Decarbonization in Design and Post-Occupancy:

The Next Generation of Healing and Learning Environments

IMEG

- Describe the difference between operational and embodied carbon and how design teams' decisions impact each.
- Identify the tools needed to develop a campus's carbon reduction roadmap.
- Identify the energy efficiency benefits of retro and monitoring based commissioning for post occupancy carbon reduction.
- Identify the simplest things that can be done right now to lessen the carbon footprint of healthcare and education campuses.
- Demonstrate examples of past projects success and challenges through the decarbonization process.

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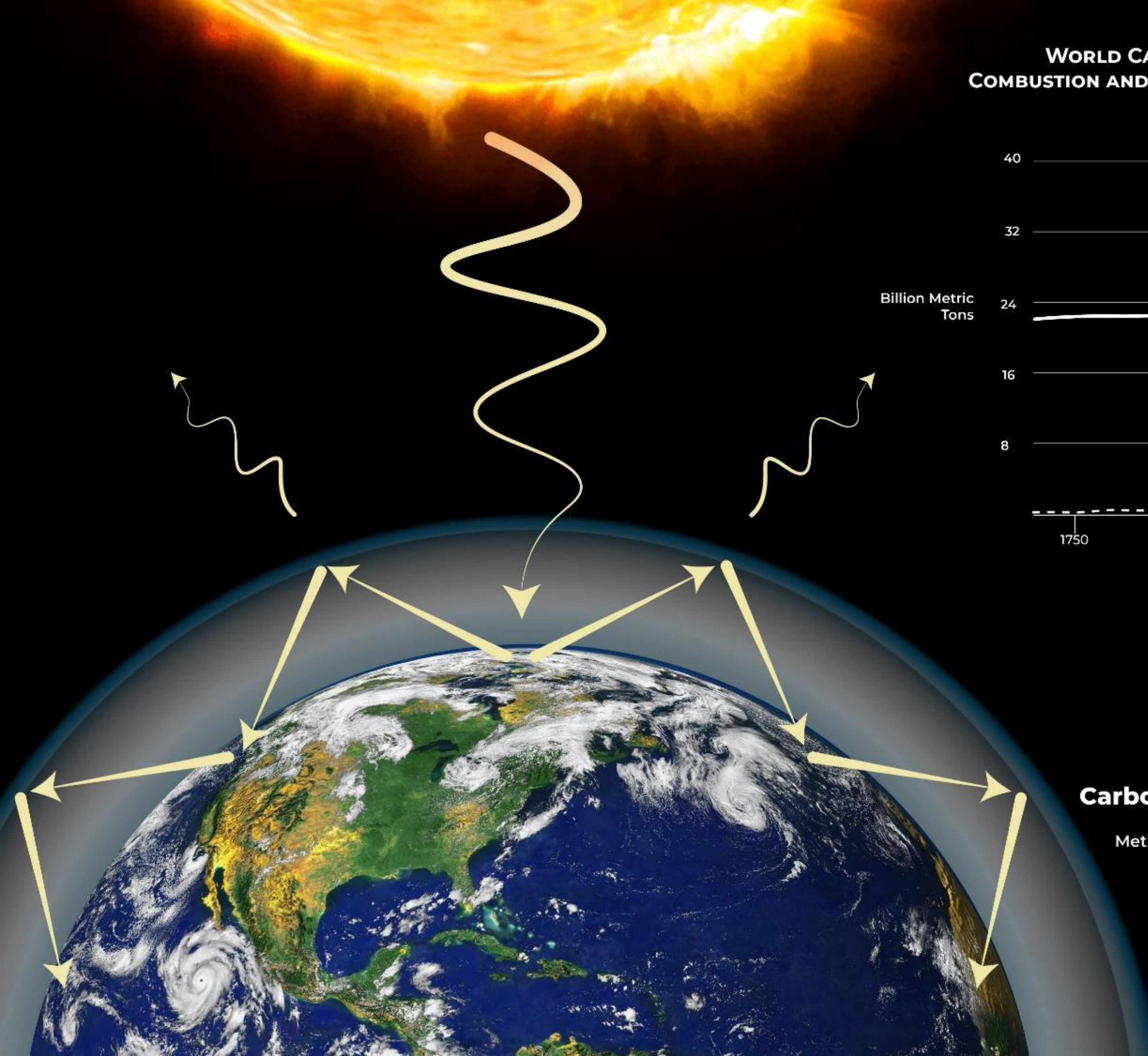
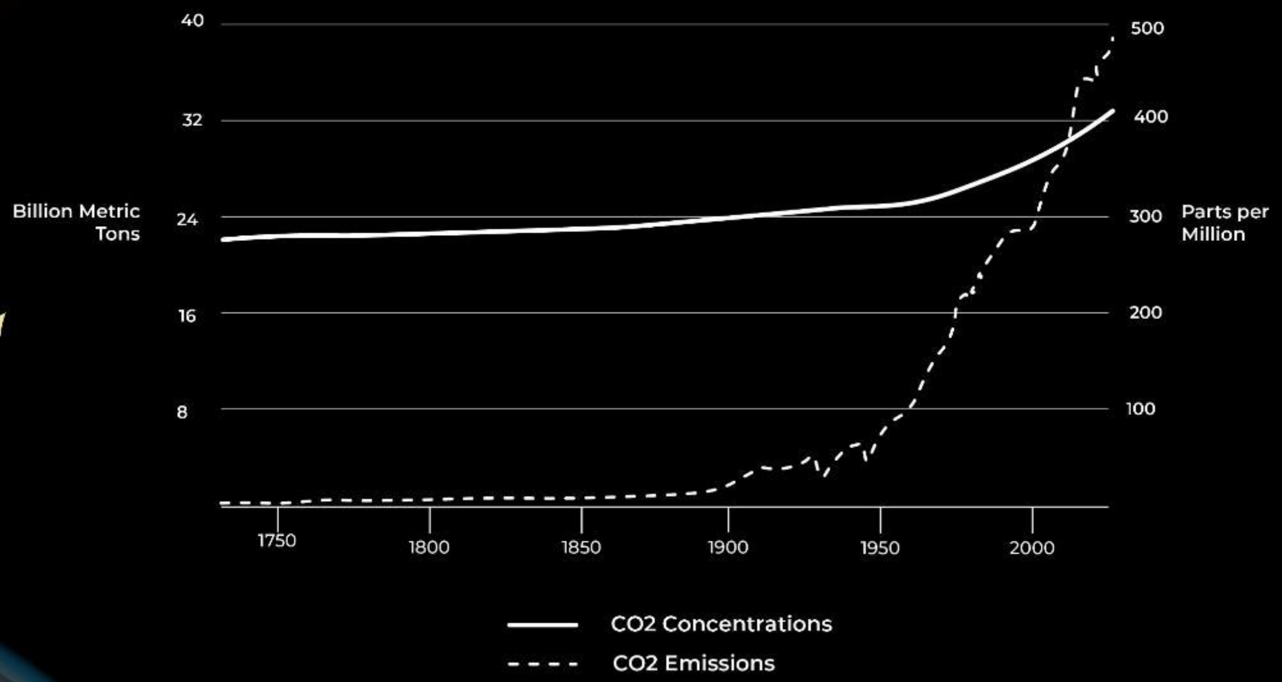
Learning Objectives

Why Carbon?



World Carbon Dioxide (CO2) Emissions From Fossil Fuel Combustion and Global Atmospheric Concentrations CO2 (1751 - 2020)



Carbon Dioxide (CO_2)

Methane (CH_4)

Nitrous Oxide (N_2O)

Halocarbon & SF6

Molecular Hydrogen (H_2)

Carbon is the leading cause of climate change and there are health and environmental co benefits if the healthcare industry drastically reduces its carbon footprint and targets zero carbon

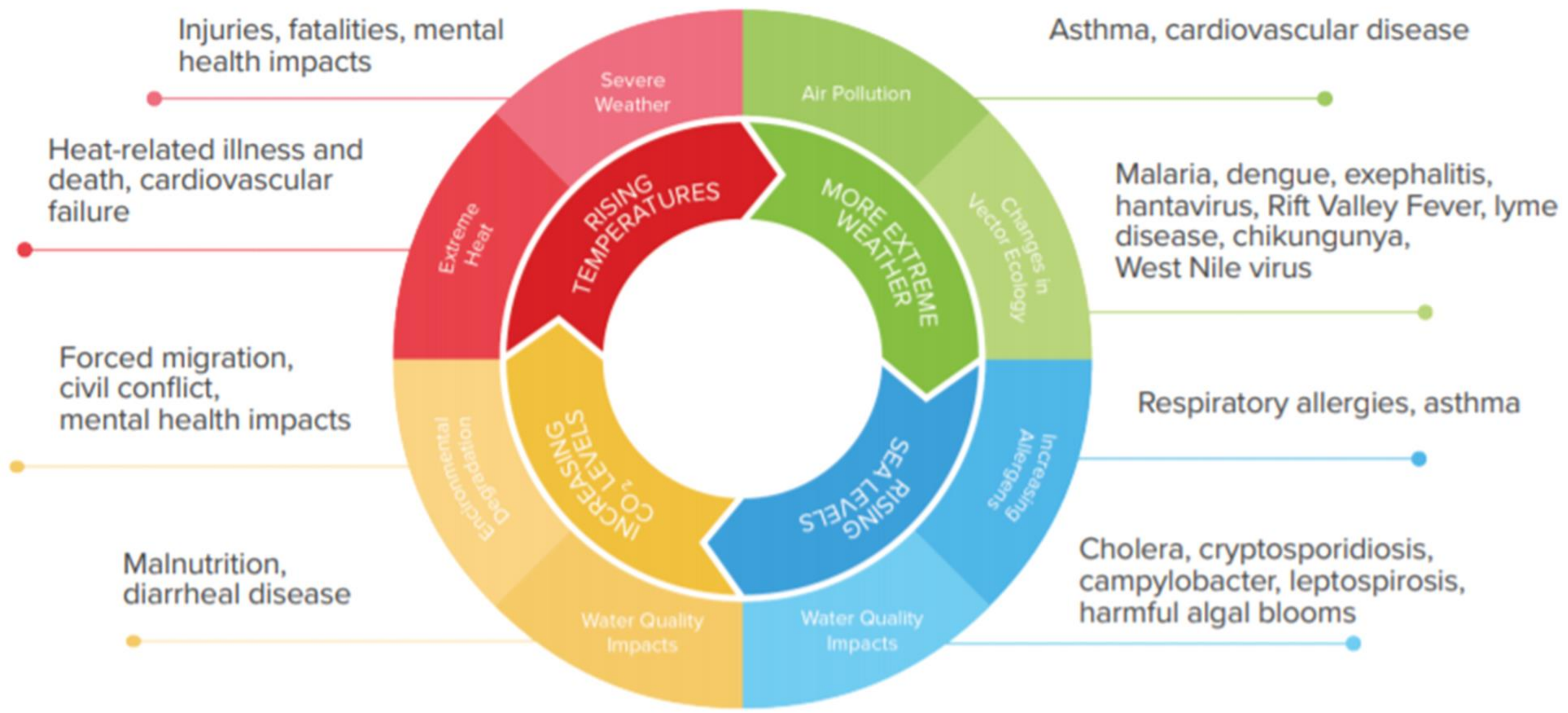


Figure 1: Impact of climate change on human health (Source: U.S. Centers for Disease Control and Prevention)

Why Carbon?

HEALTH SECTOR CLIMATE PLEDGE

1. 2030 - Reduce emissions by 50%
   2050 - Net Zero

2. 2023 - Designate an Elective Lead
   2024 - Develop an inventory of Scope 3 emissions

3. 2023 - Climate Resilience Plan for Continuous Operation

CARBON NEUTRALITY COMMITMENTS

SCOPE 1–EMISSIONS ELIMINATED BY 2040

Scope 1 GHG emissions result from **direct, on-campus sources.** To eliminate them, our first actions include **installing geothermal heating and cooling** for some new construction projects (a first step in phased transition of heating and cooling systems), **electrifying our bus fleet,** and **launching a revolving fund for energy efficiency projects, starting with $25 million** over five years.

SCOPE 2–CARBON NEUTRAL BY 2025

Scope 2 GHG emissions come from **purchased electricity.** To eliminate them, we will **secure all purchased electricity from renewable sources.**

SCOPE 3–ESTABLISH GOALS BY 2025

Scope 3 GHG emissions are all of the upstream and downstream GHGs resulting from **indirect sources** like commuting, food procurement, and university-sponsored travel. Our first steps will be to **better measure these emission sources and develop roadmaps for mitigating them.**

OHIO STATE SUSTAINABILITY GOALS

Resource Stewardship

7. Implement specific, "world-leading" university-wide operational goals to reduce resource consumption, neutralize carbon emissions and minimize waste, including:
   a. Achieve carbon neutrality by 2050 per Presidents' Climate Leadership Commitment;
   b. Increase the energy efficiency of the university per building square foot by 25% by 2025;
   c. Reduce potable water consumption by 10% per capita every five years, resetting baseline every five years;
   d. Increase Ecosystem Services Index score to 85% by 2025;
   e. Reduce carbon footprint of university fleet per thousand miles traveled by 25% by 2025;

Climate Action

Taking Action in a Changing Climate

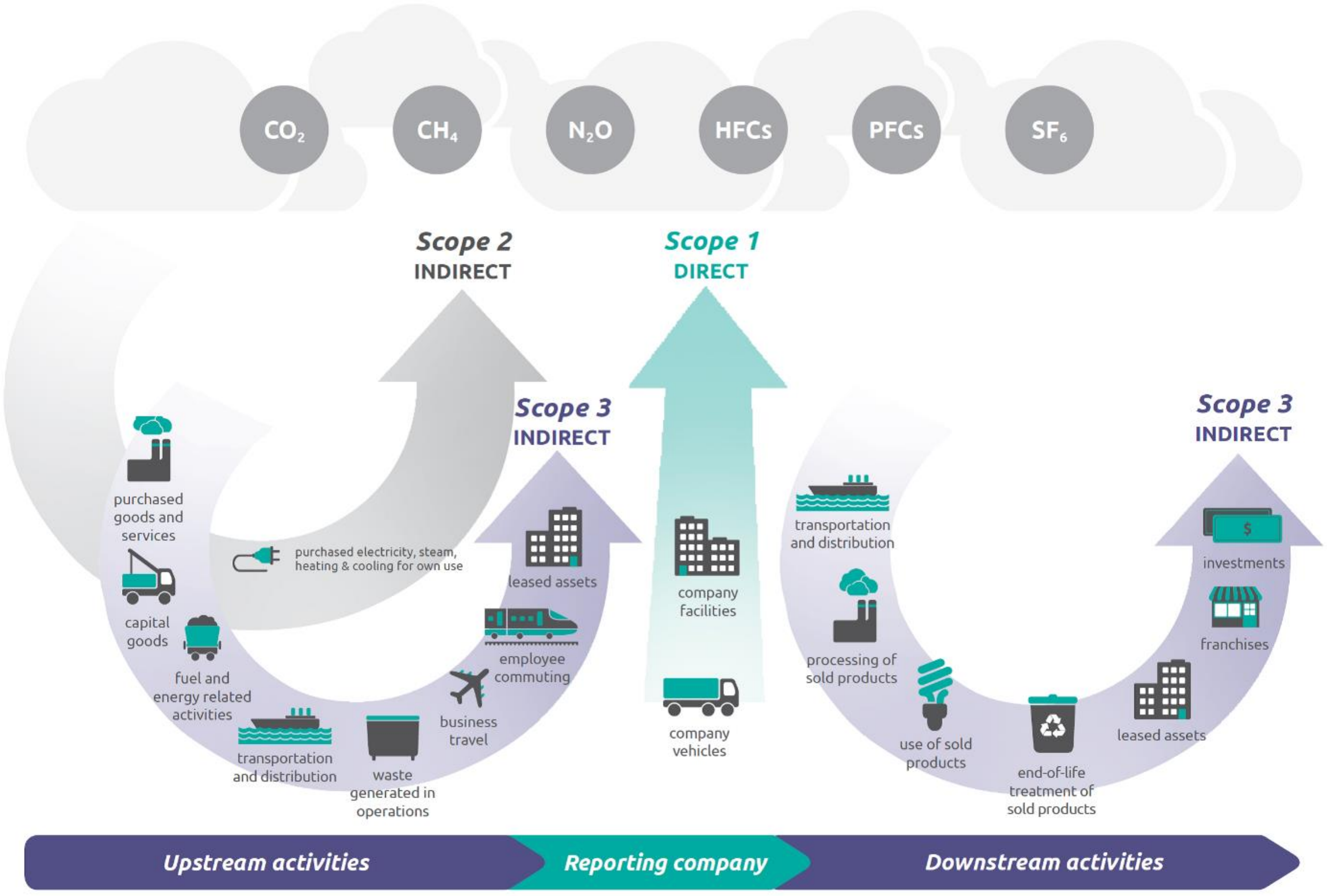
Yale is committed to achieving zero actual carbon emissions by 2050 with an interim goal to reach net zero emissions by 2035. Net zero will be attained primarily by reducing campus emissions 65% below 2015 levels and, as needed, retiring high-quality, verifiable carbon offsets. Zero actual carbon emissions will be accomplished by fully minimizing campus emissions and deploying clean energy technology.

Prairie Trails School

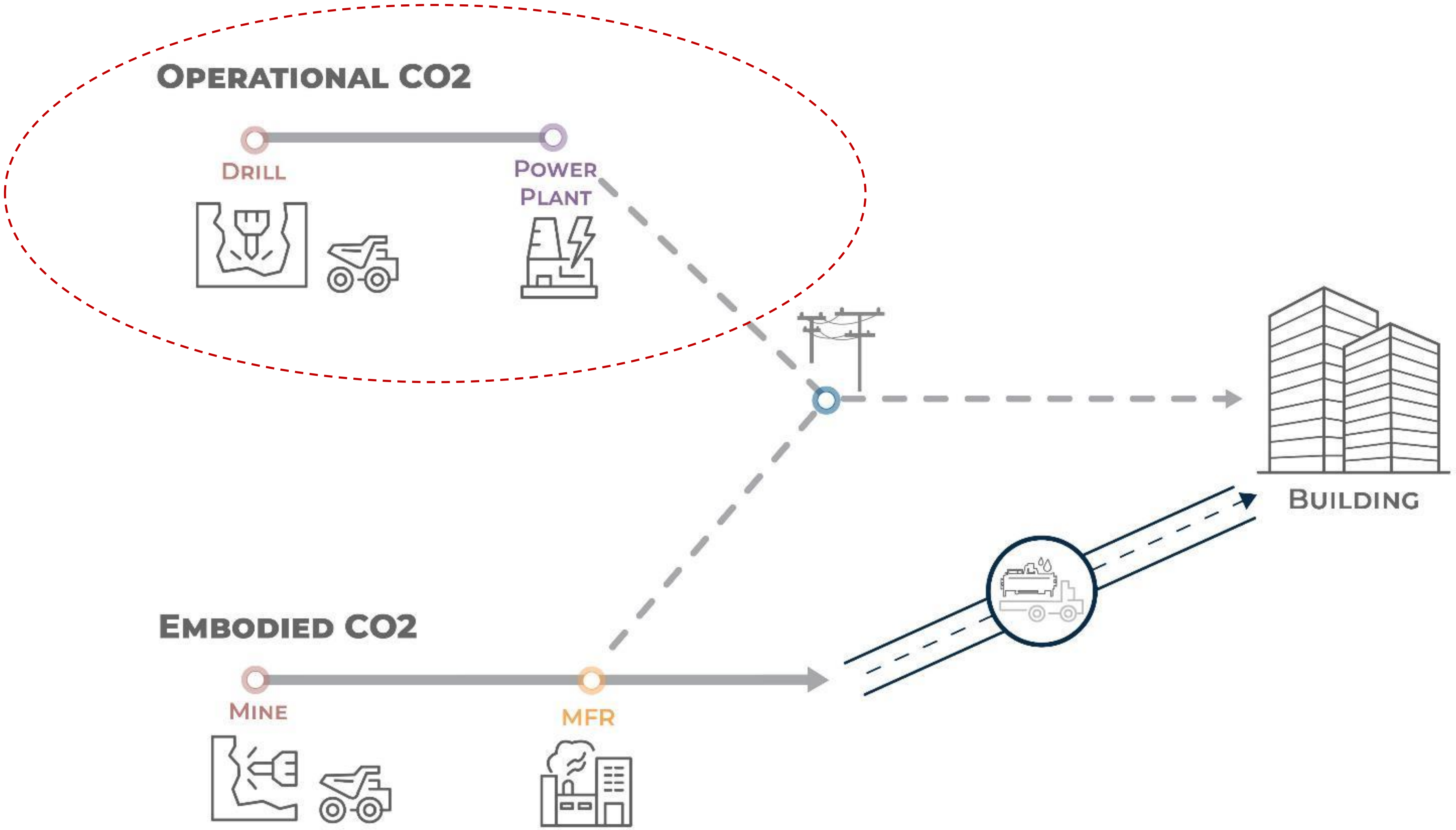
From 2020 to 2021, the district completely remodeled the district's Early Learning Center and renamed it Prairie Trails School. The renovation focused on making the building better suited for our students, as well as more energy efficient and eco-friendly. Both objectives were achieved, resulting in an innovative school that houses the district's pre-kindergarten and kindergarten students, as well as becoming Mount Prospect's first net-zero energy facility. Learn more about the school and some of its features.

Increase in Education Sector Goals

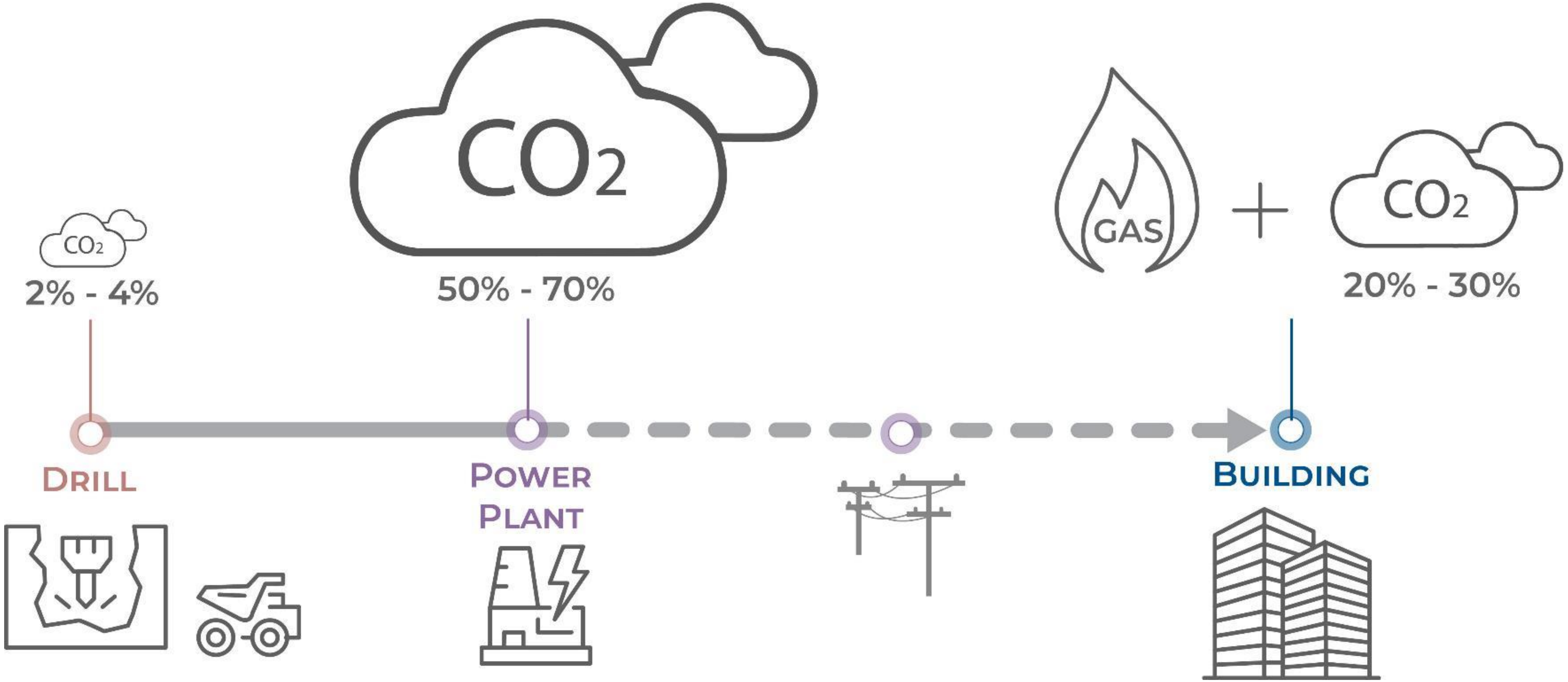
Understanding Carbon



Scope 1, 2, 3 emissions



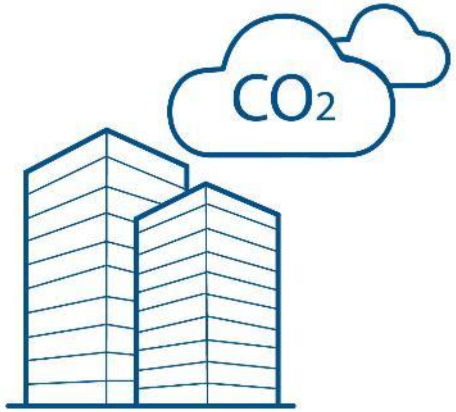
Two Primary Carbon Streams



CO2
2% - 4%
CO2
50% - 70%
GAS
+
CO2
20% - 30%
DRILL
POWER
PLANT
BUILDING

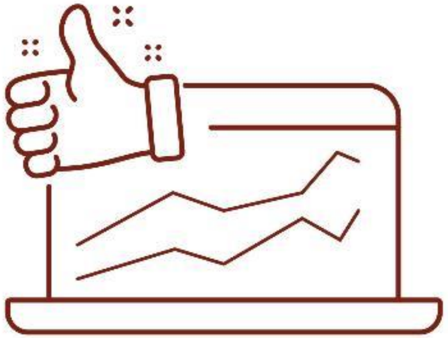
Carbon Reduction Roadmap

Decarbonization approach



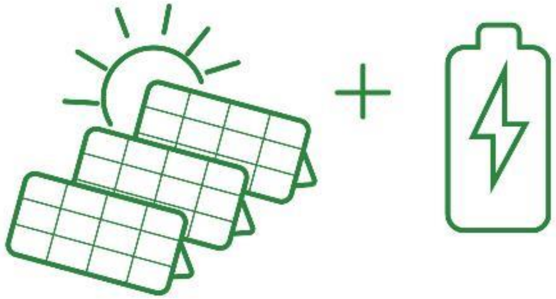
1 Assess Carbon Footprint

- Operational Carbon
- Embodied Carbon



2 Optimize Building Performance

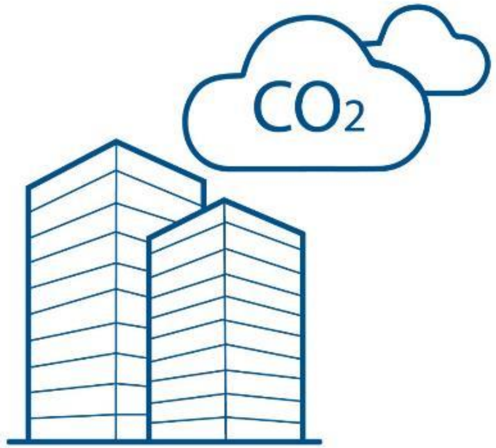
- Energy modeling
- Monitoring & Analytics



3 Integrate Renewable Energy

- Consider on - site and off - site options
- Identify path to net zero energy and carbon neutral

ELECTRIFICATION



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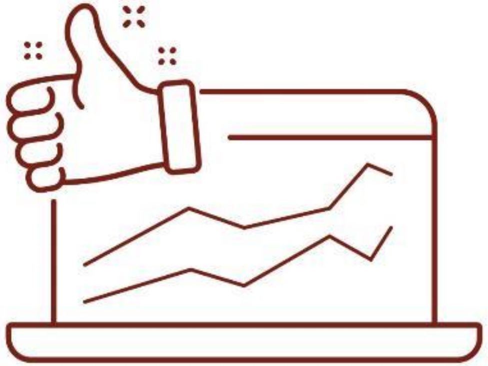

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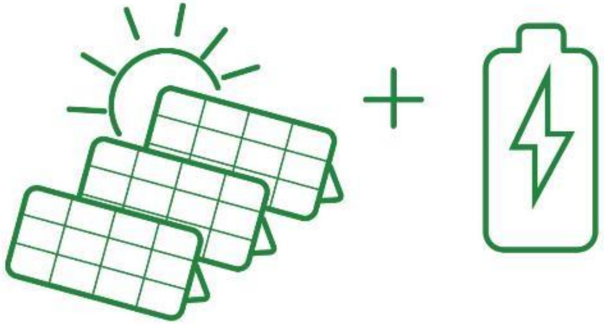

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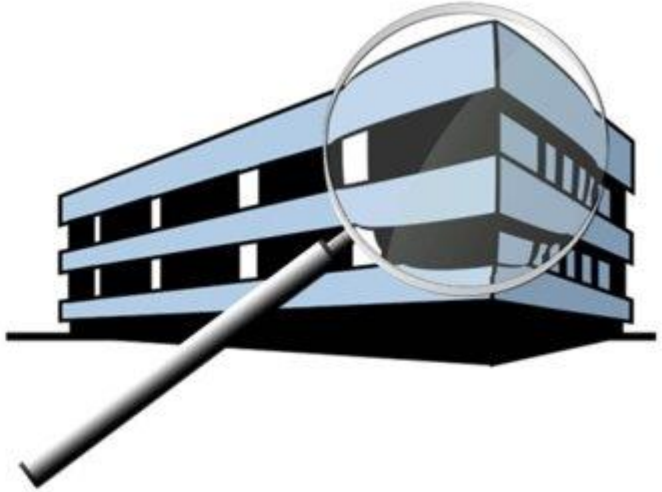
Decarbonization approach

Carbon Footprint Assessment Components

- Building data: SF, energy usage, owned/leased, utility source, BAS, ENERGY STAR number
- **Energy use intensity (EUI) and operational carbon footprint**
- Facility master plan
- Capital program
- Asset management
- Infrastructure renewal
- Operation and maintenance



Optimizing Energy Performance and Carbon Reduction

For Scope 1 & 2 Carbon Emissions

2 Optimize Building Performance

Strategies Goals & Plans

Carbon Footprint Assessment

Plan Execution: Commissioning, Retro-commissioning, BAS Optimization

Measuring Results: Carbon/Energy Monitoring & Analytics

Process Integration: master/capital planning, asset management, O & M

Optimizing Energy Performance and Carbon Reduction

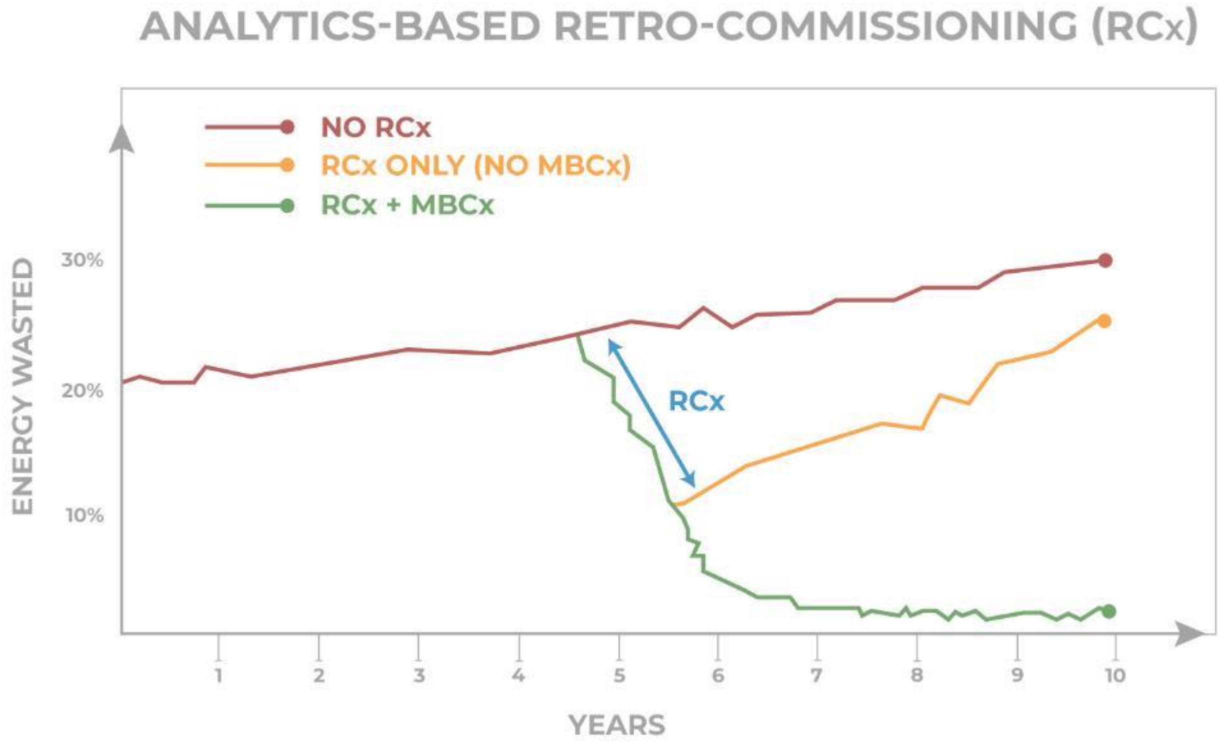
Plan Execution: Retro-commissioning impact on energy performance and carbon reduction

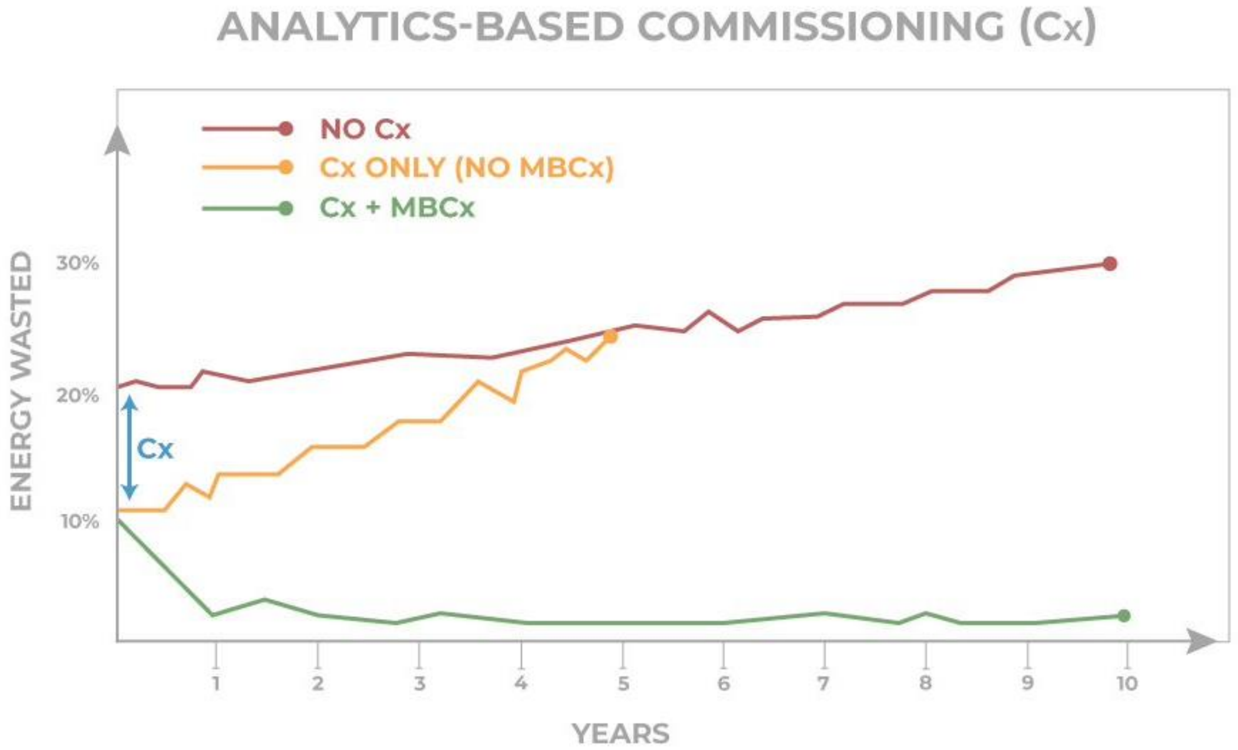
1. **Retro-commissioning:** 10-20% energy usage reduction
   - 0-2 year payback energy efficiency measures
2. **Capital energy efficiency measures:** 10-20% energy usage reduction
   - 2-10 year payback energy efficiency measures
3. **Capital program/infrastructure renewal:** 10-20% energy usage reduction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

30% - 50% total energy usage reduction

Sustaining Energy Performance and Carbon Reduction

Plan Execution: Retro-commissioning impact on energy performance and carbon reduction



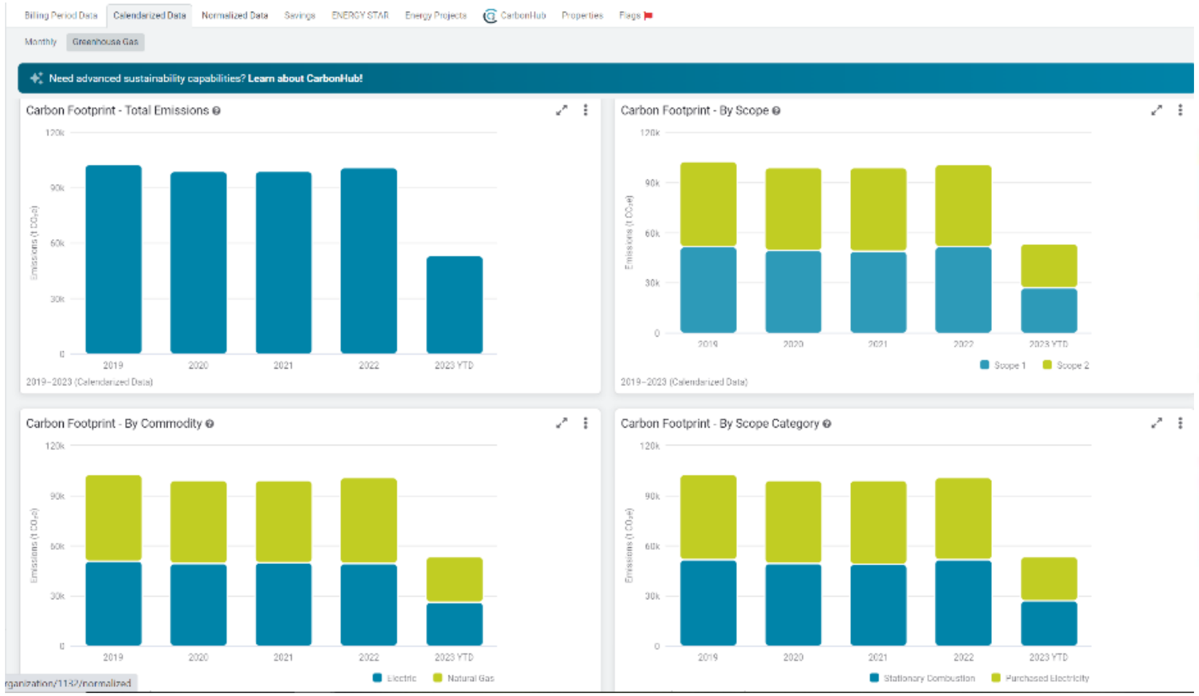


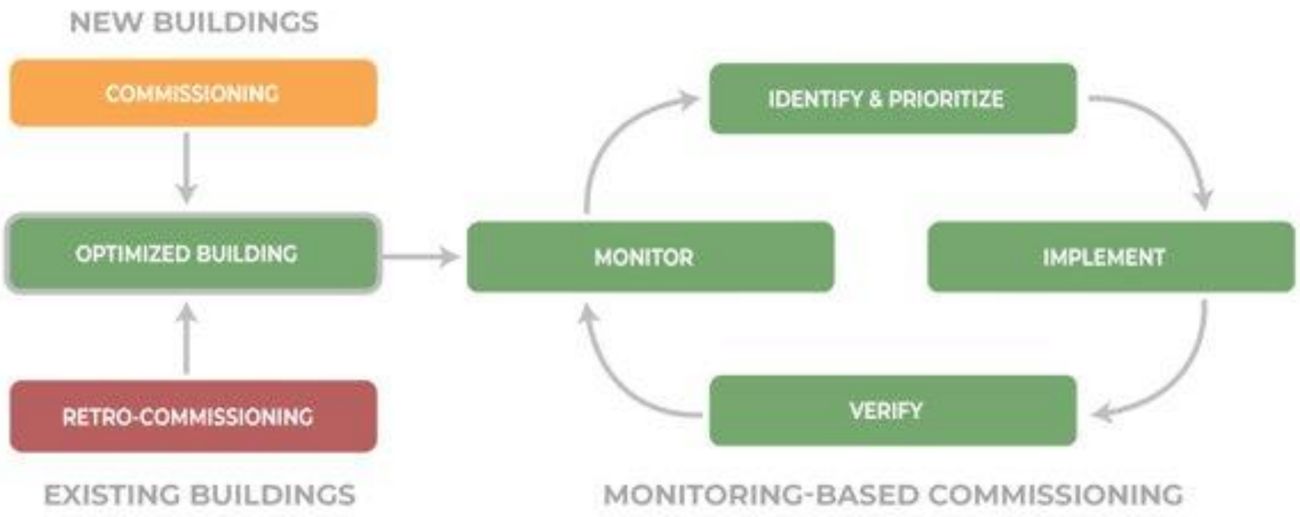
Optimizing and Sustaining Performance

Measuring Results & Process Integration

2 Optimize Building Performance

- Carbon and energy tracking
- Continuous verification and improvement
- Portfolio-wide – existing and new
- Integrated with overall FM and PDC





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
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Electrification

Generating HWS

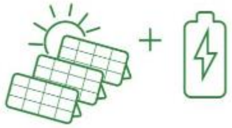
ELECTRIFICATION

	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

Electrification options – Hydronic

Offsetting with Renewables

Reducing Operational Carbon in Buildings



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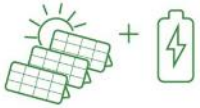

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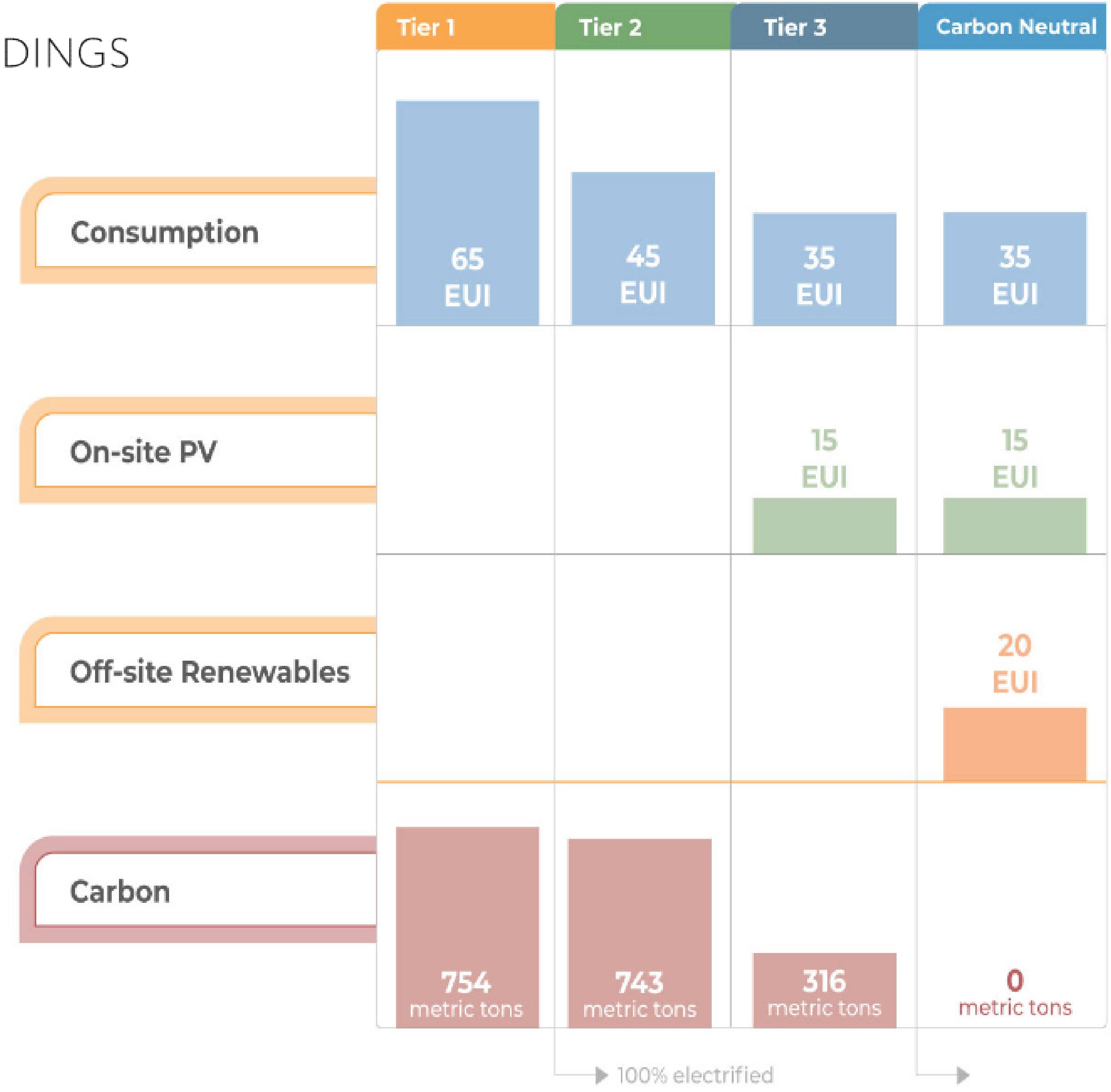
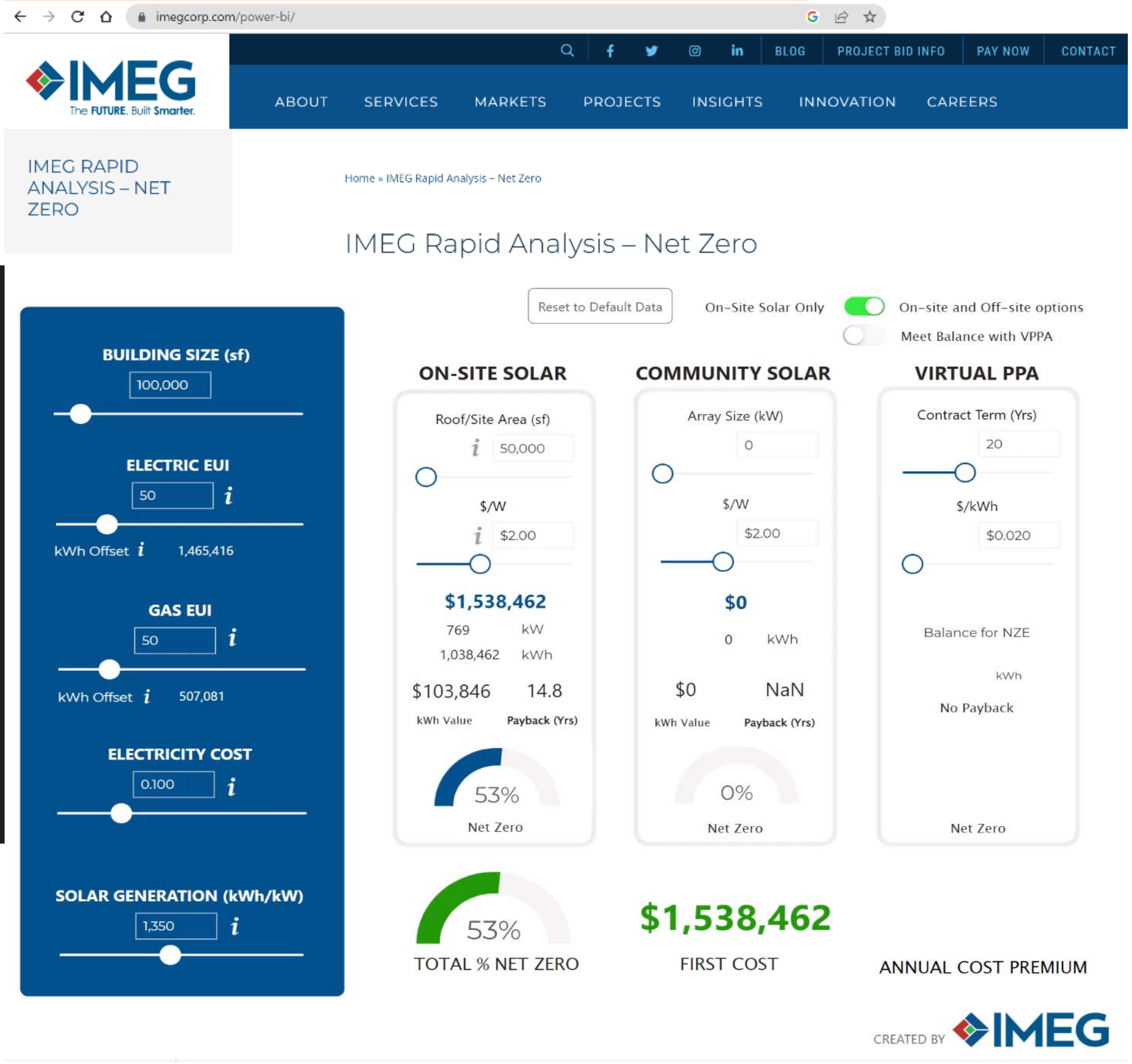


Path to Carbon Neutral

3 INTEGRATE RENEWABLE ENERGY



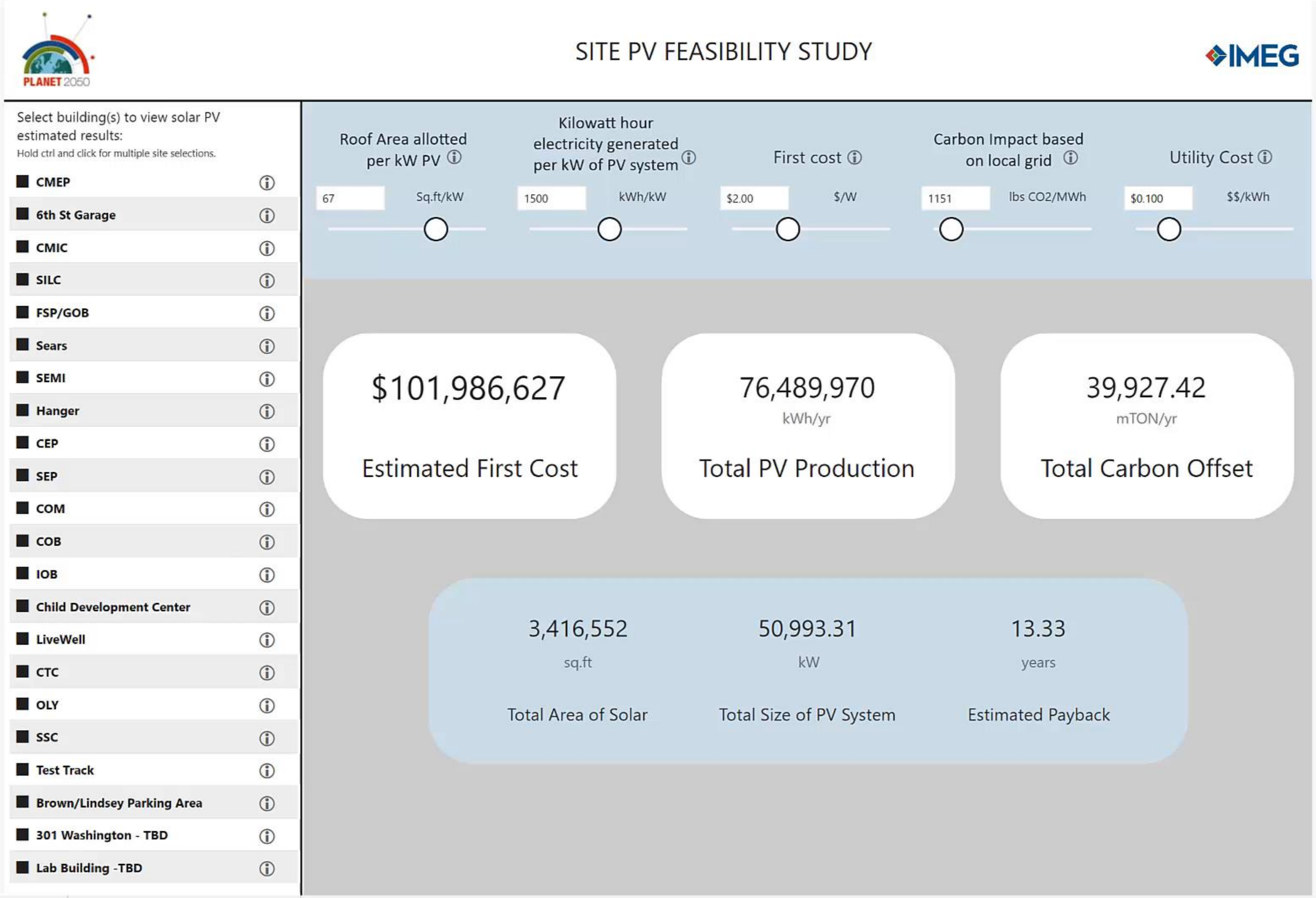
SCAN ME

https://www.imegcorp.com/imeg-rapid-analysis-net-zero-2/

Offset with renewable energy

SOLAR PV FOR PORTFOLIOS

3 INTEGRATE RENEWABLE ENERGY



Decarbonization Project Examples

Optimization Strategies & Goals
Healthcare Example

1 Assess Carbon Footprint

Strategies

- Design standards
- Project planning
- Commissioning (Cx), retro-Cx, monitoring-based Cx
- Utility analytics
- Building automation system (BAS)
- Funding/financial
- Regulatory compliance

Goals

- Return-on-investment
- EUI
- ENERGY STAR
- Carbon emissions

EUI Portfolio Assessment
Healthcare Example

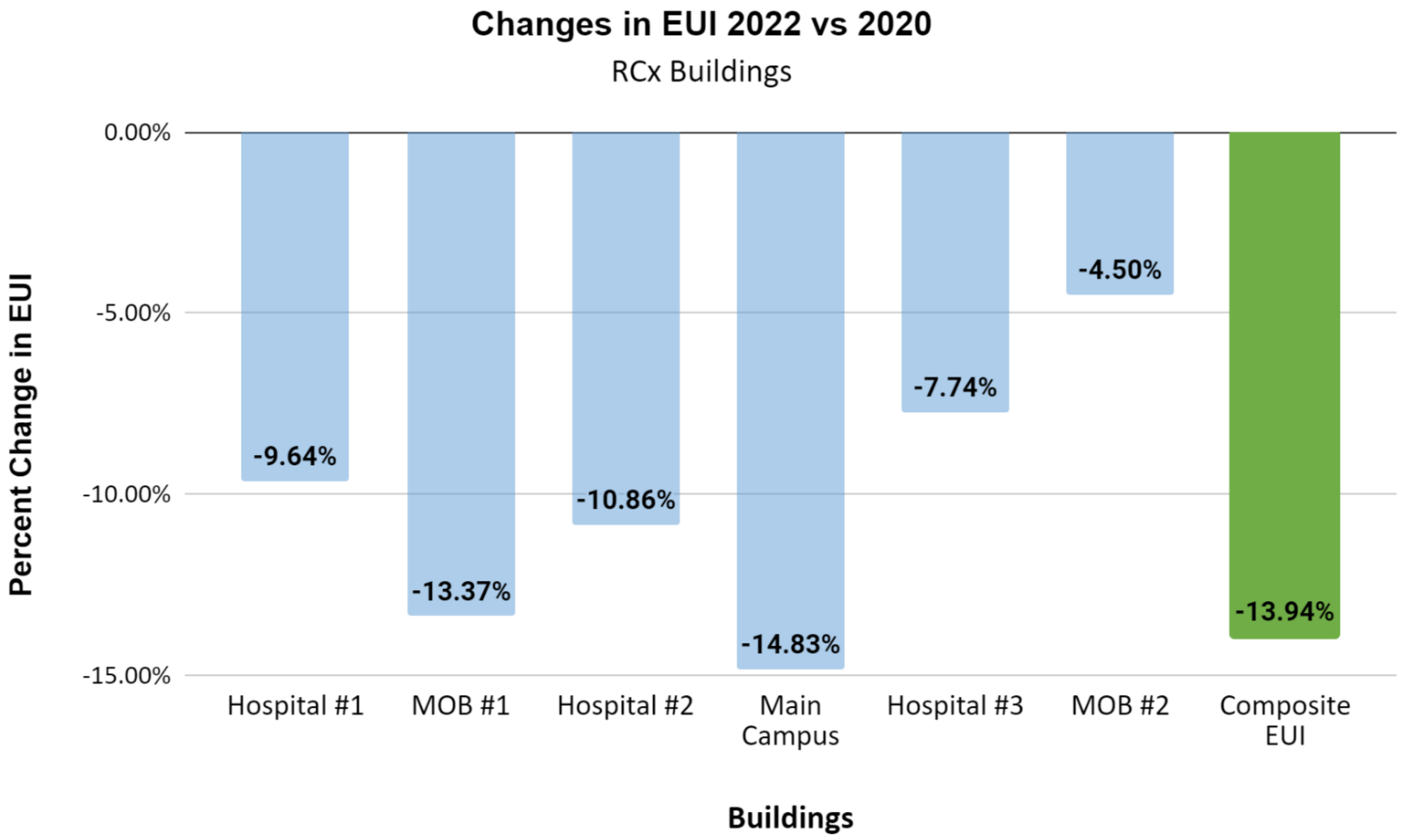
EUI (kBtu/SF)						
Hospital	Size (SF)	Industry Medians*		Baseline (2021)	Current (thru 3/2023)	% Change
		Industry Survey	CBECS			
1st Campus	1,878,964	234.3	229.1	209.9	208.2	-0.8%
2nd Campus	264,678	234.3	229.1	163.8	229.3	+40.0%
3rd Campus	248,117	234.3	229.1	150.0	149.4	-0.4%
4th Campus	189,726	234.3	229.1	215.7	286.7	+32.9%
Off Campus Owned Building	173,235	N/A	51.2	75.6	76.0	+0.5%

Opportunity

Opportunity

*ENERGY STAR Portfolio Manager Technical Reference U.S. Energy Use Intensity by Property Type

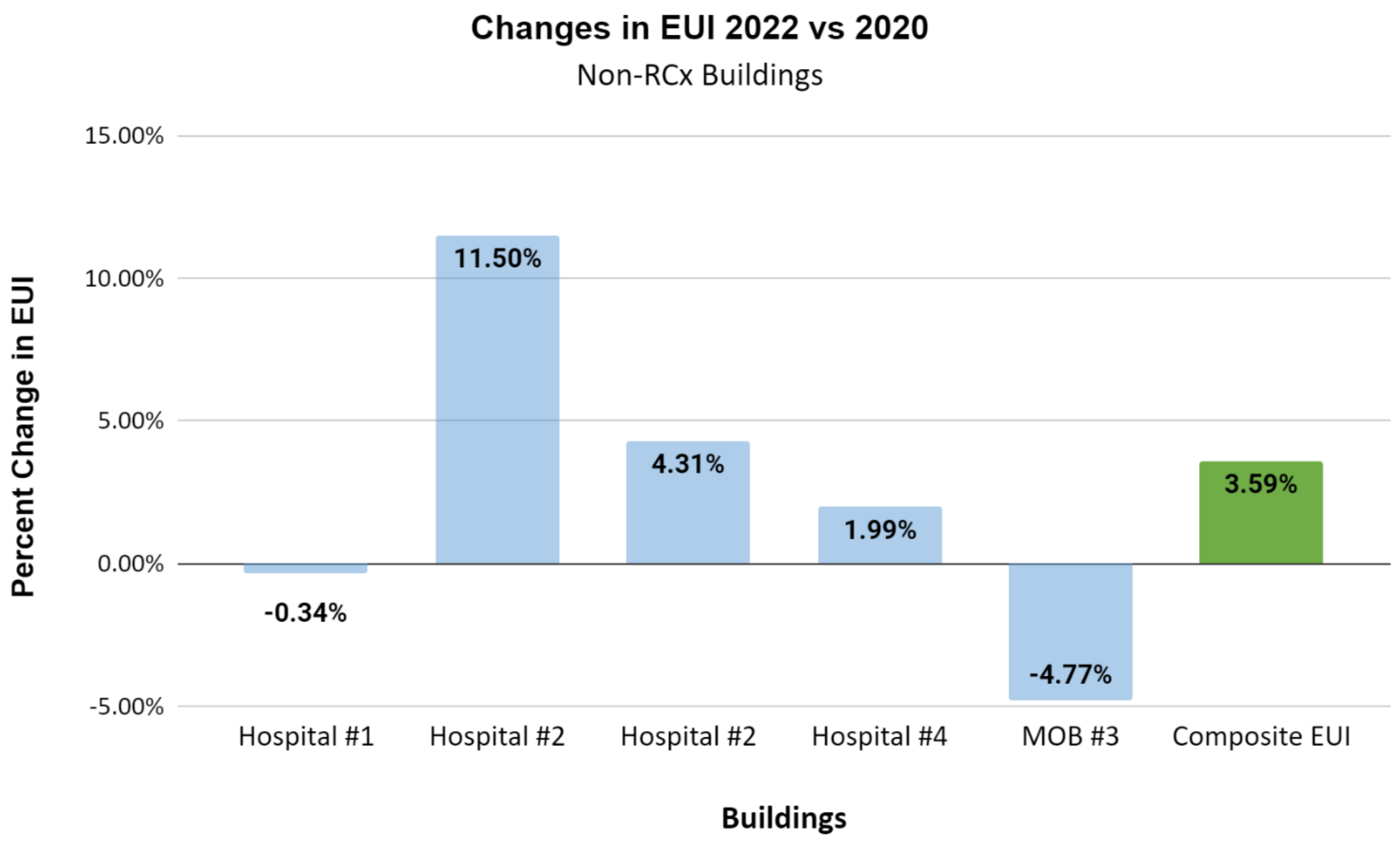
EUI Change for RCx Buildings
Healthcare Example



2 Optimize Building Performance

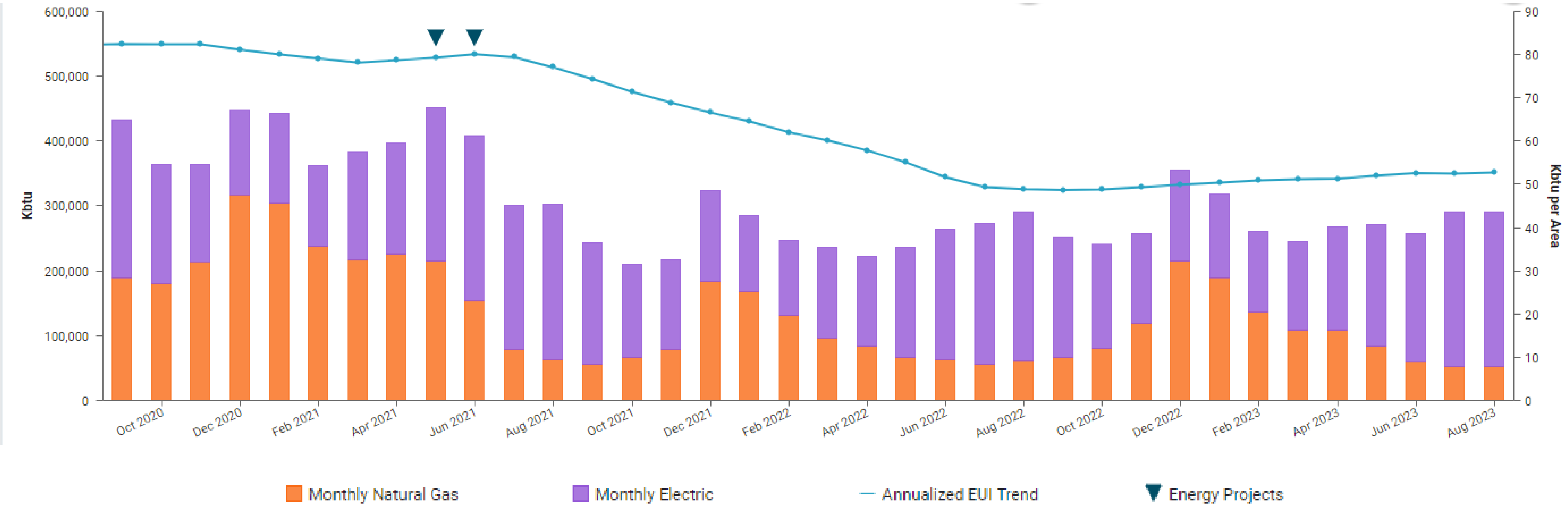
EUI Change for Non-RCx Buildings

Healthcare Example



Energy and Carbon Tracking
Healthcare Example

Energy Use Intensity Trend for an MOB on the Main Camus



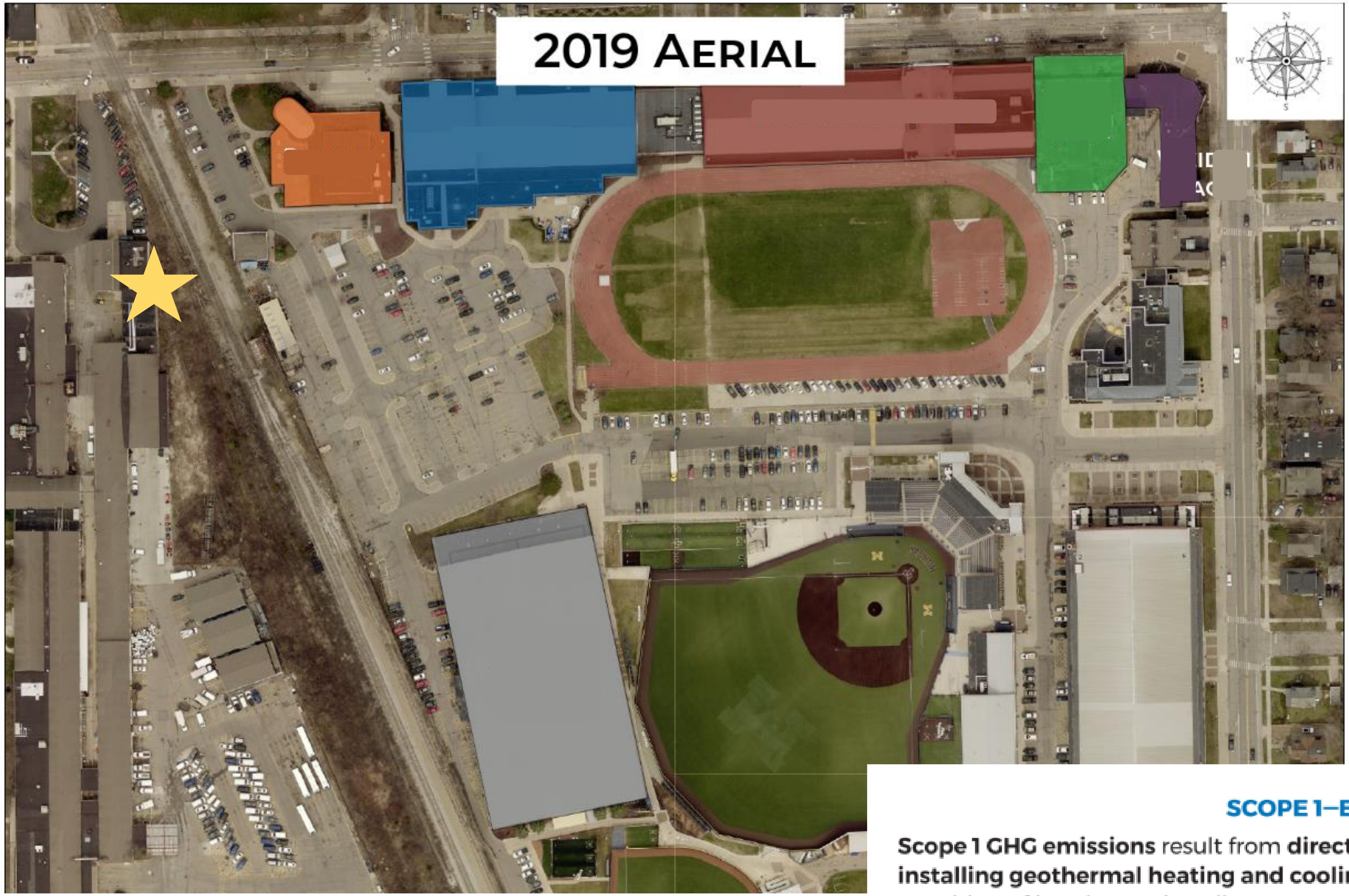
Lessons Learned & Keys to Success

Healthcare Example

- Establish goals and measurements for success
- Executive level buy in and stakeholder engagement
- Energy and carbon tracking is key for continuous performance
- Overcoming staffing obstacles – delegate work to experts
- Overcoming financial obstacles – start with the high ROI strategies
- Comprehensive, continuous, customized process

University Example

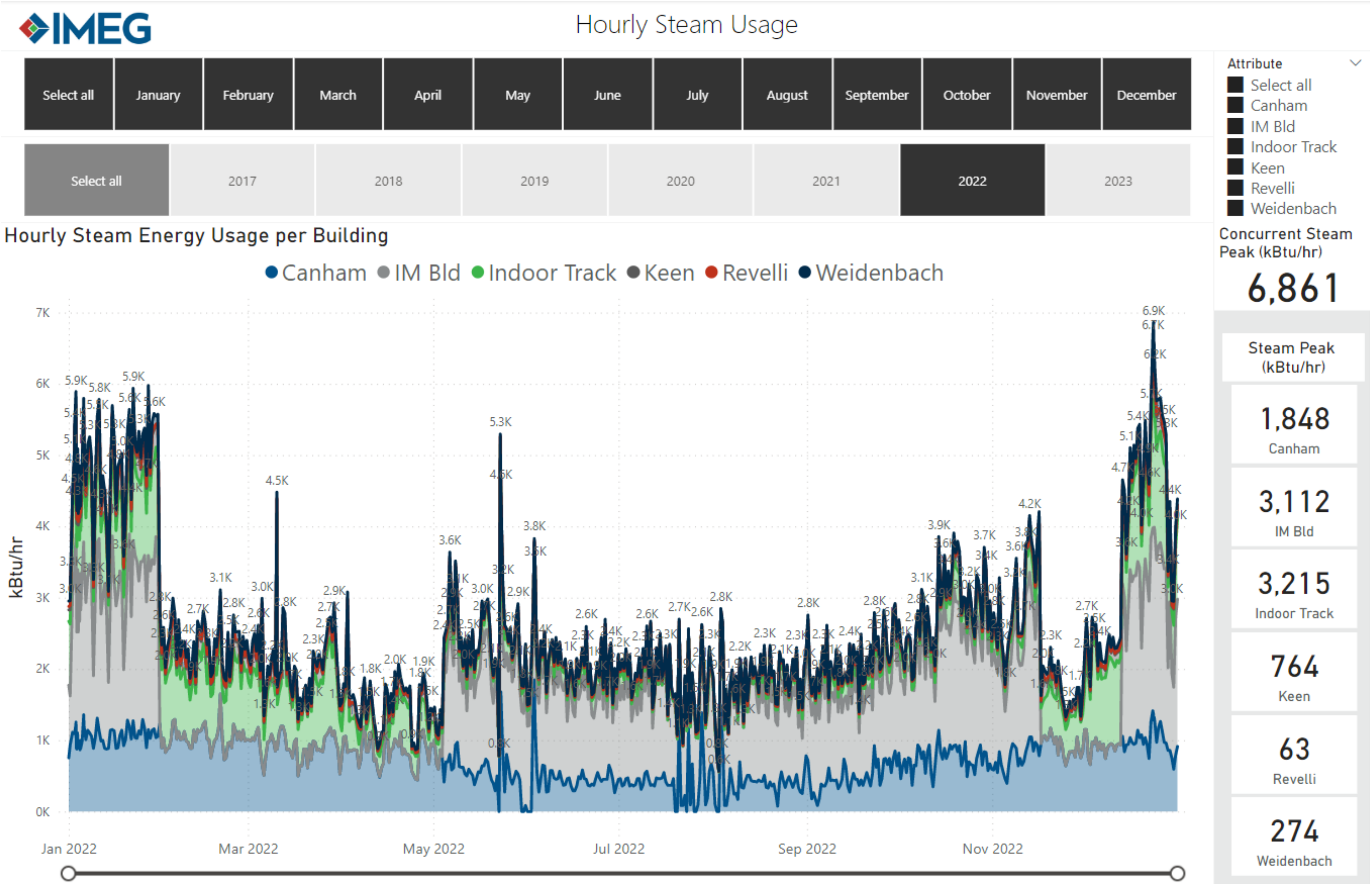
- Midwest
- Old buildings with steam coils and high temp hot water
- Goals:
  - No NG over the next 15-17 years – how to transition?
  - Path to convert to geothermal



SCOPE 1—EMISSIONS ELIMINATED BY 2040

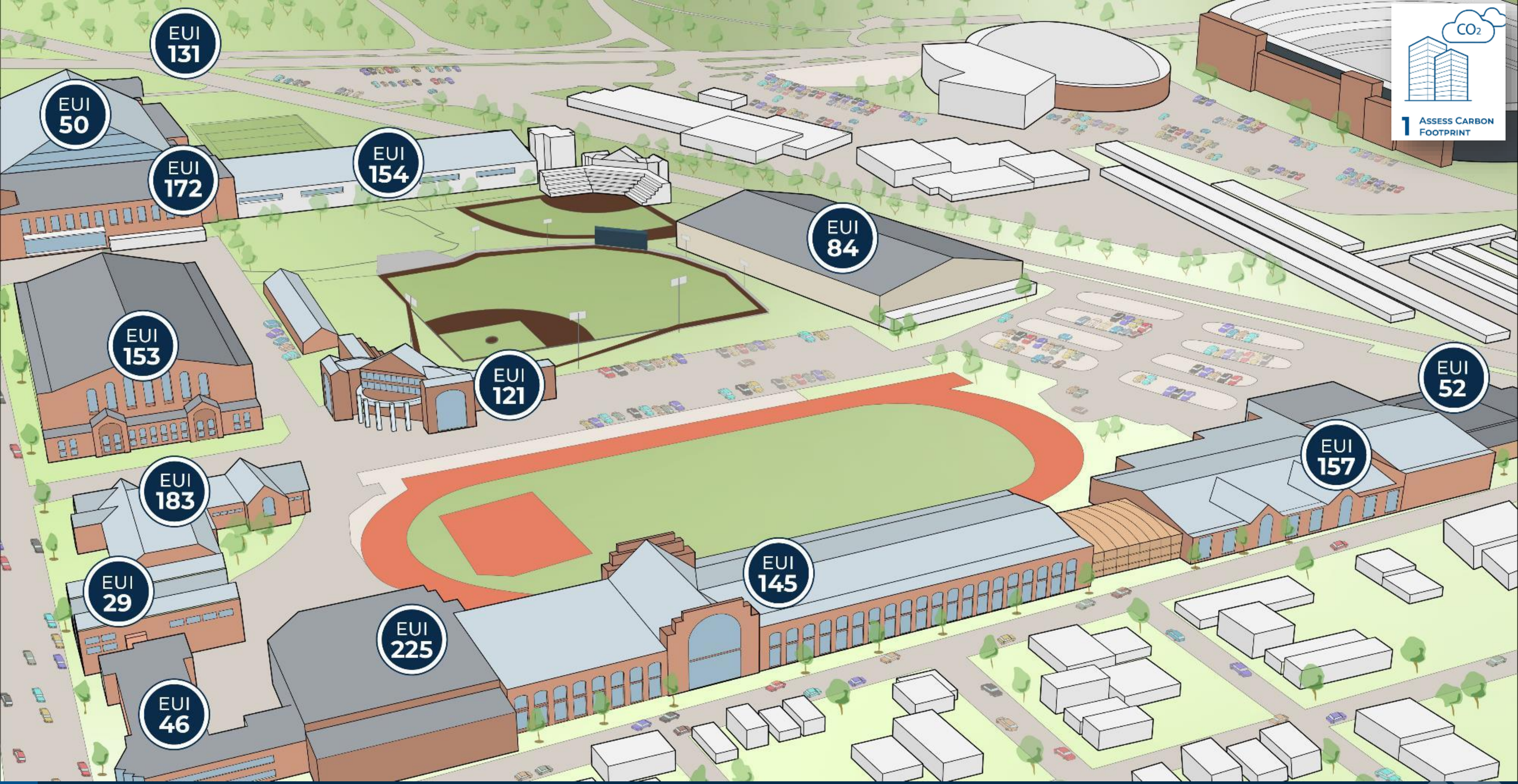
Scope 1 GHG emissions result from **direct, on-campus sources.** To eliminate them, our first actions include **installing geothermal heating and cooling** for some new construction projects (a first step in phased transition of heating and cooling systems), **electrifying our bus fleet,** and **launching a revolving fund for**

University Example: Decarbonization - Electrification



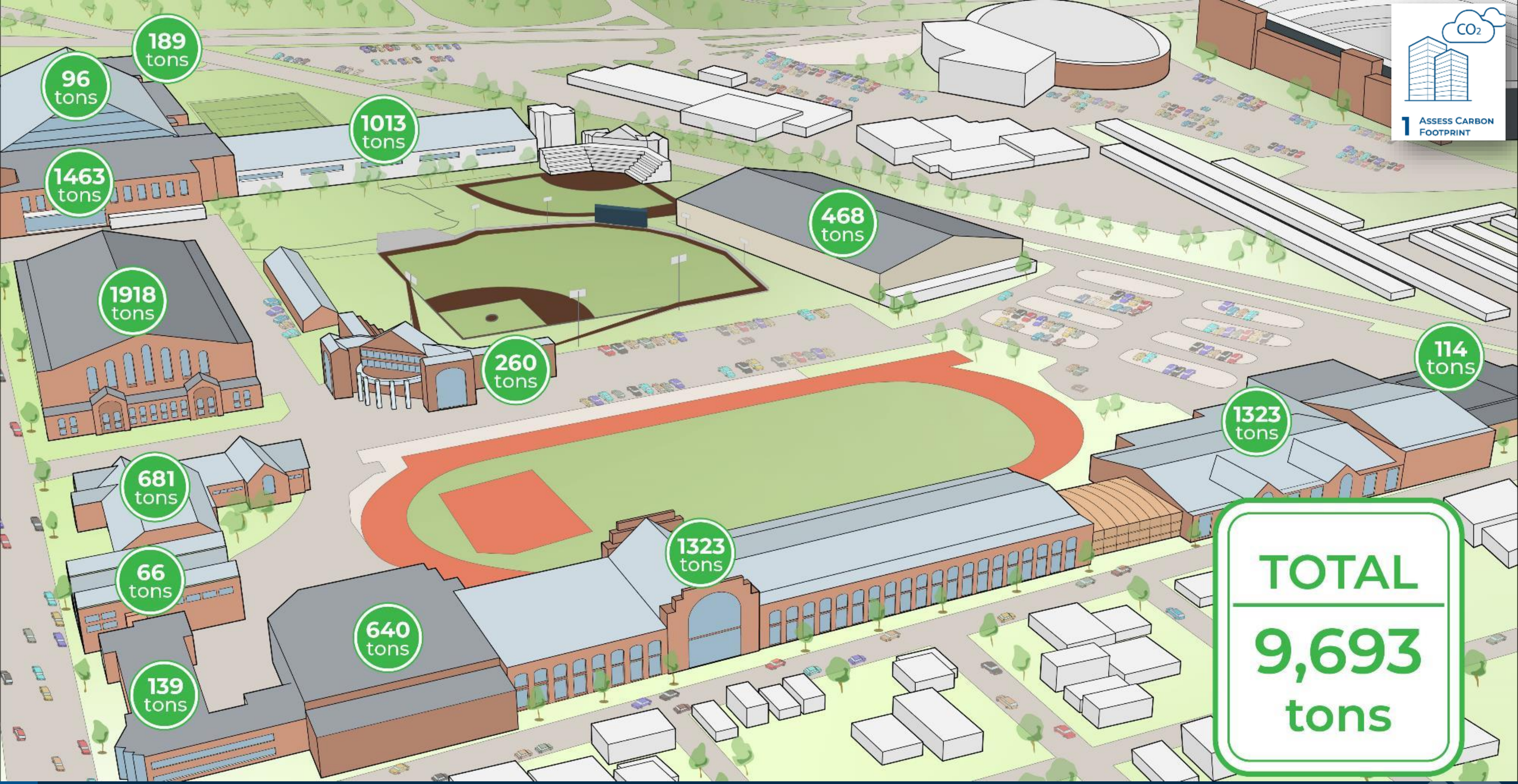
1 Assess Carbon Footprint

Data Analytics

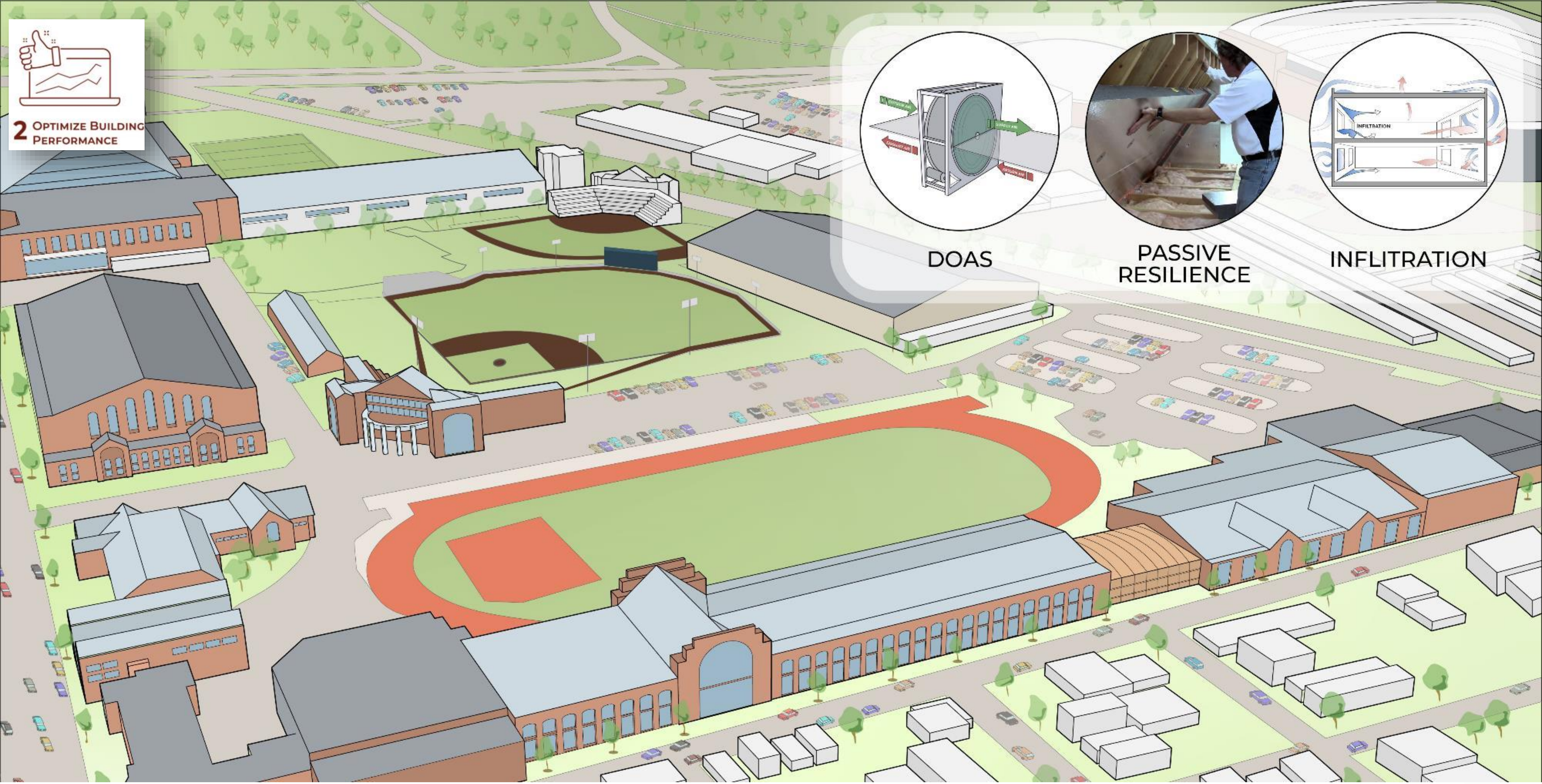


CO_2
1 Assess Carbon Footprint

Assessing EUI



Assessing Carbon



Optimization - Load Reduction Opportunities

ELECTRIFICATION

15,300sqft

- 16000 CFM AHU HW COIL
- DX Cooling
- 40 tons Condensing Unit
- Steam Dom. HW
- Heating Water Radiation

Basement 6132 sqft
1st Floor: 49,000 sqft
2nd Floor: 17,200 sqft

- 3 Pool Units on 2nd Floor
- Radiant Infloor Heat
- Hydronic Hx
- Domestic Hx W/Tank
- Heat Recovery for water heating
- RTU on Roof
- 3 Accus Replaced by One Larger

Basement: 47,000 sqft
Ground Floor: 22,600 sqft
Ground MEZZ: 3,900 sqft
1st Floor: 39,400 sqft
2nd Floor: 6,400 sqft
3rd Floor: 6,400 sqft

- Steam to HW HX
- 215 tons Cooling
- 3 AHUS, 2 with Energy Recovery
- Vav Reheat System

Basement: 6,100 sqft
1st Floor: 18,500 sqft
1st Floor MEZZ: 9,500 sqft
2nd Floor: 17,000 sqft

- No MEP Asbuilt

Steam to Hot Water HX
Some perimeter heat
Reheat coil system
Two central AHUs
Air Cooled Chiller

- Air Colled Chiller 100T
- Steam/Hx HWS/R
- 4 Pipe Fan Coils
- Doas No Heating Recovery
- 1650 MBH Heating

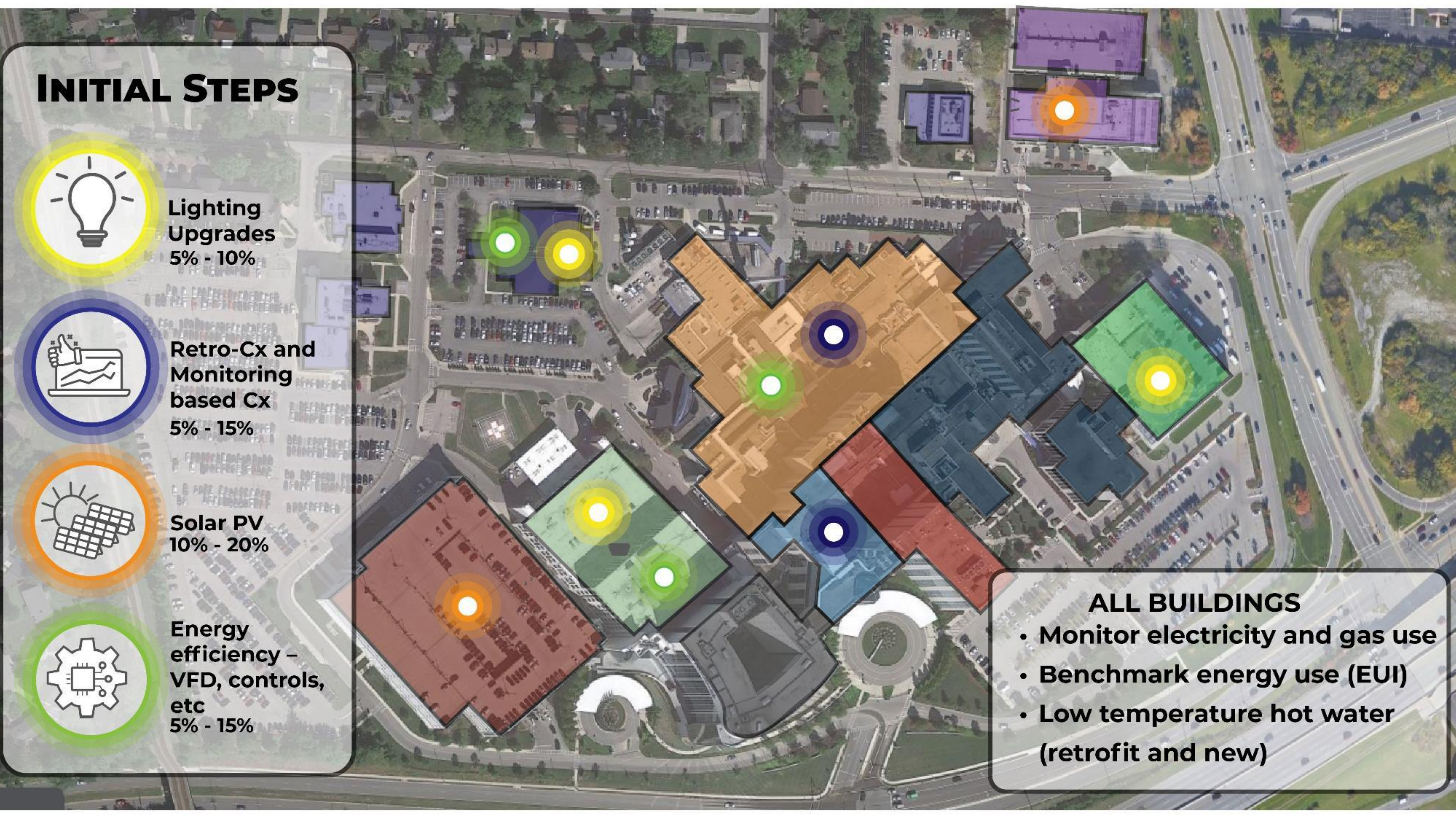
- Gas Fired HW Boilers 2 @ 1200 MBH
- Gas Fired Humidifiers
- 130 T ACCU
- AHU VAV Reheat

- 40 ton Air Cooled Chiller
- Electic Humidification
- 4 Pipe Fan Coil (200 F Water)
- Electric Resistance Heating
- Electric Water Heating

- **NEED to have hourly meter data**
  - Sporadic peaks can cause oversizing of future electrified systems
- **Phase the discussion about campus decarbonization**
  - University campuses are usually huge so understanding the overall goal and where can we focus our efforts
- **Hardest part is sequencing a campus conversion to electric**
  - Need to be on the same page that its going to be a 15 yr commitment

Steam University: Lessons Learned

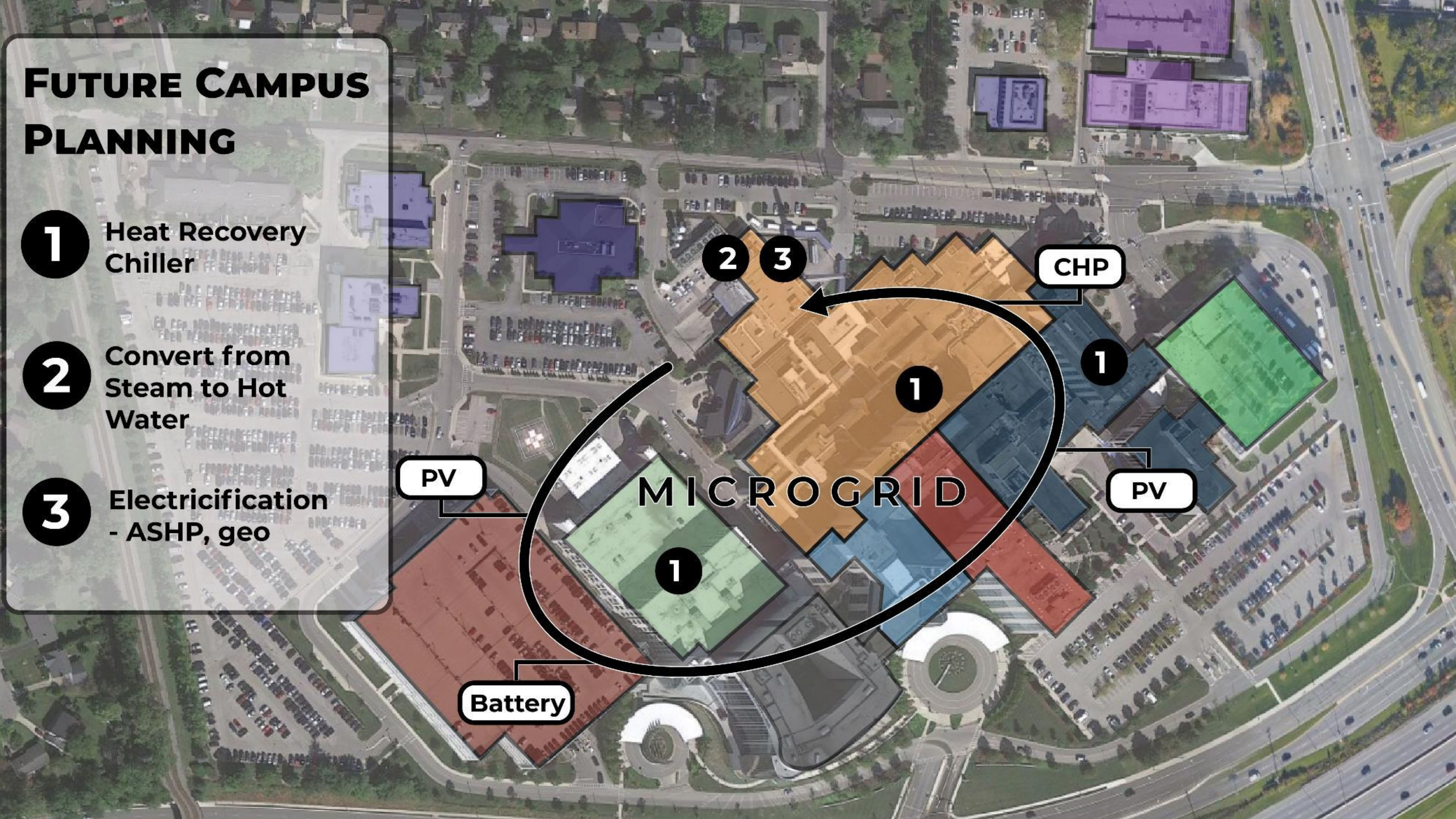
First Steps to Carbon Reductions



INITIAL STEPS
Lighting Upgrades
5% - 10%
Retro-Cx and Monitoring based Cx
5% - 15%
Solar PV
10% - 20%
Energy efficiency – VFD, controls, etc
5% - 15%
ALL BUILDINGS
• Monitor electricity and gas use
• Benchmark energy use (EUI)
• Low temperature hot water (retrofit and new)

Future Campus Planning

1. Heat Recovery Chiller
2. Convert from Steam to Hot Water
3. Electricification - ASHP, geo



Decarbonization in Healthcare

A Practical Approach for the Built Environment

By Eric Vandenbroucke | Mike Zorich | Adam McMillen | Doug Sitton

Decarbonization of the built environment is rapidly gaining attention in healthcare. Many in the industry have come to recognize the significant and symbolic role that healthcare organizations, their designers, and builders, can play in reducing the carbon emissions, or greenhouse gases, introduced by the built environment of their facilities. Others are skeptical of the need to decarbonize, dubious of the impact it will have, or, understandably, overwhelmed at the effort and expense it could entail.

On a global scale, the healthcare industry accounts for a yearly average of 5 percent of the total carbon emissions of industrialized nations, according to Environmental Research Letters. Despite having only 4.25 percent of the global population, the United States is responsible for 28 percent of all global emissions. With healthcare responsible for 8.5% of the nation's emissions, doing the math shows that the U.S. healthcare industry is responsible for 2.4 percent of the world's total emissions and nearly 50 percent of global healthcare emissions.

As the scientific data and environmental organizations confirm, per capita healthcare emissions in the U.S. are greater than that of any other country.

Considering the operational burden of U.S. healthcare facilities such as hospitals and clinics—24/7 operation, large consumption of supplies, exacting climate control and electricity needs, 6.6 million hospital personnel driving to and from work every day—it's understandable that the industry owns such an outsized portion of carbon emissions. By rethinking the built environment, however, healthcare—and other industries—can substantially accelerate its decarbonization goals in a path-of-least-resistance toward net-zero carbon emissions.

IMEG
The FUTURE. Built Smarter.

Questions