NEEA Product Council – Spring 2024

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About the UW IDL

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College of Built Environments
Department of Architecture
Integrated Design Lab
at the Bullitt Center

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UW IDL Annual Report

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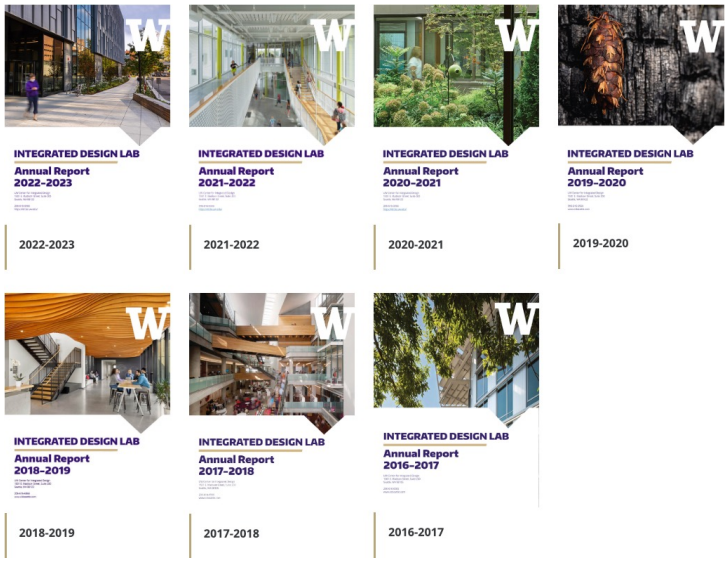

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Healthcare Decarbonization

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Hospital Decarbonization Guide

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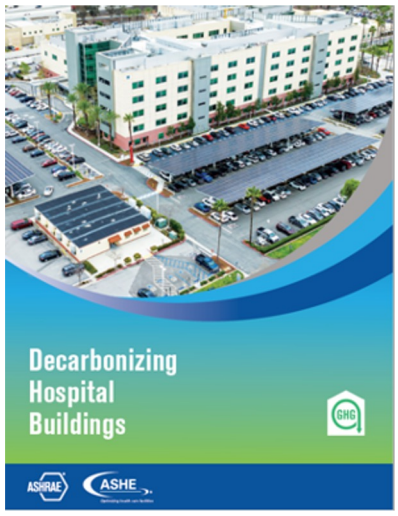
ASHRAE Decarbonizing Hospital Buildings Guide

ASHRAE Position Document Alignment:

- Net-Zero emissions of operational GHG
- 40% reduction in embodied carbon



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Healthcare – Disproportionate Emitter

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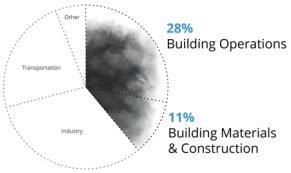
US Healthcare spending in 2021 was $4.3 trillion. This represents a whopping ***18% of the national GDP***.

CMS.gov

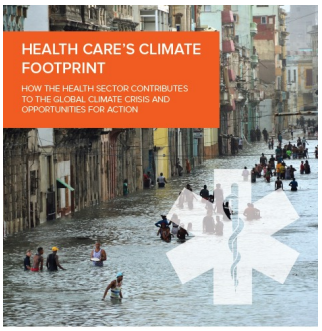
8.5%

Healthcare's contribution to US emissions

Eckelman, Matthew J, Kaixin Huang, Robert Lagasse, Emily Senay, Robert Dubrow, and Jodi D Sherman. "Health Care Pollution And Public Health Damage In The United States: An Update." *Health Affairs Web Exclusive* 39, no. 12 (2020): 2071-079.



Data Sources: Global ABC Global Status Report 2018, EIA



ARUP

Health Care Without Harm
Climate-smart health care series
Green Paper Number One

Produced in collaboration with Arup
September 2019

https://noharm-uscanada.org/content/global/health-care-climate-footprint-report

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Energy Use by Country

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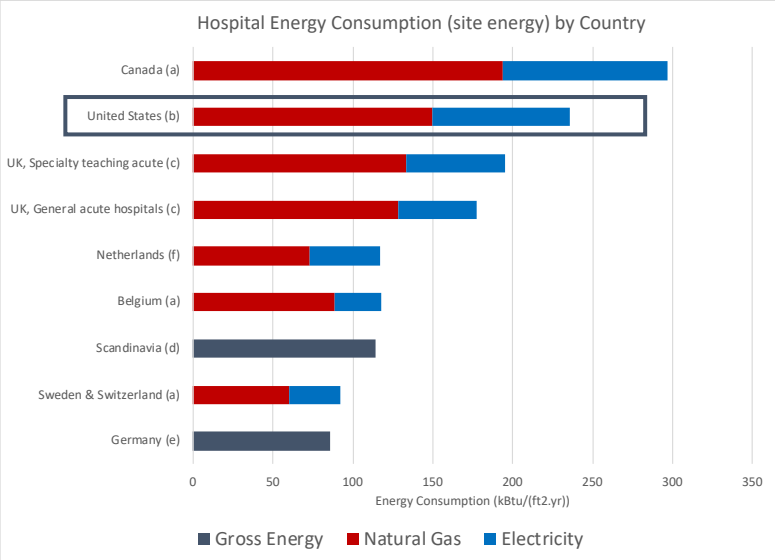
at the Center for Integrated Design



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In Context of Other Nations

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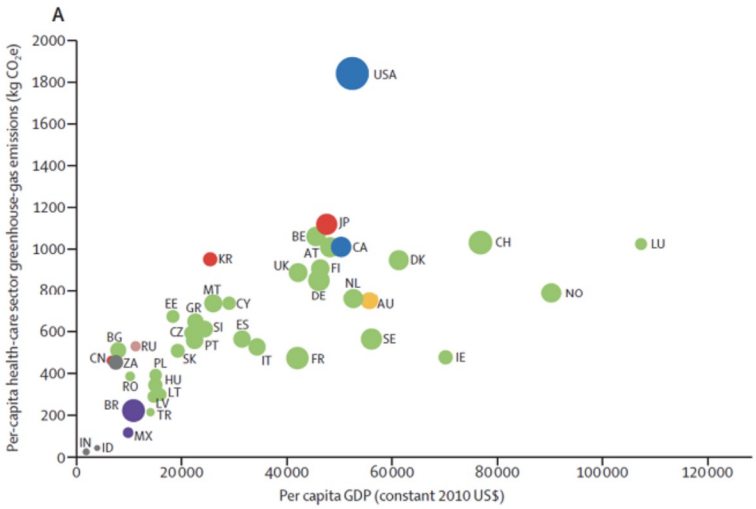
If global healthcare were a nation, it would be the 5th largest source of emissions on the planet.

Healthcare's Environmental Footprint



(A) Health-care sector emissions as a function of GDP per capita (bubble widths indicate the proportion of national spending on healthcare).

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In Context of Other Building Types (in US)

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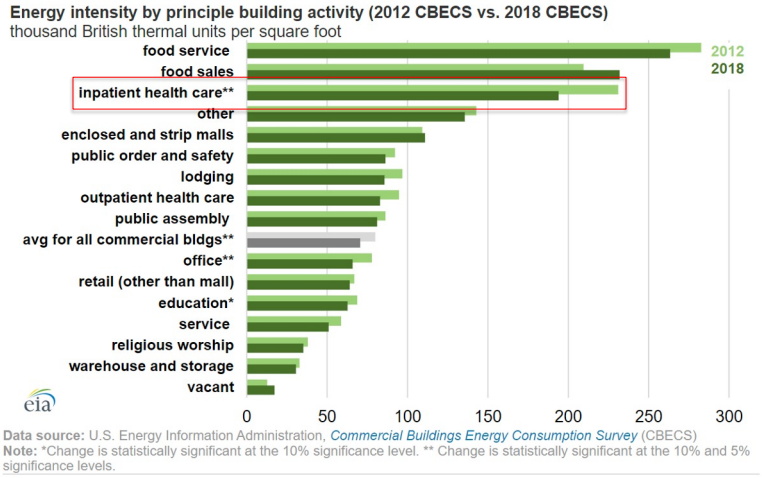
US hospitals are the second most intensive building type per square foot

Healthcare is the 3rd most energy intensive building type (kBTU/sf)



Data source: U.S. Energy Information Administration, *Commercial Buildings Energy Consumption Survey* (CBECS)
Note: *Change is statistically significant at the 10% significance level. ** Change is statistically significant at the 10% and 5% significance levels.

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Position Statements on Decarbonization

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American Society for Healthcare Engineering (ASHE)

Decarbonizing the U.S. health care footprint is an important and necessary step to mitigating the effects of climate change. ASHE supports the decarbonization of health care and is dedicated to leading the field by providing tools and resources to both reduce the health care carbon footprint and to inform public policy.

American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE)

By 2030, the global built environment must at least halve its 2015 GHG emissions, whereby

- All new buildings are net zero GHG emissions in operation,
- Widespread energy-efficiency retrofits of existing assets are well underway, and
- Embodied carbon of new construction is reduced by at least 40%.

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Hospital Decarbonization Guide

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ASHRAE WORKING GROUP

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Kara Brooks American Hospital Association	**Shanti Pless** National Renewable Energy Labs
Travis R. English Kaiser Permanente	**Kim Shinn** TLC Engineers

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Forwards

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Foreword by
Dr. Kristie Ebi, PhD, MPH, MS

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Foreword by Dr. Victor Dzau, President of the Institute of Medicine

NATIONAL ACADEMY of MEDICINE

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Boundaries

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- ALL GHGs
- NEW buildings
- HOSPITALS
- NOT regurgitate everything under the sun about how to save energy in hospitals
- ONLY Building-related emissions
- GHG Protocol (vs any others)
- Strong Focus on what is hard / unique
- Because ASHE publication, focus on operational implications

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Three Scopes of Emissions – Organization of Guide

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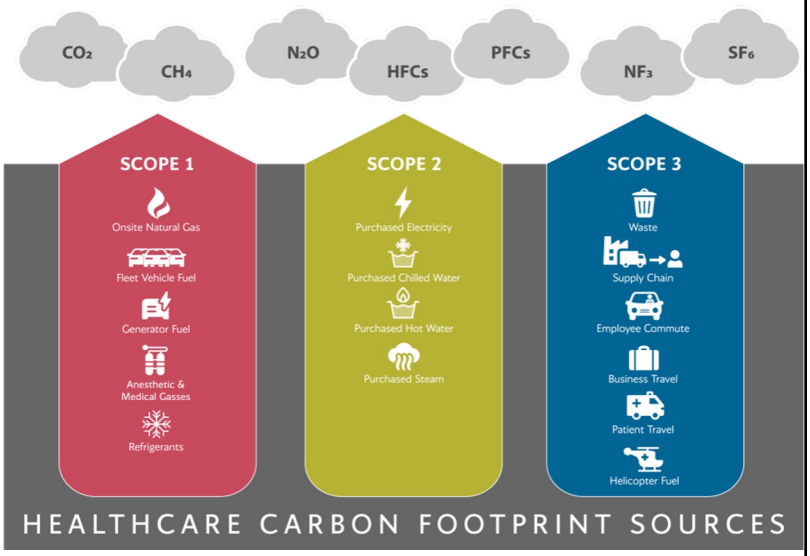
SCOPE 1
Direct emissions from fossil fuels burned on site or in owned and operated vehicles

SCOPE 2
Purchased electricity or other purchased utilities (ie. steam or chilled water)

SCOPE 3
Other emissions the occur as a result of the entity's business such as waste or commuter travel.



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Hospital Decarbonization: New Construction

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- **Don't burn anything to generate energy; electrify everything.**
- **Move heat** within the building, connecting the building's energy flows **through heat pumping**.
- **Store heat and energy** utilizing it for times when it is needed.
- **Don't generate new heat**, except in exceptional circumstances when all existing sources of heat are depleted.
- Do all the above using the **lowest amount of electrical energy possible.**
- **Use no or low carbon electricity sources.**
- **Balance embodied carbon with operational carbon** tradeoffs to minimize whole life carbon.
- Use **point-of-use bottled anesthetic gasses** with re-capture technology.
- **Manage refrigerants** including releases, leakage, and use low GWP refrigerants.
- **Procure sufficient Renewable Energy Credits (RECs)** or offsets equivalent to any emissions from remaining emissions.
- **Manage ongoing operations** to meet GHG emissions targets.

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Electric Hospital Considerations

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Every building MUST be all-electric from now on!
(BUT)

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Challenges
Dirty Grid
Grid capacity
Size of equipment
Specialty end uses (sterilization, kitchen, etc.)
Vehicle electrification
Thermal energy in all climates
Emergency operation/resilience

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Carbon Intensity of the Grid

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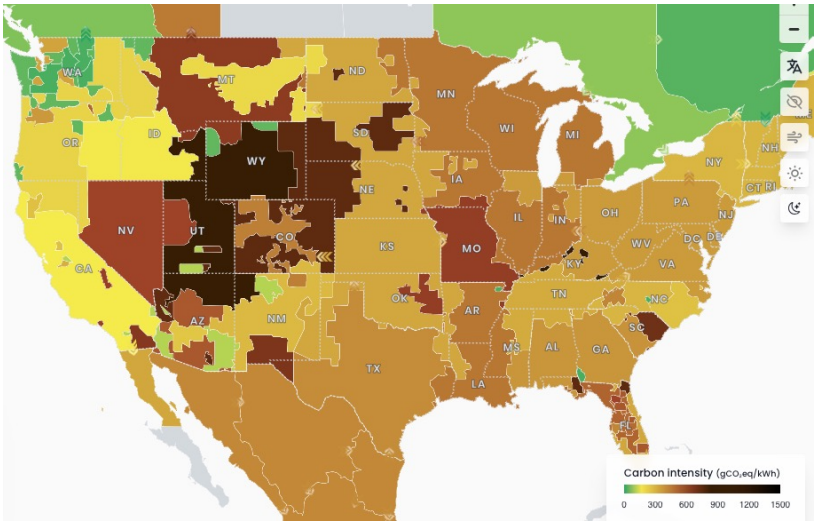

https://app.electricitymaps.com/map

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Carbon Intensity of Electricity Generation

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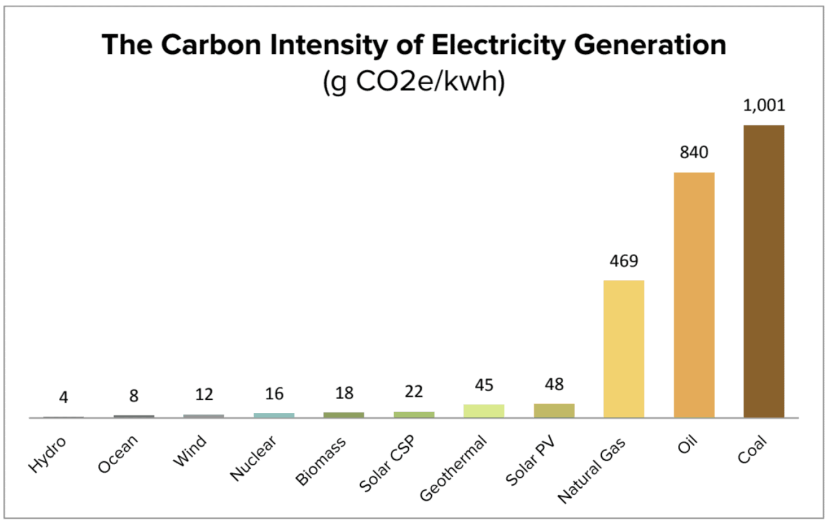

Source: Adapted from IPCC special Report on Renewable Energy Sources and Climate Change Mitigation.

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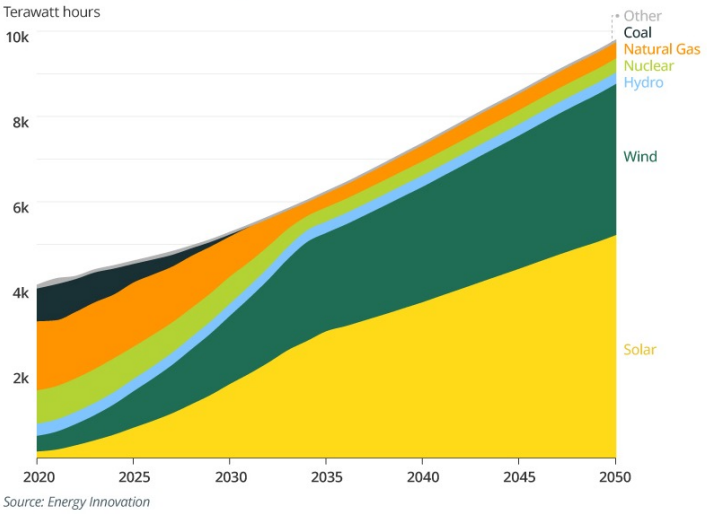
U.S. Electricity Generation by Source in Net-zero Scenario 2020-2050 (Projected)



Source: Energy Innovation

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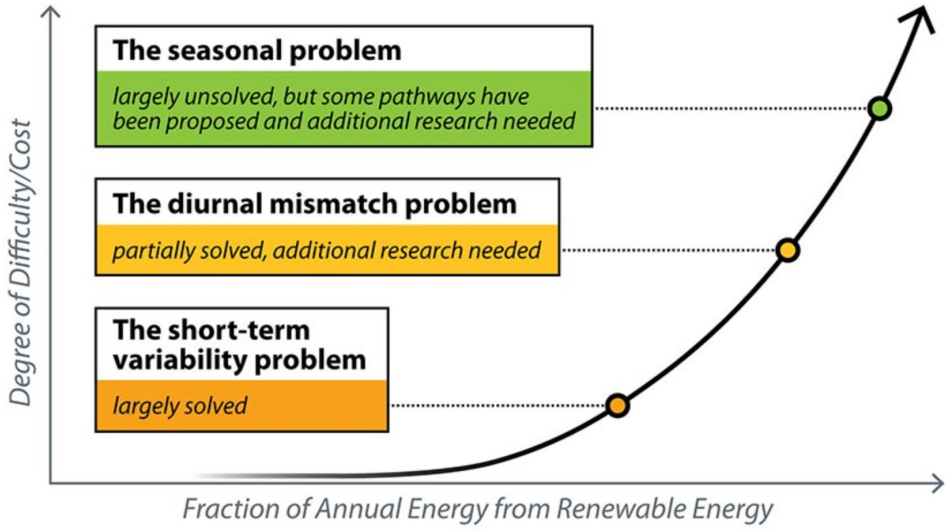

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Challenges to Overcome

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- Grid capacity – **Right-sizing, On-site generation; 25% more space for main electrical room**
- Size of equipment – Right-sizing, **elimination of gas-fired equipment**
- Vehicle electrification – Fleet +%, bi-directional; **space on site**
- Emergency operation – thermal energy storage, Long duration energy storage, hydrogen (eventually), LNG on site; **space!**

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Non-emitting Thermal strategies

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Technical Strategies: Thermal Energy Highlight

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- Don't generate new heat.
- Use heat pumps to capture and re-use heat within the building.
- Store excess heat for use at other times.
- Don't burn anything to generate energy; electrify everything.
- Do all the above using as little electrical energy as possible.

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A Traditional, Disconnected Energy Flow

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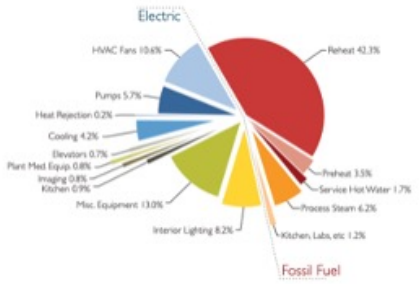
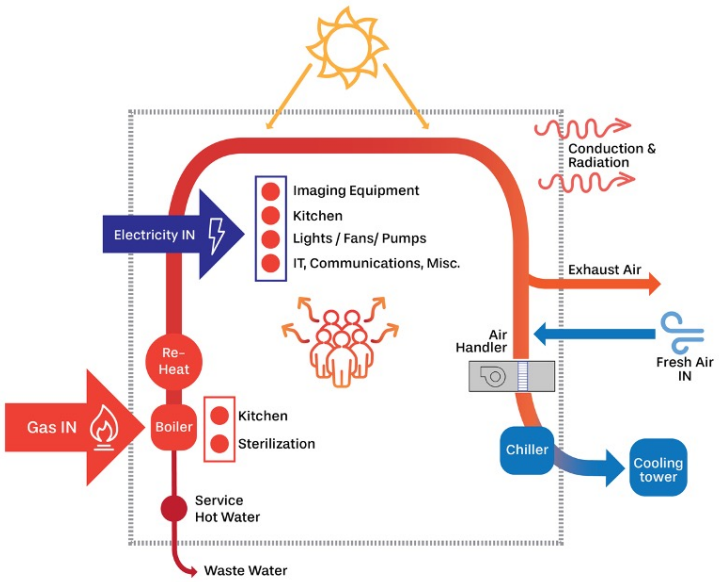
- Generates new heat through combustion of fossil fuels
- Treats heat as a "waste" product, rather than an asset





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Connect and Maximize Energy Flows

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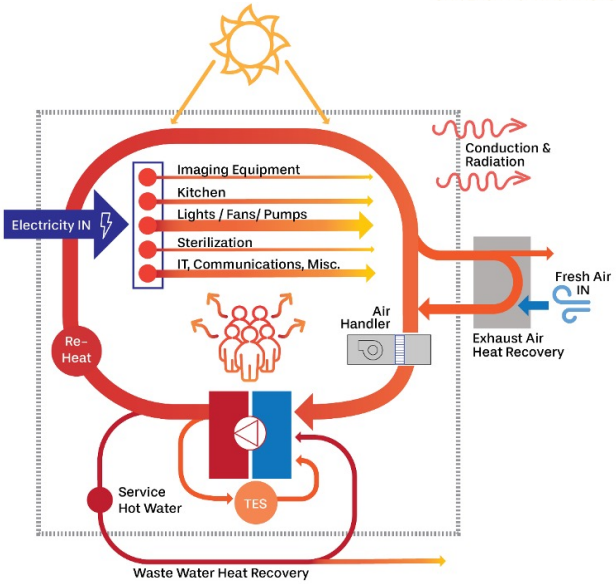
- Electricity IN = HEAT
- No combustion
- Capture heat from all sources:
  - Chilled water systems
  - Condenser water systems
  - Exhaust air systems
  - Data center cooling systems
  - Kitchen refrigeration systems
  - Kitchen exhaust systems
  - Wastewater heat recovery / sewer water energy exchange
  - Water-cooled medical equipment
  - Water-cooled ice machines
  - Other year-round cooling equipment
  - Electrical generation equipment
- Move the heat spatially and temporally



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Connect and Maximize Energy Flows

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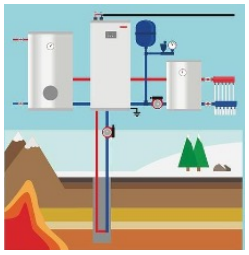
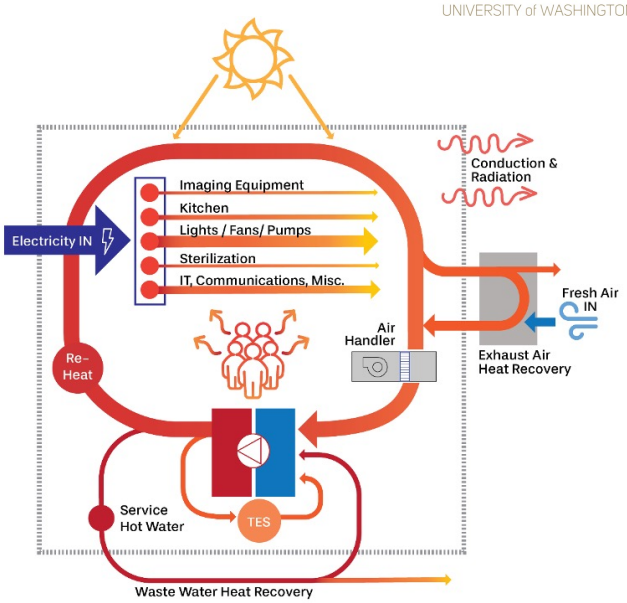
- Use heat pumping to MOVE heat, connect energy flows
- Types of heat pumps
  - Heat Recovery Chiller
  - Ground (or water or air) Source Heat Pumps

https://www.carrier.com/commercial/en/us/products/chillers-components/heat-recovery/



https://www.pace-equity.com/benefits-of-ground-source-heat-pumps-for-commercial-properties-part-1/



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When Existing Heat Isn't Enough

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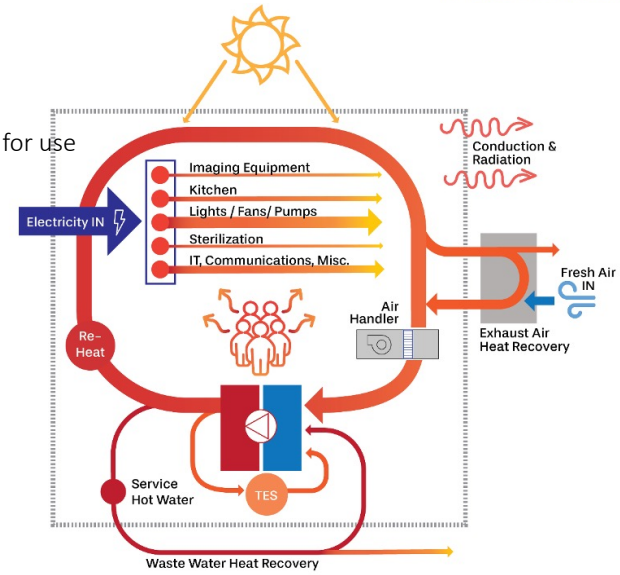
- Store heat with Thermal Energy Storage (TES) for use when it is not available
- Can shift heat diurnally or seasonally
  - Hot Water TES
  - Chilled Water TES
  - Borehole TES
  - Ice TES
  - Condenser Water TES
  - Engineered Phase Change Materials



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When Existing Heat Isn't Enough

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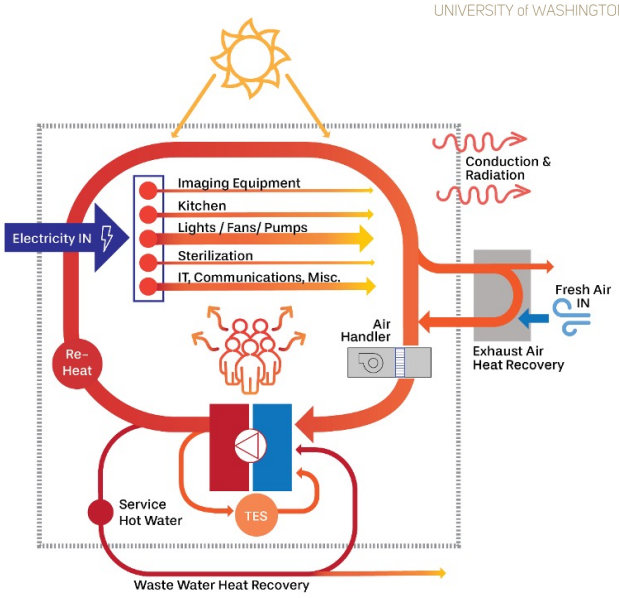
Only generate heat with renewable, clean sources when temps are below thermal balance point - rare!

- Solar Thermal
- Electric Peaking Boilers
- On-site Waste to Energy (Pyrolysis)



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Other Areas to Eliminate Combustion

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Service Hot Water

Sterilization

Humidification

Food Service

Laundry

Laboratory

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Load Reduction – Reduce the Magnitude

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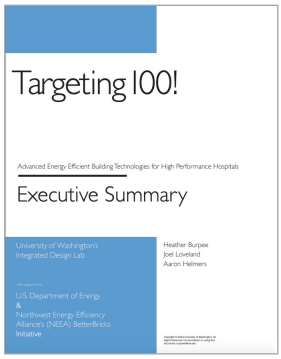
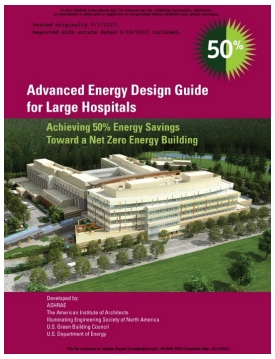
Use as little electrical energy as possible:

- Passive Design Strategies
- Building Envelope Improvements
- Program Distribution & Zoning
- VAV Systems
- De-Coupling Heating, Cooling, Dehumidification from Ventilation
- Displacement Ventilation
- Control Systems to Manage Air-Flow Rates

Other Efficiency Design Guides:





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On-Site Generation Strategies

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- Wind (generally for show)
- Solar Thermal (good, but needs backup)
- Solar PV (good, but lots of space and needs backup)
- Diesel generators (cheap, easy, high fuel density)
- Natural gas turbines (cheap, easy, LNG storage?)
- Fuel cells (base load only, needs batteries for load leveling, LNG storage?)

https://www.energy.gov/eere/wind/how-do-wind-turbines-work

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Other Considerations

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Anesthetic Gases

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Gas	GWP_{100}	GWP_{20} GWP_{2020}	Lifetime (years)	citation
Nitrous Oxide	265		114	(5th Assessment Report, IPCC) (Varughese and Ahmed 2021)
Sevoflurane		349	1.1-5.2	(Ryan and Nielsen 2010) (Varughese and Ahmed 2021)
Isoflurane		1401	2.6-5.9	(Ryan and Nielsen 2010) (Varughese and Ahmed 2021)
Desflurane		3714	8.9-21.0	(Ryan and Nielsen 2010) (Varughese and Ahmed 2021)

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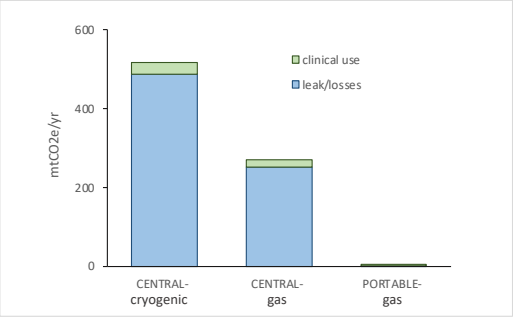
https://medlineplus.gov/anesthesia.html



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Refrigerants

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			GWP 100-year CO2-e		GWP 20-year CO2-e		
Common Refrigerants	***Type***	***Composition***	**AR6**	ref	**AR6**	ref	**PFAS**
Carbon Dioxide	CO_2		1.0	a	1.0	a	No
R-404A	HFC	44% R125, 4% R134a, 52% R143a	4728	a	7208	a	Yes
R-410A	HFC	50% R125, 50% R32	2255	a	4715	a	Yes
R-134a	HFC	100% R134a	1530	a	4140	a	Yes
R-32	HFC	100% R32	771	a	2690	a	No
R-143a	HFC	100% R143a	616	a	2170	a	Yes
R-454b	HFC/HFO	68.9% R32, 31.1% R1234yf	531	a	1854	a	Yes
R-513a	HFC/HFO	44% R134a, 56% R1234yf	673	a	1823	a	Yes
R-123	HFC	100% R123	90	a	325	a	Yes
R-514a	HFO	74.7% 1336mzz(Z), 25.3% trans-1,2-dichloroethylene (t-DCE)	2	a	6	a	Yes
R-1234ze	HFO	100% 1234ze(E)	1	a	5	a	Yes
R-1234yf	HFO	100% 1234yf	1	a	2	a	Yes
R-1233zd(Z)	HCFO	100% 1233zd(Z)	0	a	2	a	Yes
R-744	Natural	Carbon Dioxide (CO_2)	1	a	1	a	No
R-290	Natural	Propane (C_3H_8)	0	a	0	a	No
R-717	Natural	Ammonia (NH_3)	0	b	0	b	No

https://rgasrefrigerants.com/

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Reducing Embodied Carbon by 40%

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Technical Strategies – Embodied Carbon

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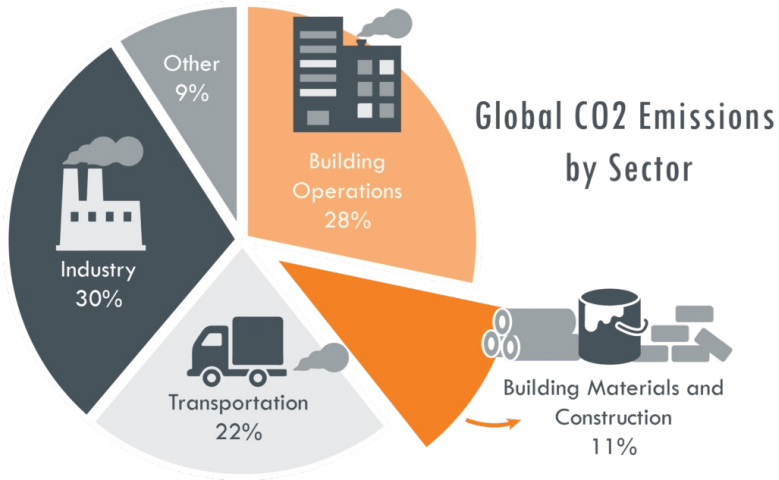

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Lifetime Embodied & Operational

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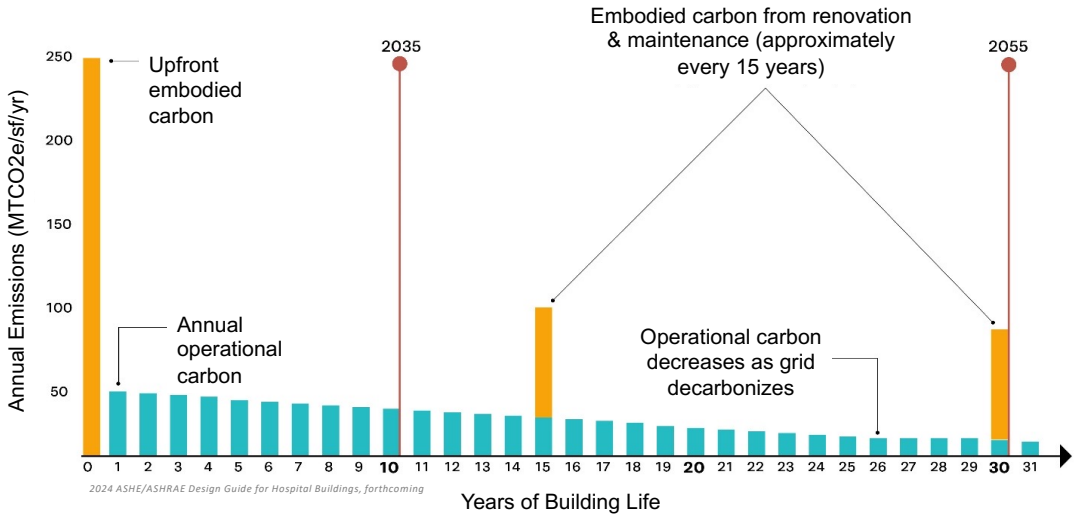

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Whole Life Carbon

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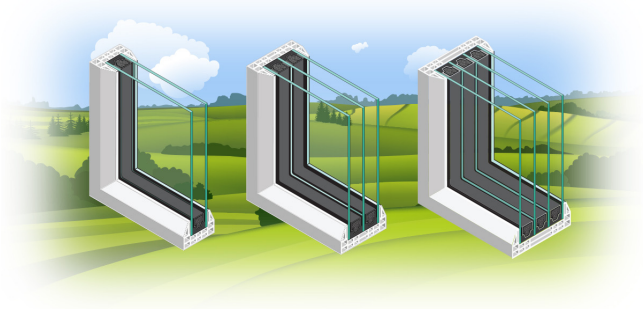
- Measuring – and balancing – both operational and embodied carbon is critical to success
- Strategies/technologies for operational carbon reduction can significantly increase embodied carbon emissions



Reference parallel ASHRAE design guide: Whole Life Carbon Guide for Building Systems

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Minimizing Embodied Carbon

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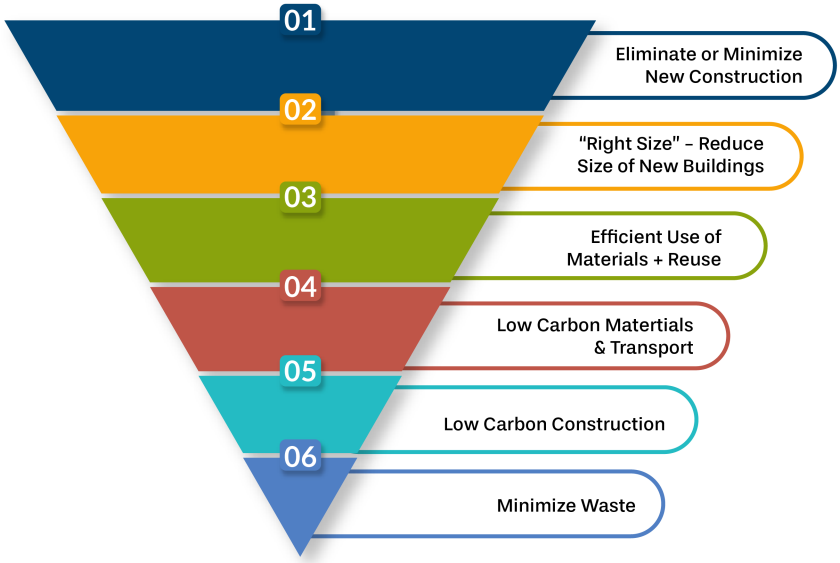

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***nb**bj*

Metropolis Magazine: St. Michael Medical Center Embraces its Northwest Setting

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Operations & Maintenance

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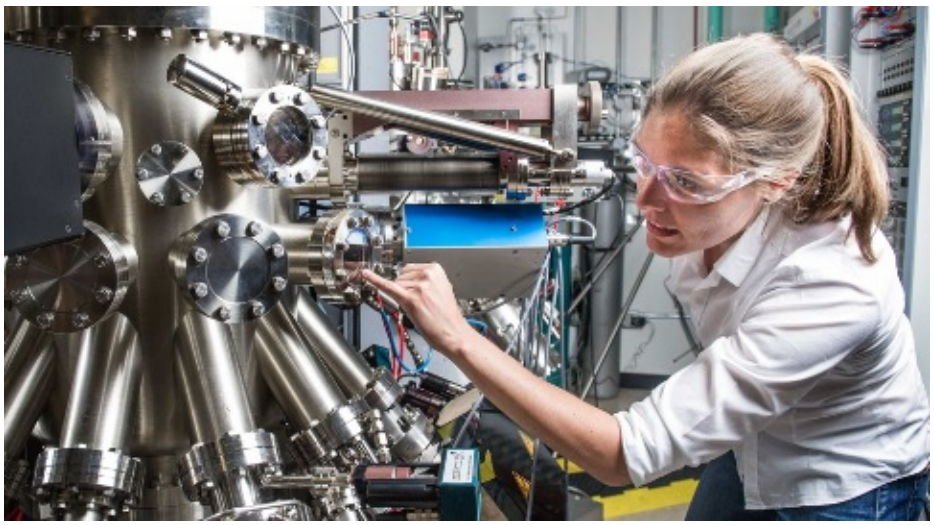

https://www.velents.com/job-descriptions/facilities-engineer/

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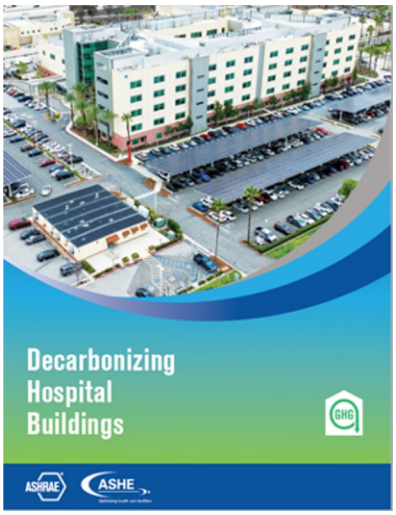

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Thank You!

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