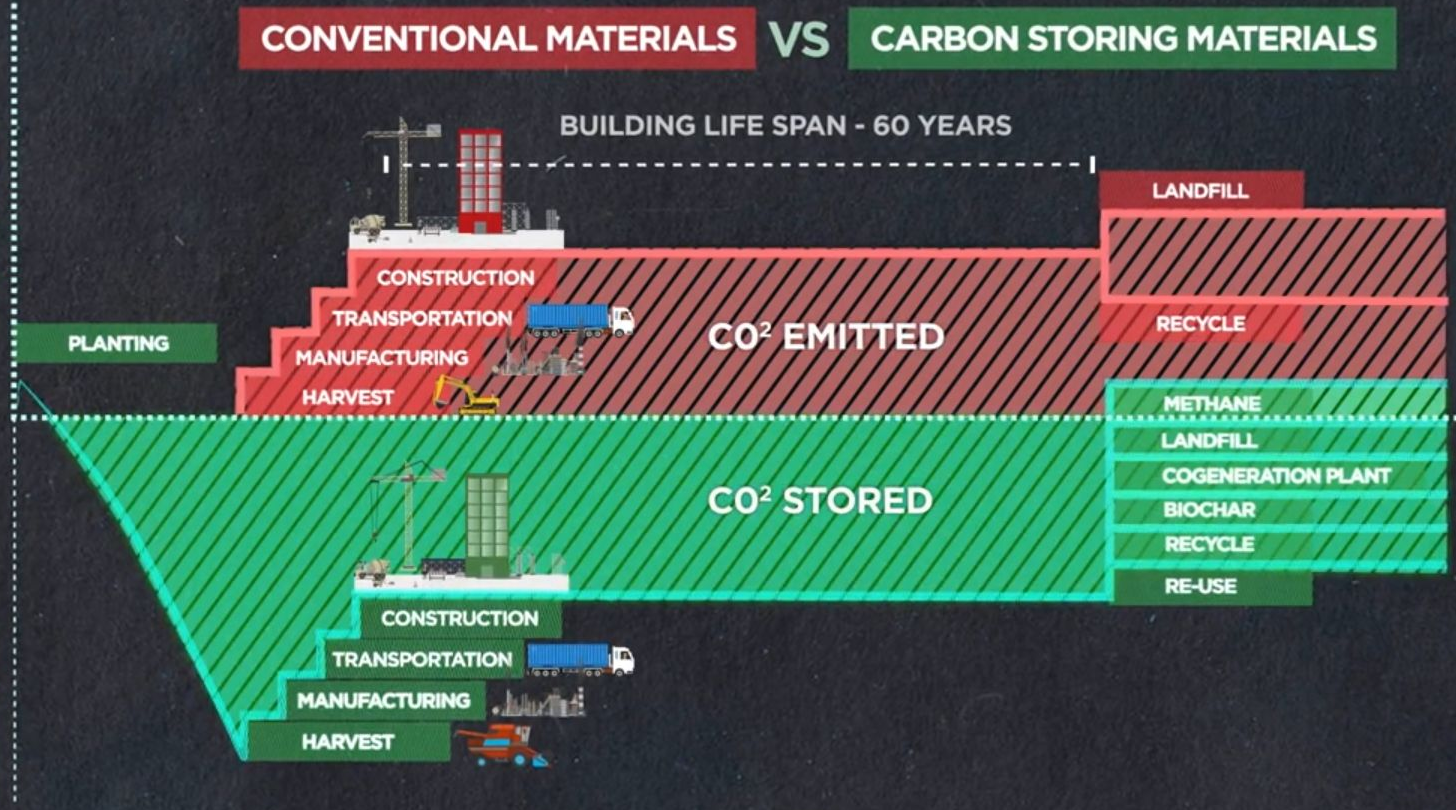
1.5°C (50% likelihood)



Friedlingstein, P., O'Sullivan, M., Jones, M. W., Andrew, R. M., Bakker, D. C. E., Hauck, J., Landschützer, P., Le Quéré, C., Luijkx, I. T., Peters, G. P., Peters, W., Pongratz, J., Schwingshackl, C., Sitch, S., Canadell, J. G., Ciais, P., Jackson, R. B., Alin, S. R., Anthoni, P., … Zheng, B. (2023). **Global Carbon Budget 2023**. Earth System Science Data, 15(12), 5301–5369. https://doi.org/10.5194/essd-15-5301-2023

IMAGE: ROCKSTRÖM, TED, 2024

THE CARBON DIFFERENCE



Global CO_2 Emissions

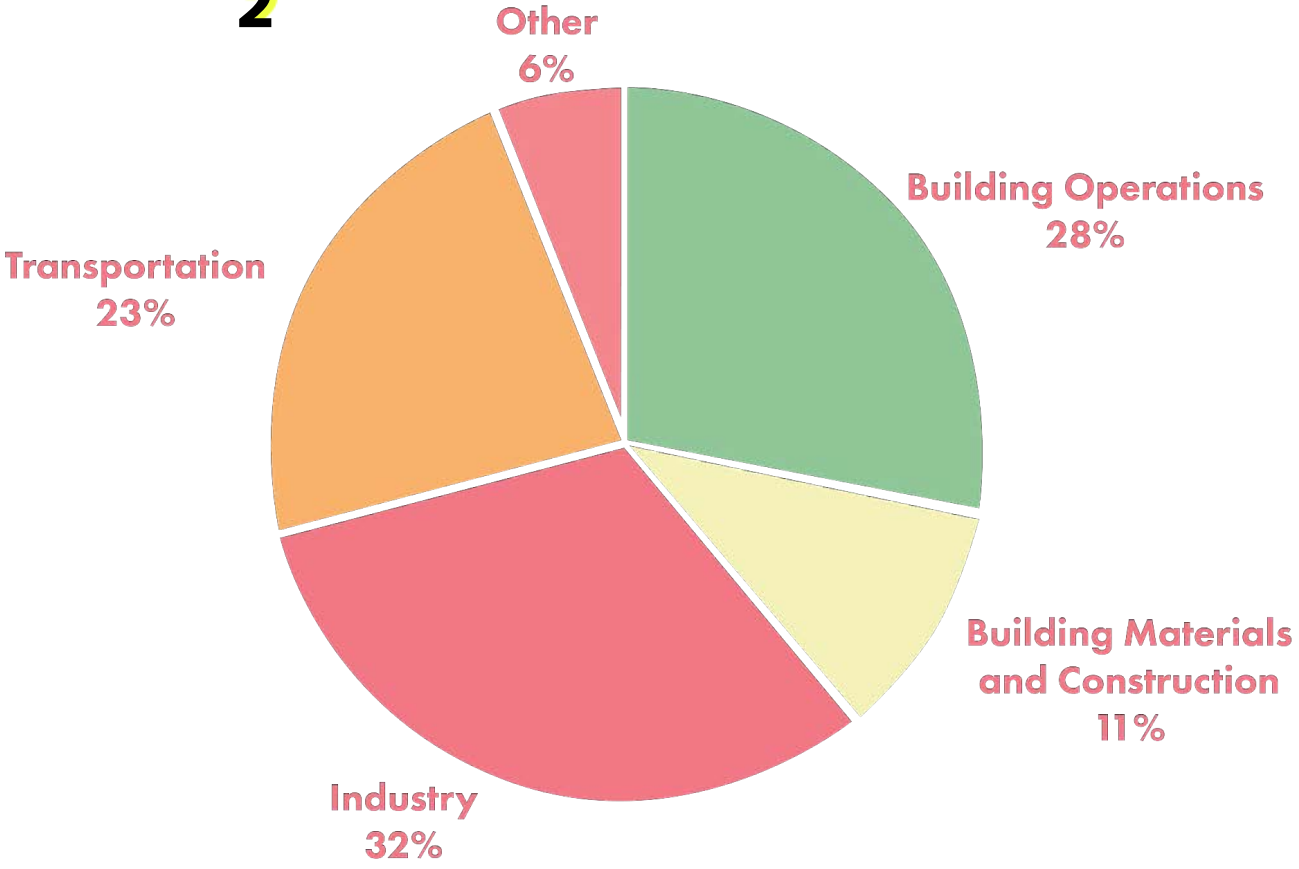


IMAGE: LEMLEY. DATA: ARCHITECTURE 2030

Global CO_2 Emissions + Production

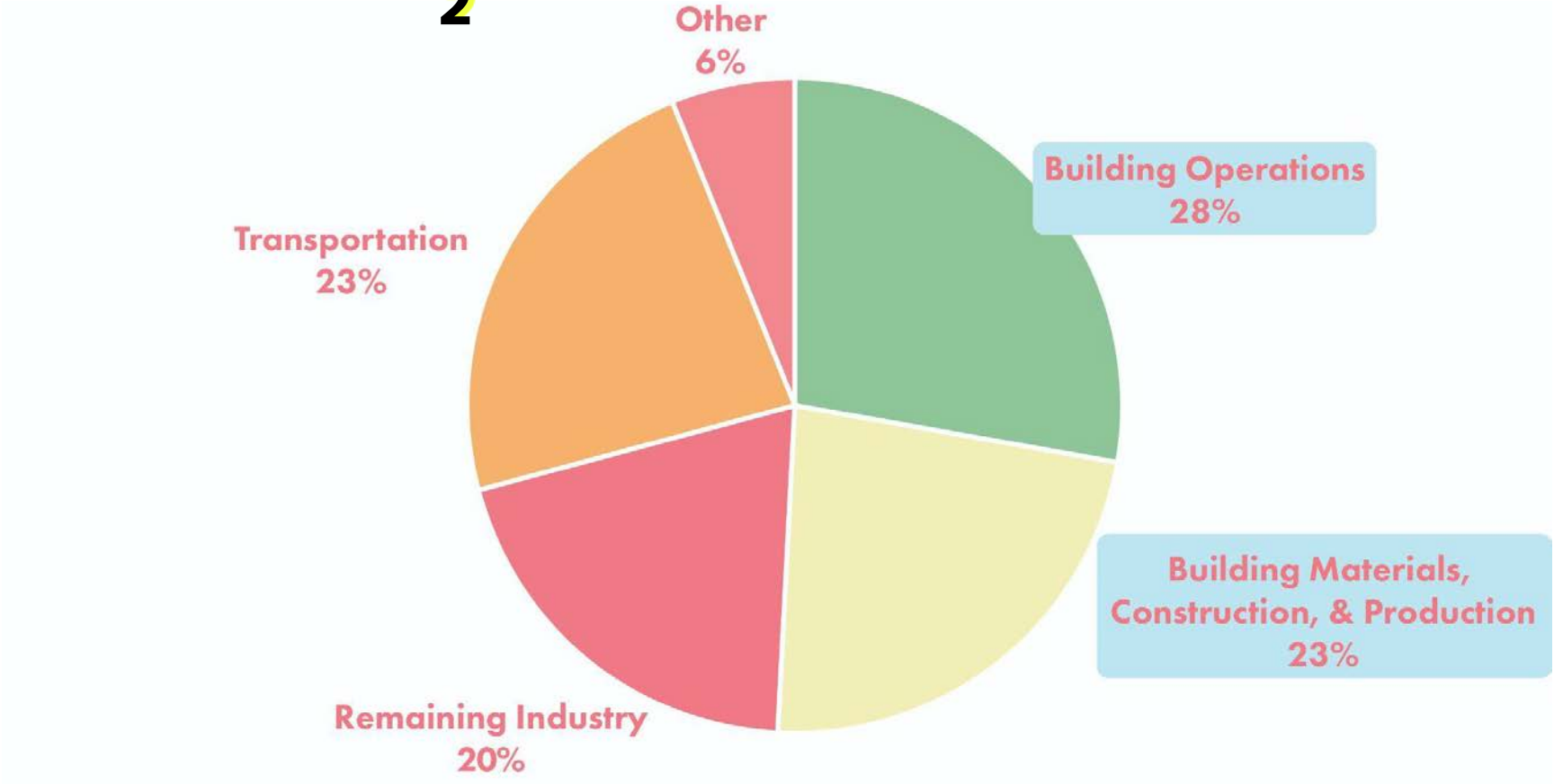
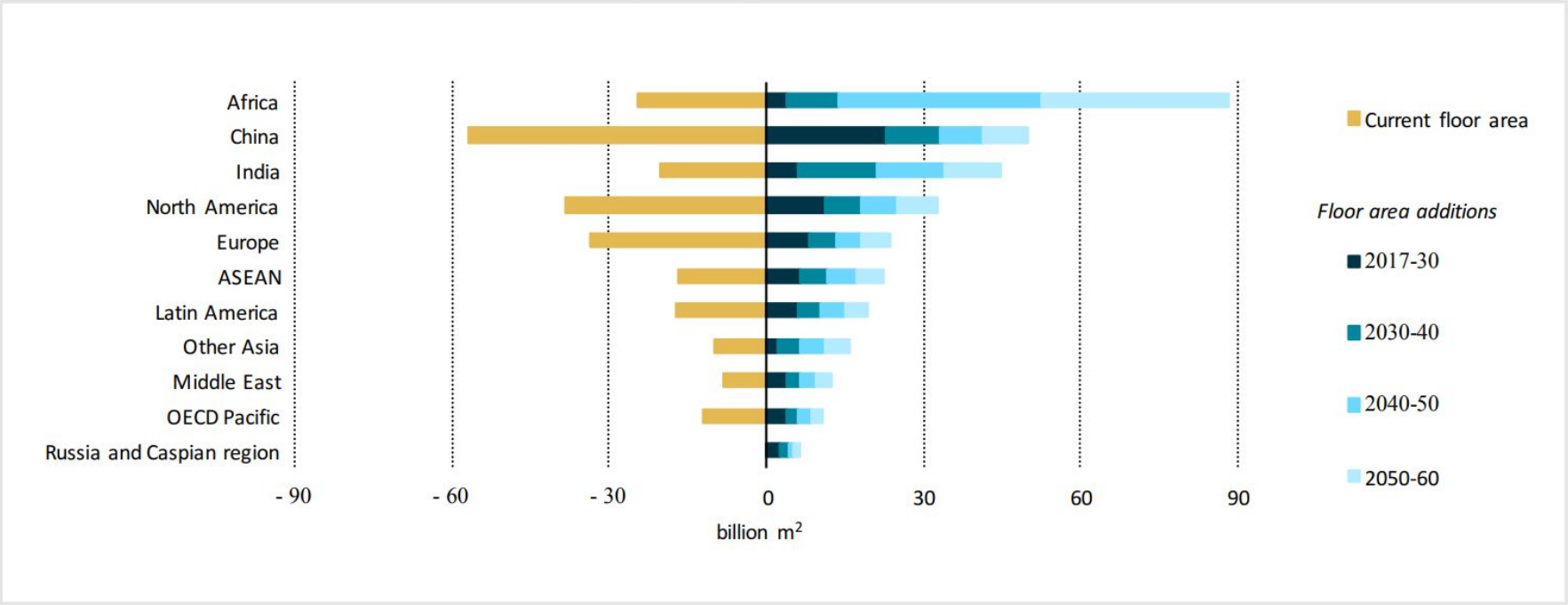


IMAGE: LEMLEY. DATA: ARCHITECTURE 2030

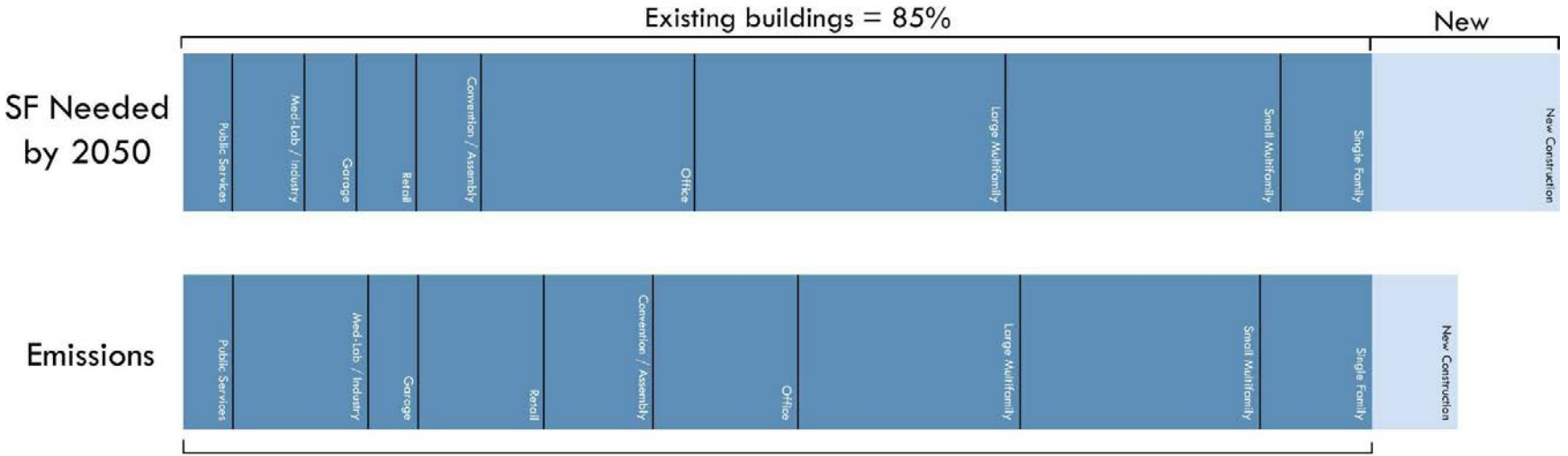
We continue to multiply

FIGURE 3 Floor area additions to 2060 by key regions



Notes: OECD Pacific includes Australia, New Zealand, Japan and Korea; ASEAN = Association of Southeast Asian Nations.
Source: IEA (2017), Energy Technology Perspectives 2017, IEA/OECD, Paris, www.iea.org/etp

Aging buildings use too much!



Existing buildings = **92%** of building emissions in 2050

LET'S GET TO ZERO!

IMAGE: LEMLEY. DATA: CARBON FREE BOSTON 2019

Low-hanging fruit, is there any?

IMAGE: PUBLIC DOMAIN PICTURES .NET

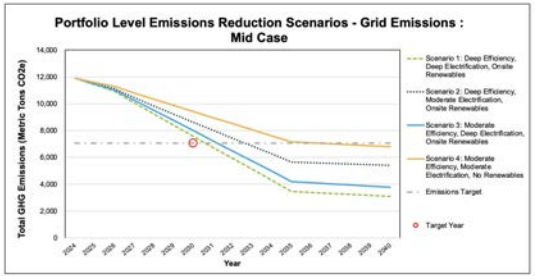
Decarbonization Planning

Scoping studies

Design studies

Scoping Studies

Portfolio Level



Building Level

- Explain the major systems
- Highlight opportunities
- Rough order of magnitude

IMAGE: KUDRA

Design Studies

Pathway	Measures *Indicates Inclusion in Rehab Budget	Emissions Savings (kgCO2e)	Energy Savings (MMBtu)	Est. Solar Production	Total Bundle Cost ($)
Near-Term	1. ERV 2. Exhaust Retro-commissioning 3. In-unit Energy Star patio door replacements* 4. In-unit Energy Star window replacements* 5. Compartmentalization 6. Embue thermostats 7. Multipurpose room RTU replacement 8. Rooftop solar PV 9. Electrical and structural feasibility studies for electrification and solar 10. Exterior insulation feasibility study	187,780 (35% of 2022 emissions)	3,044 (36% of 2022 use)	81,000 kWh (8% of 2022 *electric* use)	$3,640,000
Long-Term	1. Exterior insulation system 2. Cumulative whole building air sealing 3. Heat pump space heating 4. Heat pump DHW	58,096 (11% of 2022 emissions)	1,332 (16% of 2022 use)	N/A	$6,871,000

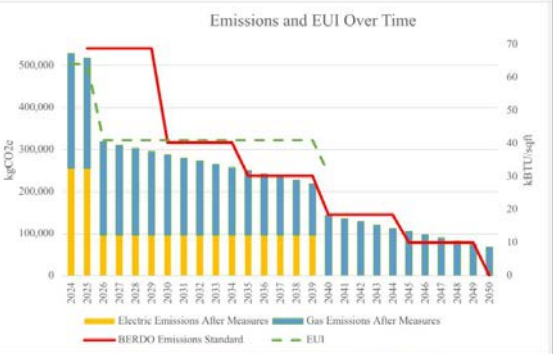


Figure 6: Timeline of Decarbonization Measures and EUI against BERDO Limits

Air sealing can reduce heat loss while mitigating moisture issues and improving occupant comfort. Multiple measures proposed in the timeline, in both near- and long-term bundles, have effects that will improve the air sealing performance of the building. The cumulative effects of these measures were modeled as a 20% overall reduction in envelope leakage. The savings are presented here as a long-term measure to fully account for the large improvement in sealing from the exterior insulation system (Measure 11, above). Proper airtight integration of replacement windows and doors is a critical aspect of this measure, as was confirmed by unit blower door testing. As windows are included as a near-term measure, they should be installed in such a way as to anticipate eventual continuity of the air and moisture control layer. The cost of this measure is included with the Measure 11 cost.

13. Domestic Hot Water Air-to-Water Heat Pump

Estimated Energy Savings: 710 MMBtu

Estimated Carbon Savings: 30,700kgCO2e (5.6% of 2022 Emissions)

Estimated Design Cost: $75,000
Estimated Project Cost: $1,800,000
Total Estimated Cost: ***$1,875,000***

Conversion from gas to electric hot water heating is delayed until future years as today's technologies are less than ideal for a building this size. More specifically, slower recovery rates require significantly more capacity and storage which requires more space and more capital. For today's ballpark planning purposes, Mitsubishi's QAHV system was selected as the basis for design as it uses CO_2 as the refrigerant which has minor global warming potential.

14. Hybrid Variable Refrigerant Flow (HVRF) System

Estimated Energy Savings: 1760 MMBtu

Estimated Carbon Savings: 6300 kgCO2e (1.2% of 2022 Emissions)

Total Estimated Cost: $3,772,000

In this report, full electrification is delayed until future years as the existing boilers are relatively new and today's technologies are less than ideal for buildings this size. For ballpark planning purposes, an HVRF system was selected as the basis of design. An HVRF is a heating and cooling system which consists of outdoor compressors connected to indoor cassettes in tenant units, offices, and common areas. Typical VRF systems run refrigerant piping throughout the entire building, but these "hybrid" systems rely mostly on hydronic piping, a better choice for large multifamily.

An HVRF system would completely replace the existing hydronic heating system and the chiller. Demo costs for the existing boiler and chiller were not included in the project cost.

Stretch break! Discussion

Questions from first half?

Do No Harm

1. **Financing vs project schedule**
2. Avoid wasting client time and money
3. Utility bill impacts
4. Interactions between systems
5. Dewpoint movement

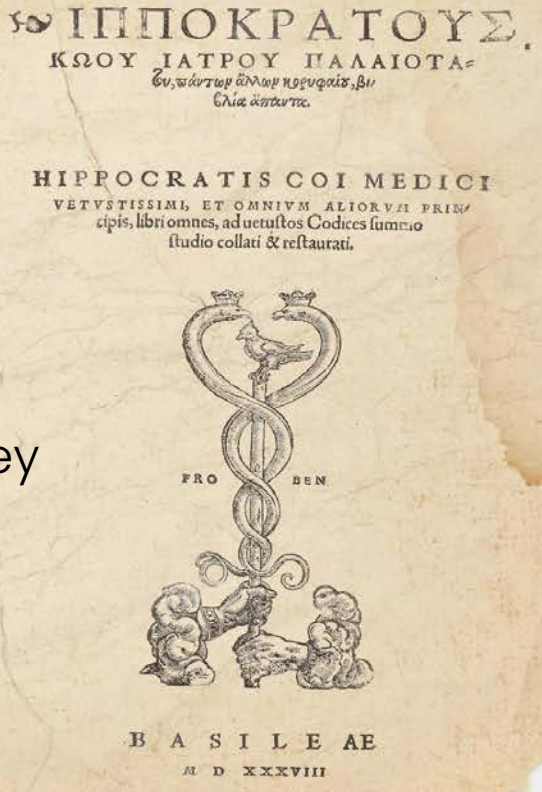


IMAGE: WORKS OF HIPPOCRATES, 1538

Do No Harm

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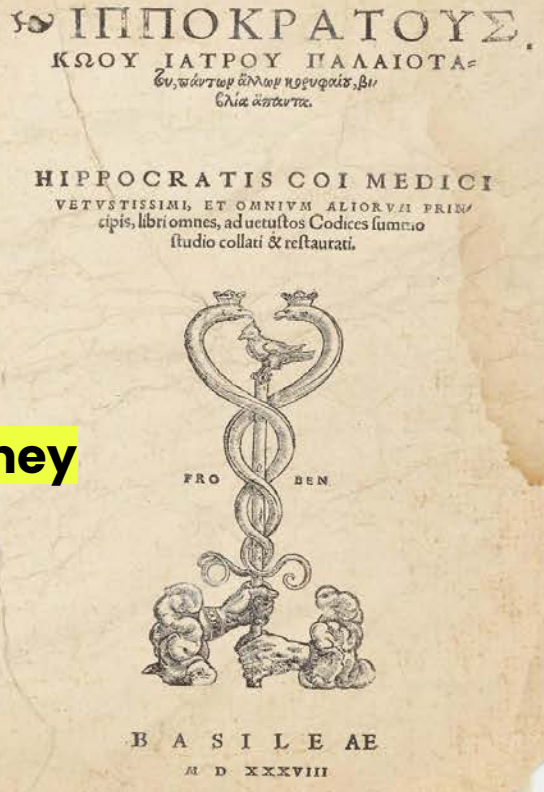


IMAGE: WORKS OF HIPPOCRATES, 1538

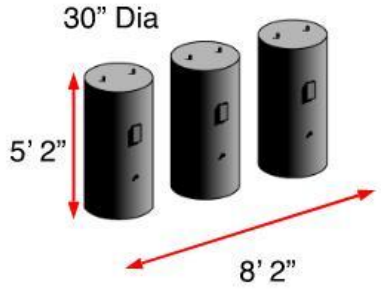
Investigate!

To avoid wasting time and money:

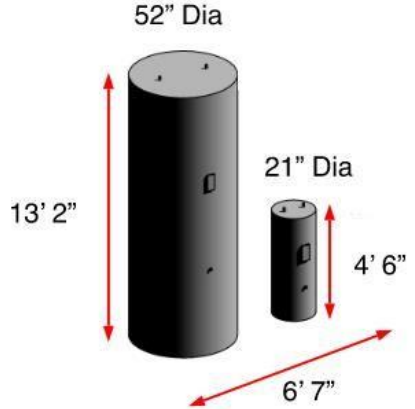
Confirm feasibility and constructability

- Electrical capacity
- Space for equipment
- Structural Integrity
- Building code triggers

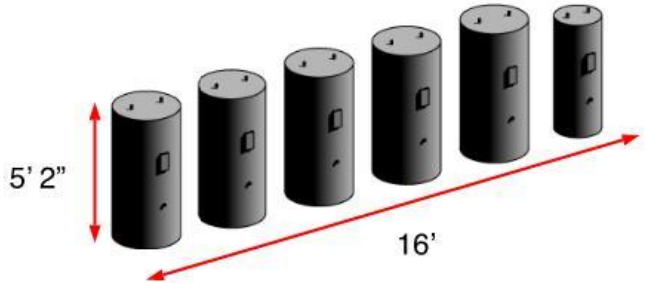
Example: DHW Storage



A: Existing Condensing Boiler Plant DHW Storage tanks



B: HP Storage Tanks - Single ASME



C: HP Storage Tanks - Non-ASME

IMAGE: RPM

Investigate!

To avoid wasting time and money:

Confirm feasibility and constructability

- Electrical capacity
- Space for equipment
- Structural Integrity
- Building code triggers

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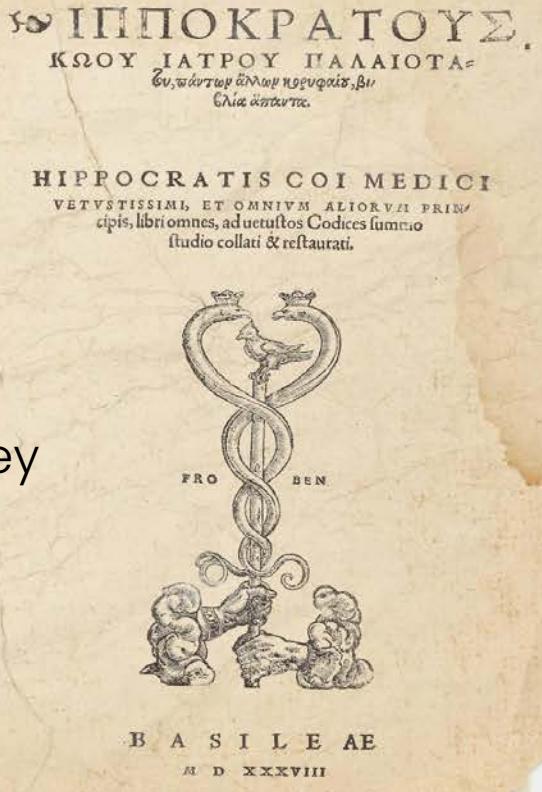
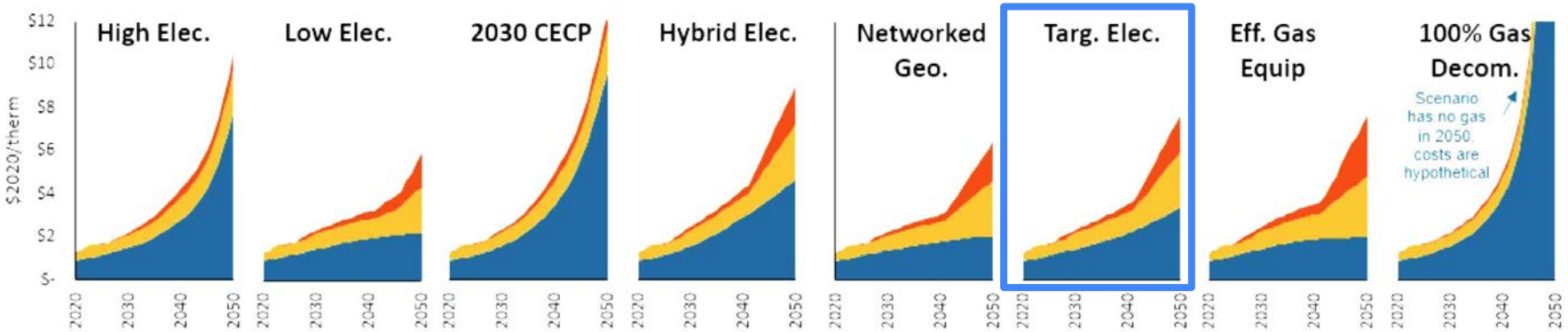


IMAGE: WORKS OF HIPPOCRATES, 1538

Gas Price Futures



COMMODITY COST (CONSERVATIVE)

CONSERVATIVE (OPTIMISTIC)

DELIVERY RATE

VOLUMETRIC RESIDENTIAL RATES INCLUDING DELIVERY COSTS AND COMMODITY COSTS ($/THERM)

IMAGE: DECARBONIZATION PATHWAYS REPORT, MA

Gas Prices vs Electric Prices

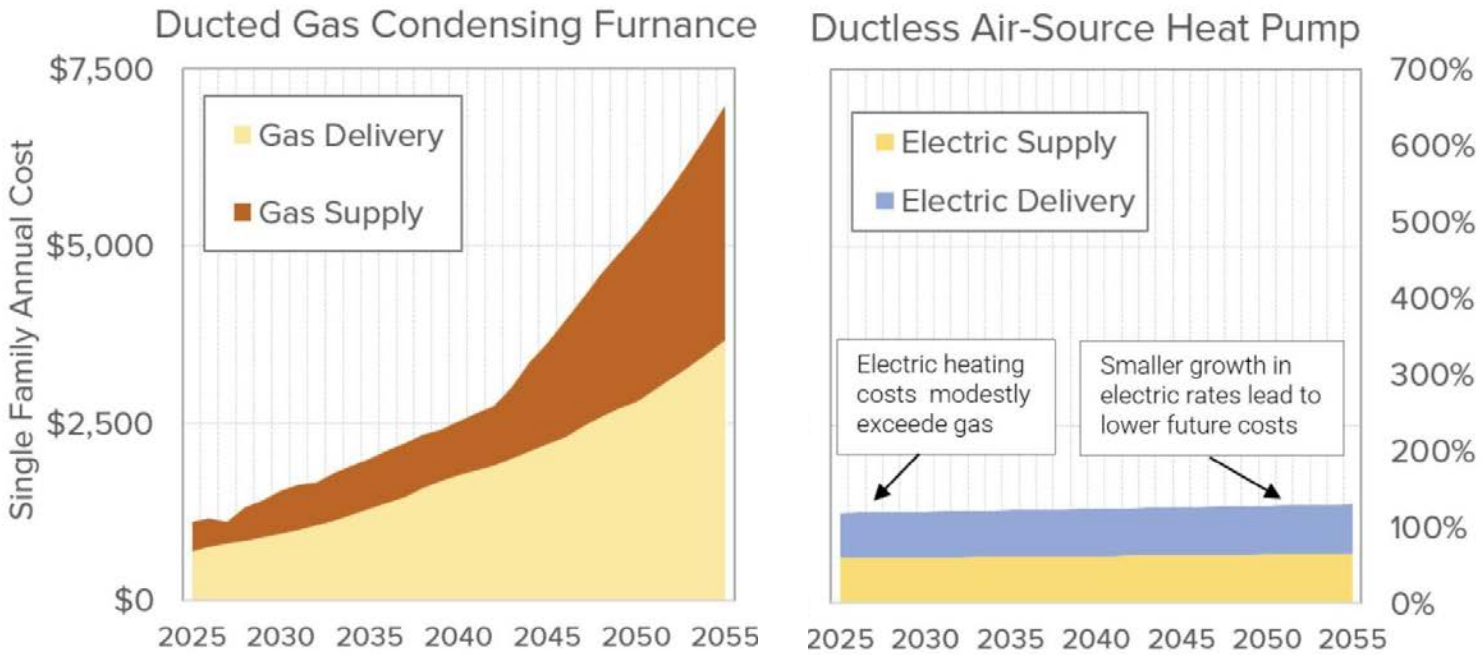


IMAGE: GROUNDWORK DATA AND ZERO CARBON MA

Savings of Electric vs Gas

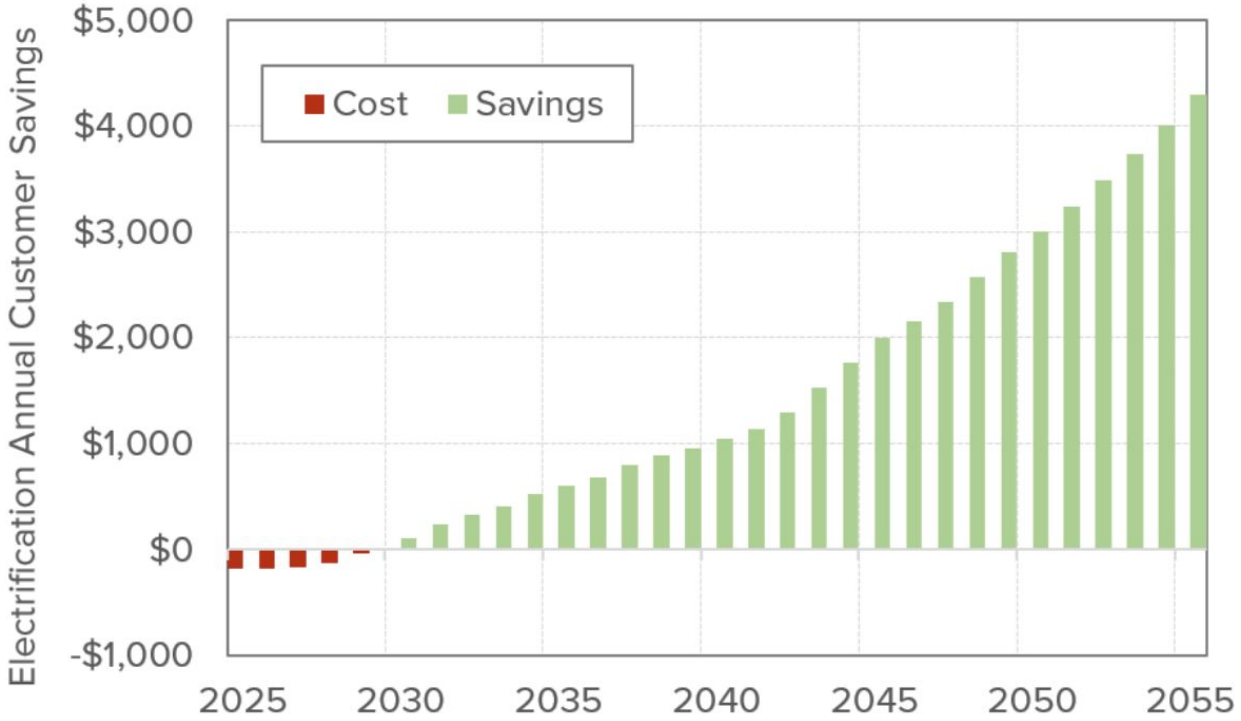


IMAGE: GROUNDWORK DATA AND ZERO CARBON MA

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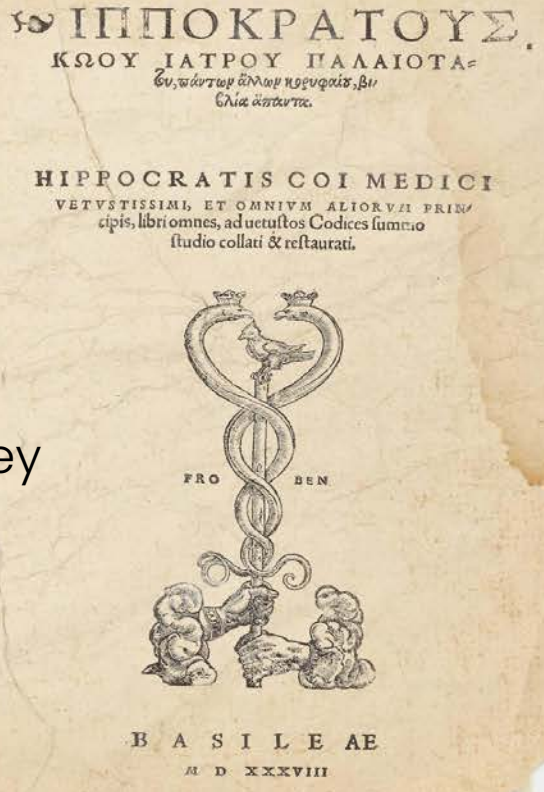
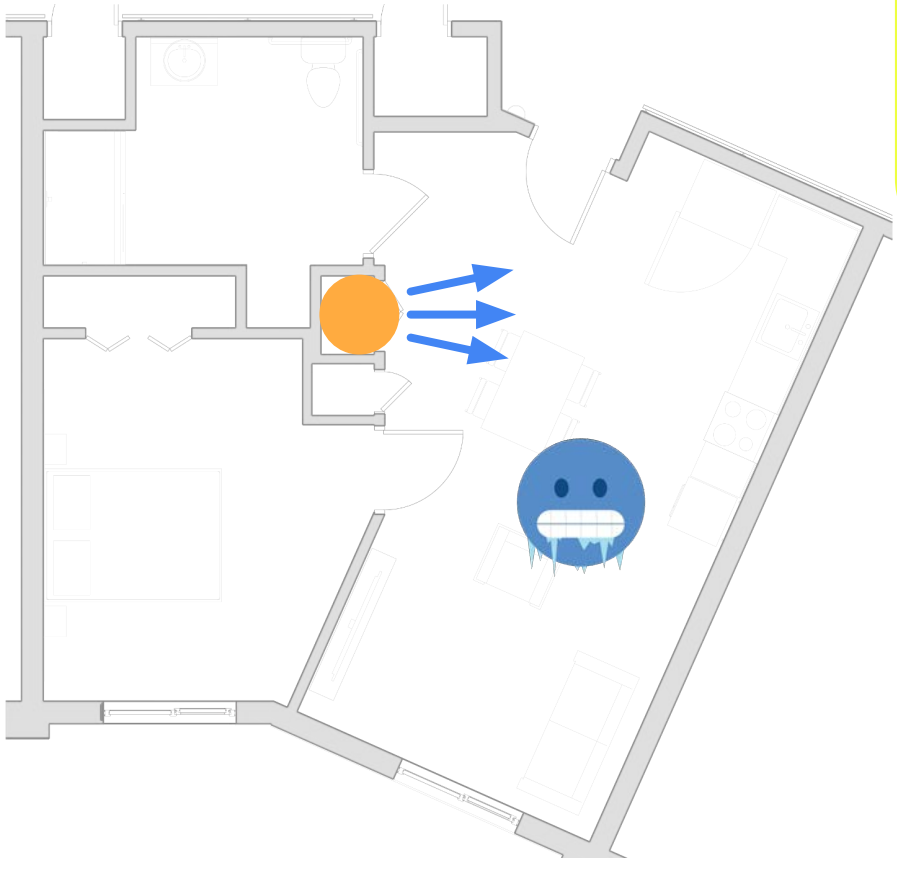
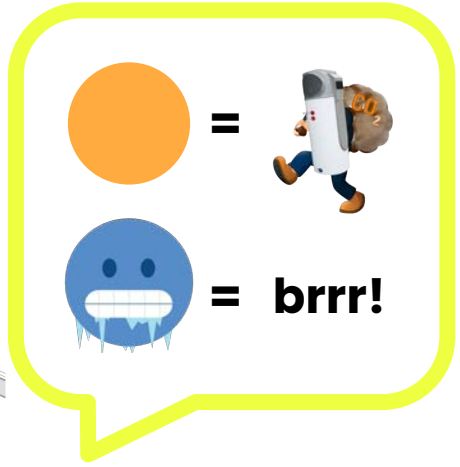


IMAGE: WORKS OF HIPPOCRATES, 1538

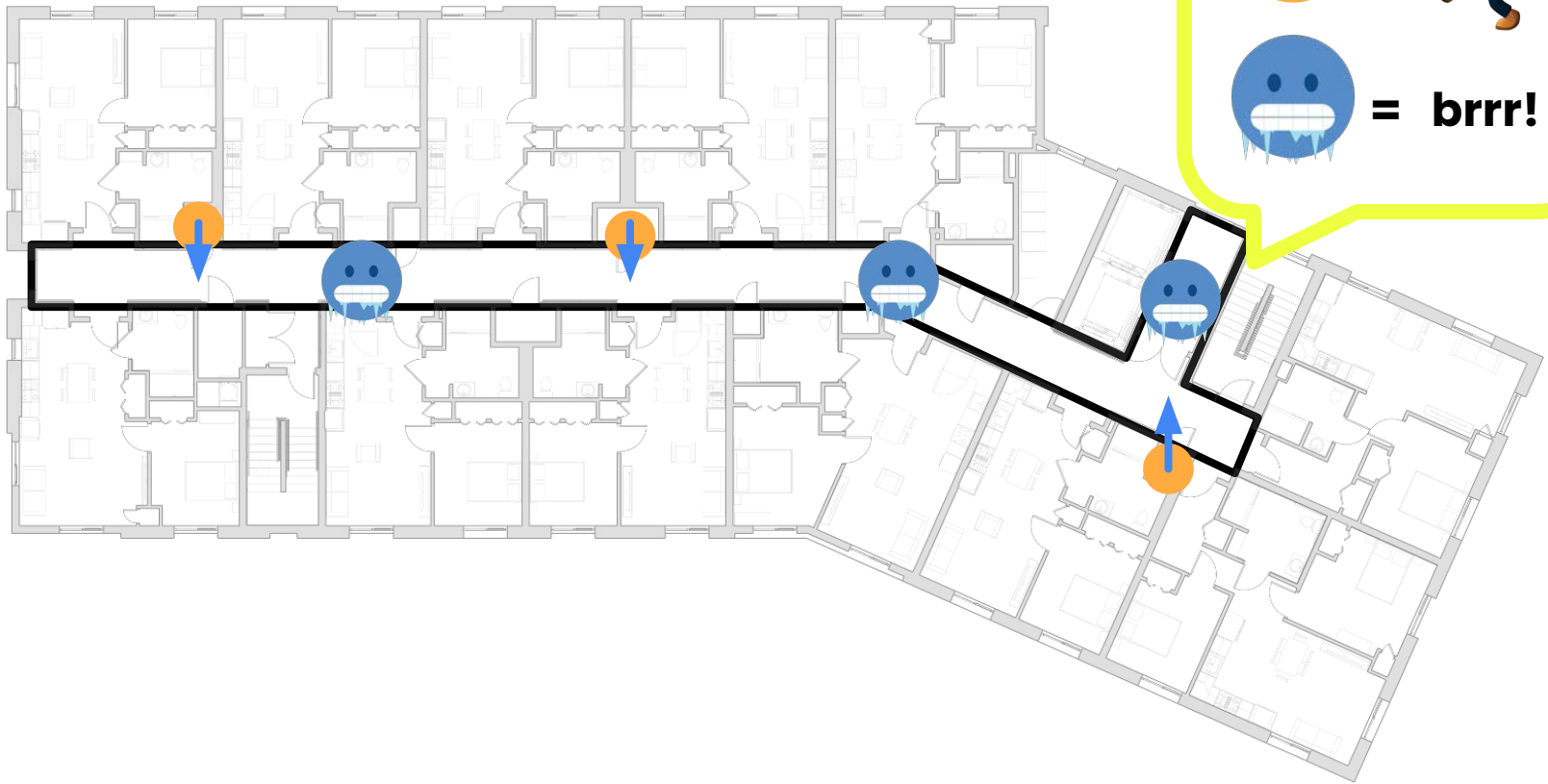
IMAGE: LEMLEY + STOCK IMAGES

HPHW: In-Unit





HPHW: In-Corridor



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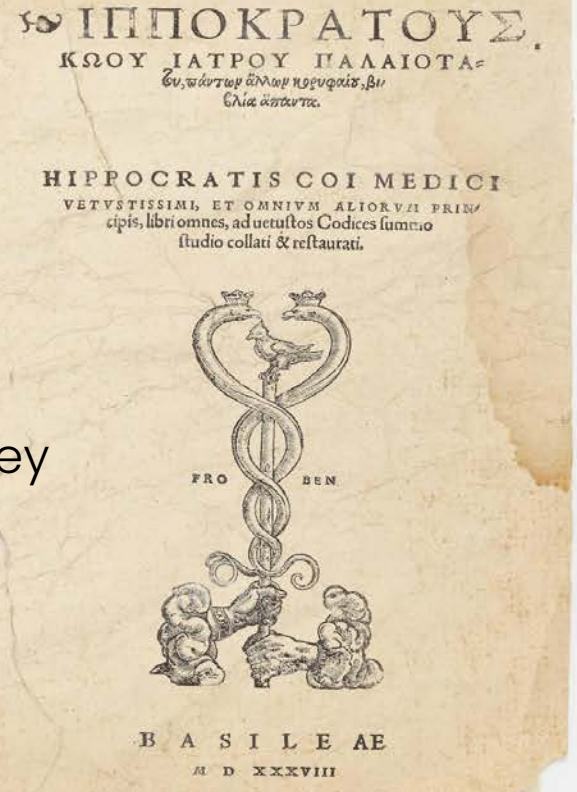


IMAGE: WORKS OF HIPPOCRATES, 1538

DECARB DO NO HARM

Newsworthy

theguardian

Mon 12 Aug 2024 04.00 EDT

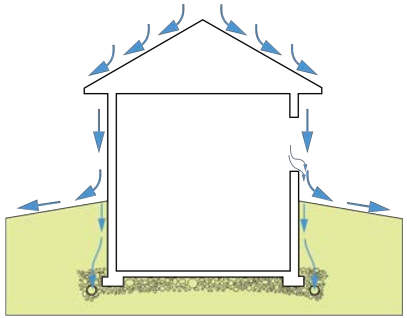
‘They encouraged us to insulate our home. Now it’s unmortgageable’

UK householders are angered by the discovery they cannot remortgage or sell their homes after installing spray-foam insulation to cut energy use

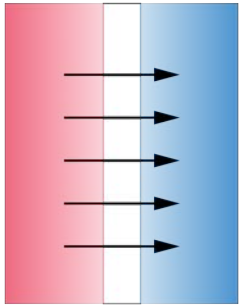
Jim Bunce and his wife Liz had their retirement hopes dashed after installing spray-foam insulation and couldn’t get an equity release mortgage. Photograph: Richard Saker/The Observer

Jim Bunce thought he was doing the right thing for his purse and the planet: in 2022, as fuel costs soared, he and his wife decided to improve the energy efficiency of their house.

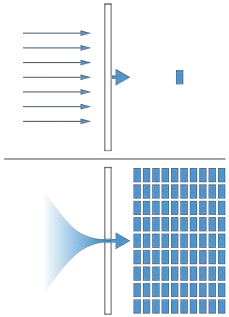
Moisture Transfer and Dewpoint



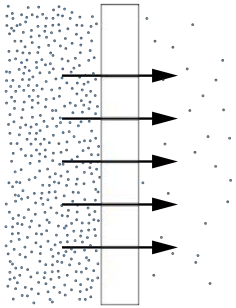
Drainage



Warm-to-Cold



Discontinuous Air Barriers



Vapor Diffusion

Capillary Action

IMAGE: LEMLEY

Moisture Transfer and Dewpoint

BRICK AND CMU ARE ***NOT*** AIR CONTROL

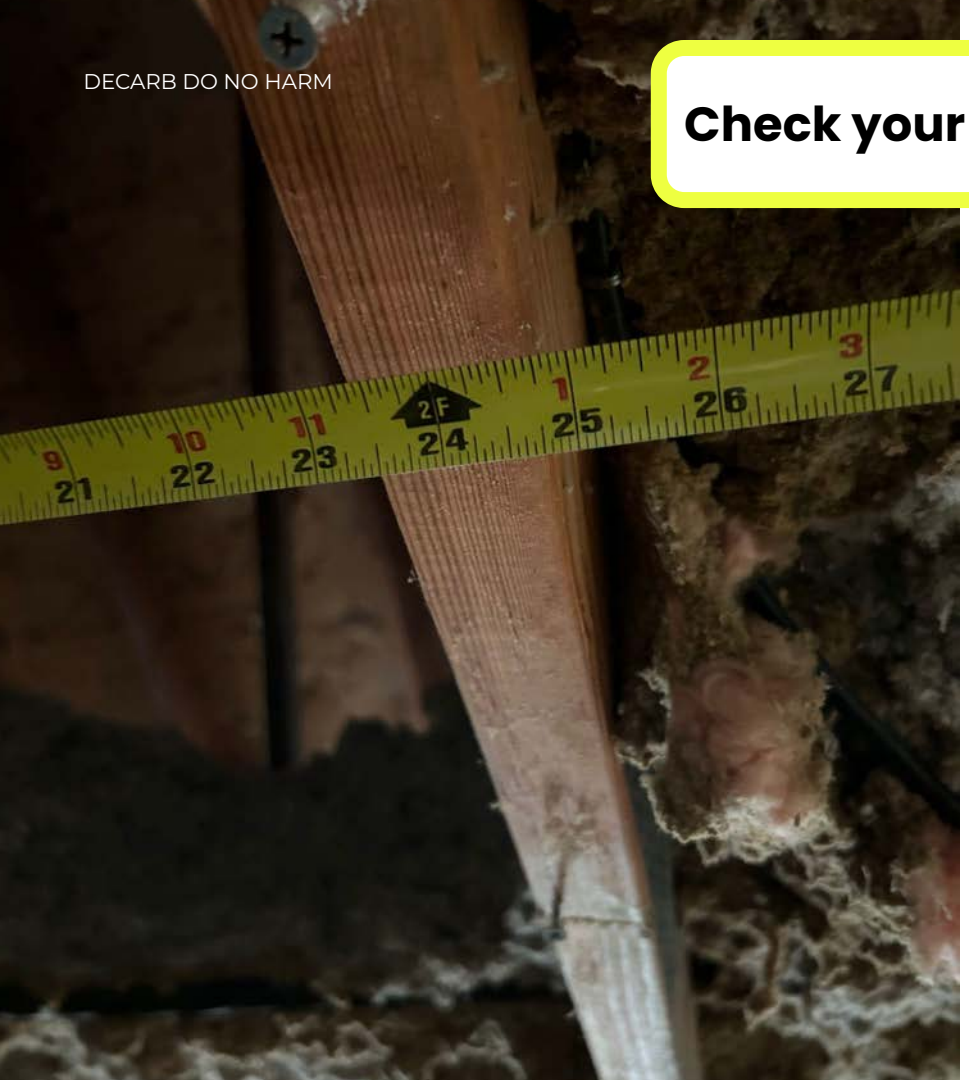
BRICK AND CMU ARE ***NOT*** VAPOR CONTROL

Look out for hidden attic spaces!

IMAGE: RPM

DECARB DO NO HARM

Check your structure!



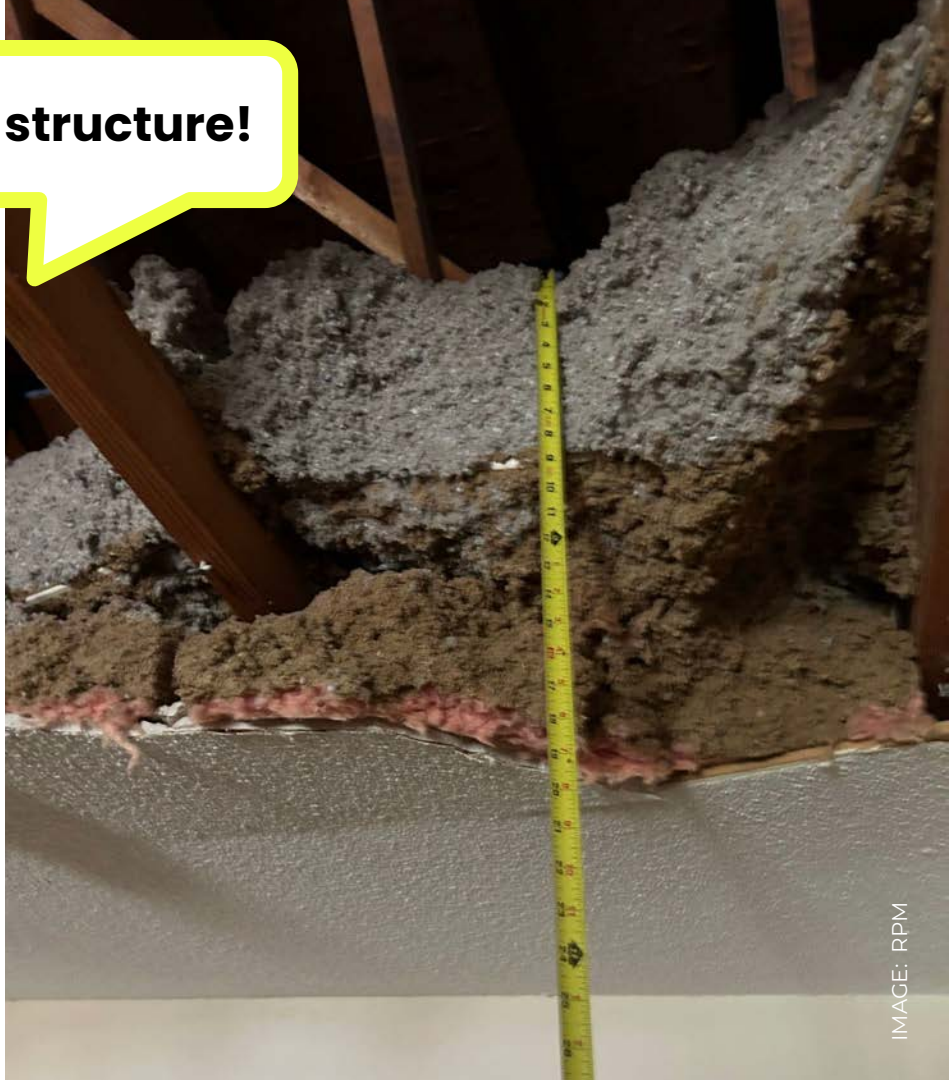


IMAGE: RPM


Causing costly (but clever) repair
IMAGE: RPM

Takeaways

Use LESS

Electrify wisely and carefully/ strategically

BE PREPARED

Q&A

DER Resources for Owners – US DOE

Framework for Emissions Reduction Planning: Building Portfolios
Framework for Emissions Reduction Planning: Industrial Portfolios
Emissions Reduction Audit: A Checklist for Owners
Emissions Reduction Audit Scope of Work Template

For Practitioners – NREL

Emissions Reduction Audit Scope of Work Template
Cold Climate Air Source Heat Pumps (ccASHPs) Technology