Continuous Building Performance Optimization and Decarbonization

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The FUTURE. Built Smarter.

Introductions

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IMEG

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Sr. Principal

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Learning Objectives

1. Explain the value and process of establishing an energy efficiency and decarbonization plan that maximizes return-on-investment.
2. Describe how the energy and carbon master planning process integrates with master planning, planning/design/construction, and facility management.
3. Describe how the energy and carbon master planning process integrates with asset management and reliability centered maintenance.
4. Describe the value of BAS/metering optimization and monitoring and analytics in measuring and sustaining building performance.
5. Review a health system's process and approach to integrating all of these initiatives into one customized, comprehensive, continuous program.

Healthcare Decarbonization Drivers

- U.S. health sector = 8.5% of national carbon emissions
- HHS Health Sector Climate Pledge: 133 orgs/900 hospitals
- Purpose: connection between health and environment; staff/patient expectations
- Financial: reduce energy/O&M costs; capture funding
- Regulatory: compliance; certification

HHS Health Sector Climate Pledge

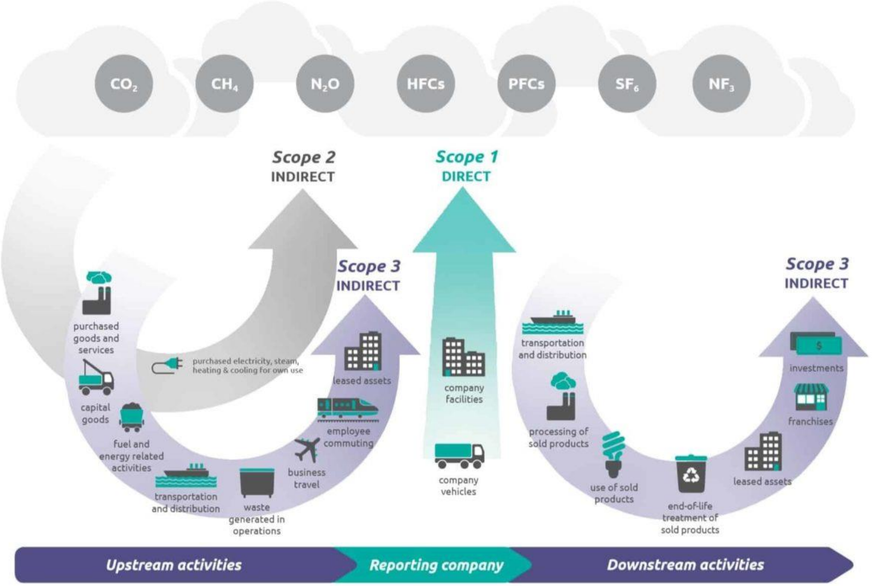
- At minimum, **reduce organizational emissions by 50% by 2030** (from a baseline no earlier than 2008) and achieve **net-zero by 2050**, publicly accounting for progress on this goal every year.
- Designate an executive-level lead for their work on reducing emissions by 2023 or within six months of signing the pledge and conduct an **inventory of Scope 3 (supply chain) emissions by the end of 2024.**
- Develop and release a **climate resilience plan** for continuous operations **by the end of 2023 or within six months of signing the pledge**, anticipating the needs of groups in their community that experience disproportionate risk of climate-related harm.

Carbon Emissions

- Scope 1: direct, controlled
- Scope 2: indirect, purchased
- Scope 3: supply chain

- <u>Operational</u> Scopes 1 & 2
  - Existing buildings
  - New construction/renovation

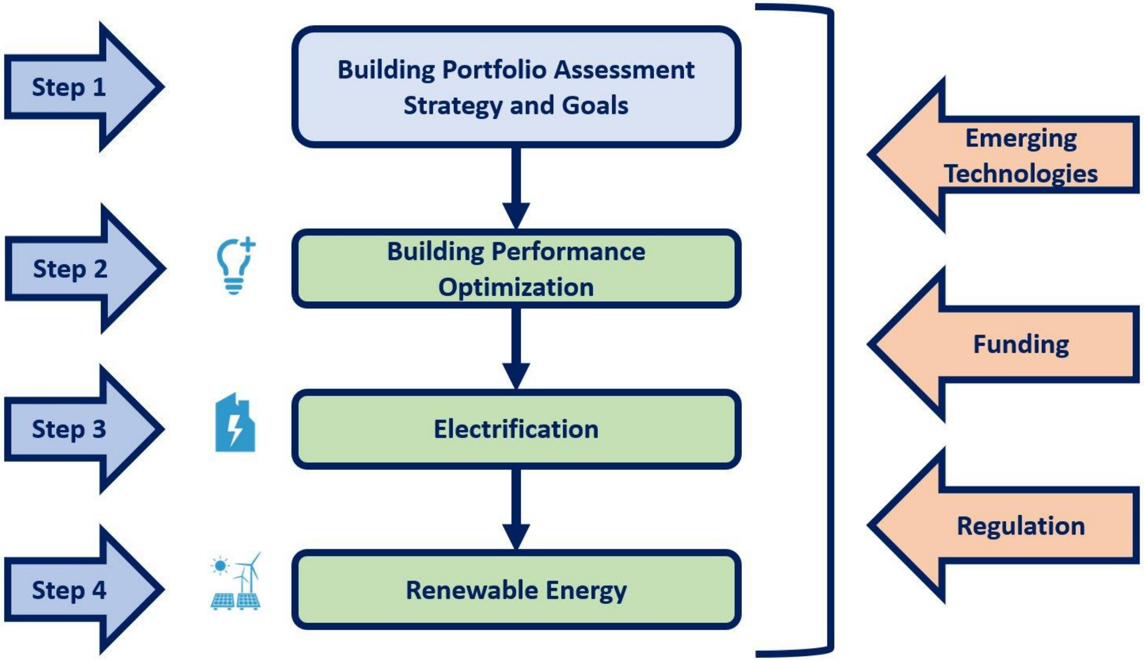
- <u>Embodied</u> Scope 3
  - New construction/renovation



Decarbonization Obstacles

- Financial and staffing resources
- Patient care is top priority
- Changing building portfolio
- Changing external landscape
  - Regulations
  - Funding
  - Emerging technologies

Portfolio-wide BPO & Decarbonization



Reducing energy (financial) and carbon (environmental) in one integrated process.

Dynamic Planning Process (vs. Static Plan)

- Comprehensive, continuous, integrated process
- Portfolio-wide – existing and new/PDC and FM
- Customized and adaptable to changing landscape
- Continuous verification and improvement
- Recurring planning/review sessions

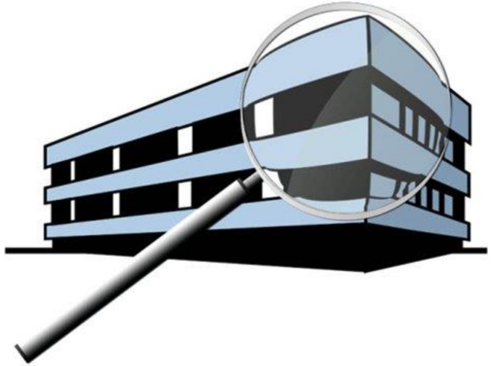
Static plans are immediately outdated in today's fast changing world.

Value of Dynamic, Integrated Process

- Maximized and sustained energy/O&M cost savings and carbon emission reduction
- Optimized and sustained space comfort/health
- Enhanced building knowledge and collaboration
- Continuous feedback loops
- Avoidance of silos, gaps, duplications, reboots, wasted effort, loss of momentum
- Peace of mind

Step 1: Building Portfolio Assessment

- Today-2030-2050
- Rightsizing
- Adapting to ongoing changes
  - New buildings/additions
  - Renovations
  - Closures/divestments
- Preparing for:
  - Electrification
  - Emerging technologies



Step 1: Goals

- Energy use
- Energy use intensity
- ENERGY STAR
- Carbon emissions
- Payback/return-on-investment
- Facility condition index
- Certifications

Step 1: Strategy/Plan Components

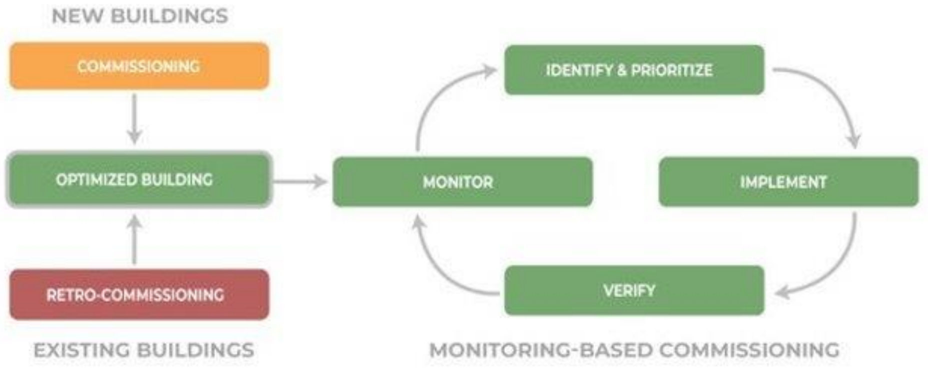
- Utility Analytics
- Planning and Tracking – Building, Project, O & M
- Commissioning/Retro-commissioning/Monitoring-based Commissioning
- Building Controls/Metering
- Design Guidelines
- Central Utility Plant
- Electrification
- Renewable Energy
- Funding and Building Performance Reporting Programs
- Integration of FM/PDC Processes

BPO Integration with PDC and FM

- Master planning
- Reliability centered maintenance
- Maintenance management
- Asset management
- Compliance
- Resiliency
- Embodied carbon

Step 2: Reducing Energy Use

- **Retro-commissioning:** 10-20% energy reduction
  - 0-2 year payback
- **Capital energy efficiency measures:** 10-20% energy reduction
  - 2-10 year payback
- **Capital program/infrastructure renewal:** 10-20% energy reduction
  - Design guidelines
  - Performance targets (OPR)

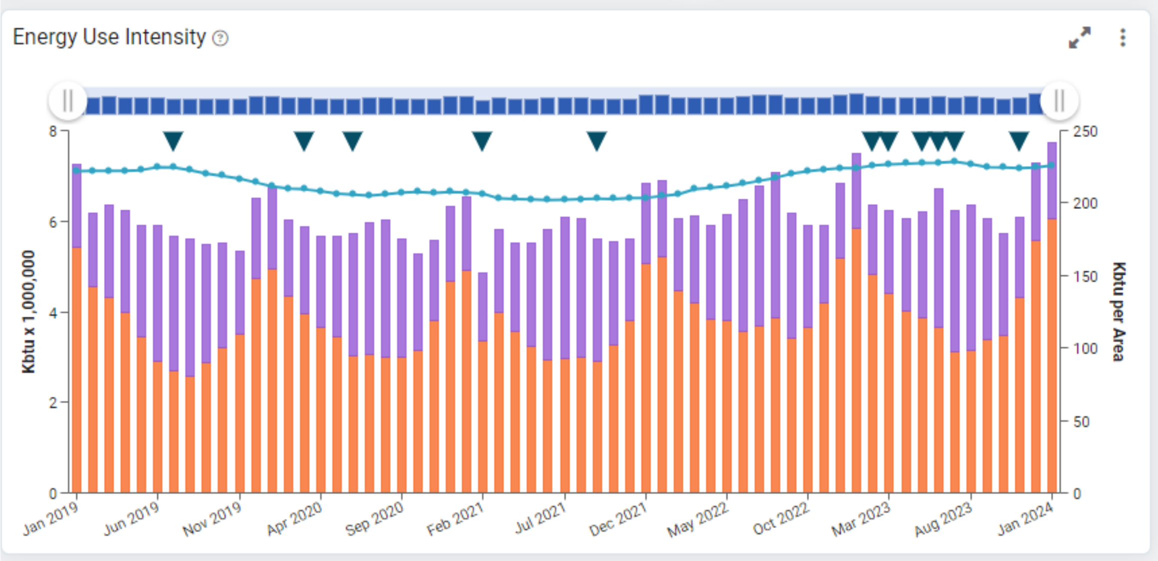


Step 2: RCx-MBCx Results

- Annual Energy Savings: $10,000,000+
- Utility Incentives: $10,000,000+
- **Simple Payback (Years): 0.64**
- Buildings: 200+
- Square Footage: 25,000,000+

Step 2: Performance Tracking and Analytics

- System
- Campus
- Building
- Equipment
- Project

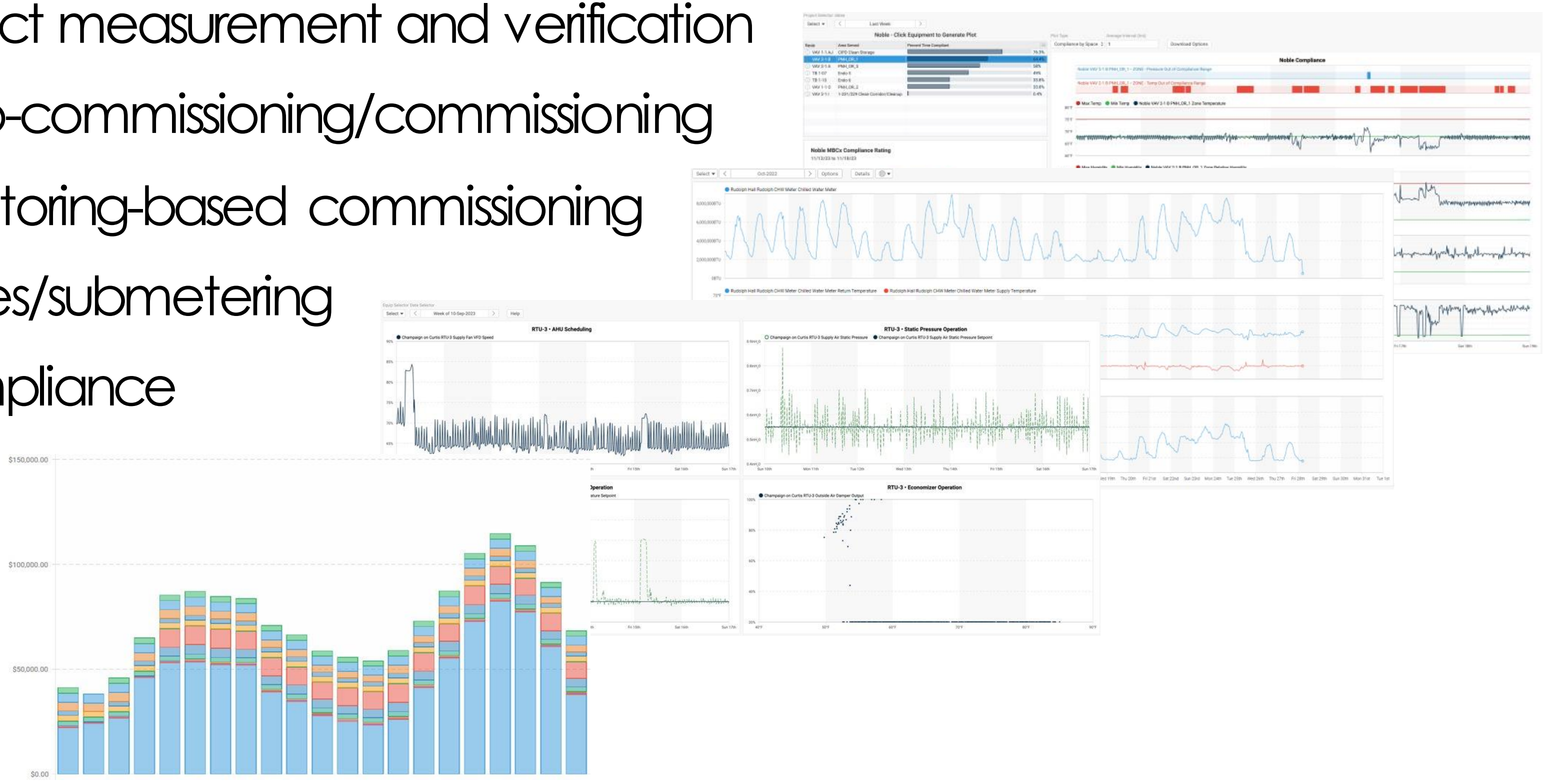


Impacts: projects, O & M

Reporting: ENERGY STAR, ASHE Energy to Care, BPS programs

Step 2: Monitoring and Analytics

- Project measurement and verification
- Retro-commissioning/commissioning
- Monitoring-based commissioning
- Utilities/submetering
- Compliance



Parkview Health-IMEG (2019-) - IN/OH

- 5+ million square feet, 11 hospitals
- Energy Savings Results
  - **Total Savings Last 5 Years: $3.9M**
  - **Current Annual Savings: $1.5M**
  - **RCx Payback: < 1.5 years**
- EUI* vs. 2020: **-16.58%**

*EUI of hospitals not yet included: **+3.77%**

Parkview Health-IMEG (2019-) - IN/OH

PARKVIEW HEALTH

EUI Tracking
Parkview Health

IMEG

RCx Buildings

	2023 Square Footage	Changes in EUI			
Buildings		2021 vs 2020	2022 vs 2021	2023 vs 2022	2023 vs 2020
Huntington Hospital	135,188	-11.42%	2.00%	-10.12%	-18.79%
Huntington MOB	34,396	-20.86%	9.80%	-9.44%	-21.31%
LaGrange Hospital	77,906	-10.20%	-0.73%	-6.03%	-16.23%
LaGrange MOB	17,332	3.05%	1.98%	-2.63%	2.33%
PRMC Campus	2,024,206	-1.06%	-6.64%	-2.53%	-9.97%
Wabash Hospital	82,460	-3.86%	-4.04%	-3.45%	-10.92%
Wabash MOB	32,258	-6.84%	2.51%	-1.10%	-5.56%
Composite EUI	2,403,746	**-8.65%**	**-5.66%**	**-3.20%**	**-16.58%**

Pre-RCx Buildings

	2023 Square Footage	Changes in EUI			
Buildings		2021 vs 2020	2022 vs 2021	2023 vs 2022	2023 vs 2020
DeKalb Hospital	252,962	-0.31%	0.00%	3.69%	3.36%
DeKalb MAC-99	15,000	-1.75%	4.69%	-12.86%	-10.37%
DeKalb MAC East	37,481	1.25%	-8.03%	-25.53%	-30.65%
DeKalb MAC West	16,334	3.20%	0.25%	-16.51%	-13.62%
Noble Hospital	117,225	8.99%	2.30%	-3.37%	7.74%
Randallia Hospital	853,848	-1.17%	4.83%	3.09%	6.81%
Whitley Hospital	109,961	1.64%	0.34%	-10.43%	-8.65%
Whitley MOB	61,746	-2.91%	-1.91%	-8.67%	-13.03%
Composite EUI	1,464,557	**0.17%**	**2.99%**	**0.59%**	**3.77%**

HSHS-IMEG Results (2013-) - IL/WI

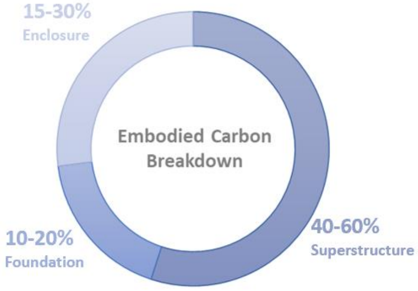
- 7+ million square feet, 15 hospitals
- Estimated Savings Results:
  - **Annual Energy Savings: $1,328,738**
  - **Utility Incentives: $1,418,083**
  - **Payback: 0.61 years**

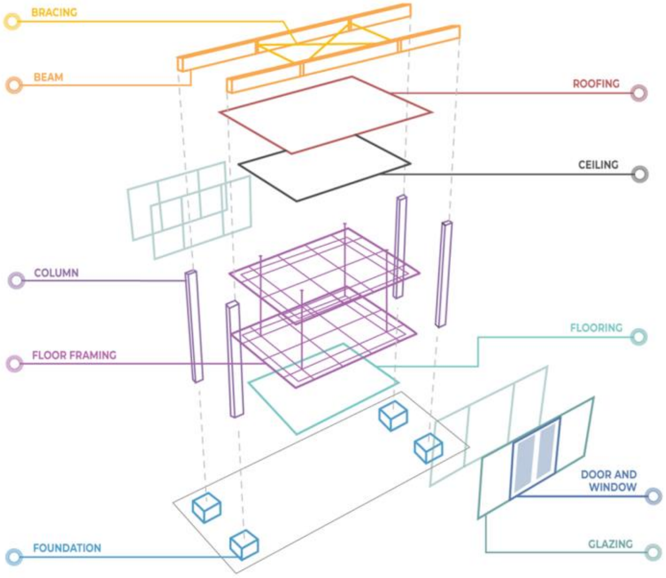
Step 2: Design Guidelines

- **Operational carbon (Scopes 1 and 2)**
  - Building envelope
  - Building orientation
  - LED lighting and controls
  - HVAC systems efficiency and controls
  - Electric systems or preparation for future electrification

Step 2: Design Guidelines

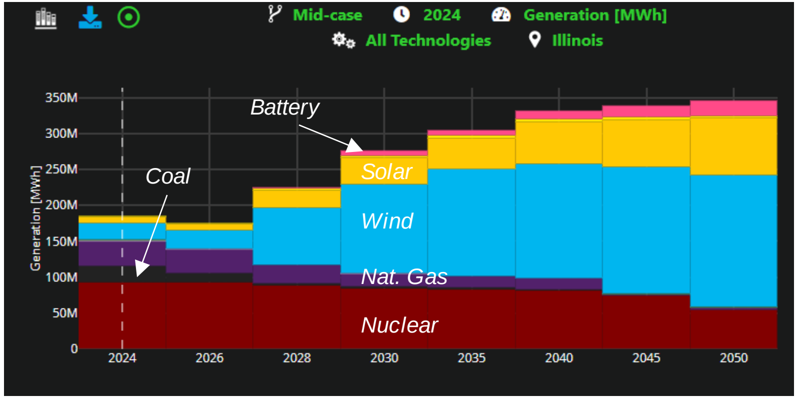
- **Embodied carbon (Scope 3)**
  - Material Selection
    - Prioritize low-carbon materials
  - Optimize Design
    - Durability and longevity
    - Reduce material usage
  - Modular Construction
  - Local Sourcing
  - Recycling and Reuse

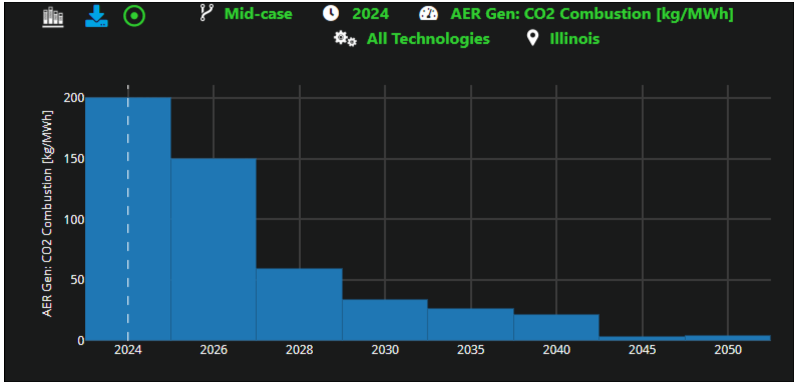




Step 3: Electrification

Preparing for a cleaner grid to come





Step 3: Electrification

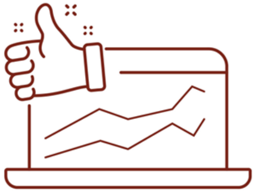
ELECTRIFICATION

Inventory distribution
- piping and coils for conversion to low temperature HW

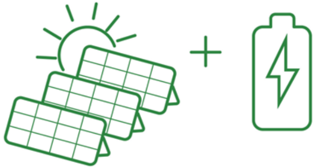
Reduce heating load
- Conduction
- Infiltration
- Outside air treatment

Convert to an electrified source:
- Geothermal
- Air source heat pump
- Hot water storage tanks
- Heat recovery (data center, ice rink)

1 Assess Carbon Footprint
- Operational Carbon
- Embodied Carbon



2 Optimize Building Performance
- Energy modeling
- Monitoring & Analytics



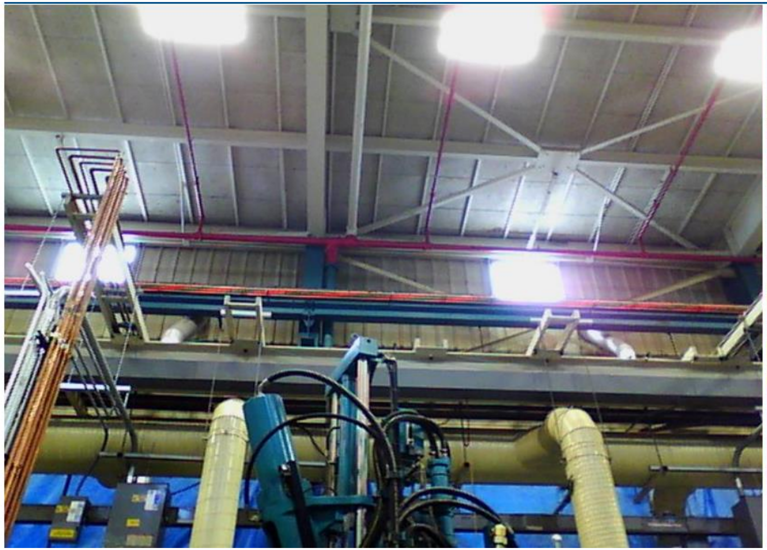
3 Integrate Renewable Energy
- Consider on - site and off - site options
- Identify path to net zero energy and carbon neutral

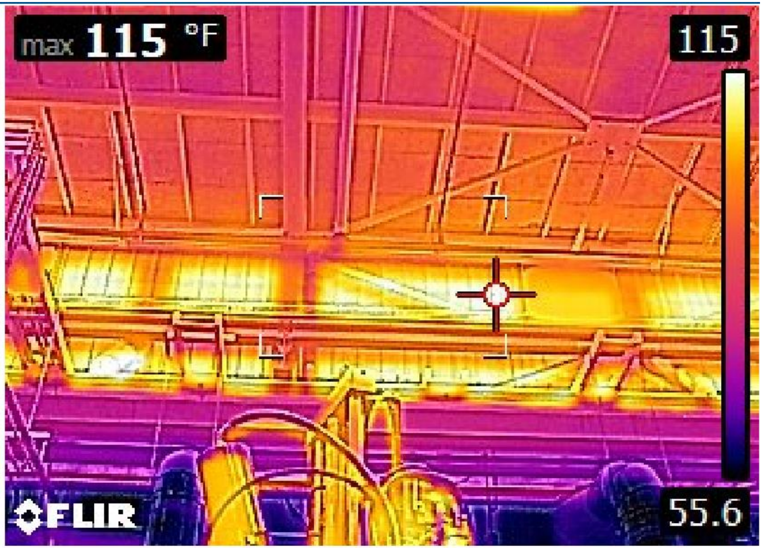
Step 3: Electrification – Inventory

Component	Quantity	Scope
Steam boilers (10040 lb/hr each)	3	Replace with electric boilers, air source heat pump, geothermal, or hybrid combination of these
Steam to HW heat exchanger	2	Remove or replace for converstion to LTHW*
AHU	9	Convert steam heating coils to LTHW
AHU humidification	7	Replace with electric or adiabatic
Duct mounted humidifcation	14	Replace with electric or adiabatic
VAV boxes	513	Test heating capacities at LTHW, replace as required to meet load
Radiant ceiling panels	all patient rooms	Test heating capacities at LTHW, replace as required to meet load
Baseboard	7	Test heating capacities at LTHW, replace as required to meet load
Steam unit heaters (304 Mbh each)	5	Convert from steam to LTHW, extend HW piping (304 Mbh each)
HW unit heaters (~70 Mbh each)	4	Test heating capacities at LTHW, replace as required to meet load
HW cabinet heaters (~50 Mbh each)	13	Test heating capacities at LTHW, replace as required to meet load

*LTHW - Low Temperature Hot Water (130-135F is maximum HW supply temperature for current heat pump technology)

Step 3: Electrification – Reduce Load





DOAS Energy Recovery Wheel

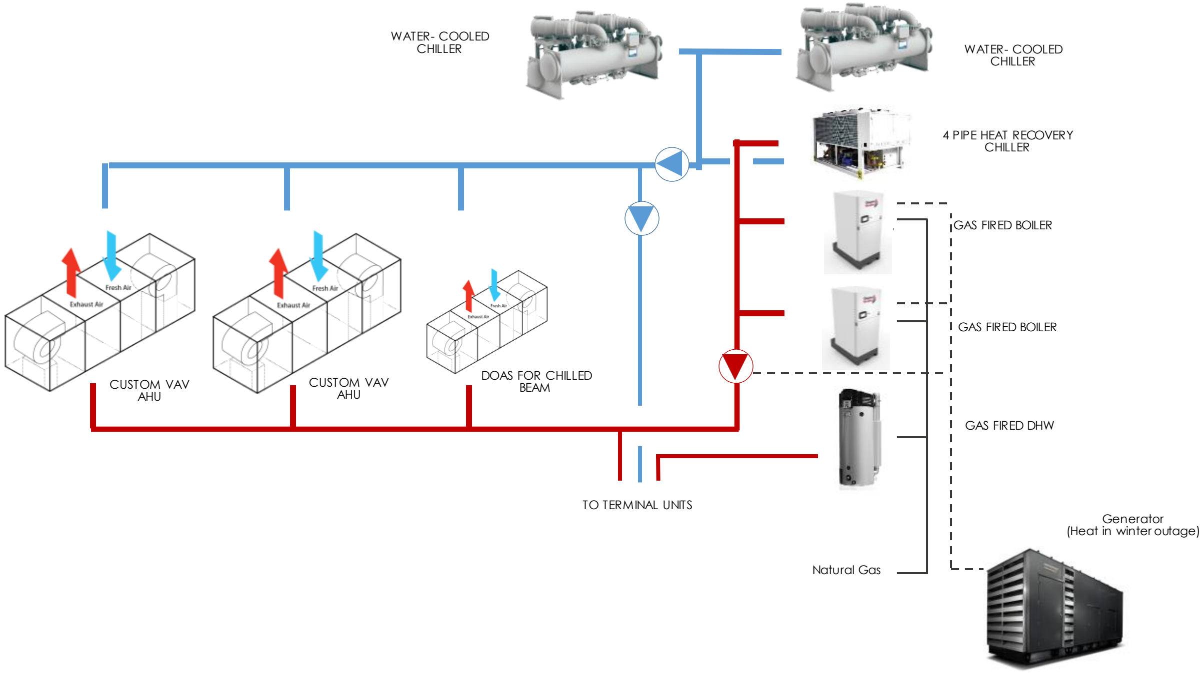
Passive Resilience

Step 3: Electrification – Options

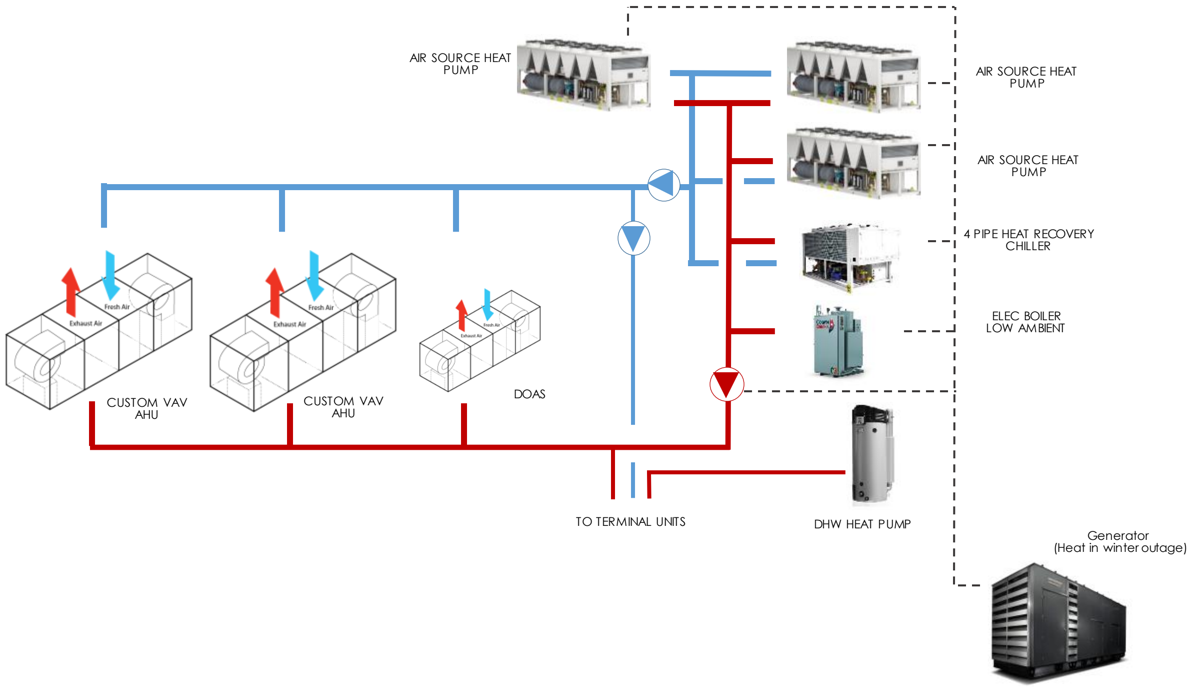
Generating HWS

	Electric resistance	Air Source Heat Pump	Heat recovery chiller	Geothermal WTW HP
Minimum OA operating temp.	NA	0 - 15 F	NA	NA
Heating COP	1.0	2.0 - 3.5	3.5 - 7.0	4.0 – 5.5
Key Benefit	Lowest first cost	Energy cost on par with gas when OA >30F	High COP at any OA temp	Ground heat exchange, not air
Key Limitation	High energy cost 3x+	Minimum OA temp Low HWS temp Capacity falls off as OA drops	Only handles simultaneous load Maintenance and min. load	Well field size and cost
Max HWS temp	Same as gas	125 - 130 F	130 – 140 F	130 – 140 F

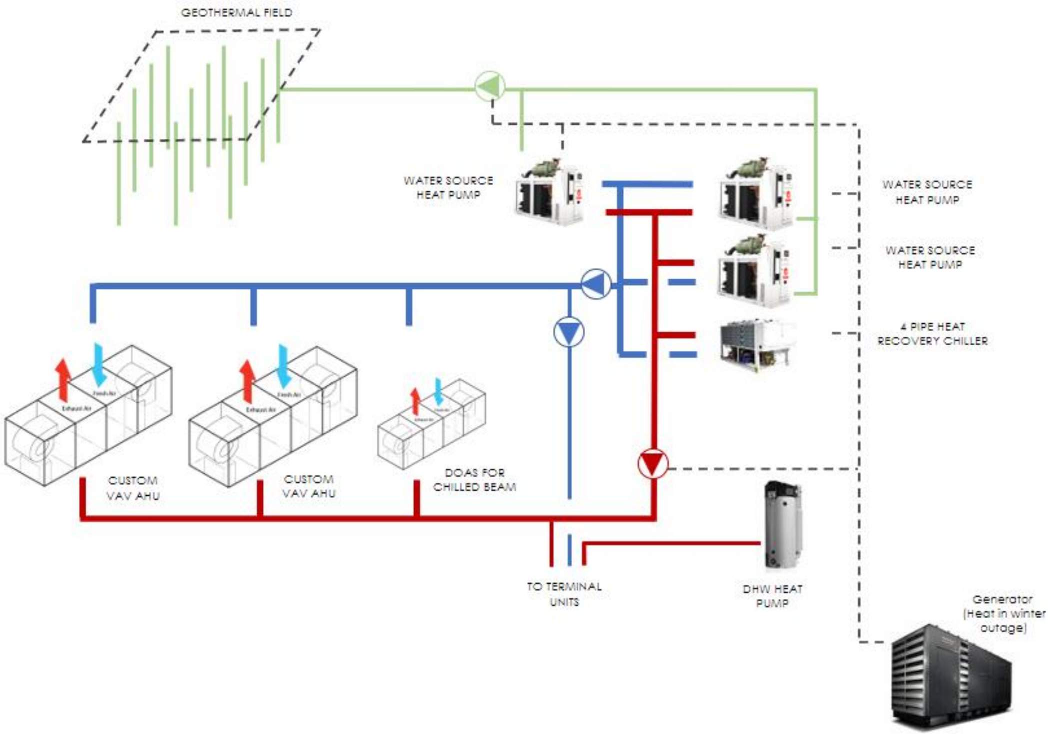
Step 3: Electrification – Traditional



Step 3: Electrification – Options



Step 3: Electrification – Options

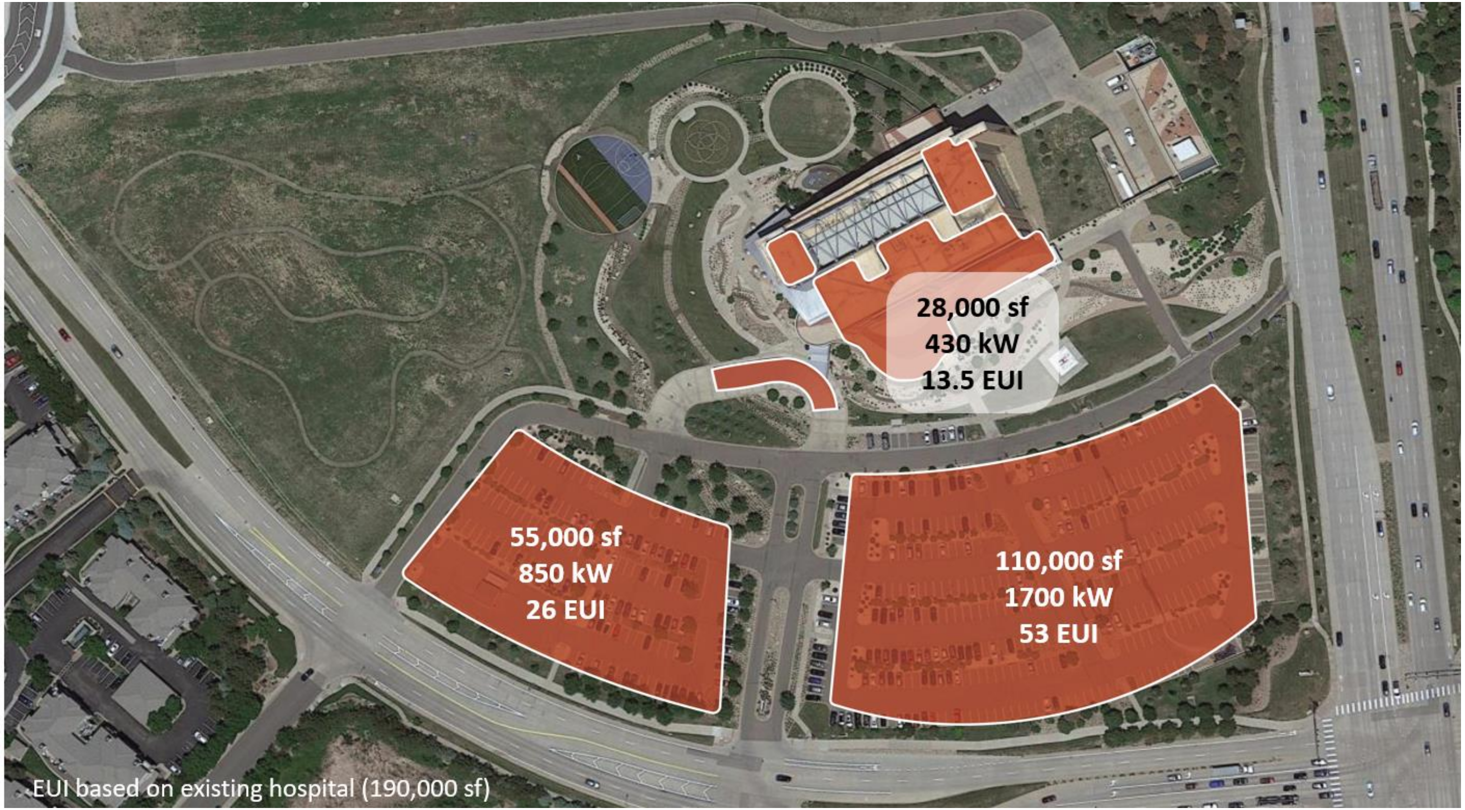


Step 4: Renewable Energy

- Options
  - On-site
  - Off-site (virtual/physical)
  - RECs
- Factors
  - Pace of decarbonization
  - Future energy costs

Eastpark Medical – UW Health (1.1 MW)

On-Site Generation



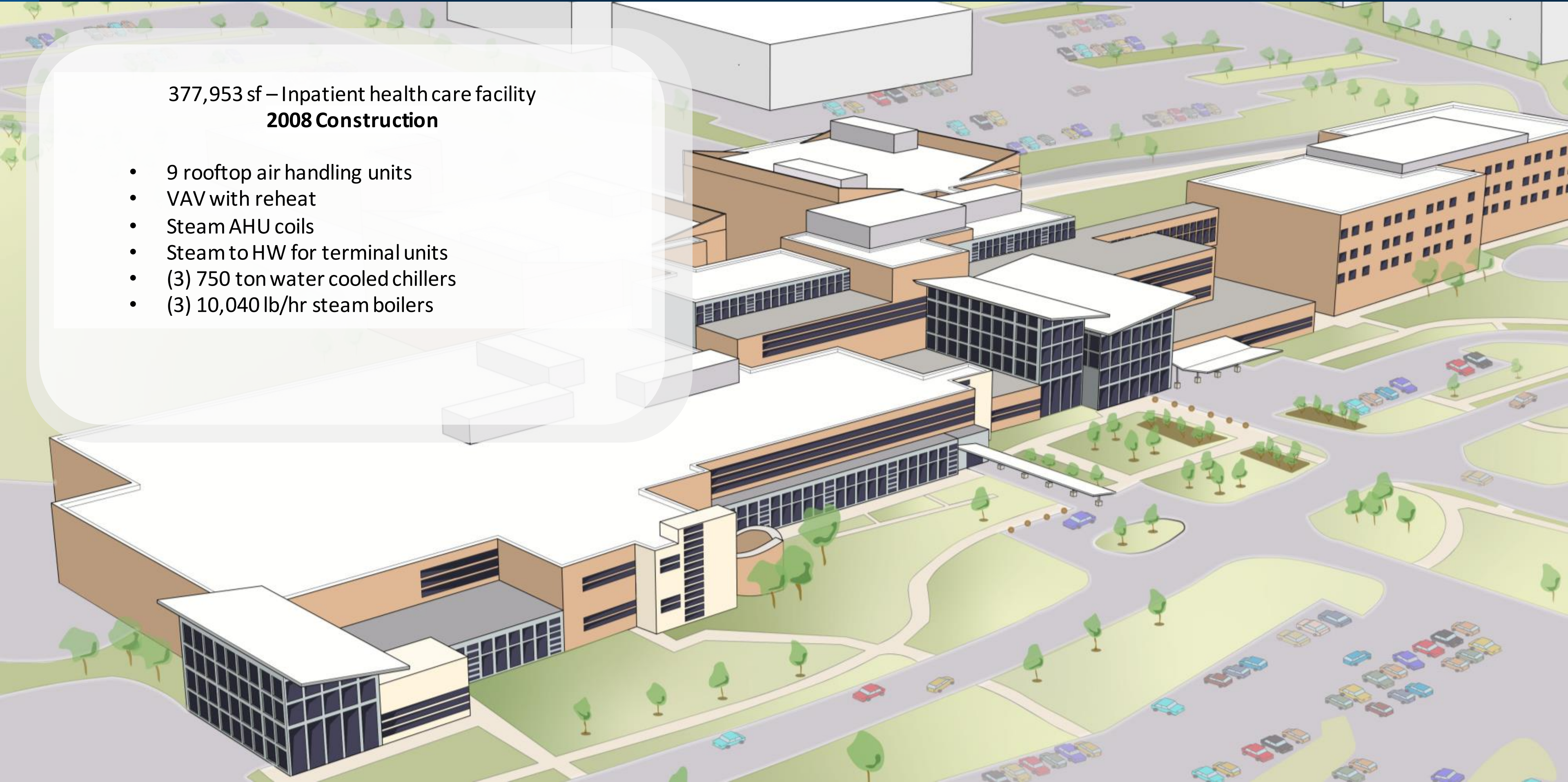
DECARBONIZATION

Midwest Healthcare - Inpatient

Site Overview

377,953 sf – Inpatient health care facility
2008 Construction

- 9 rooftop air handling units
- VAV with reheat
- Steam AHU coils
- Steam to HW for terminal units
- (3) 750 ton water cooled chillers
- (3) 10,040 lb/hr steam boilers



DECARBONIZATION

FOUNDING PILLARS

1

ASSESS CARBON FOOTPRINT

Understand major sources of carbon emissions

2

OPTIMIZE PERFORMANCE

Minimize operational carbon

3

ELECTRIFICATION

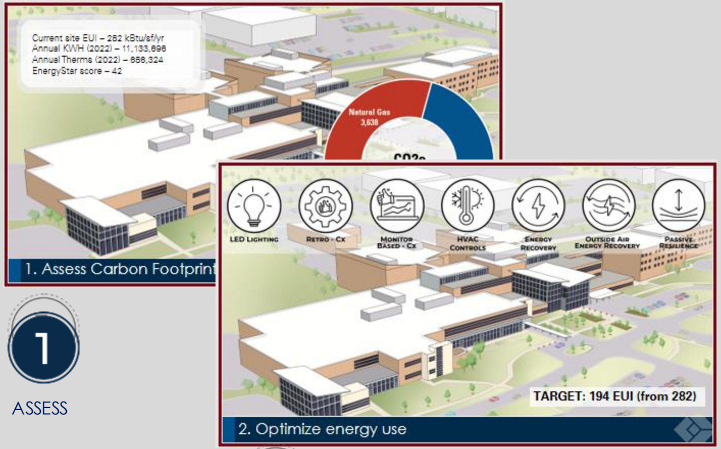
Eliminate the use of fossil fuels on site

4

OFFSET WITH RENEWABLES

Consider on-site, off-site and storage solutions

Key Steps

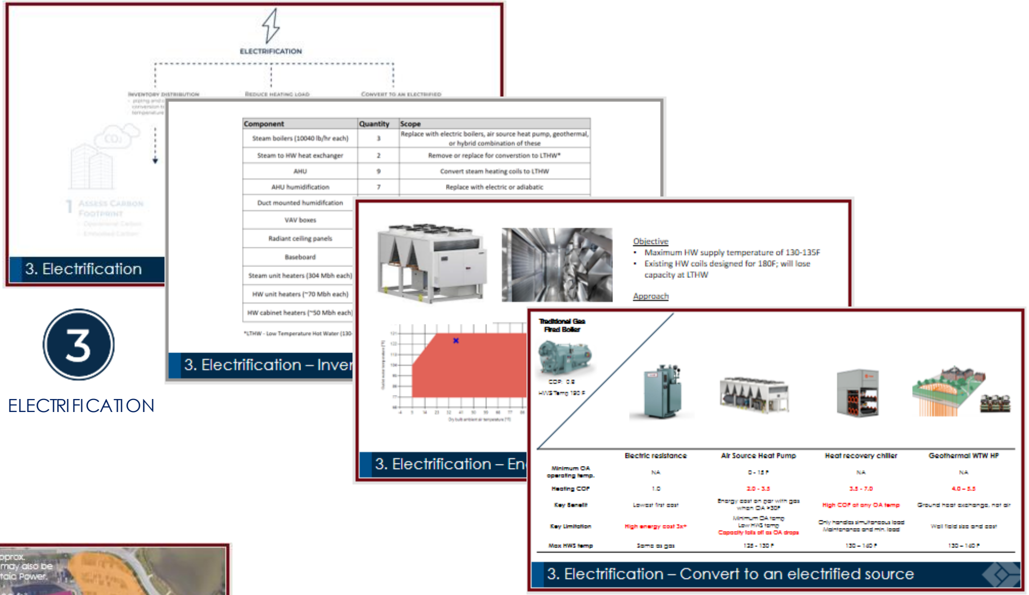


1

ASSESS

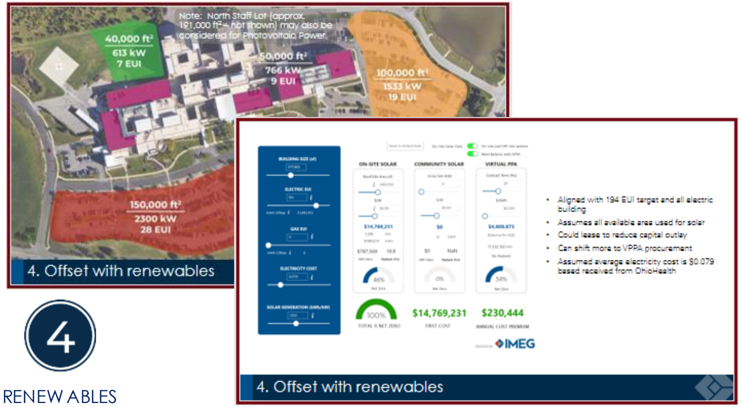
2

OPTIMIZE



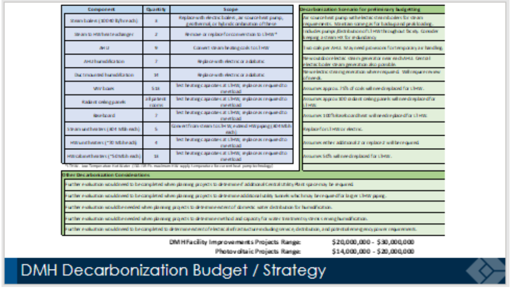
3

ELECTRIFICATION



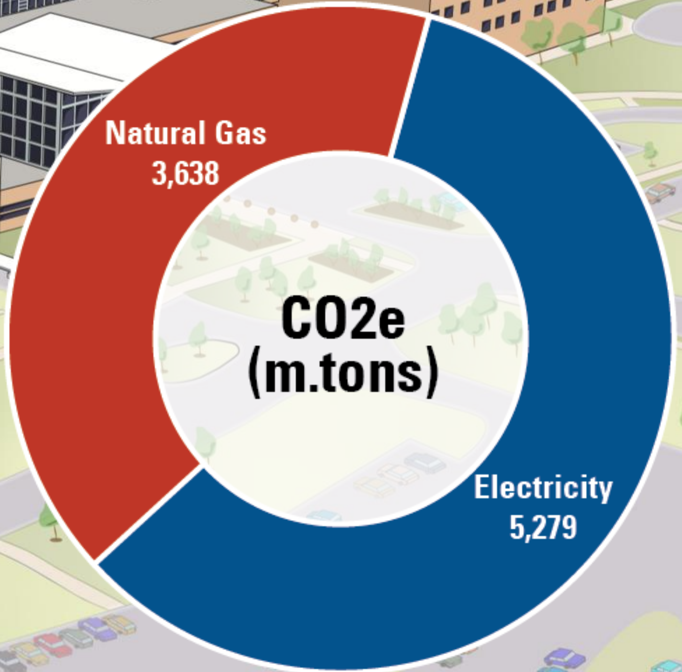
4

RENEWABLES

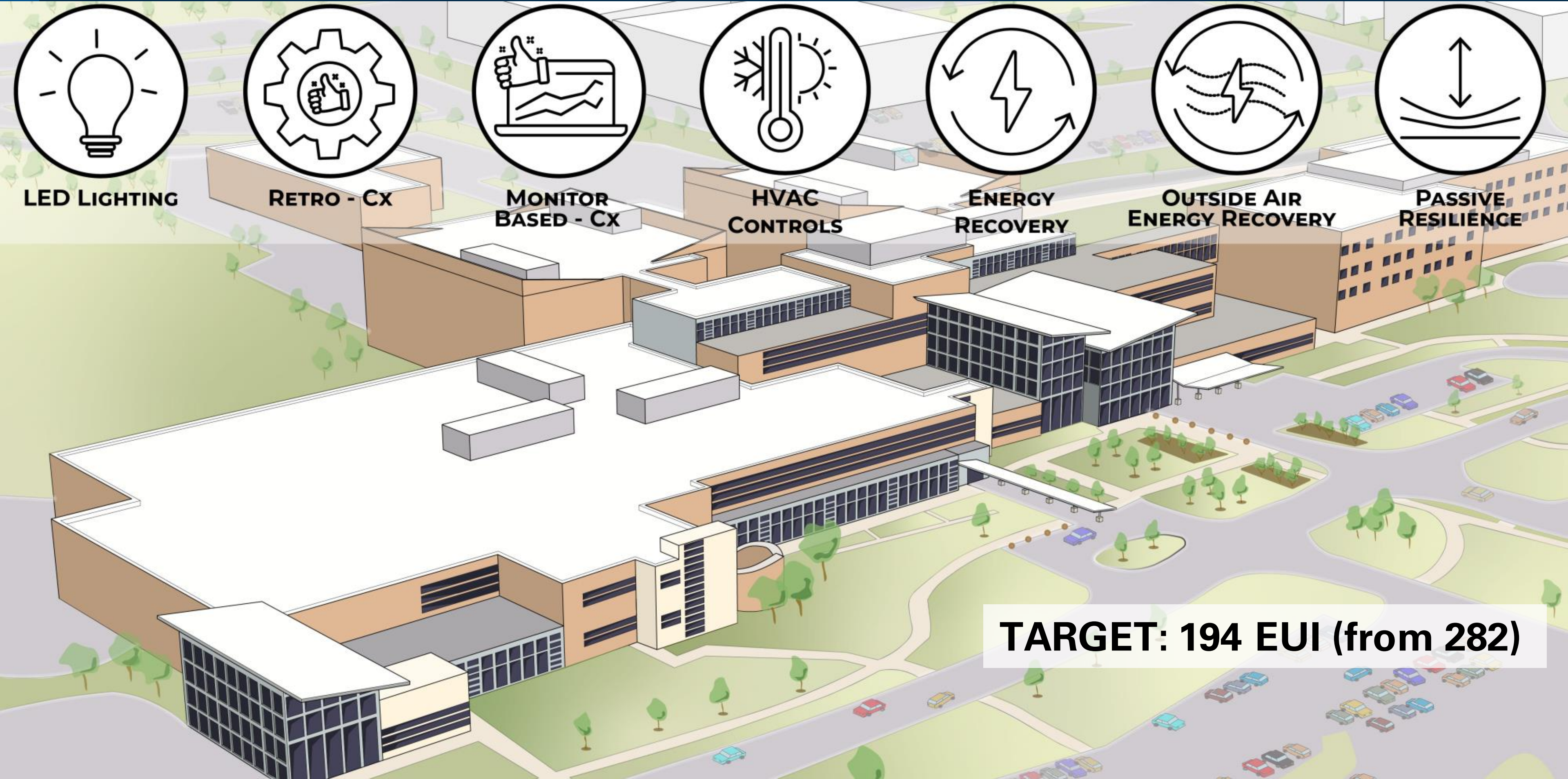


1. Assess Carbon Footprint

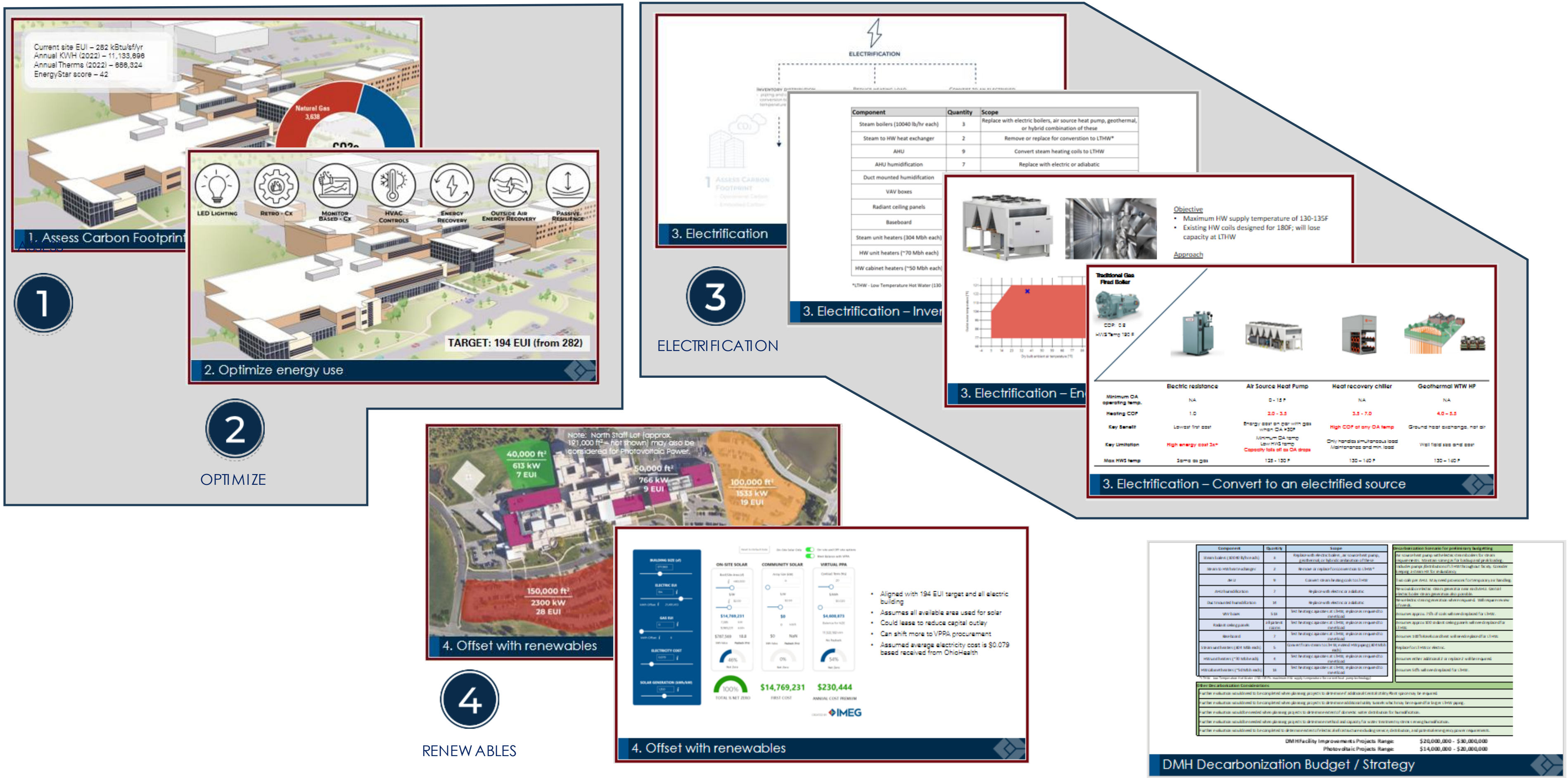
Current site **EUI – 282** kBtu/sf/yr
Annual KWH (2022) – 11,133,696
Annual Therms (2022) – 686,324
EnergyStar score – 42



2. Optimize Energy Use



Key Steps



Current site EUI – 282 kBtu/sf/yr
Annual KWH (2022) – 11,133,696
Annual Therms (2022) – 656,324
EnergyStar score – 42
Natural Gas
3,638
1. Assess Carbon Footprint
1
LED Lighting
Retro - Cx
Monitor Based - Cx
HVAC Controls
Energy Recovery
Outside Air Energy Recovery
Passive Resilience
TARGET: 194 EUI (from 282)
2. Optimize energy use
2
OPTIMIZE
ELECTRIFICATION
3. Electrification
3
ELECTRIFICATION
3. Electrification – Inver
Objective
Maximum HW supply temperature of 130-135F
Existing HW coils designed for 180F; will lose capacity at LTHW
Approach
3. Electrification – En
Electric resistance
Air Source Heat Pump
Heat recovery chiller
Geothermal WTW HP
3. Electrification – Convert to an electrified source
40,000 ft²
613 kW
7 EUI
50,000 ft²
766 kW
9 EUI
100,000 ft²
1533 kW
19 EUI
150,000 ft²
2300 kW
28 EUI
4. Offset with renewables
4
RENEWABLES
Aligned with 194 EUI target and all electric building
Assumes all available area used for solar
Could lease to reduce capital outlay
Can shift more to VPPA procurement
Assumed average electricity cost is $0.079 based received from OhioHealth
$14,769,231
$230,444
IMEG
4. Offset with renewables
DMH Decarbonization Budget / Strategy

3. Electrification – Enable Low Temp Hot Water

Objective

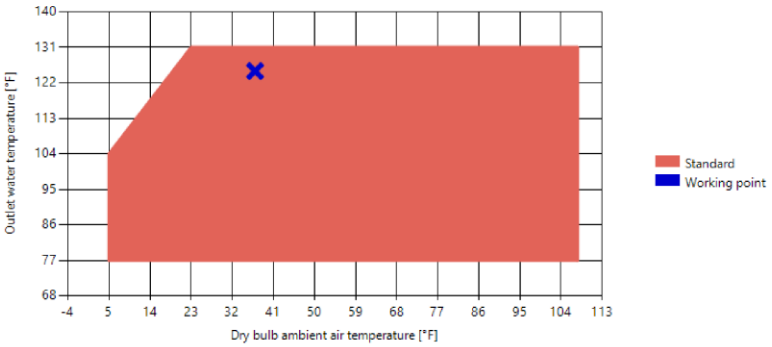
- Maximum HW supply temperature of 130-135F
- Existing HW coils designed for 180F; will lose capacity at LTHW

Approach

- Check existing coil cut sheet capacities vs. load
- Trend coil valve position in BAS to find critical coils
- Reduce HW in the building over time to confirm problem areas

Outcome

- Some HVAC coils will be sufficient as they are – others will need to be replaced

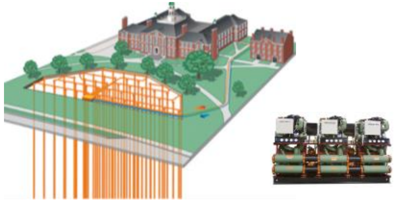


3. Electrification – Convert to an Electrified Source

Traditional Gas Fired Boiler

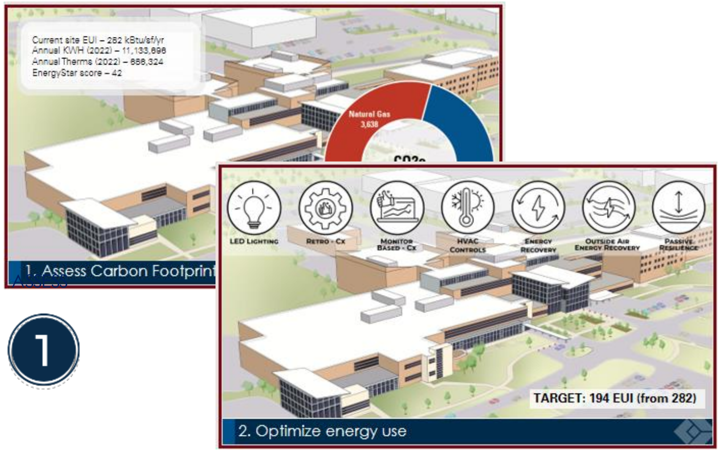
COP: 0.8

HWS Temp 180 F



	Electric resistance	Air Source Heat Pump	Heat recovery chiller	Geothermal WTW HP
Minimum OA operating temp.	NA	0 - 15 F	NA	NA
Heating COP	1.0	**2.0 - 3.5**	**3.5 - 7.0**	**4.0 – 5.5**
Key Benefit	Lowest first cost	Energy cost on par with gas when OA >30F	**High COP at any OA temp**	Ground heat exchange, not air
Key Limitation	**High energy cost 3x+**	Minimum OA temp Low HWS temp **Capacity falls off as OA drops**	Only handles simultaneous load Maintenance and min. load	**Well field size and cost**
Max HWS temp	Same as gas	125 - 130 F	130 – 140 F	130 – 140 F

Key Steps

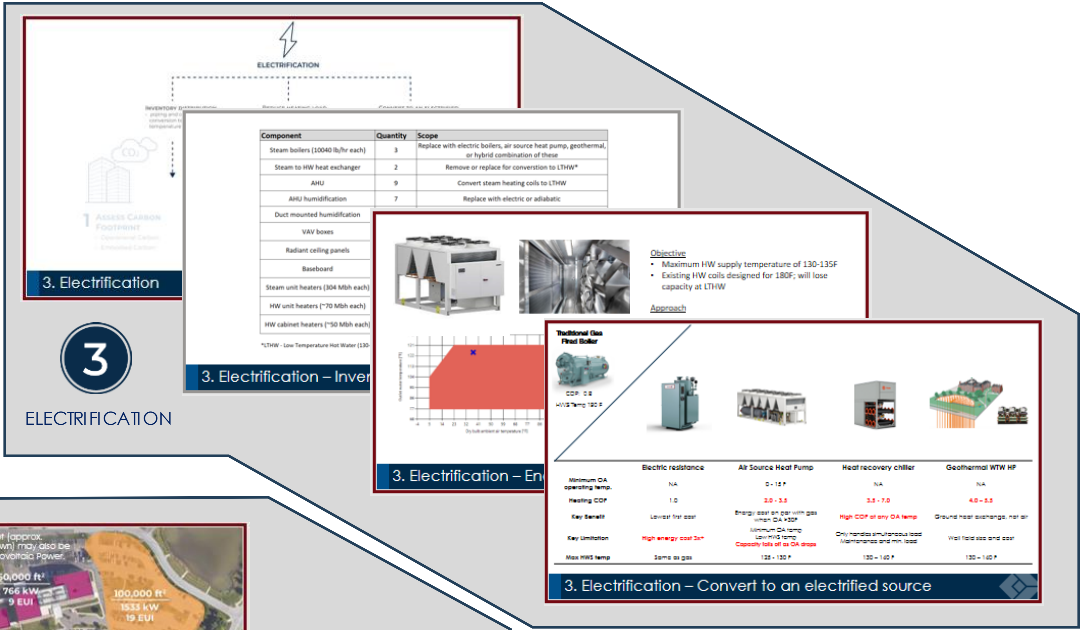


1

ASSESS

2

OPTIMIZE

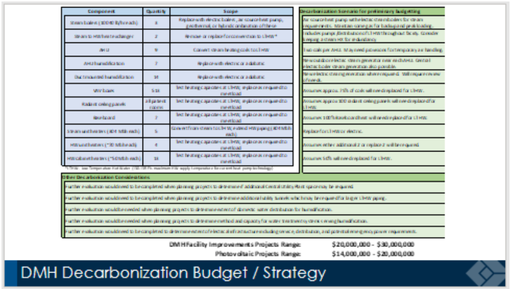


3

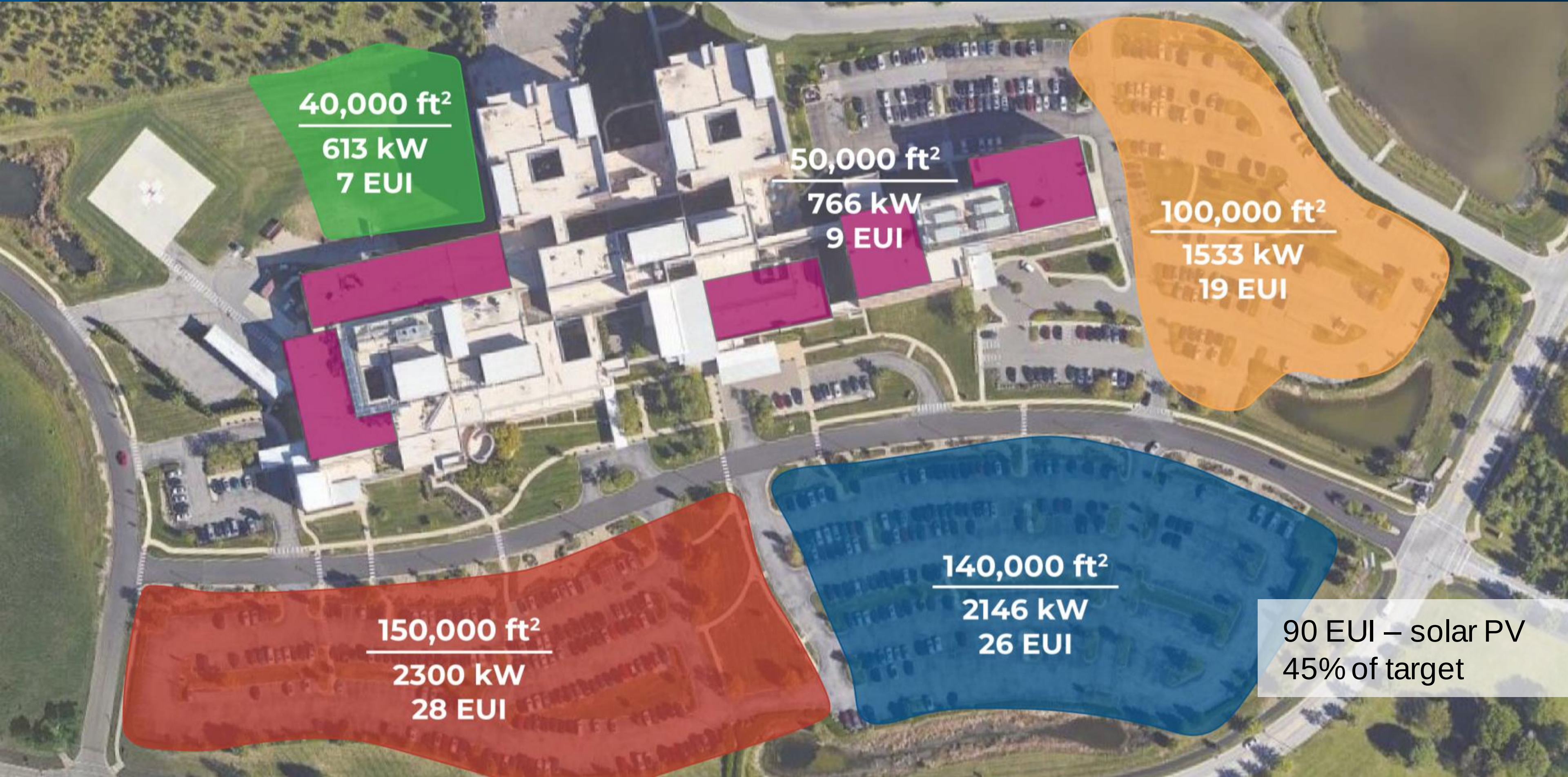
ELECTRIFICATION

4

RENEWABLES



4. Renewable Energy



90 EUI – solar PV
45% of target

DMH Decarbonization Budget / Strategy

Component	Quantity	Scope	Decarbonization Scenario for preliminary budgetting
Steam boilers (10040 lb/hr each)	3	Replace with electric boilers, air source heat pump, geothermal, or hybrid combination of these	Air source heat pump with electric steam boilers for steam requirements. Maintain some gas for backup and peak loading.
Steam to HW heat exchanger	2	Remove or replace for converstion to LTHW*	Includes pumps/distribution of LTHW throughout faciity. Consider keeping a steam HX for redundancy
AHU	9	Convert steam heating coils to LTHW	Two coils per AHU. May need provisions for temporary air handling.
AHU humidification	7	Replace with electric or adiabatic	New outdoor electric steam generator near each AHU. Central electric boiler steam generation also possible.
Duct mounted humidifcation	14	Replace with electric or adiabatic	New electric steam generation where required. Will require review of needs.
VAV boxes	513	Test heating capacities at LTHW, replace as required to meet load	Assumes approx. 75% of coils will need replaced for LTHW.
Radiant ceiling panels	all patient rooms	Test heating capacities at LTHW, replace as required to meet load	Assumes approx 100 radiant ceiling panels will need replaced for LTHW.
Baseboard	7	Test heating capacities at LTHW, replace as required to meet load	Assumes 100% Baseboard heat will need replaced for LTHW.
Steam unit heaters (304 Mbh each)	5	Convert from steam to LTHW, extend HW piping (304 Mbh each)	Replace for LTHW or electric.
HW unit heaters (~70 Mbh each)	4	Test heating capacities at LTHW, replace as required to meet load	Assumes either additional 2 or replace 2 will be required.
HW cabinet heaters (~50 Mbh each)	13	Test heating capacities at LTHW, replace as required to meet load	Assumes 50% will need replaced for LTHW.

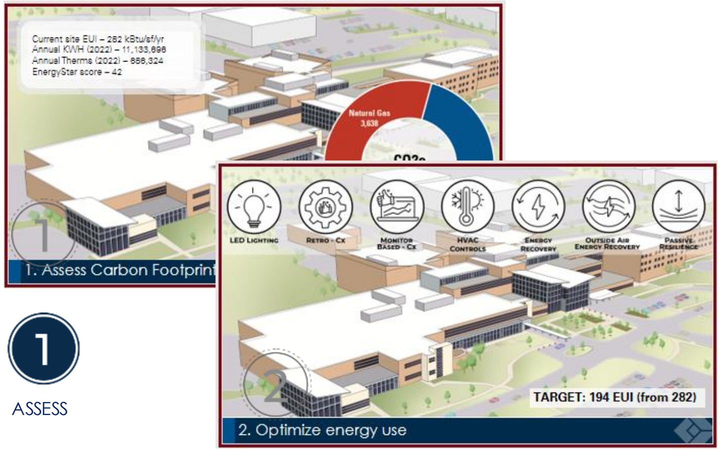
*LTHW - Low Temperature Hot Water (130-135F is maximum HW supply temperature for current heat pump technology)

Other Decarbonization Considerations
Further evaluation would need to be completed when planning projects to determine if additional Central Utility Plant space may be required.
Further evaluation would need to be completed when planning projects to determine additional utility tunnels which may be required for larger LTHW piping.
Further evaluation would be needed when planning projects to determine extent of domestic water distribution for humidification.
Further evaluation would be needed when planning projects to determine method and capacity for water treatment systems serving humidification.
Further evaluation would need to be completed to determine extent of electrical infrastructure including service, distribution, and potential emergency power requirements.

DMH Facility Improvements Projects Range: $20,000,000 - $30,000,000

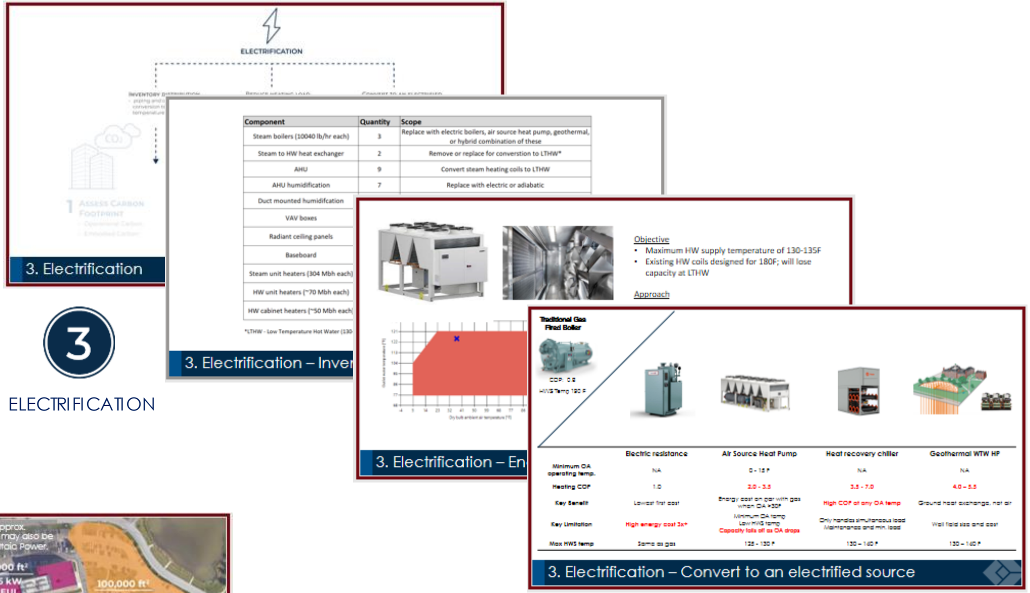
Photovoltaic Projects Range: $14,000,000 - $20,000,000

Key Steps

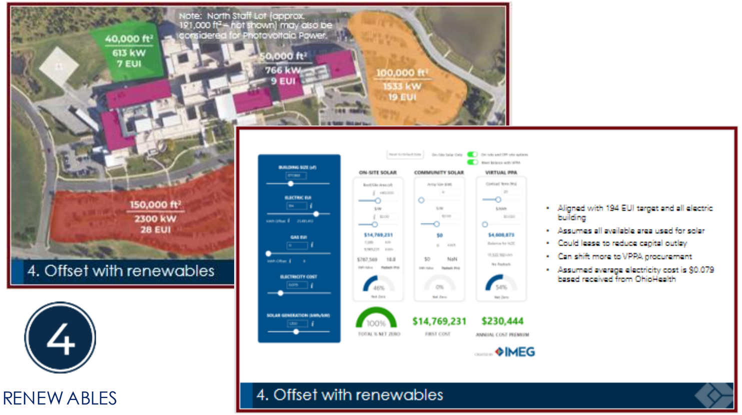


1 ASSESS

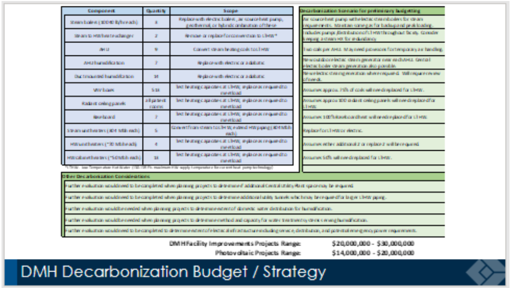
2 OPTIMIZE



3 ELECTRIFICATION

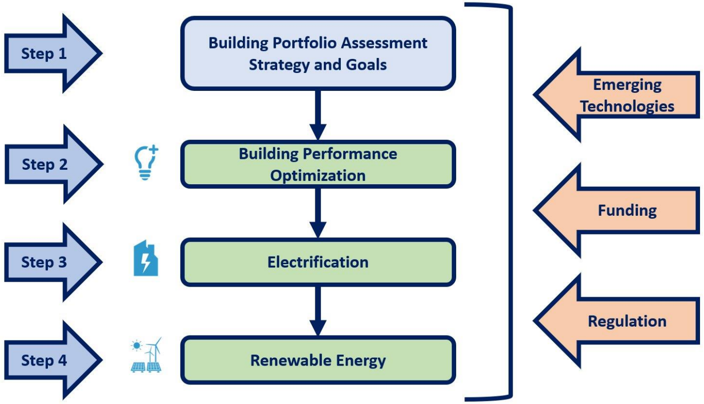


4 RENEWABLES



Customized, Dynamic Planning

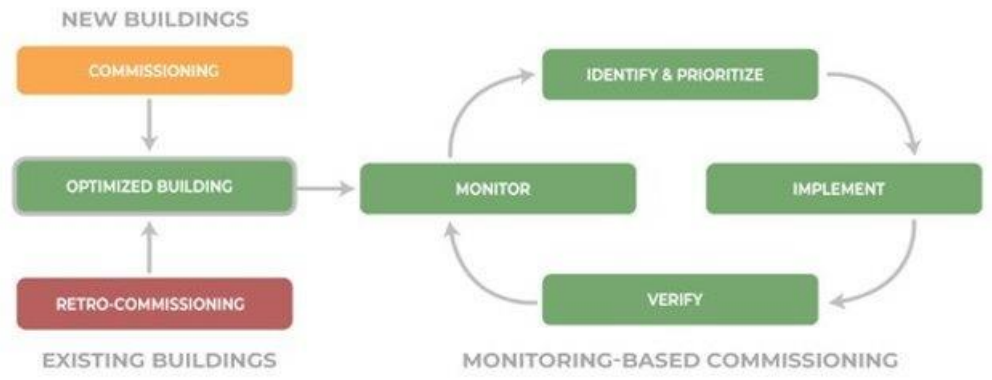
Do we have a dynamic process that addresses these questions continuously against external conditions – funding, regulations, emerging technologies?



1. Building portfolio: what do we have/what will we have?
2. Optimization: are we optimizing performance . . . continuously?
3. Electrification: how are we preparing for/moving toward electrification?
4. Renewable energy: what renewable energy should we do ourselves to complement the electric grid?

Getting Started: Dynamic Planning

1. Strategy workshop
2. Utility data benchmarking and analytics
3. Initiate recurring strategy/review sessions
4. Retro-commissioning strategy/plan



Q & A

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Continuous Building Performance Optimization and Decarbonization

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