BUILDINGENERGY BOSTON

Saving Energy in Hospitals with Passive House Techniques

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Curated by Keirstan Field and Tammy Ngo

Northeast Sustainable Energy Association (NESEA)
March 29, 2023

SAVING ENERGY IN HOSPITALS WITH PASSIVE HOUSE TECHNIQUES

Increasing Efficiency, Protecting Assets and Reducing Operating Costs

Responsive buildings.
Responsive people.

INTRODUCTIONS

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LEARNING OBJECTIVES

- Define changing local and national carbon and energy consumption regulations, and their intersection with healthcare requirements like ASHRAE 170.
- Recommend areas of design where Passive House strategies can be most impactful on overall energy consumption.
- Compare case studies of Hospital projects utilizing Passive House.
- Conclude how a Passive House principles and techniques can have a high impact on new Hospital design and construction projects.

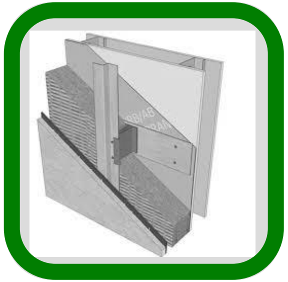
GOAL:

Improve energy performance of healthcare facilities while delivering quality care and improving patient outcomes.

STRATEGY:

Build efficient buildings, to lower heating and cooling loads. Meet those heating and cooling loads with fully electrified equipment and renewable energy.

STRATEGY



Energy Efficiency

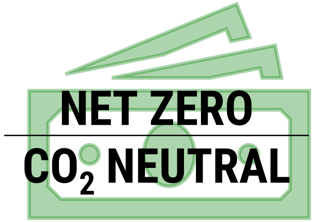
+

Electrification
(Heat + Hot Water)

+

Renewable
Energy

=

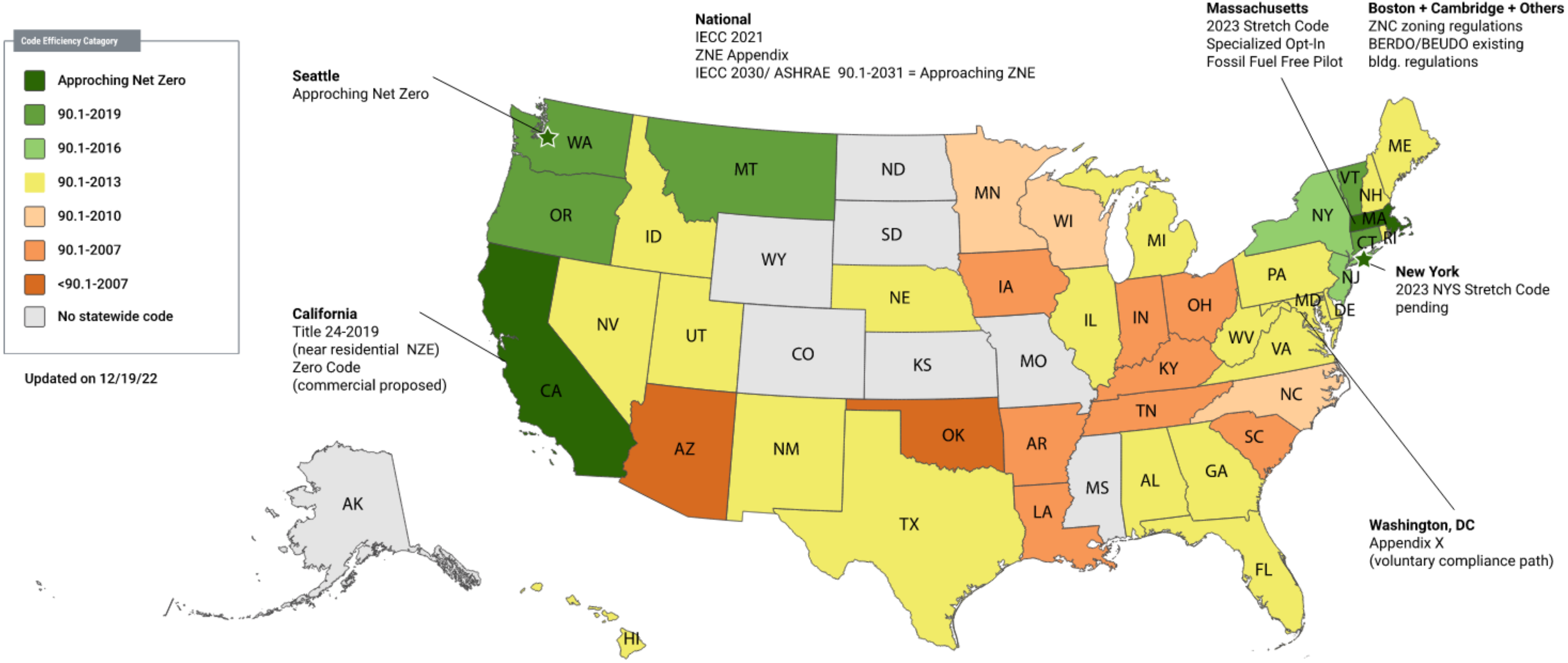


OVERVIEW

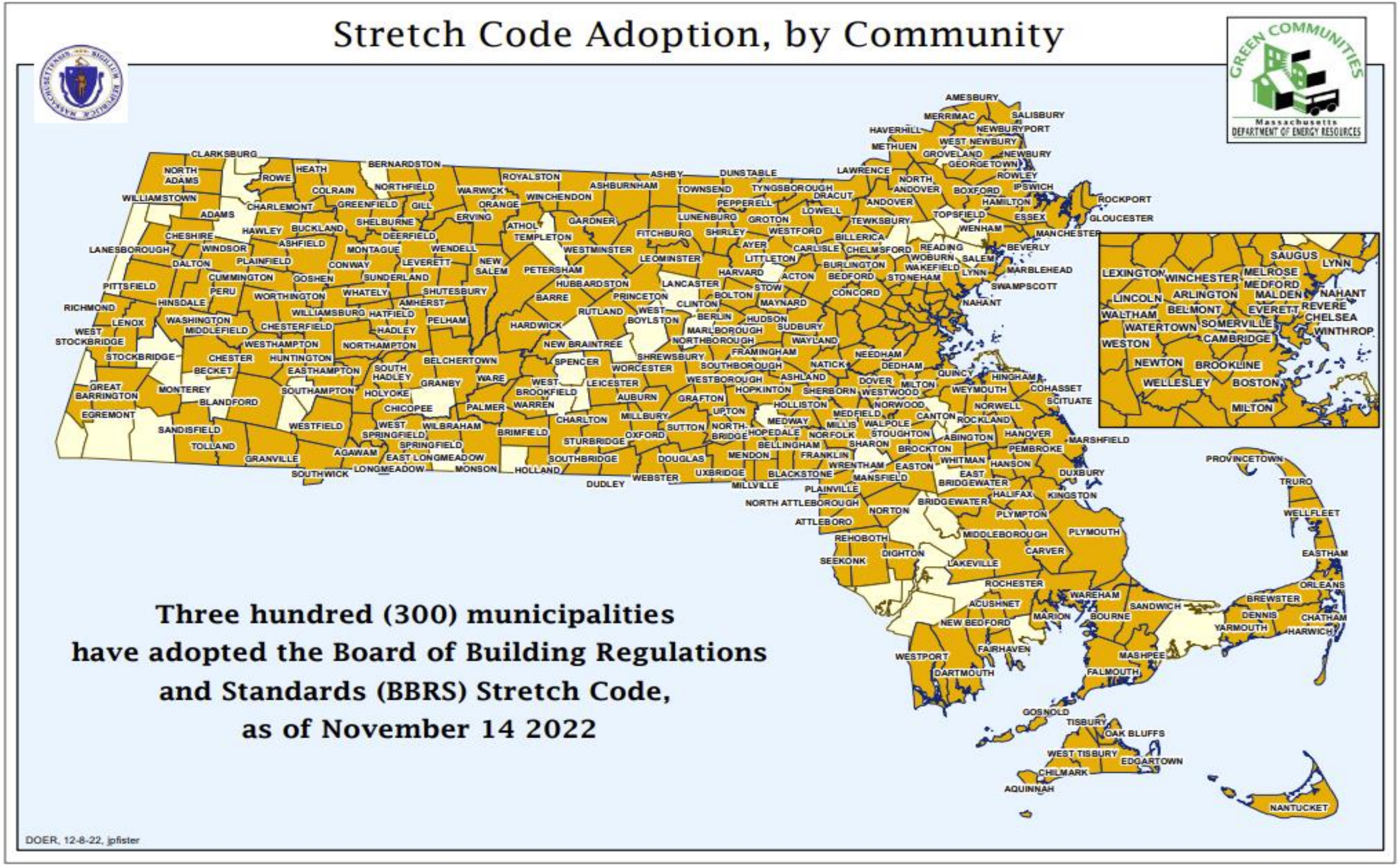
1. Context: Changing Regulation
2. Defining Passive House
3. Defining Healthcare Environment: Energy Intensive Features
4. Case Study 1: PH Strategies Employed
5. Case Study 2: Cost of PH
6. How to Future Proof: Best Practices

CONTEXT: CHANGING REGULATONS

NATIONAL ZNE CODE PRECEDENTS



Boston Carbon/Energy Regulation



NEW YORK CITY: LOCAL LAW 97

NYC 80 x 50
80% carbon reduction by 2050

LOCAL LAW 97

2024-2029 limits will affect the 20% most carbon-intensive buildings

2030-2034 limits will affect the 75% most carbon-intensive buildings

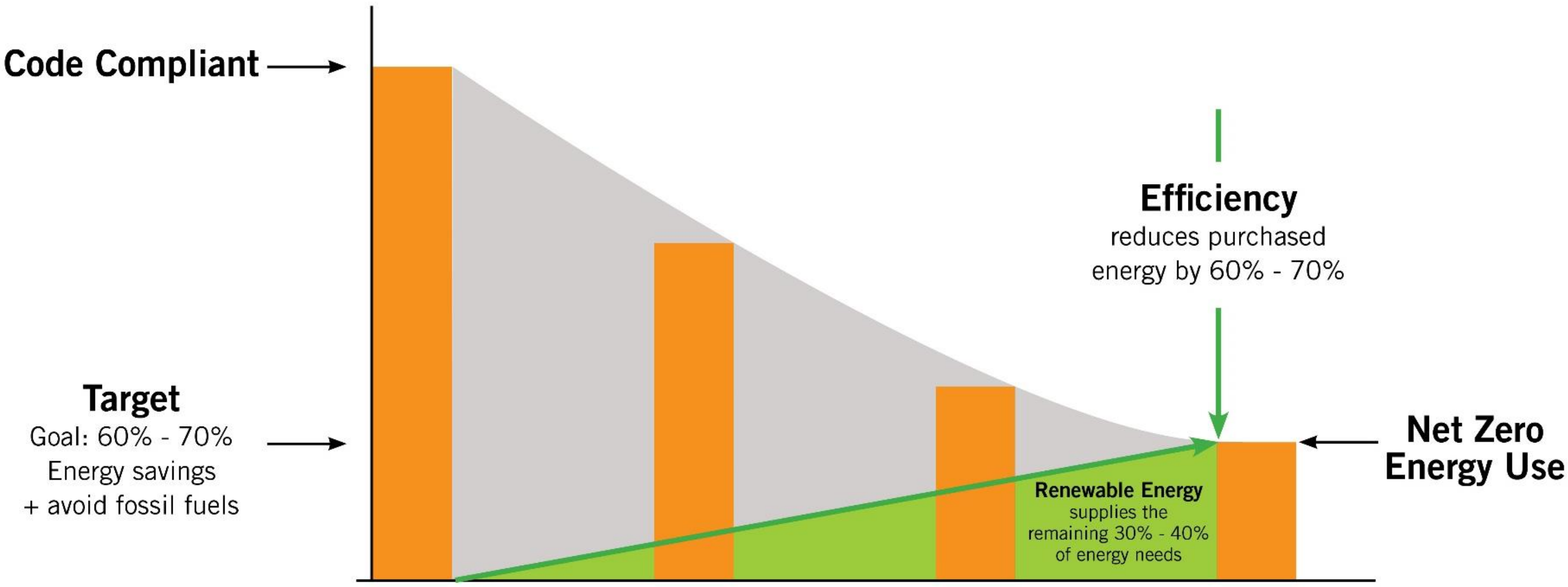
Expensive penalties to those buildings exceeding the limits.

Local Law 154 - NYC Natural Gas Ban

2023 – buildings below 7 stories

2027 - all buildings

Path to Net Zero Energy Use



ASHRAE 227

Proposed Passive Building Design Standard

Authorities having Jurisdiction can adopt as a path to compliance using Passive House Building design principles.

- Envelope
- Heating and cooling equipment
- Ventilation
- Service hot water
- Lighting
- Plug loads

DEFINING PASSIVE HOUSE

WHAT IS PASSIVE HOUSE?

Design and construction concept – Focus on Balance Gains and Losses

Highest Energy Standard – PHI and PHIUS

Quiet, clean, healthy, comfortable

Images courtesy of PHIUS.org

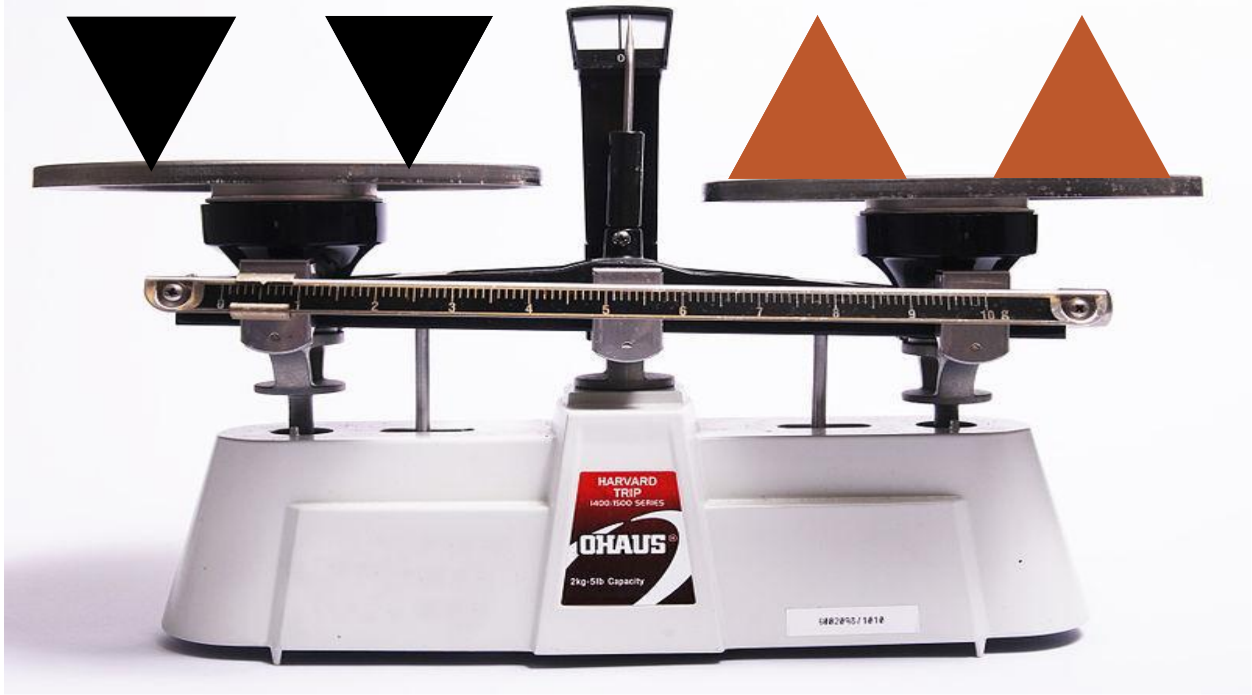
ENERGY BALANCE

2 LOSS PARAMETERS:

- Transmission Loss
- Ventilation Loss

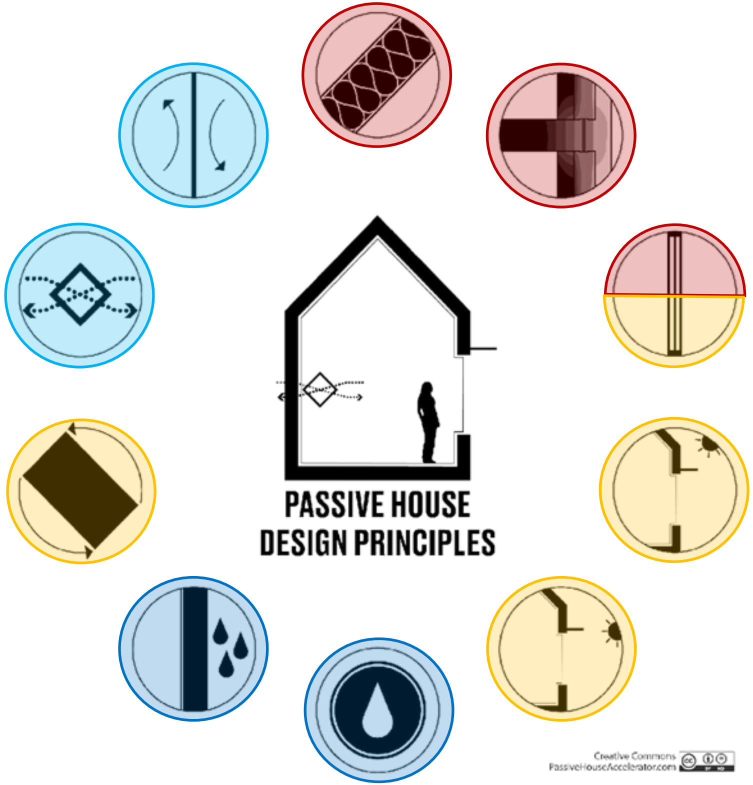
2 GAIN PARAMETERS:

- Solar Gains
- Internal Gains



PASSIVE HOUSE (PH) PRINCIPLES

- Thermal Control
  - High Performance Enclosure
  - Thermal Bridge Elimination
- Air Control
  - Airtightness
  - Balanced ventilation with heat and moisture recovery
- Radiation Control
  - High Performance Glazing
  - Shading and Daylighting
- Moisture Control
  - Material Moisture
  - Air Humidity



CERTIFYING BODIES

Phius 2021
Performance Criteria Calculator v3.1

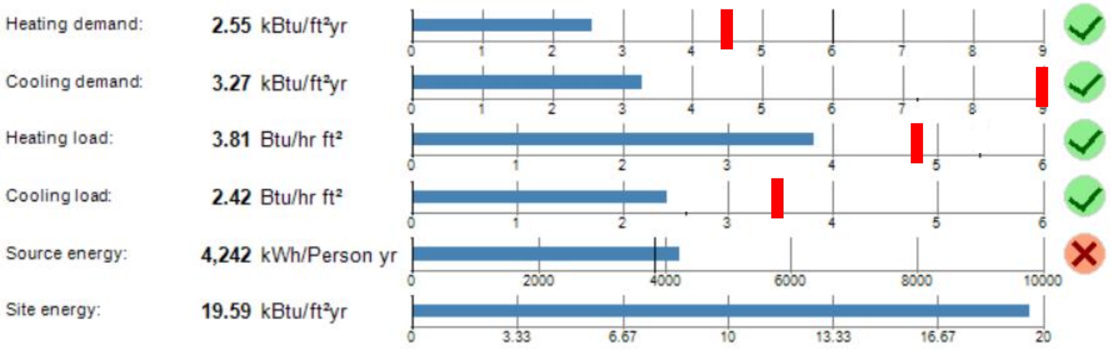
UNITS:	IMPERIAL (IP)
BUILDING FUNCTION:	NON-RESIDENTIAL
PROJECT TYPE:	NEW CONSTRUCTION

STATE/ PROVINCE	NEW YORK
CITY	NEW YORK LAGUARDIA

Envelope Area (ft²)	77,560.0
iCFA (ft²)	206,059.0
Average Occupancy	600
Design (Max) Occupancy	1,000

Space Conditioning Criteria		
Annual Heating Demand	4.6	kBtu/ft²yr
Annual Cooling Demand	10.7	kBtu/ft²yr
Peak Heating Load	4.8	Btu/ft²hr
Peak Cooling Load	3.3	Btu/ft²hr

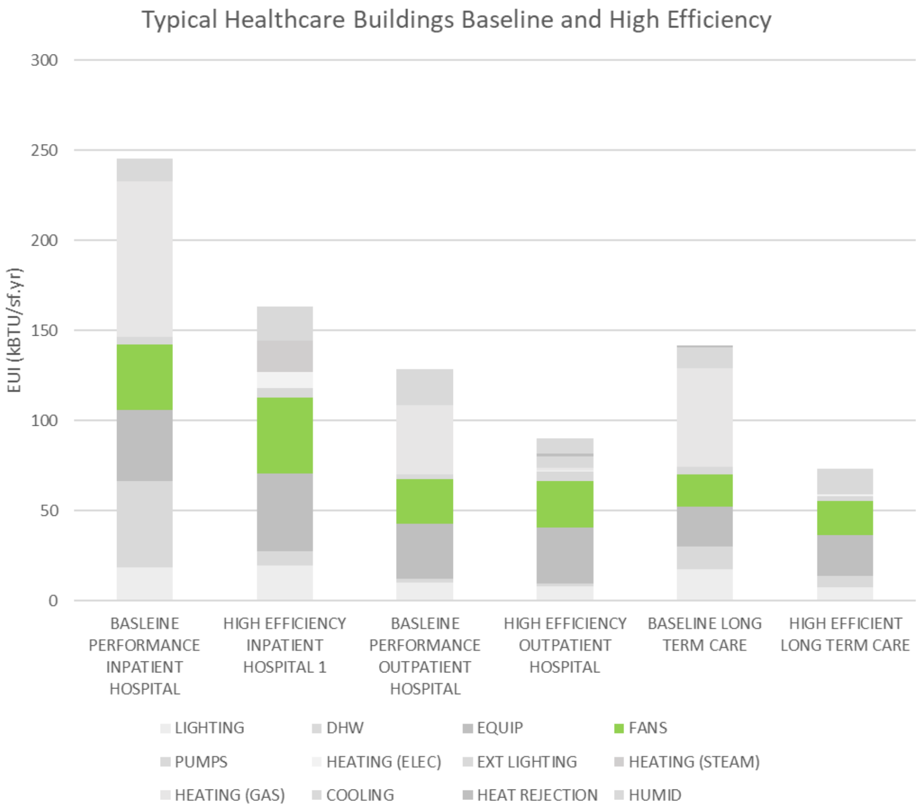
Source Energy Criteria		
Phius CORE	24.5	kBtu/ft²yr
Phius ZERO	0	kBtu/ft²yr



DEFINING HEALTHCARE ENVIRONMENT: ENERGY INTENSIVE FEATURES

LARGEST CONTRIBUTORS TO HEALTHCARE ENERGY CONSUMPTION

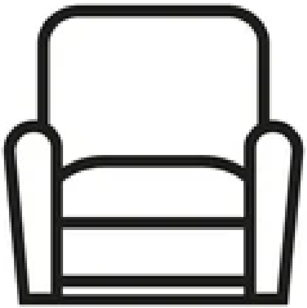
- Equipment
  - MRI / CT/ Imaging equipment, etc.
- Hot Water and Steam
  - Domestic Hot Water
  - Sterilization
- Occupant Density
  - Patients, faculty and staff, families
- Ventilation
  - ASHRAE 170 rates



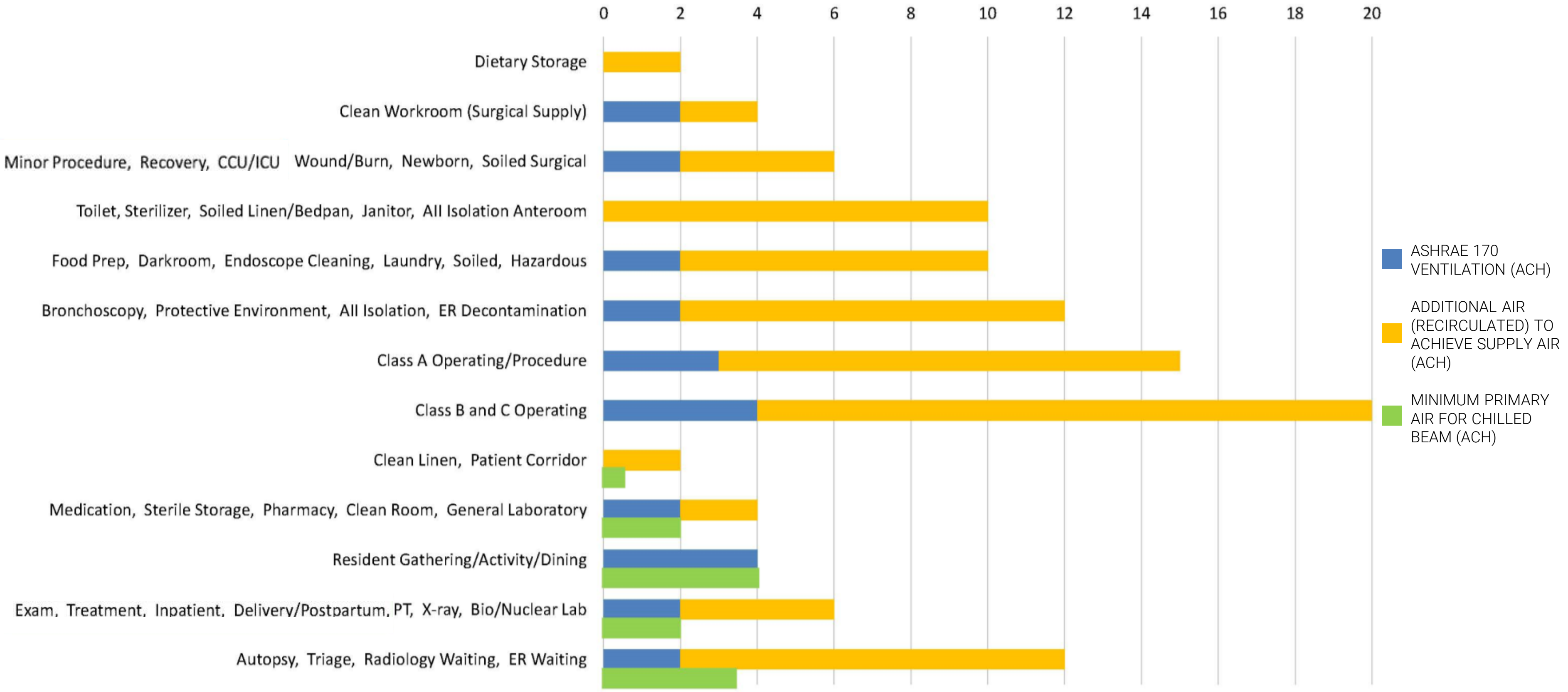
DEFINE HEALTHCARE TYPOLOGY & VENTILATION REQUIREMENTS

– **Healthcare Typology:** hospitals, in-patient, out-patient, nursing homes, psychiatric facility, etc.

– **ASHRAE 170:** defines ventilation system design requirements for **comfort, health, and contaminants** in healthcare facilities.

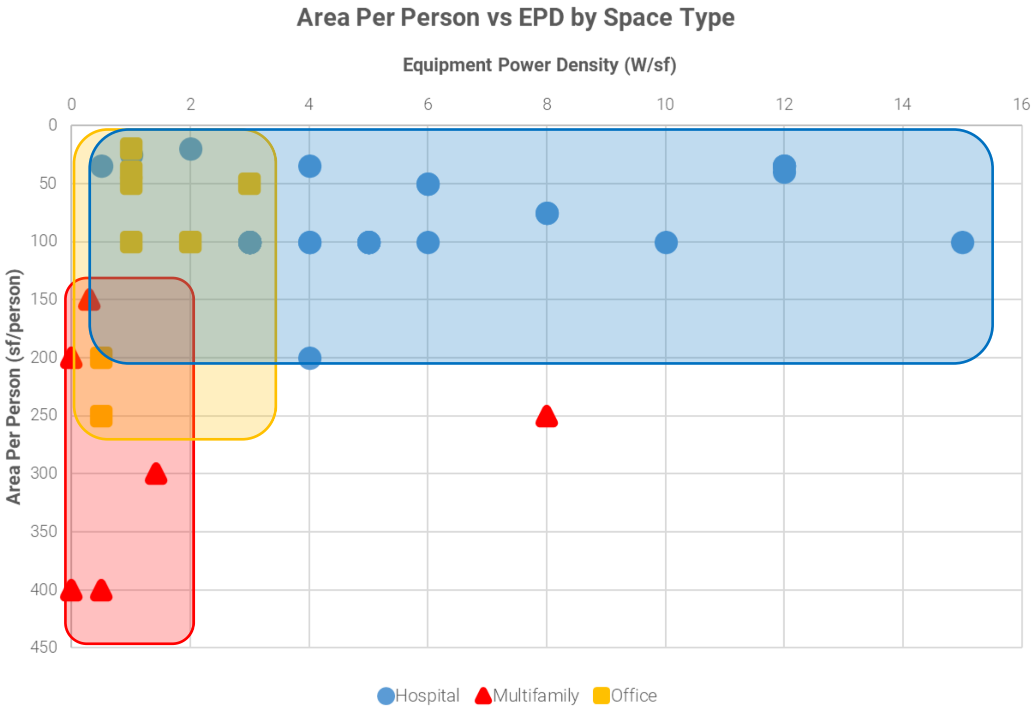


ASHRAE 170 VENTILATION RATES

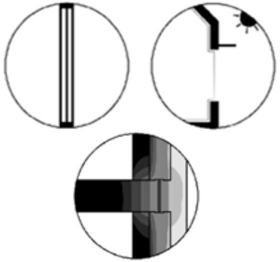


BENCHMARKING HEALTH CARE SPACE TYPES

Parameter	MF	Office	Healthcare
Ventilation	low	med	high
Occupant Density	low	high	med
Equipment Power Densities	low	med	high



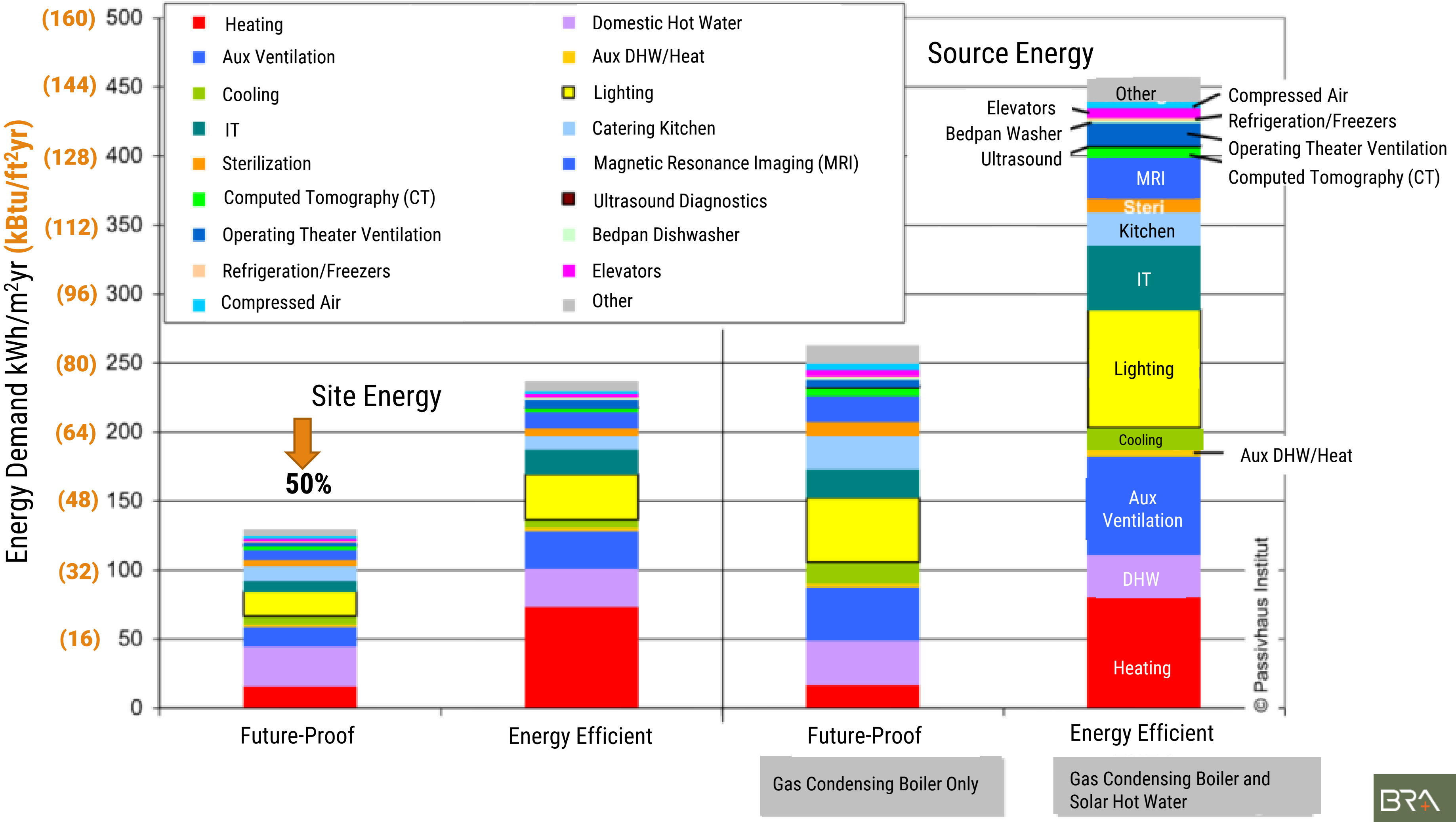
CHALLENGES APPLYING PH PRINCIPLES TO HEALTHCARE



Challenge	Heating Limits	Cooling Limits	Source Energy
ASHRAE 170 Ventilation	X	X	X
Occupant Density		X	
Internal Gains		X	X
High Window-to-Wall Ratio	X	X	
Large Service Hot Water Demand	X		X

CASE STUDY 1:
PH STRATEHGIES EMPLOYED


Klinikum Frankfurt Höchst



Heating
Aux Ventilation
Cooling
IT
Sterilization
Computed Tomography (CT)
Operating Theater Ventilation
Refrigeration/Freezers
Compressed Air
Domestic Hot Water
Aux DHW/Heat
Lighting
Catering Kitchen
Magnetic Resonance Imaging (MRI)
Ultrasound Diagnostics
Bedpan Dishwasher
Elevators
Other
Source Energy
Site Energy
50%
Energy Demand kWh/m²yr (kBtu/ft²yr)
(160) 500
(144) 450
(128) 400
(112) 350
(96) 300
(80) 250
(64) 200
(48) 150
(32) 100
(16) 50
0
Other
Elevators
Bedpan Washer
Ultrasound
Compressed Air
Refrigeration/Freezers
Operating Theater Ventilation
Computed Tomography (CT)
MRI
Steri
Kitchen
IT
Lighting
Cooling
Aux DHW/Heat
Aux Ventilation
DHW
Heating
© Passivhaus Institut
Future-Proof
Energy Efficient
Future-Proof
Energy Efficient
Gas Condensing Boiler Only
Gas Condensing Boiler and Solar Hot Water

CASE STUDY 2: COST OF EMPLOYING PH

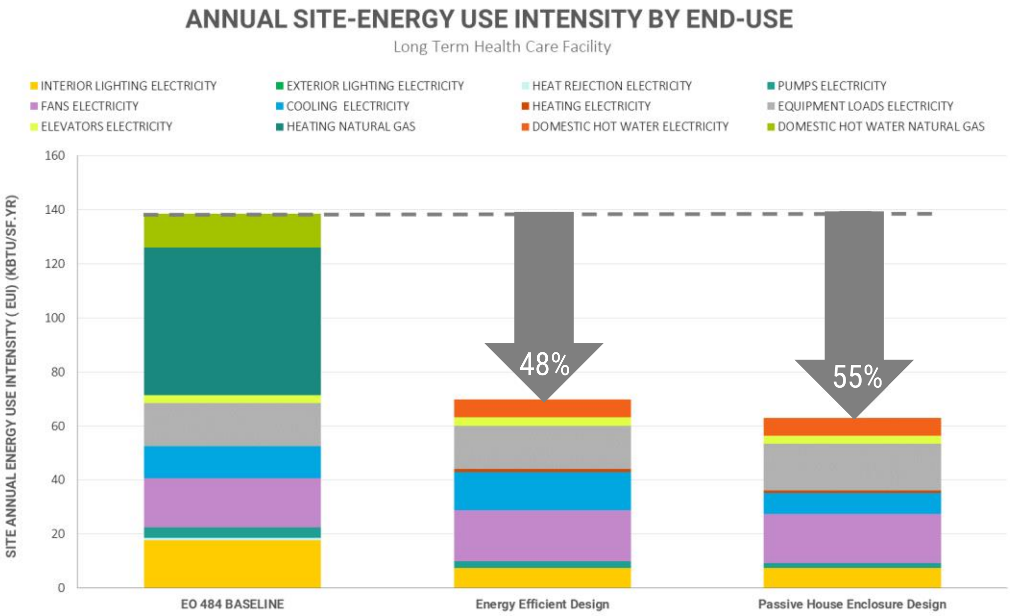
REDUCING LOADS

ENCLOSURE

MODEL INPUT PARAMETER	HIGH EFFICIENCY CASE	PASSIVE HOUSE CASE
Wall Assembly - Above Grade	*Face brick: U-0.043*	*Face brick: U-0.030*
Vertical Glazing - U-Value	0.19 Curtainwall	0.172 Curtainwall
Air Infiltration	0.083 INF-ACH	0.035 INF-ACH

VENTILATION ENERGY RECOVERY

MODEL INPUT PARAMETER	HIGH EFFICIENCY CASE	PASSIVE HOUSE CASE
Exhaust Air Energy Recovery	Enthalpy wheel + Desiccant wheel	Dual core



LOW CARBON PRINCIPLES IN ACTION

CONFIDENTIAL LONG-TERM CARE FACILITY

Life Cycle Cost Analysis (LCCA)

All Values in $ Millions	Baseline Current Design with Solar PV	Baseline no PV Current Design without Solar PV	Alternate Improved Envelope with Solar PV	Alternate no PV Improved Envelope without Solar PV
TOTAL CONSTRUCTION COSTS	$287.7	$286.2	$288.0	$286
ENVELOPE UPGRADES	-	-	$1.6	
MEP SAVINGS	-	-	-$1.4	
SOLAR PV (G40 - SITE ELEC UTILITIES)	-$1.5	-$3.0	-$1.5	
40-YR TOTAL OPERATING COSTS	$31.1	$31.8	$26.0	
40-YR MAINTENANCE + REPLACEMENT	$16.3	$16.2	$16.3	
40-YR ENERGY	$14.8	$15.5	$9.7	$10.5
40-YR DEMAND CHARGE (*TBD)	2nd Highest	Highest	Lowest	2nd Lowest
40-YR NET PRESENT COST	**$317.3**	**$315.0**	**$312.7**	**$310.4**
40-YR NET PRESENT COST DIFFERENCE	**$0.0**	**$2.3**	**$4.6**	**$6.9**
PERCENT DIFFERENCE FROM BASE	-	0.7%	1.4%	2.2%
LBS CO2e PER SF (ISO NE 2019)	11.8	12.4	7.8	8.4
KG CO2e PER SF (ISO NE 2019)	5.4	5.6	3.5	3.8
40-YR CO2e EMISSIONS (KILOTONNES)	70,765	74,423	46,636	50,294
40-YR CO2e EMISSIONS DIFFERENCE	-	3,658	(24,129)	(20,471)

ADDITIONAL SAVINGS WHEN ACCOUNTING FOR REDUCTION IN CARBON EMISSION FINES FROM LOCAL REGULATIONS LIKE LL97

CERTIFYING BODIES - BALANCING PERFORMANCE AND COST

PHIUS BUILDING PROTFOLIO DATA:

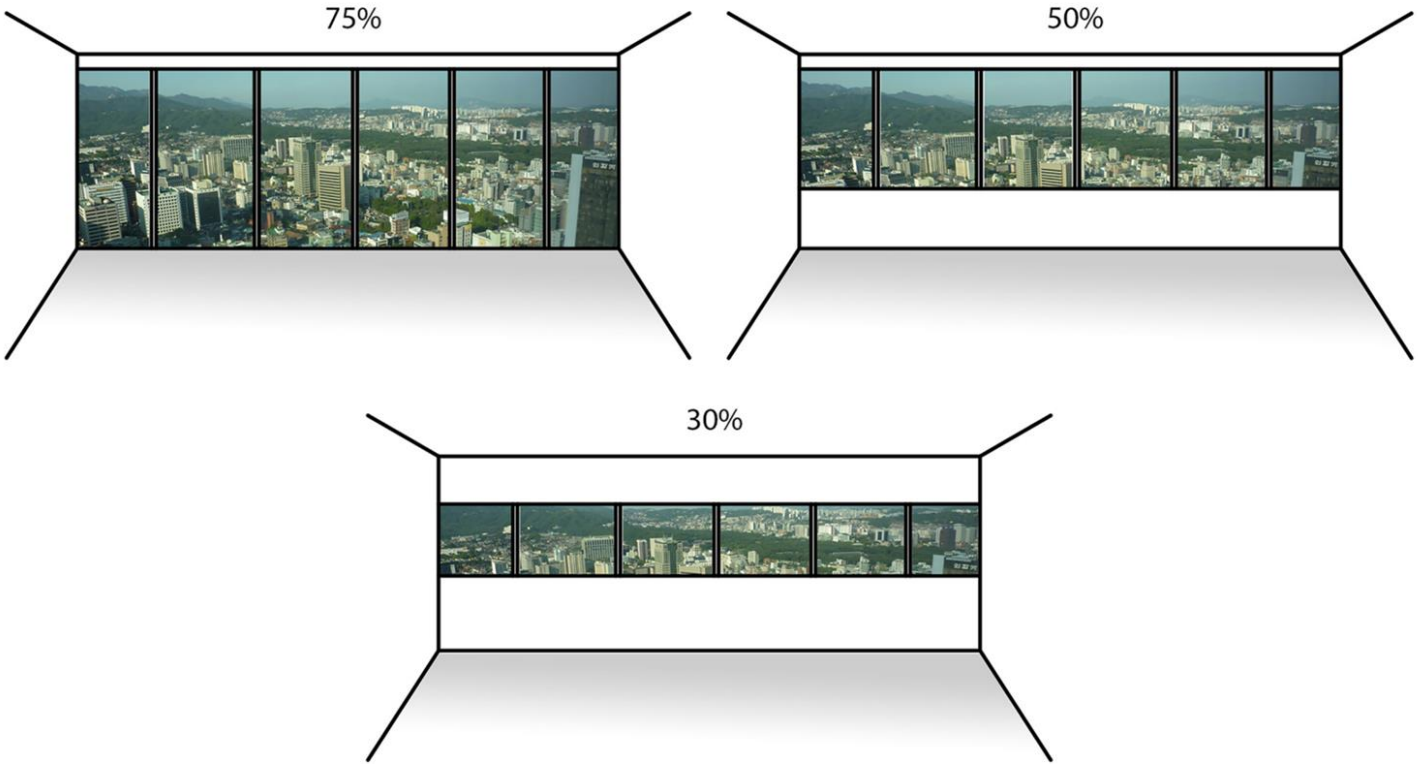
- Phius buildings perform up to 85% better than conventional buildings.
- Building to the Phius standard costs only 3-5% more than conventional building methods for a conventional home
- Larger projects benefit from the economy of scale:
  - multifamily passive building typically only costs 0-3% more than a building built to an energy star baseline.

PHIUS.org

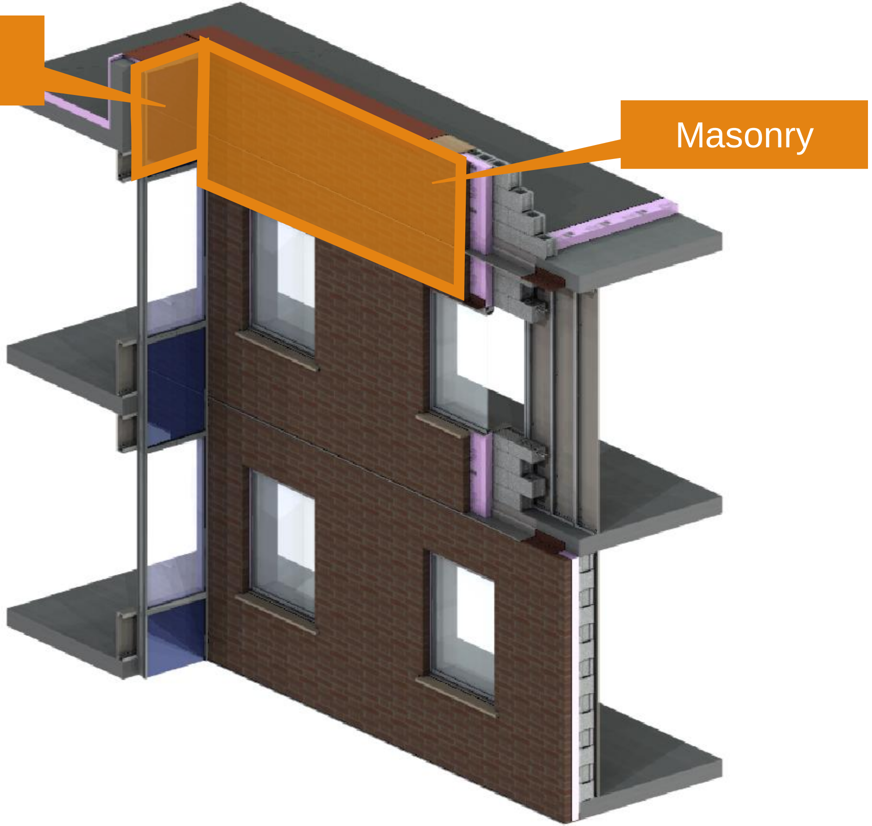
PASSIVE HOUSE STRATEGIES AND BEST PRACTICES

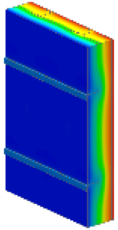
ENCLOSURE

RETHINKING FENESTRATION TO WALL RATIOS



THERMAL BRIDGING

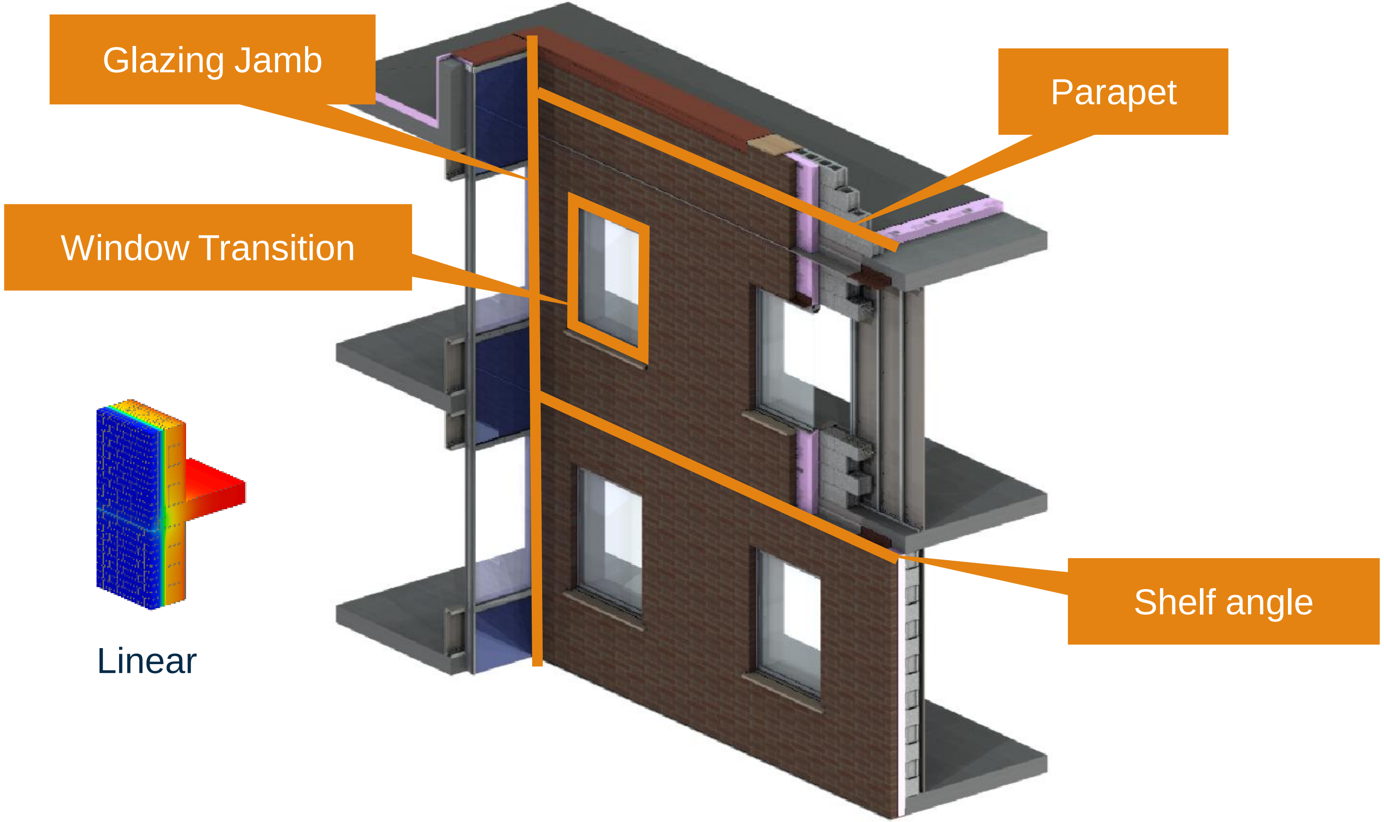




Clear
Field

Images courtesy of Morrison Hershfield

THERMAL BRIDGING



Linear

Images courtesy of Morrison Hershfield

GENERAL BEST PRACTICES

HEATING, AND HOT WATER BEST PRACTICES

Heating

- **Don’t throw away BTUs**
  - Ventilation energy recovery
  - Low temp waste heat + heat pumps
- **Meet with electric equipment**
  - Avoid steam generation
  - Heat Pumps

DHW

- **Reduce Water Use:** Water saving fixtures
- **Reduce distribution losses**: with efficient layouts
- Wastewater **heat recovery**
- **Meet with Electrified Sources:**
  - Solar thermal
  - DHW HP

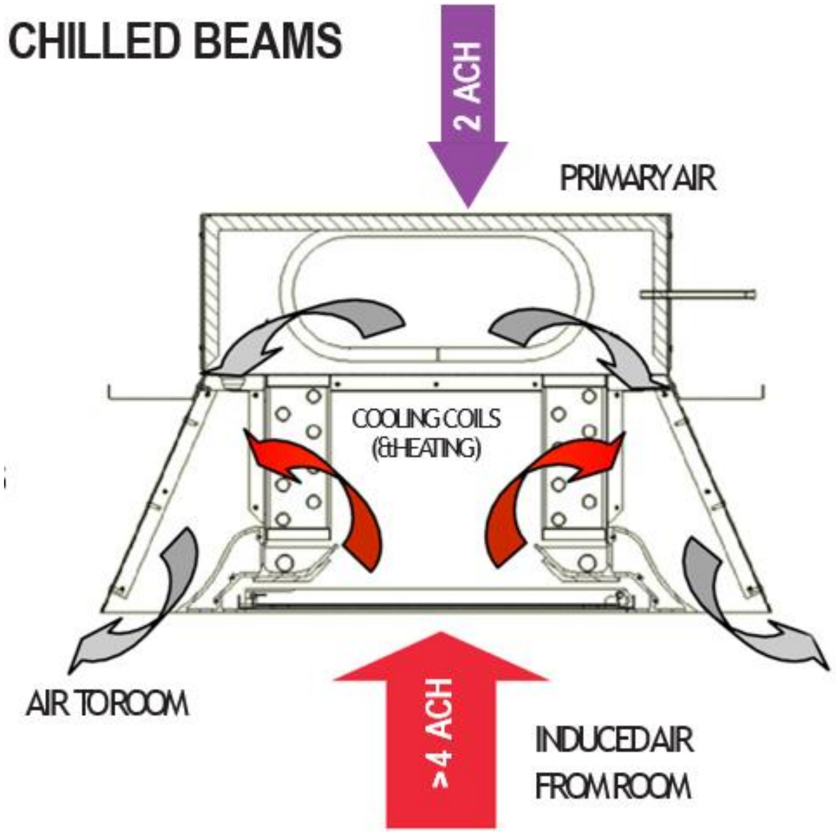
COOLING BEST PRACTICES

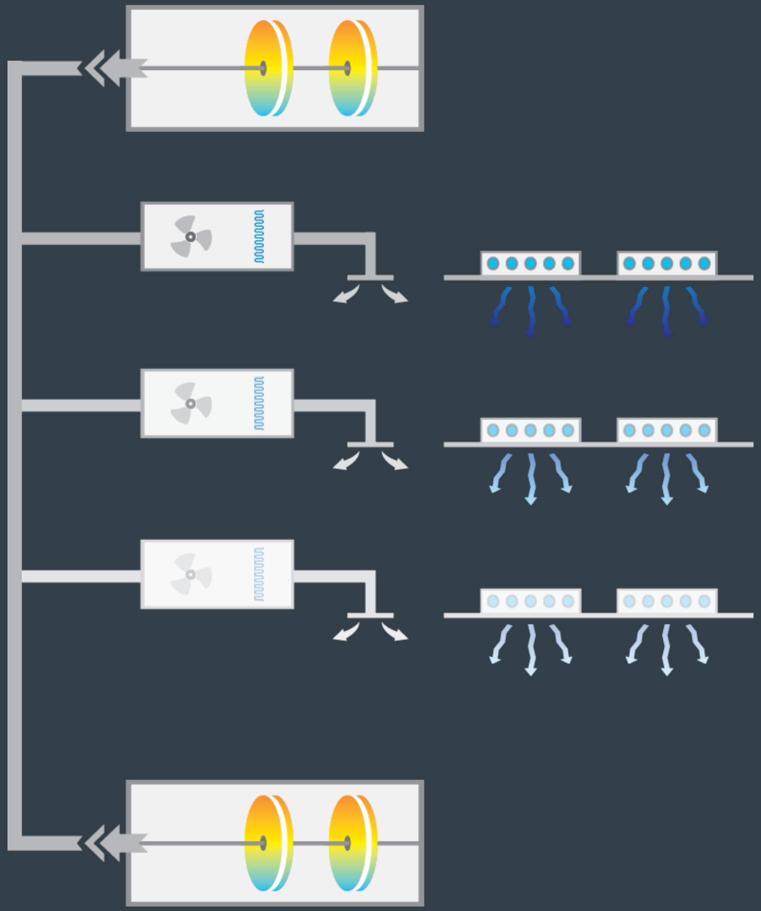
– Regulate Cooling Load

- Reduce **internal heat gains**
- Reduced **solar loads and shading**
- **Thermal mass** (exposed concrete ceilings)

– Use Efficient Equipment

- Chilled beam
- Night ventilation to help manage humidity
- Avoid ventilation pressure losses
- Efficient fans
- Evaporative cooling within ventilation unit
- Place exhaust or chilled water-cooling circuit at the source of internal heat gains





VENTILATION BEST PRACTICES TO REDUCE LOADS

- Provide efficient **energy recovery** (≥ 80 % sensible and >%75 latent)
- **Simplify** and shorten ventilation duct network
- Avoid unnecessarily high-pressure losses
- Demand control ventilation

LIGHTING BEST PRACTICES

Maximize Daylight Utilization.

– In occupied spaces the building design should strive for good daylighting conditions.

Lighting Design

– Exceed standard reflectance values of walls and ceilings.

– Specify illuminance levels within rooms

– Set targets and limits at an early stage

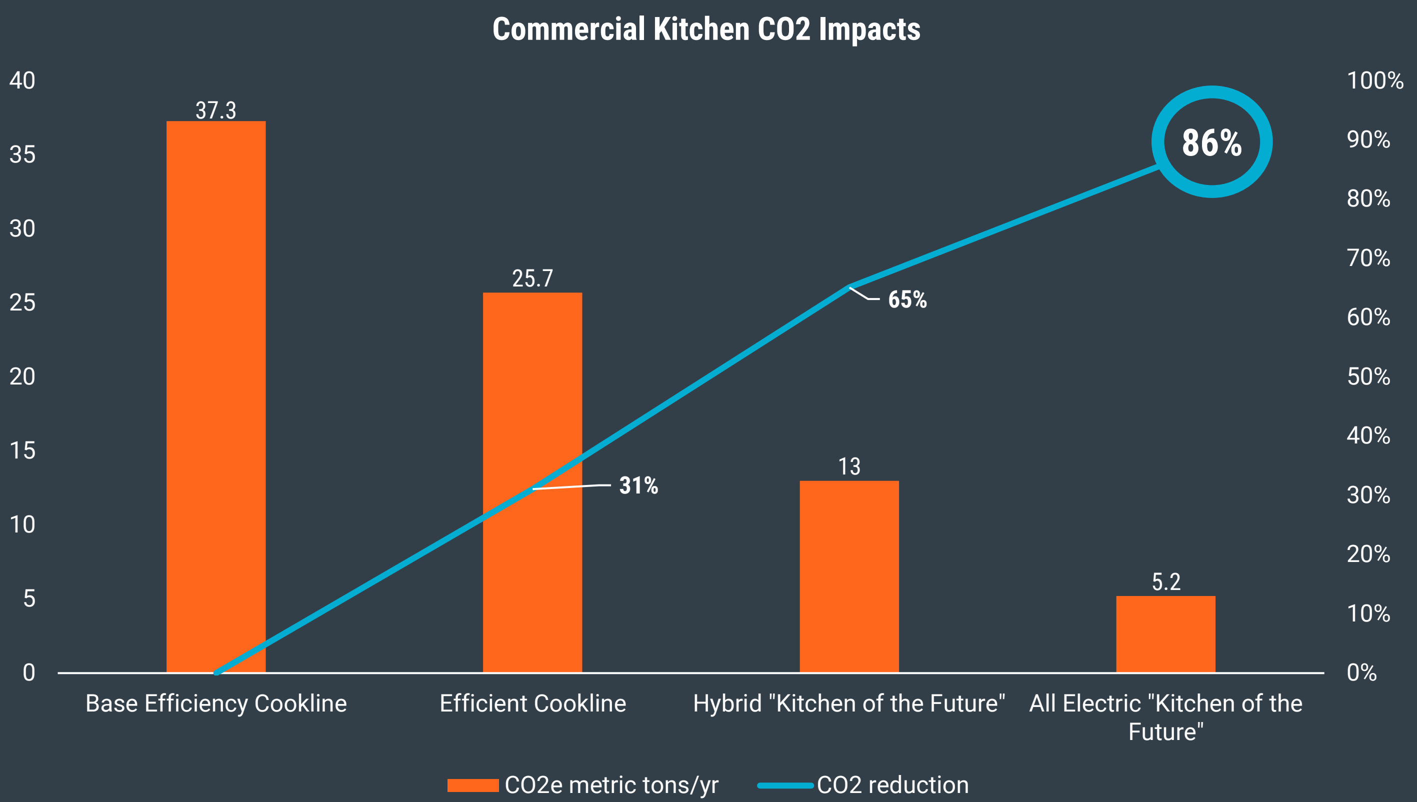
– Special attention to lighitng controls

IT BEST PRACTICES

– Servers with higher temperature tolerance should be used to reduce cooling load.

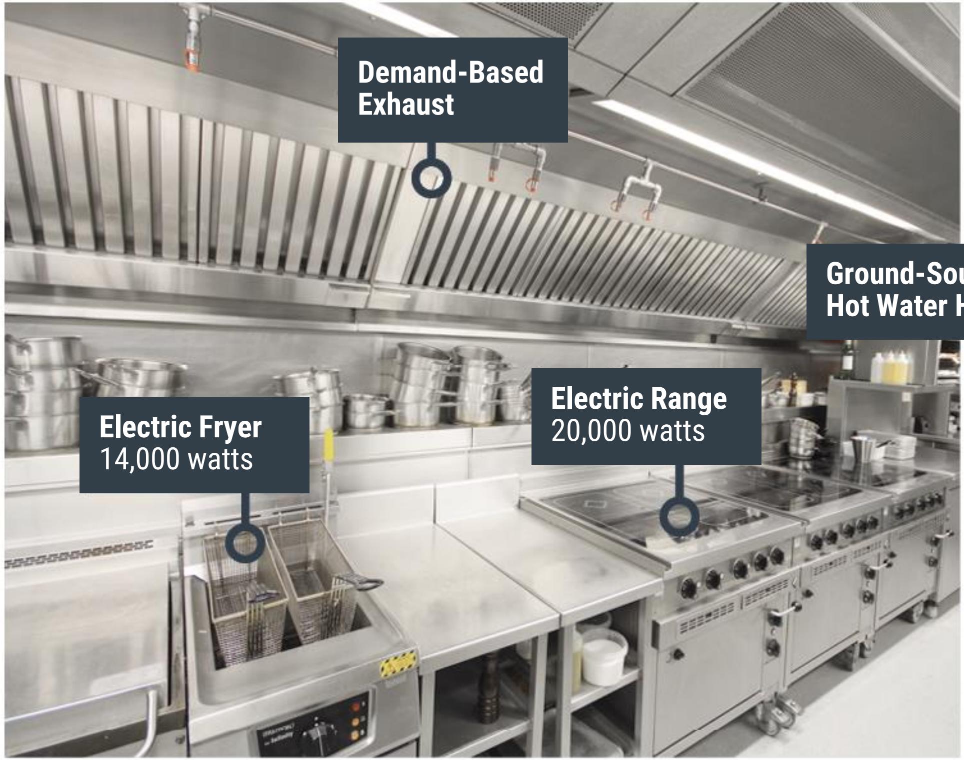
– Recover server waste heat

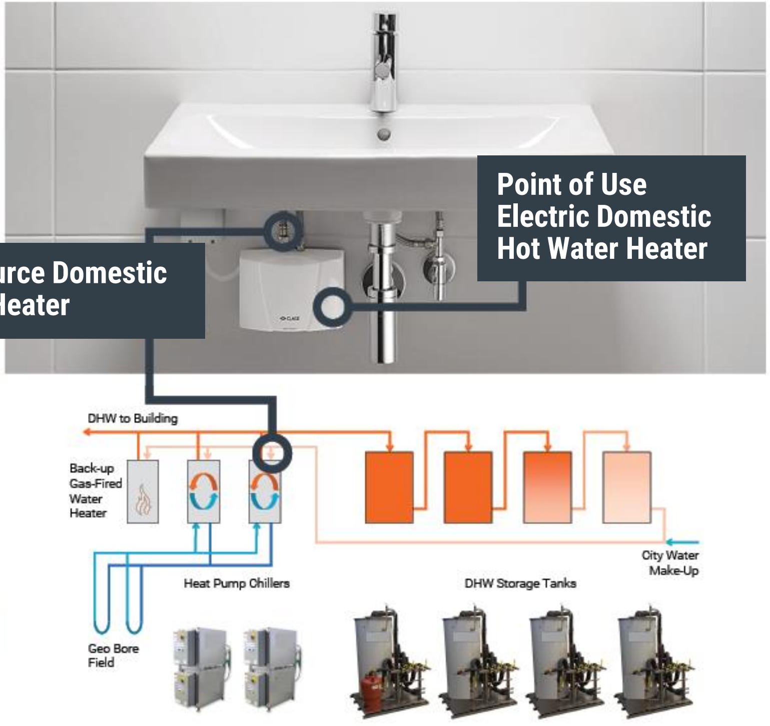
COMMERCIAL KITCHEN EMISSIONS



** Source: Food Service Technology Center 2019*

ALL ELECTRIC KITCHEN





HEALTHCARE BEST PRACTICES

MEDICAL APPLIANCES AND DEVICES BEST PRACTICES

Medical and professional equipment, that is currently available, and improved processes offer **savings potentials of more than 30%**

STERILIZATION AND GLASS WASH BEST PRACTICES

- Washer-disinfectors largest energy end use is heating water and steam.

- Solution: **economical use of water**.
  - Tank systems allow reuse of the hot deionized water from the disinfection phase.
  - Wastewater heat recovery + heat pump system

MRI

- Carefully review spec sheets
- Can significantly reduce cooling load
- New technology using superconductors shows promise for energy reductions.

CT

- Compared to previous generation, consumption of current devices is **30% lower.**
- Engage standby mode when not in-use

OTHER EQUIPMENT

- Medical coolers - Adjust Set Points
- Fume Hoods: Lower VAV Fume Hood Sashes or Automatic Controls
- Solid state lasers> gas lasers.
- Turn off Biosafety cabinets (BSC)
- Reduce compressed air

CONCLUSIONS

CONCLUSIONS

GOAL: target future proof healthcare facilities while delivering the same quality of care and improving patient outcomes.

– Prioritizing envelope efficiency and load reduction strategies to get operational cost savings and meet decarbonization goals.

– Mitigating carbon risk and future liability associated with inefficient facilities can have significant lifecycle cost savings, depending on utility rates.

– With early planning and integrated design, best-in class future-proof healthcare facilities can be built at less than 1% construction cost premium.

THANK YOU

Questions?

Responsive buildings.
Responsive people.