Massachusetts School Building Authority

SEAMAN ENGINEERING CORPORATION

The Green Engineer
Sustainable Design Consulting

LPA|A

We have created a unique virtual presentation best viewed in

“Side by Side: Speaker”

Please follow the directions in this video to ensure the optimal viewing experience. Thank you.

Zoom Meeting

LPA|A

LPA|A

We have created a unique virtual presentation best viewed in

“Side by Side: Speaker”

Please follow the directions in this video to ensure the optimal viewing experience. Thank you.

PRESENTERS

Kathryn Crockett

Principal Architect

Christina S. Bazelmans

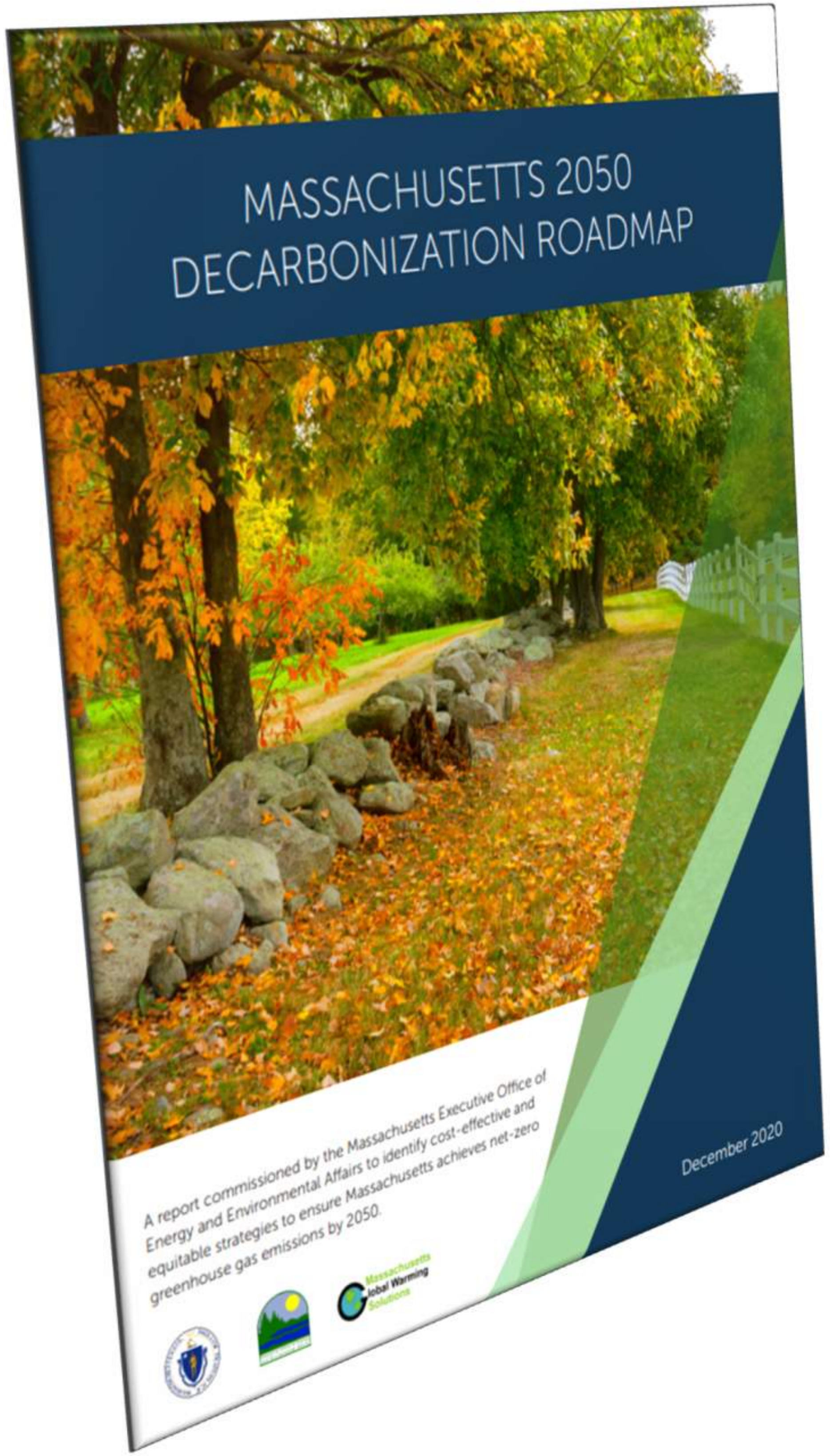
Project Manager &
Sustainability Lead

Chris Schaffner

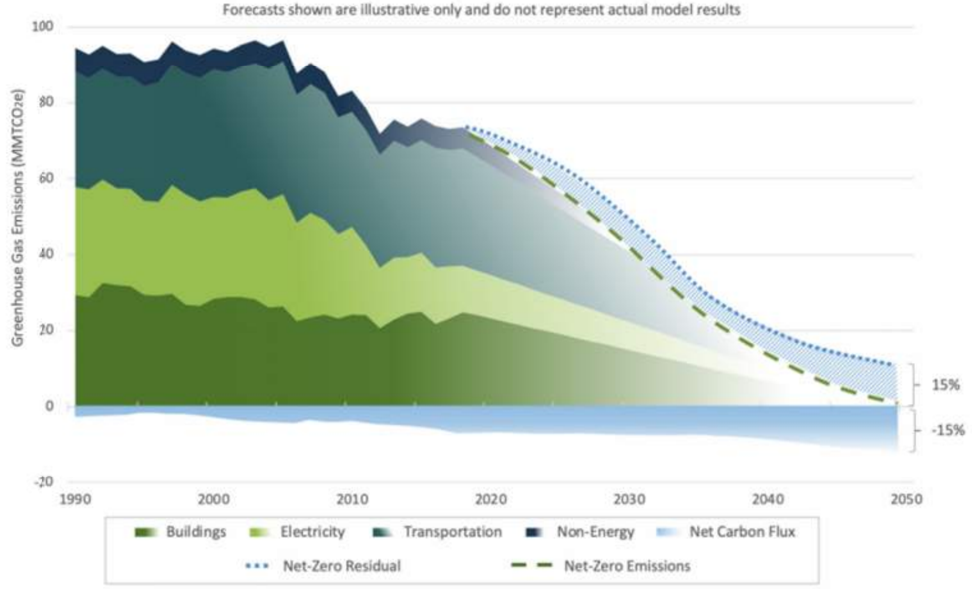
The Green Engineer

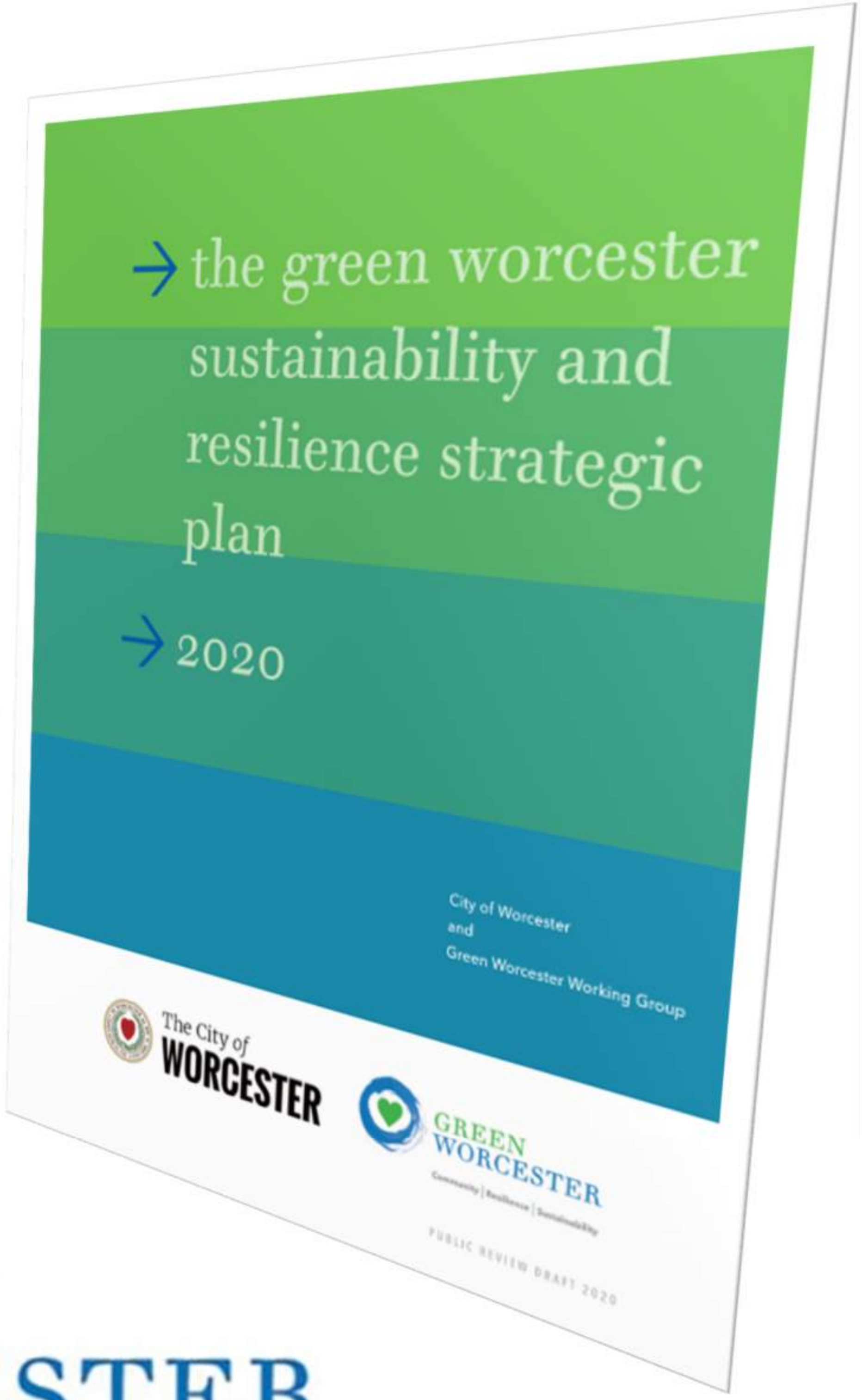
Kevin Seaman

Seaman Engineering



GHG Emissions by 2050



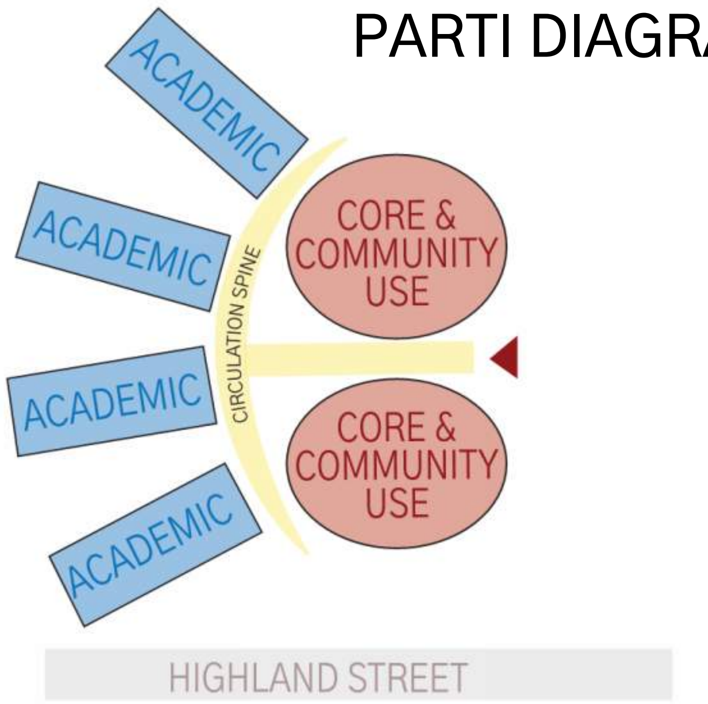


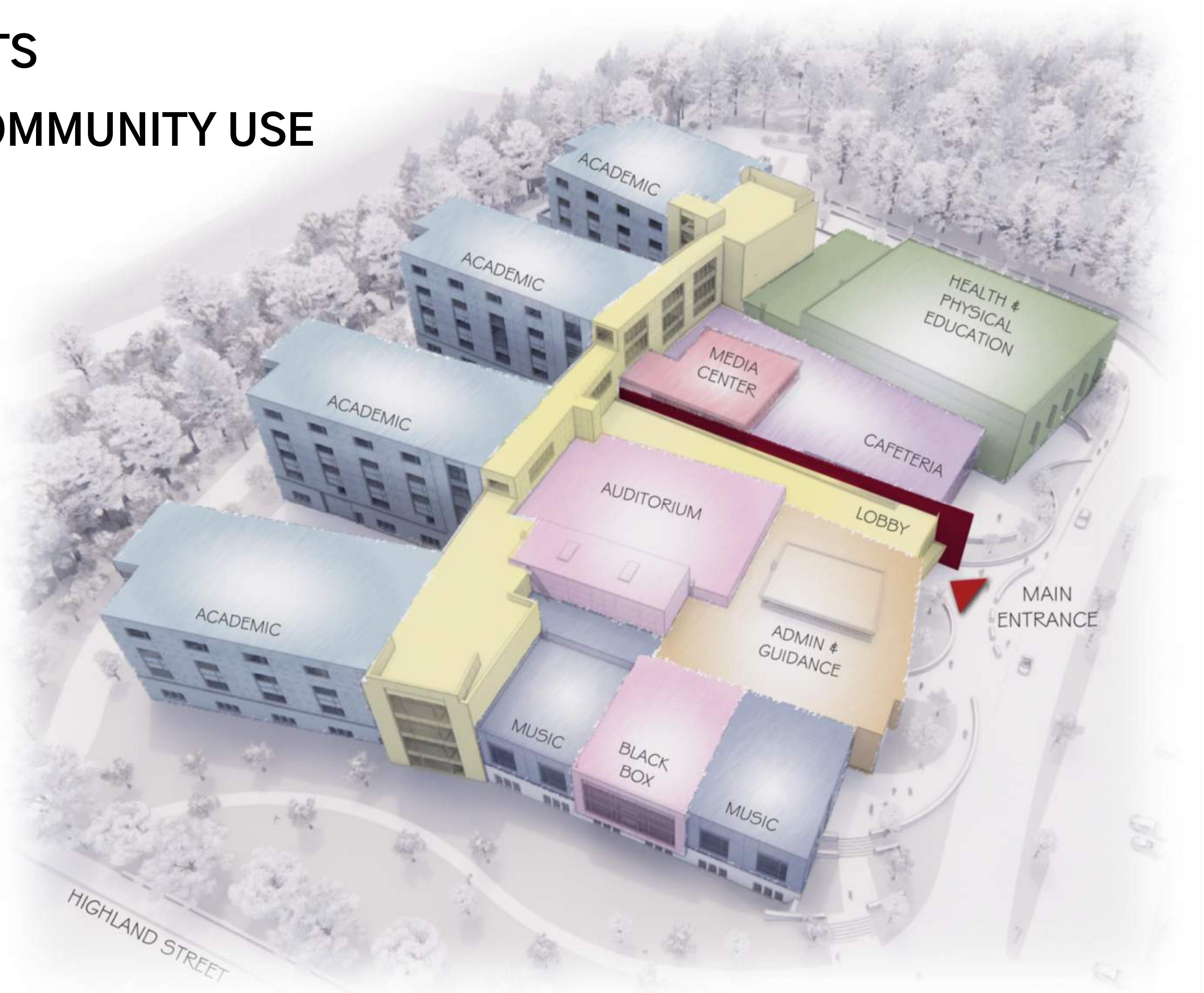
GREEN WORCESTER

PROJECT STATISTICS

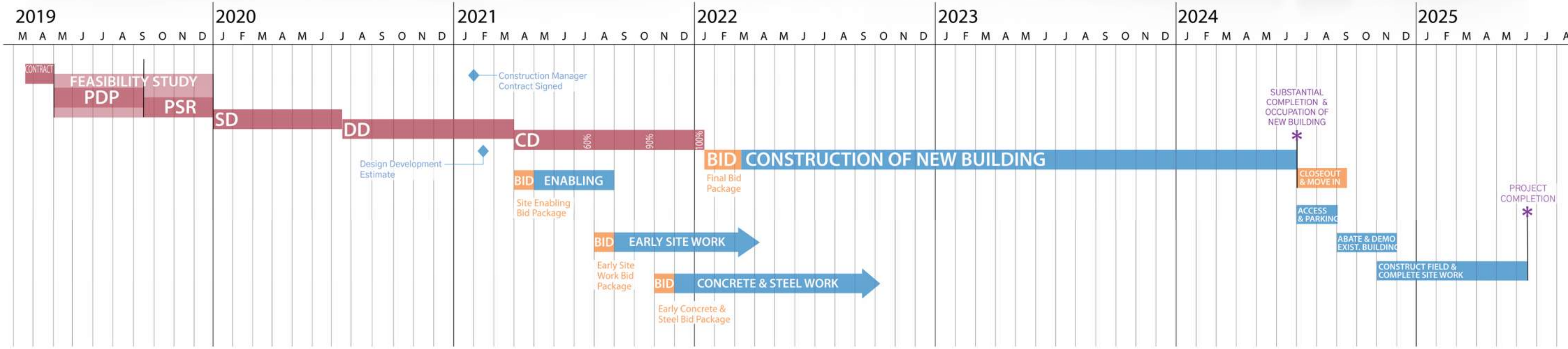
- **NEW CONSTRUCTION** ADJACENT TO THE EXISTING SCHOOL
- ENROLLMENT: **1670 STUDENTS**
- EXPANDED PROGRAM AND **COMMUNITY USE**
- AREA: +/– **422,000 SF**
- OCCUPANCY **FALL 2024**

PARTI DIAGRAM

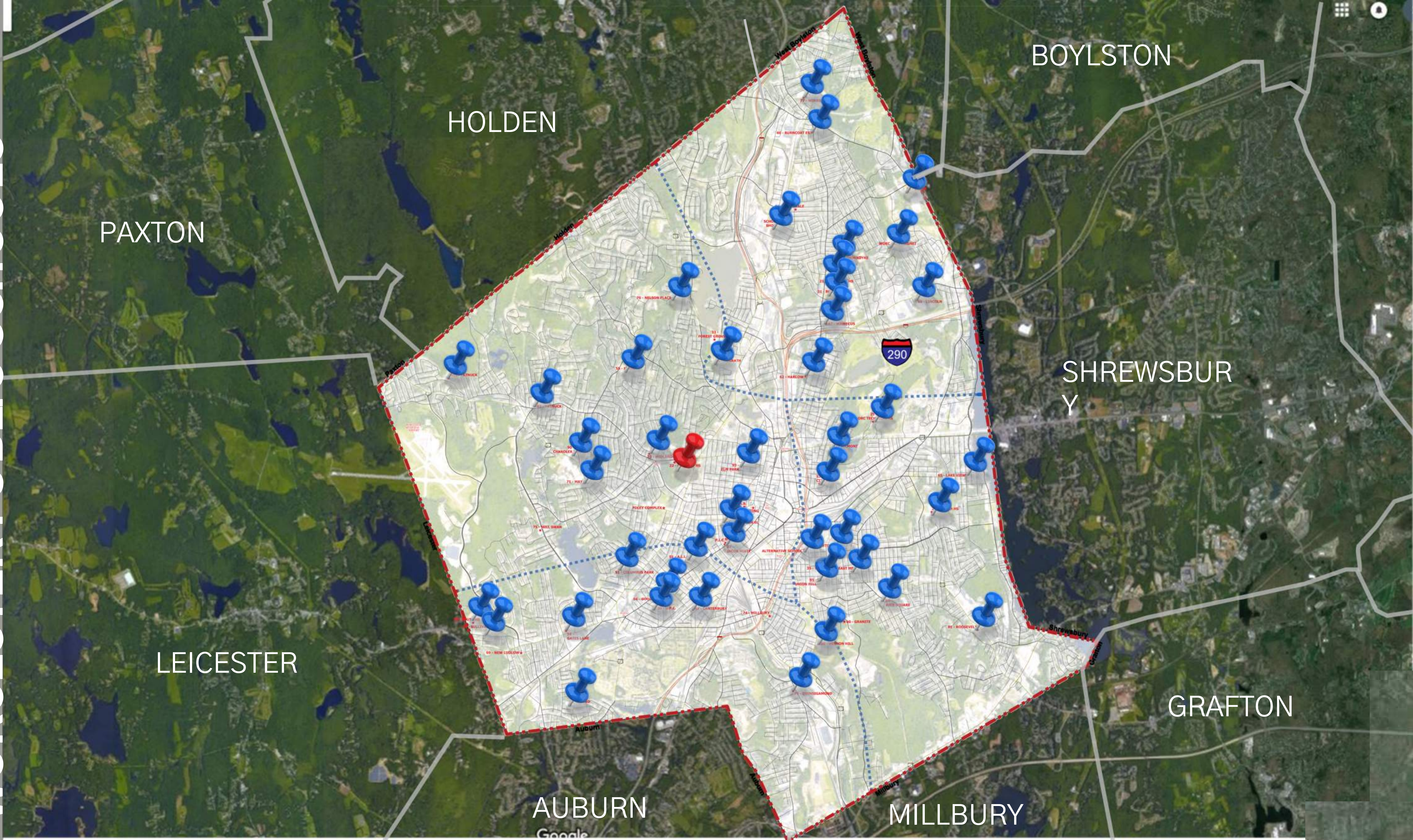




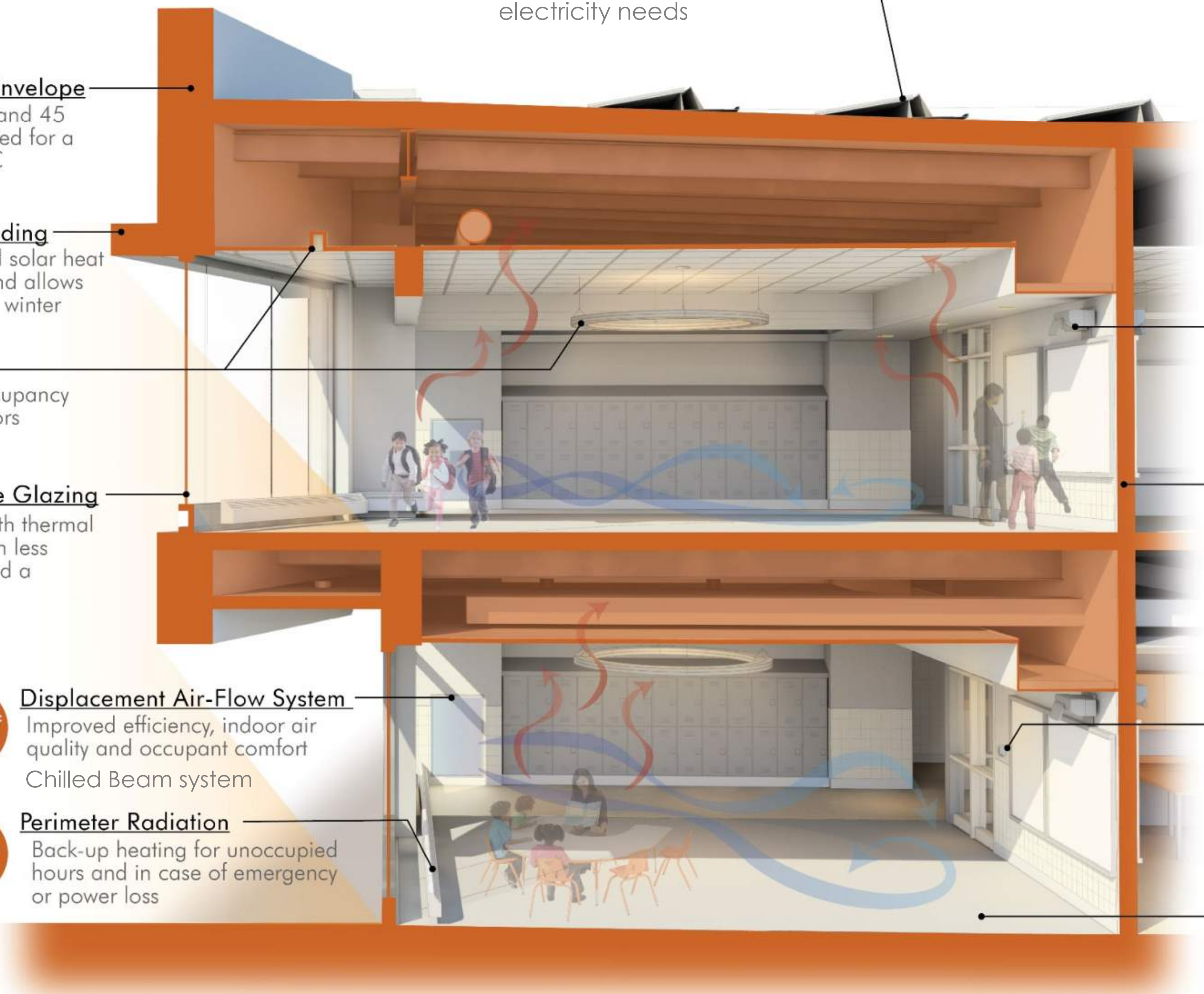
SCHEDULE


2019
2020
2021
2022
2023
2024
2025
M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A
CONTRACT
FEASIBILITY STUDY
PDP
PSR
SD
DD
CD
60%
90%
100%
Construction Manager Contract Signed
Design Development Estimate
BID
CONSTRUCTION OF NEW BUILDING
Final Bid Package
BID
ENABLING
Site Enabling Bid Package
BID
EARLY SITE WORK
Early Site Work Bid Package
BID
CONCRETE & STEEL WORK
Early Concrete & Steel Bid Package
SUBSTANTIAL COMPLETION & OCCUPATION OF NEW BUILDING
CLOSEOUT & MOVE IN
ACCESS & PARKING
ABATE & DEMO EXIST. BUILDING
CONSTRUCT FIELD & COMPLETE SITE WORK
PROJECT COMPLETION

WORCESTER PUBLIC SCHOOLS



BUILDING SUSTAINABILITY



Rooftop Photo-Voltaic System
Produces 800 kW; 50% of the school's electricity needs

Super-Insulated Envelope
25 R-value walls and 45 R-value roof allowed for a reduction in HVAC equipment sizes

Passive Solar Shading
Reduces glare and solar heat gain in summer and allows natural daylight in winter

LED Lighting
Equipped with occupancy and daylight sensors

High Performance Glazing
Double glazing with thermal coating resulting in less solar heat gain and a U-value of .21

Displacement Air-Flow System
Improved efficiency, indoor air quality and occupant comfort
Chilled Beam system

Perimeter Radiation
Back-up heating for unoccupied hours and in case of emergency or power loss

Flexible Use
Flexible use of spaces and integrated technology increases utilization

Enhanced Acoustic Performance
Reduced background noise levels and reverberation, acoustic separation of STC 50 between classrooms

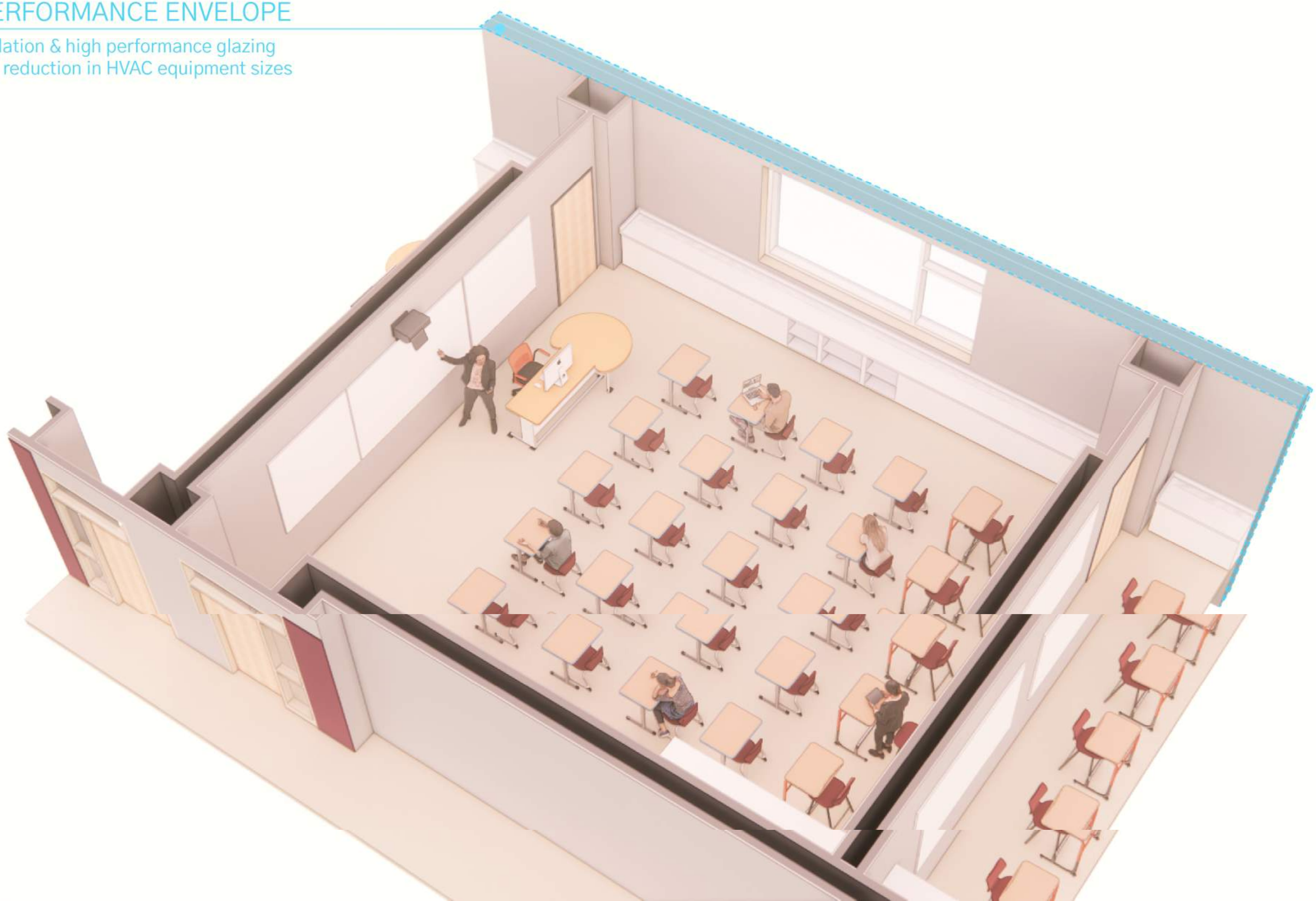
Digital Energy Management System
Controls building systems to optimize efficiency during occupied hours. Individual space temperature control is made possible by VAV terminals

Sustainable Materials
Low-emitting, low-maintenance, durable finishes with high recycled content

BASELINE SUSTAINABLE FEATURES

HIGH PERFORMANCE ENVELOPE

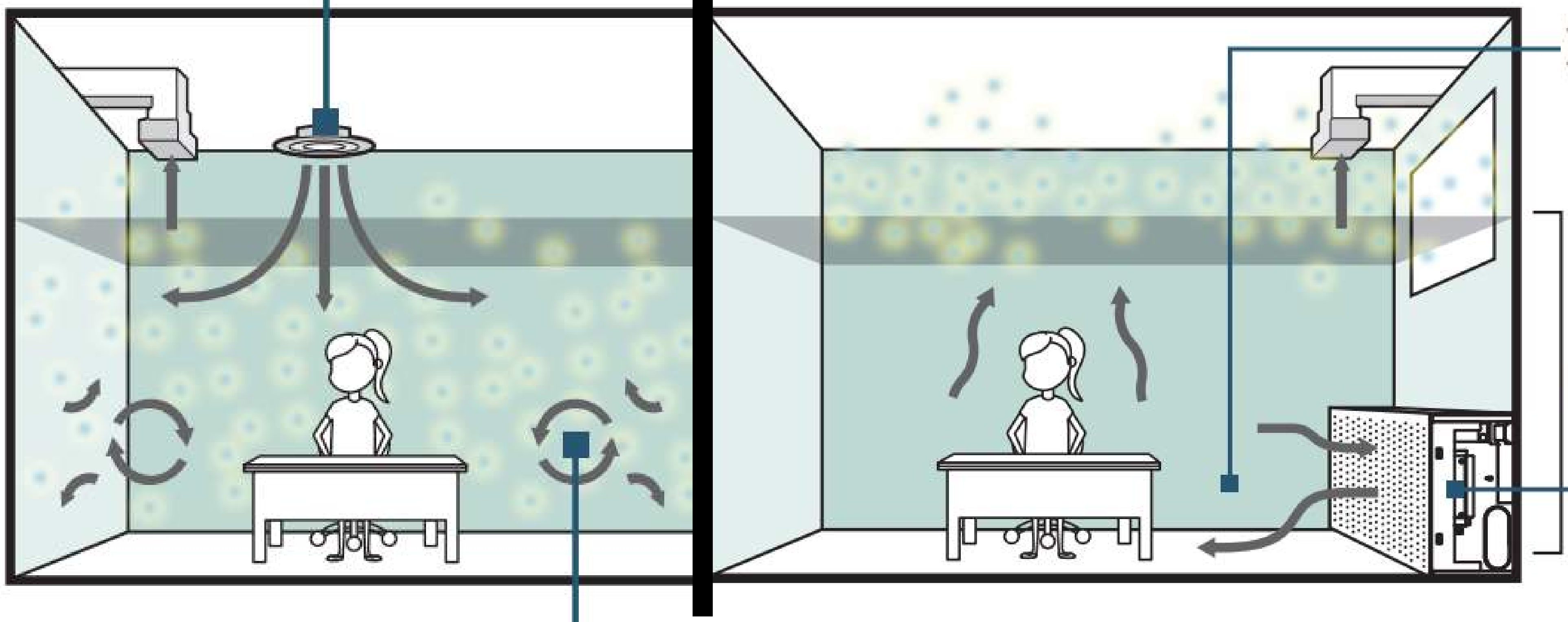
Super-insulation & high performance glazing allows for a reduction in HVAC equipment sizes

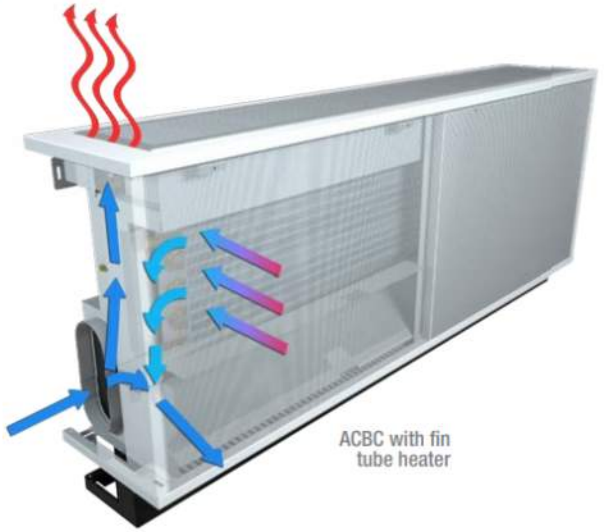


BASELINE SUSTAINABLE FEATURES

TRADITIONAL MIXING VENTILATION

DISPLACEMENT CHILLED BEAM CABINETS





- ✓ LOWER NOISE LEVELS
- ✓ LOWER MAINTENANCE
- ✓ HIGHER INDOOR AIR QUALITY
- ✓ IMPROVED THERMAL COMFORT
- ✓ MORE EFFICIENT
- ✓ LOWER OPERATING COSTS

Graphics from Price Industries

BASELINE SUSTAINABLE FEATURES

800 kW | ELECTRICITY TARGET PROVIDED BY ROOFTOP SOLAR PV ARRAY

ENERGY USE REDUCTION BEYOND CODE BASELINE | **±35%**

38 Kbtu/SF/yr | TARGET SITE ENERGY USE INTENSITY (EUI)

R VALUES OF SUPER–INSULATED WALLS/ROOF | **25** WALL / **45** ROOF

PUBLIC FEEDBACK

WORCESTER
PUBLIC SCHOOLS

SCHOOLS & PROGRAMS • PORTALS • CONTACT CALENDAR & EVENTS ENROLL

Academics • Activities • Current Families • Student Support • About •

Doherty Memorial High School Building Project

Home \ Doherty Memorial High School Building Project

Doherty Memorial High School MSBA Feasibility Study Preferred Schematic Report (PDF). (Very Large File)

News | Meeting Minutes | Community Feedback | Preliminary Design Program

December 23, 2020

October 5, 2020 Public Sustainability Workshop Summary:

- LPAAVExecutive Summary (PDF)
- Sustainability Workshop Presentation (PDF)
- Recording of Sustainability Workshop:

DOHERTY HIGH

2020 Doherty High School Graduates

Advanced Placement

Alumni Transcript Request Form (PDF)

Athletics

DHS Student Schedule – Two Week Cycle (PDF)

Doherty Memorial High School Building Project

SURVEY RESULTS

Doherty Memorial High School Sustainability Workshop Survey

The purpose of this survey is to gather community input on the sustainable design features proposed for the Doherty Memorial High School Project.

The results of this survey will help to determine the discussion topics for the Virtual Sustainability Workshop scheduled for October 5th, 2020 from 4:30-6:30 PM.

Please provide all responses by September 28, 2020.

The building and site design will incorporate many of the features shown below. Which topics are most important to you?

Please rank each of the items in the list below on a scale from 1 (Most important) to 4 (Not important).

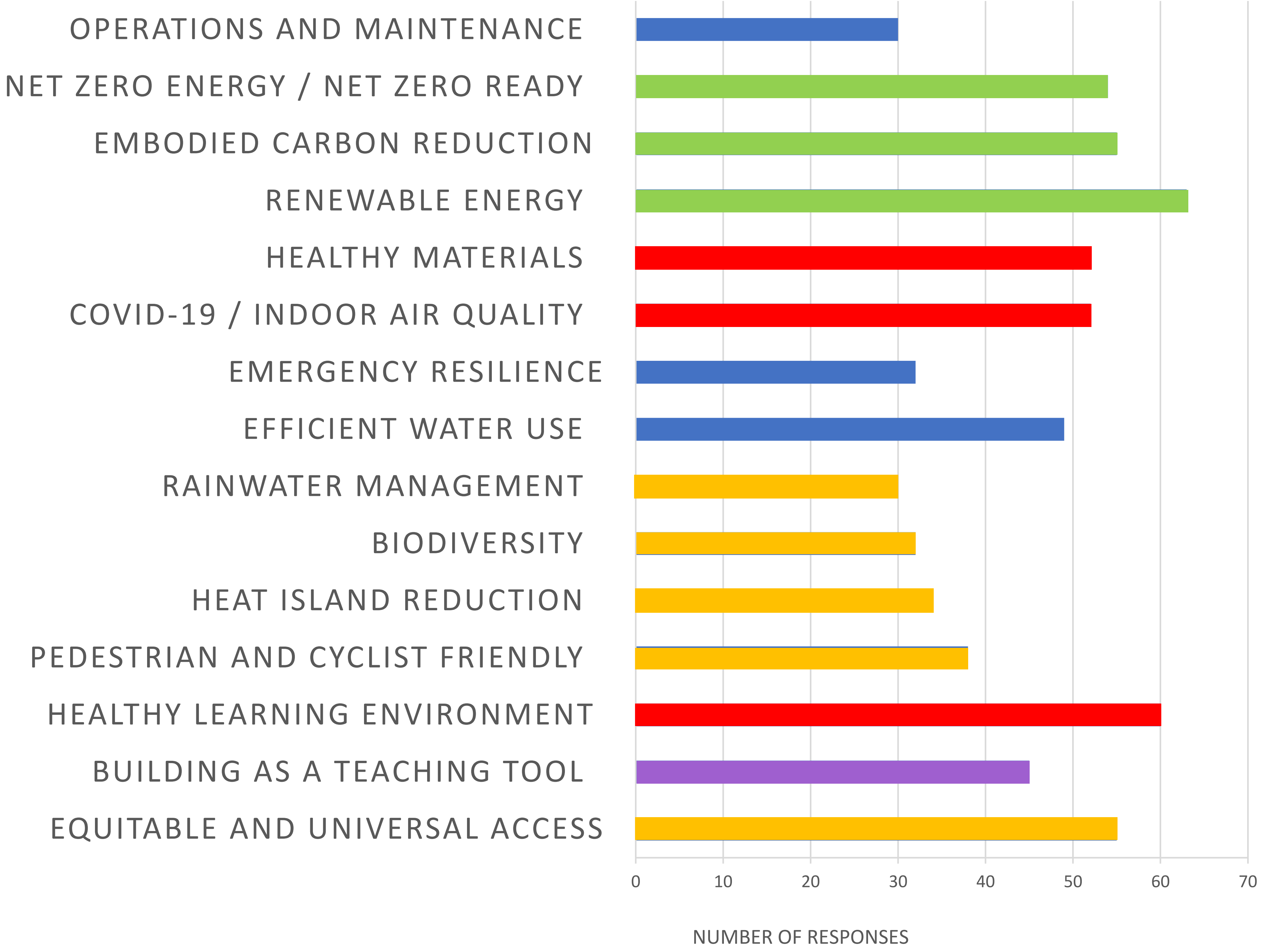
	1 (Most Important)	2 (Important)	3 (Slightly Important)	4 (Not as Important)
Heat Island Reduction	☐	☐	☐	☐
Healthy Materials	☐	☐	☐	☐
Embodied				

100+ | RESPONDENTS INCLUDING STAFF, STUDENTS, PARENTS, NEIGHBORS & CITY AND COMMUNITY REPRESENTATIVES

66% | OF RESPONDENTS BELIEVE RENEWABLE ENERGY IS A TOP PRIORITY

72 | RESPONDENTS PRIORITIZE A HEALTHY LEARNING ENVIRONMENT FOR STUDENTS AND STAFF

SURVEY RESULTS



DISCUSSION TOPIC CATEGORIES:

1 ENERGY

2 HEALTHY LEARNING ENVIRONMENT

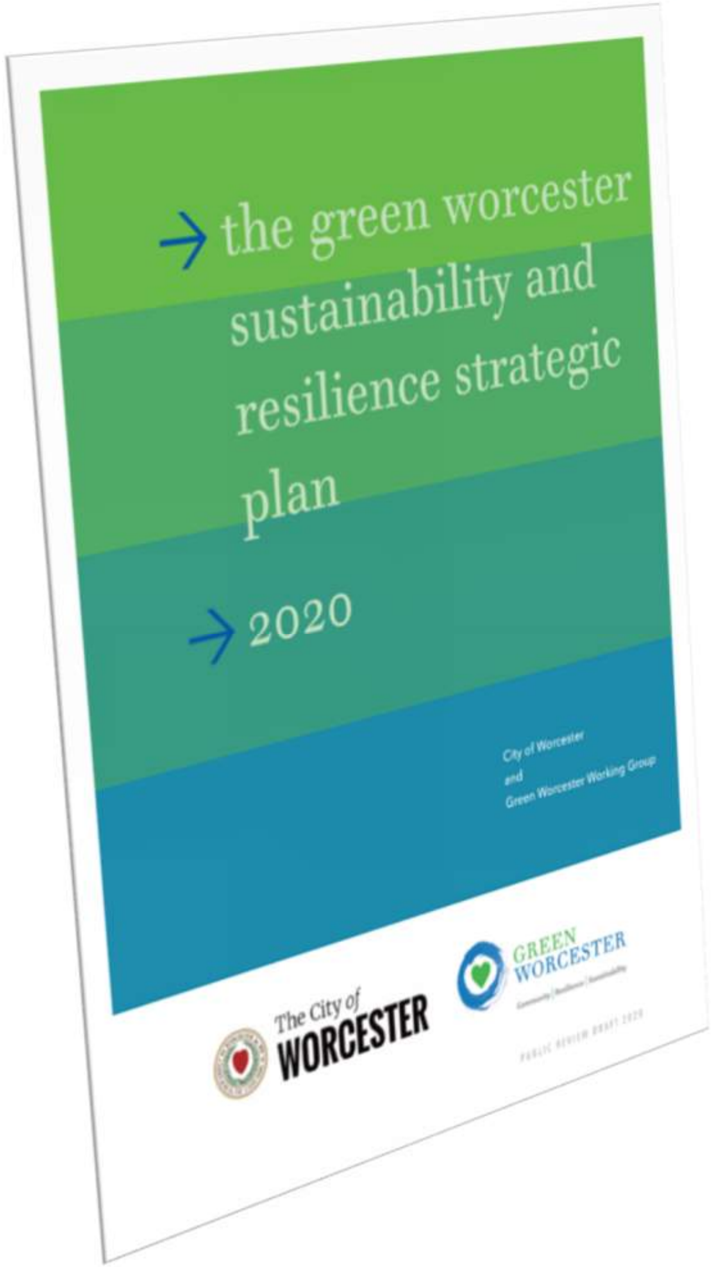
3 SITE ACCESS & SUSTAINABILITY

4 BUILDING AS A TEACHING TOOL

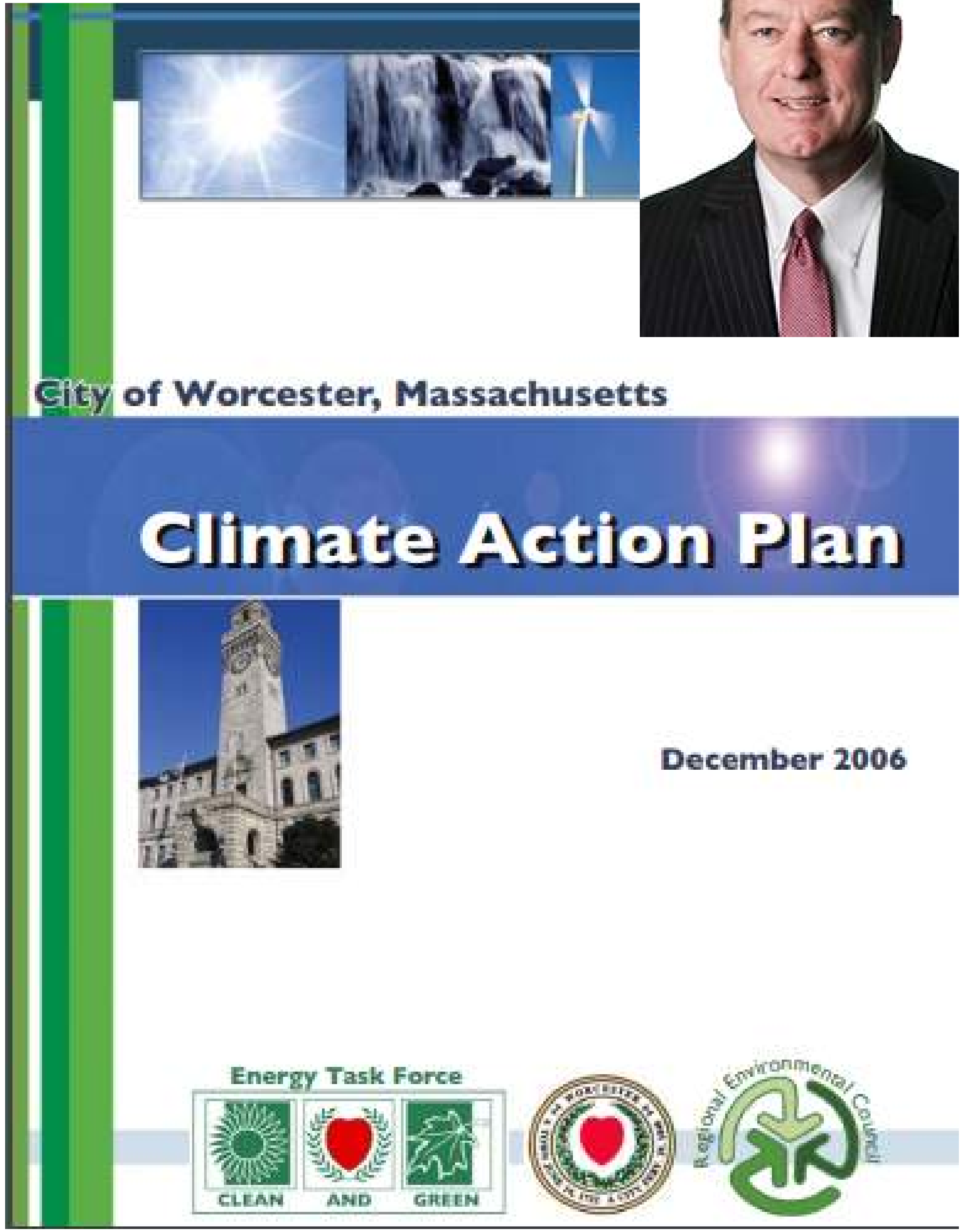
GREEN WORCESTER PLAN

GREEN WORCESTER

Community | Resilience | Sustainability

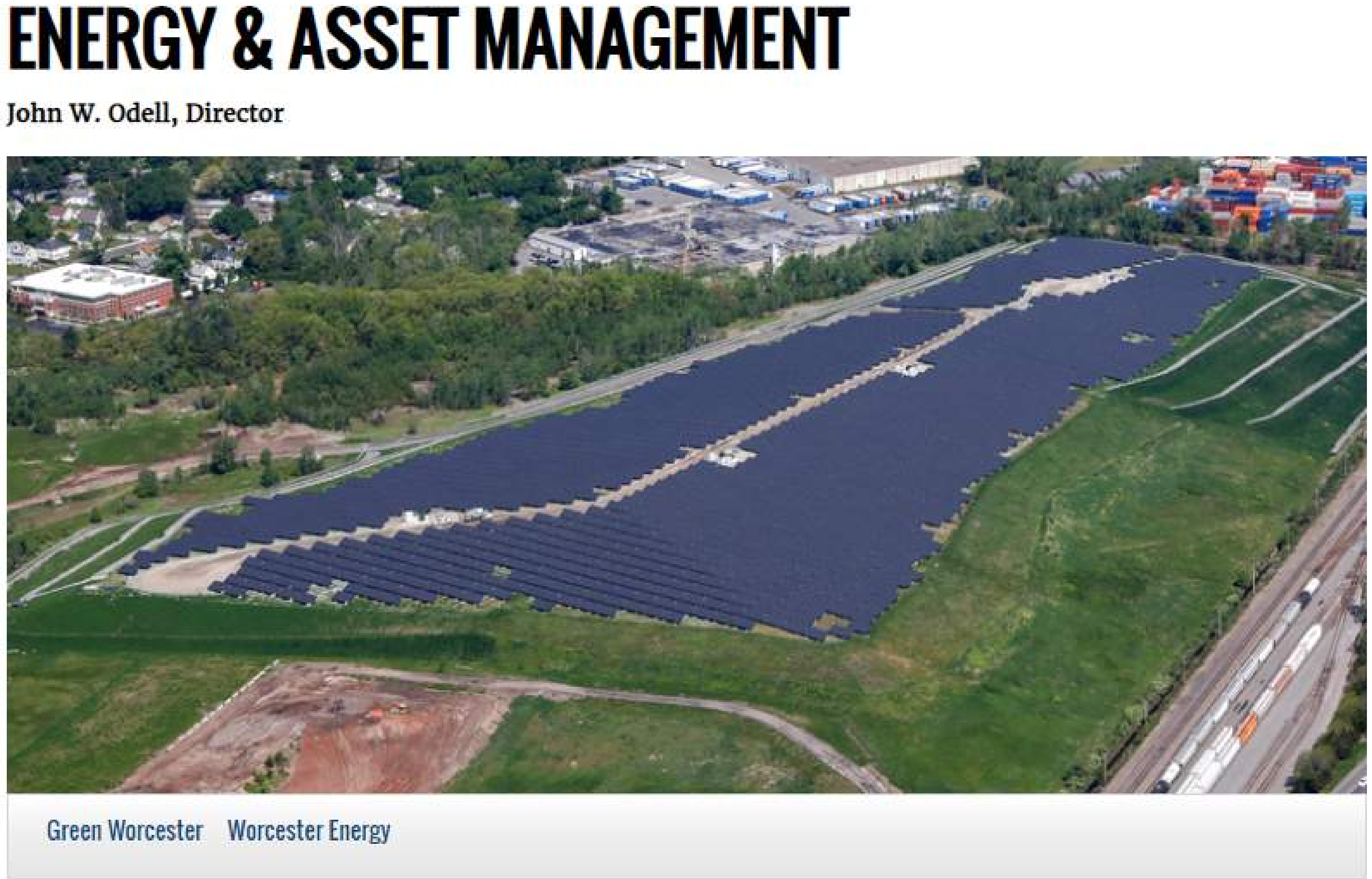


PUBLIC FEEDBACK



MOTHERS OUT FRONT

RMI
ENERGY. TRANSFORMED.



KEY DESIGN FACTORS

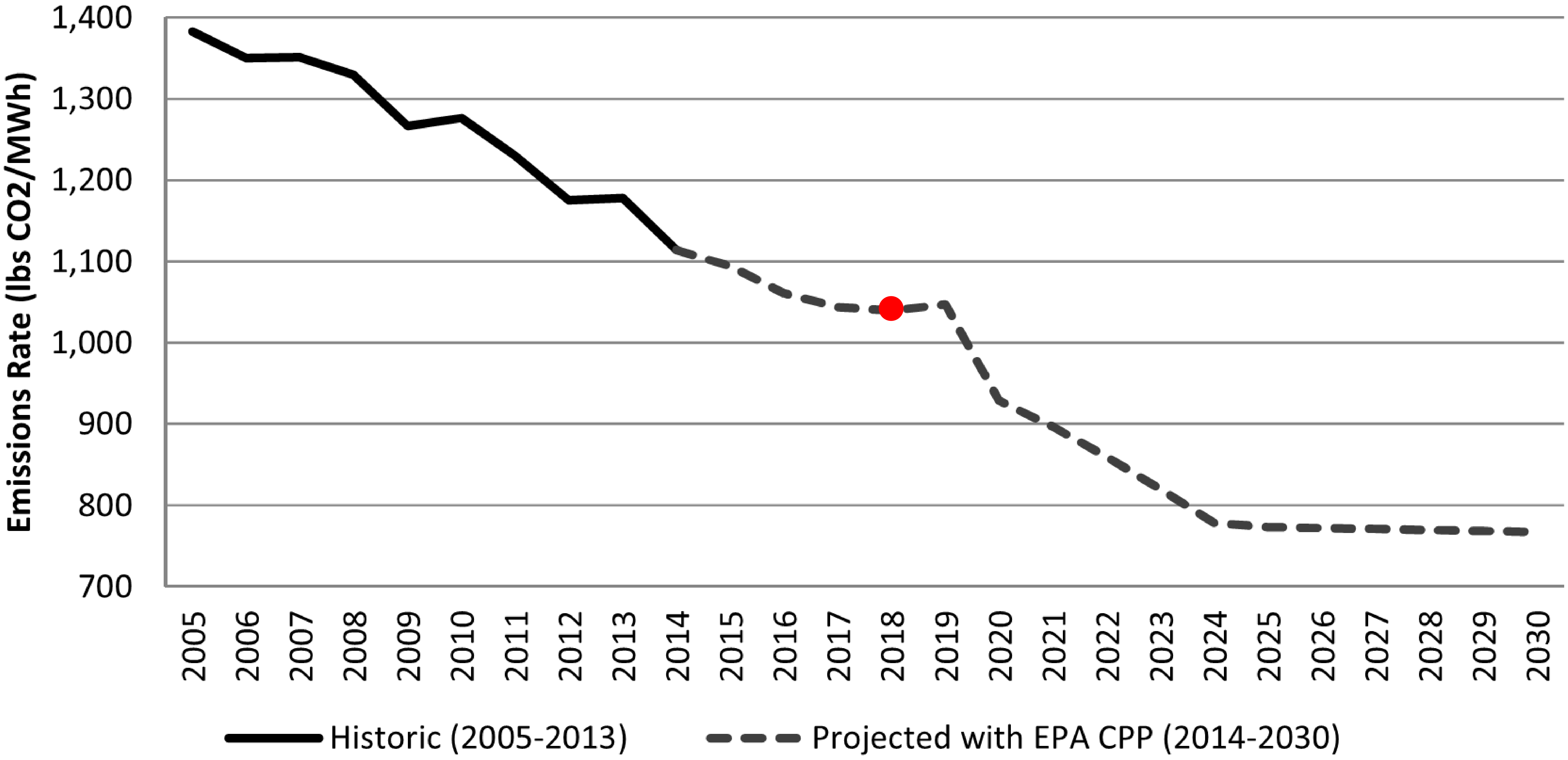
1. SUSTAINABILITY OF MAINTENANCE
   (MINIMIZE STAFFING / FUNDING RESOURCES REQUIRED)

2. INITIAL & LONG-TERM COSTS
   (CONSTRUCTION / UTILITY COSTS)

3. APPROPRIATE SYSTEM FOR A LEARNING ENVIRONMENT
   (INDOOR AIR QUALITY AND NOISE REDUCTION CONSIDERATIONS)

4. EMERGENCY RESILIENCE
   (REDUNDANT FUEL SOURCES / FUNCTION AS A WARMING SHELTER)

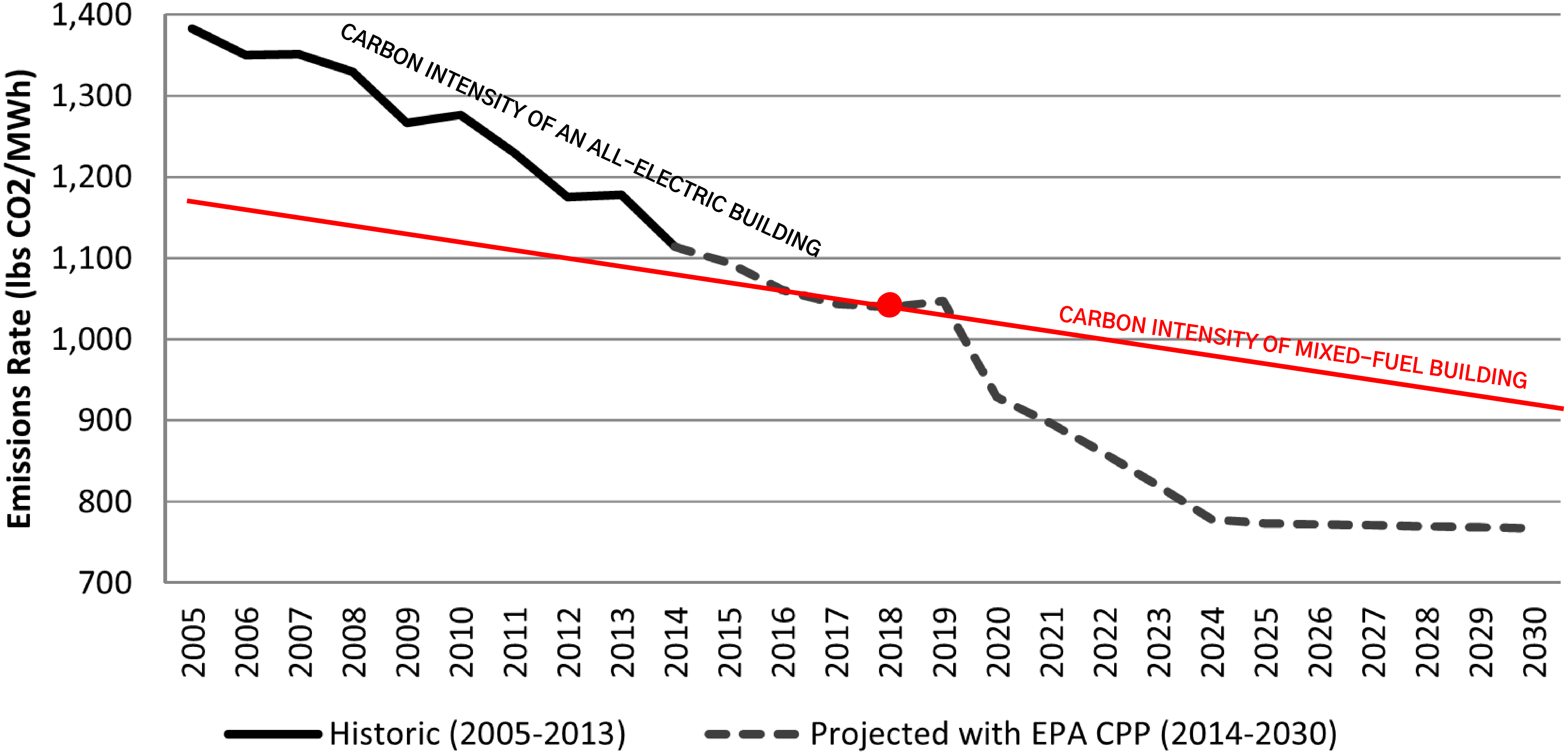
CARBON INTENSITY OF US ELECTRICAL GENERATION



Keith Dennis in The Electricity Journal http://dx.doi.org/10.1016/j.tej.2015.09.019

WHY ELECTRIFY?

ALL ELECTRIC BUILDINGS REDUCE CO_2 OVER TIME



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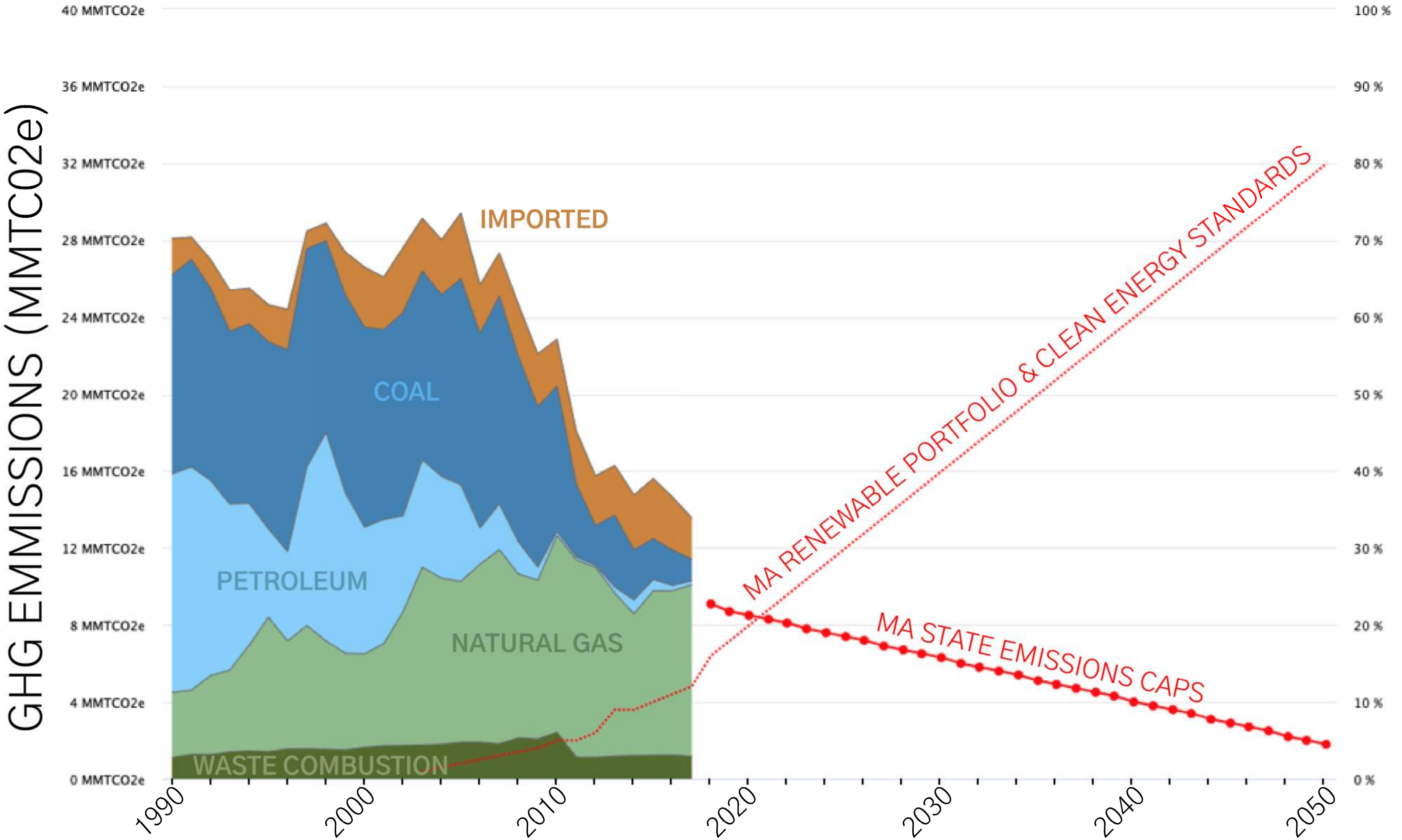
MA ELECTRICITY GHG EMISSIONS BY SOURCE



INITIAL STUDY

		"As Designed"	Hybrid	Redesign to Reduce Gas Load	Full Electric-No Fossil Fuels	Full Electric-No Fossil Fuels
		DESIGN DEVELOPMENT	**FUTURE CONVERSION**	**REDESIGN**	**ELECTRIC BOILERS**	**ALL VRF**
Expected Service Life (n) - HVAC		20.0	20.0	20	20	15
Initial Costs	Install Cost HVAC ($) 3	$ 21,012,747	$ 21,223,676	$ 21,645,534	$ 21,434,605	$ 20,590,889
	Additional Costs Electrical ($)	$ 0	$ 0	$ 1,500,000	$ 2,500,000	$ 2,500,000
	Total Initial Costs ($)	**$ 21,012,747**	**$ 21,223,676**	**$ 23,145,534**	**$ 23,934,605**	**$ 23,090,889**
Operating Costs	Annual Maintenance Costs ($)	$97,027	$ 97,027	$ 118,120	$ 97,027	$ 139,213
	Natural Gas Cost ($)	$49,054	$ 46,110	$ 12,263	$ 0	$ 0
	Electricity Cost ($)	$513,451	$ 519,408	$ 602,811	$ 662,925	$ 619,253
	Total Annual Operating Cost ($)	**$659,532**	**$ 662,546**	**$ 733,194**	**$ 759,953**	**$ 758,466**
TEAC Calcs	Annual Operating Cost ($)	$ 659,532	$ 662,546	$ 733,194	$ 759,953	$ 758,466
	Amortized Cost - HVAC + Electrical	$ 1,347,907	$ 1,361,438	$ 1,469,913	$ 1,510,658	$ 1,798,743
Total Equivalent Annual Cost ($)		**$ 2,007,439**	**$ 2,023,984**	**$ 2,203,107**	**$ 2,270,611**	**$ 2,557,209**
TEAC (Incremental Cost/SF)		$ 4.76	$ 4.80	$ 5.22	$ 5.38	$ 6.06
Electricity Consumption (kWh)		3,111,823	3,147,928	3,653,398	4,017,729	3,753,047
Gas Consumption (therms)		54,504	51,234	13,626	0	0
GHG Emissions (MTCO2e) - Energy Star Carbon Factors		**1031**	**1023**	**943**	**958**	**895**
Site EUI (kBTU/SF)		**38.0**	**37.5**	**32.7**	**32.4**	**30.2**

INITIAL STUDY

		"As Designed"	Hybrid	Redesign to Reduce Gas	Full Electric-No	Full Electric-No
		DESIGN DEVELOPM				
Expected Service Life (n) - HVAC		20.0				
Initial Costs	Install Cost HVAC ($) 3					
	Additional Costs Electrical ($)	$ 0				
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Gas Consumption (therms)						
GHG Emissions (MTCO2e) - Energy Star Carbon Factors						
Site EUI (kBTU/SF)						

TEAC = Total Equivalent Annual Cost

Amortizes the upfront cost over the life span of the systems being studied and adds that to the operating cost

Annual Operating Cost

+ Bond Payment on the Capital Cost

TEAC

GHG Emissions = Greenhouse Gas Emissions

Metric tons of carbon dioxide equivalent; a gas which contributes to the greenhouse effect

EUI = Energy Use Intensity

The amount of energy used per square-foot of building area

INITIAL STUDY

		"As Designed"	Hybrid	Redesign to Reduce Gas Load	Full Electric-No Fossil Fuels	Full Electric-No Fossil Fuels
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Initial Costs	Install Cost HVAC ($) 3	$ 21,012,747	$ 21,223,676	$ 21,645,534	$ 21,434,605	$ 20,590,889
	Additional Costs Electrical ($)	$ 0	$ 0	$ 1,500,000	$ 2,500,000	$ 2,500,000
	Total Initial Costs ($)	**$ 21,012,747**	**$ 21,223,676**	**$ 23,145,534**	**$ 23,934,605**	**$ 23,090,889**
Operating Costs	Annual Maintenance Costs ($)	$97,027	$ 97,027	$ 118,120	$ 97,027	$ 139,213
	Natural Gas Cost ($)	$49,054	$ 46,110	$ 12,263	$ 0	$ 0
	Electricity Cost ($)	$513,451	$ 519,408	$ 602,811	$ 662,925	$ 619,253
	Total Annual Operating Cost ($)	**$659,532**	**$ 662,546**	**$ 733,194**	**$ 759,953**	**$ 758,466**
TEAC Calcs	Annual Operating Cost ($)	$ 659,532	$ 662,546	$ 733,194	$ 759,953	$ 758,466
	Amortized Cost - HVAC + Electrical	$ 1,347,907	$ 1,361,438	$ 1,469,913	$ 1,510,658	$ 1,798,743
Total Equivalent Annual Cost ($)		**$ 2,007,439**	**$ 2,023,984**	**$ 2,203,107**	**$ 2,270,611**	**$ 2,557,209**
TEAC (Incremental Cost/SF)		$ 4.76	$ 4.80	$ 5.22	$ 5.38	$ 6.06
Electricity Consumption (kWh)		3,111,823	3,147,928	3,653,398	4,017,729	3,753,047
Gas Consumption (therms)		54,504	51,234	13,626	0	0
GHG Emissions (MTCO2e) - Energy Star Carbon Factors		**1031**	**1023**	**943**	**958**	**895**
Site EUI (kBTU/SF)		**38.0**	**37.5**	**32.7**	**32.4**	**30.2**

INITIAL STUDY

		"As Designed"	Hybrid	Redesign to Reduce Gas Load	Full Electric-No Fossil Fuels	Full Electric-No Fossil Fuels
		DESIGN DEVELOPMENT	**FUTURE CONVERSION**	**REDESIGN**	**ELECTRIC BOILERS**	**ALL VRF**
Expected Service Life (n) - HVAC		20.0	20.0	20	20	15
Initial Costs	Install Cost HVAC ($) 3	$ 21,012,747	$ 21,223,676	$ 21,645,534	$ 21,434,605	$ 20,590,889
	Additional Costs Electrical ($)	$ 0	$ 0	$ 1,500,000	$ 2,500,000	$ 2,500,000
	Total Initial Costs ($)	**$ 21,012,747**	**$ 21,223,676**	**$ 23,145,534**	**$ 23,934,605**	**$ 23,090,889**
Operating Costs	Annual Maintenance Costs ($)	$97,027	$ 97,027	$ 118,120	$ 97,027	$ 139,213
	Natural Gas Cost ($)	$49,054	$ 46,110	$ 12,263	$ 0	$ 0
	Electricity Cost ($)	$513,451	$ 519,408	$ 602,811	$ 662,925	$ 619,253
	Total Annual Operating Cost ($)	**$659,532**	**$ 662,546**	**$ 733,194**	**$ 759,953**	**$ 758,466**
TEAC Calcs	Annual Operating Cost ($)	$ 659,532	$ 662,546	$ 733,194	$ 759,953	$ 758,466
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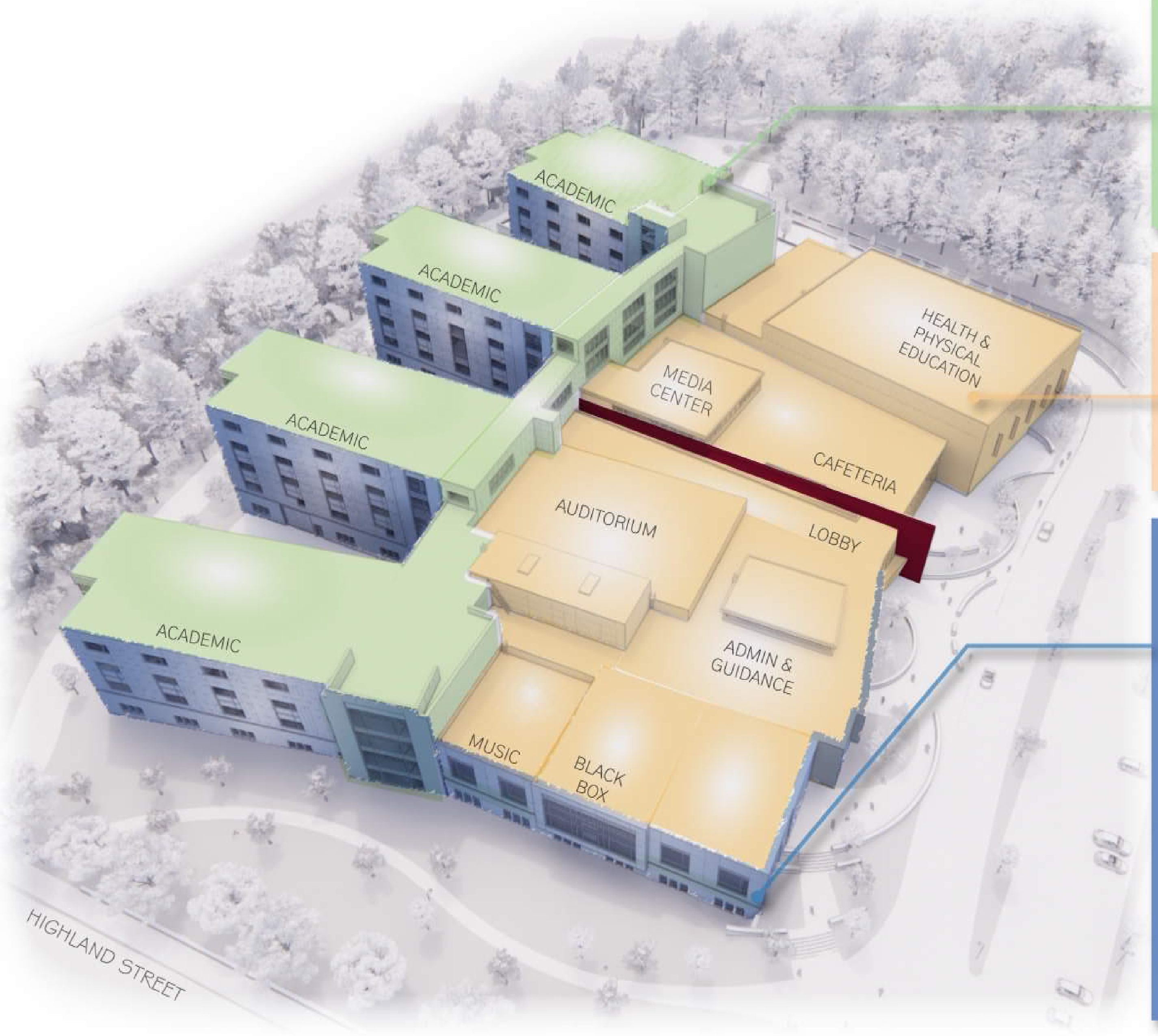
SUMMARY

	"As Designed"	Hybrid	Redesign to Reduce Gas Load	Full Electric-No Fossil Fuels	Full Electric-No Fossil Fuels
	DESIGN DEVELOPMENT	FUTURE CONVERSION	REDESIGN	ELECTRIC BOILERS	ALL VRF
Total Initial Costs ($)	$21 M	$ 21.2 M	$ 23.1 M	$ 23.9 M	$ 23.1 M
Total Annual Operating Cost ($)	$660,000	$ 663,000	$ 733,000	$ 760,000	$ 758,000
Total Equivalent Annual Cost ($)	$ 2,007,439	$ 2,023,984	$ 2,203,107	$ 2,270,611	$ 2,557,209
GHG Emissions (MTCO2e) - Energy Star Carbon Factors	1031	1023	943	958	895
Site EUI (kBTU/SF)	38.0	37.5	32.7	32.4	30.2

DESIGN DEVELOPMENT

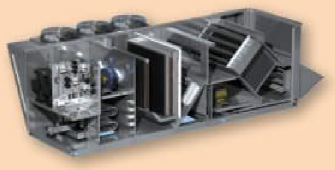


AIR COOLED CHILLER WITH OIL–LESS COMPRESSOR & FREE COOLING

COLD WATER FOR ALL BUILDING SYSTEMS

DISPLACEMENT CHILLED BEAMS WITH HYDRONIC HEAT & DEDICATED OUTDOOR AIR SYSTEM

SUPERIOR VENTILATION EFFECTIVENESS & INDOOR AIR QUALITY



HIGH EFFICIENCY PACKAGED DIRECT EXCHANGE ROOF TOP UNITS & VAV TERMINALS

HYDRONIC HEAT BACK–UP

HIGH EFFICIENCY GAS–POWERED BOILERS

HOT WATER FOR ALL PERIMETER RADIATION HEATING AND HYDRONIC COILS

HOT WATER FOR BUILDING HEATING IN CASE OF EMERGENCY POWER OUTAGE

FOSSIL FUEL REDUCTION REDESIGN

AIR COOLED HEAT RECOVERY CHILLER / HEATER

SIMULTANEOUS HOT AND COLD WATER
FOR ALL BUILDING SYSTEMS
GAS-FIRED BOILER FOR BACKUP & EMERGENCY

DISPLACEMENT CHILLED BEAMS WITH HYDRONIC HEAT & DEDICATED OUTDOOR AIR HEAT PUMP SYSTEM

SUPERIOR VENTILATION EFFECTIVENESS
& INDOOR AIR QUALITY

AIR SOURCE HEAT PUMP ROOF TOP UNITS

HYDRONIC HEAT BACKUP

VARIABLE REFRIGERANT FLOW (VRF) HEAT PUMPS WITH DEDICATED OUTDOOR AIR HEAT PUMP SYSTEM

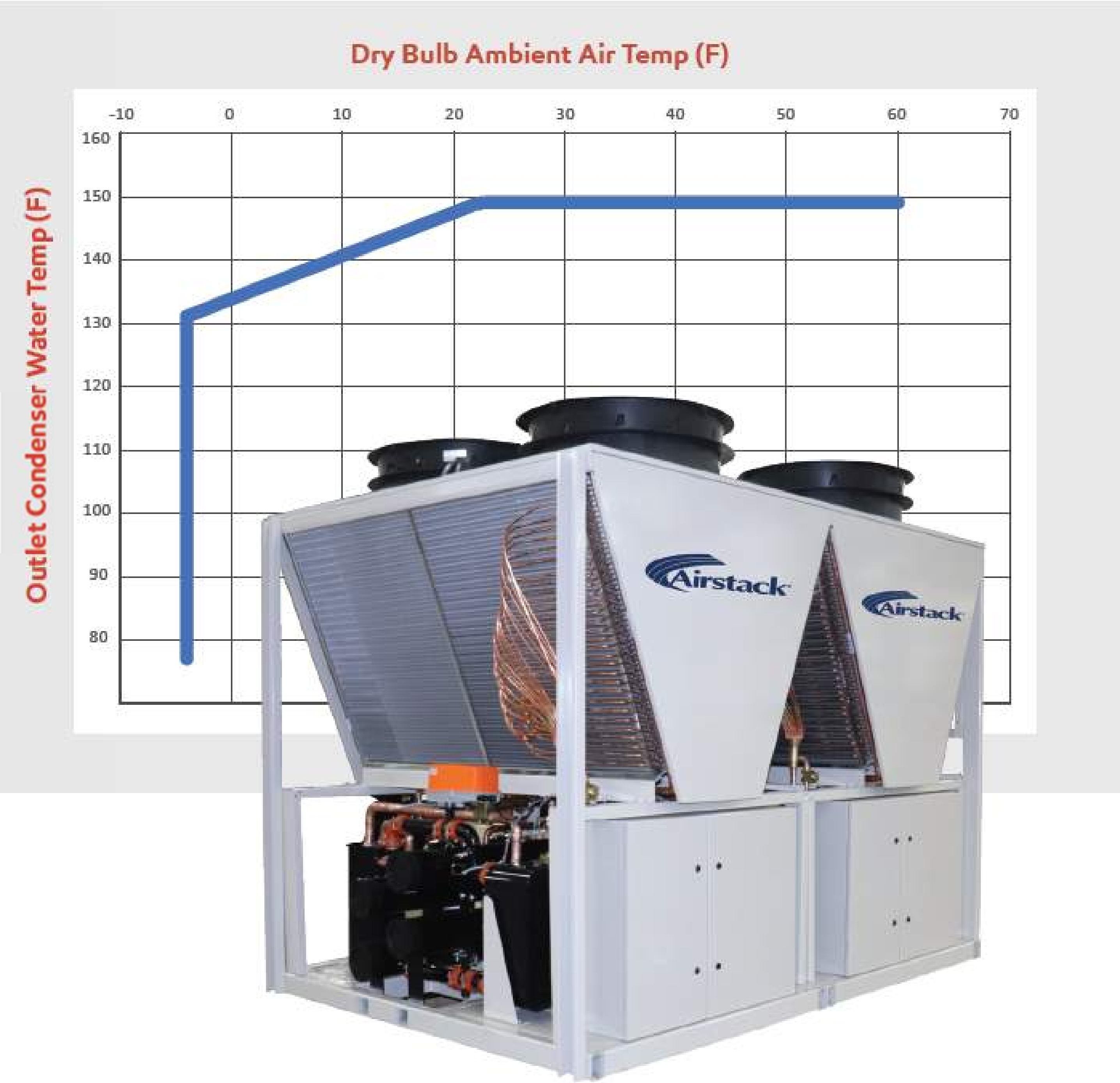
IMPROVED INDIVIDUAL ZONE CONTROL

HIGH EFFICIENCY GAS-POWERED BOILERS

PROVIDES BACK-UP HOT WATER TO SUPPLEMENT
HEAT RECOVERY CHILLER, AND IN CASE OF
EMERGENCY POWER OUTAGE

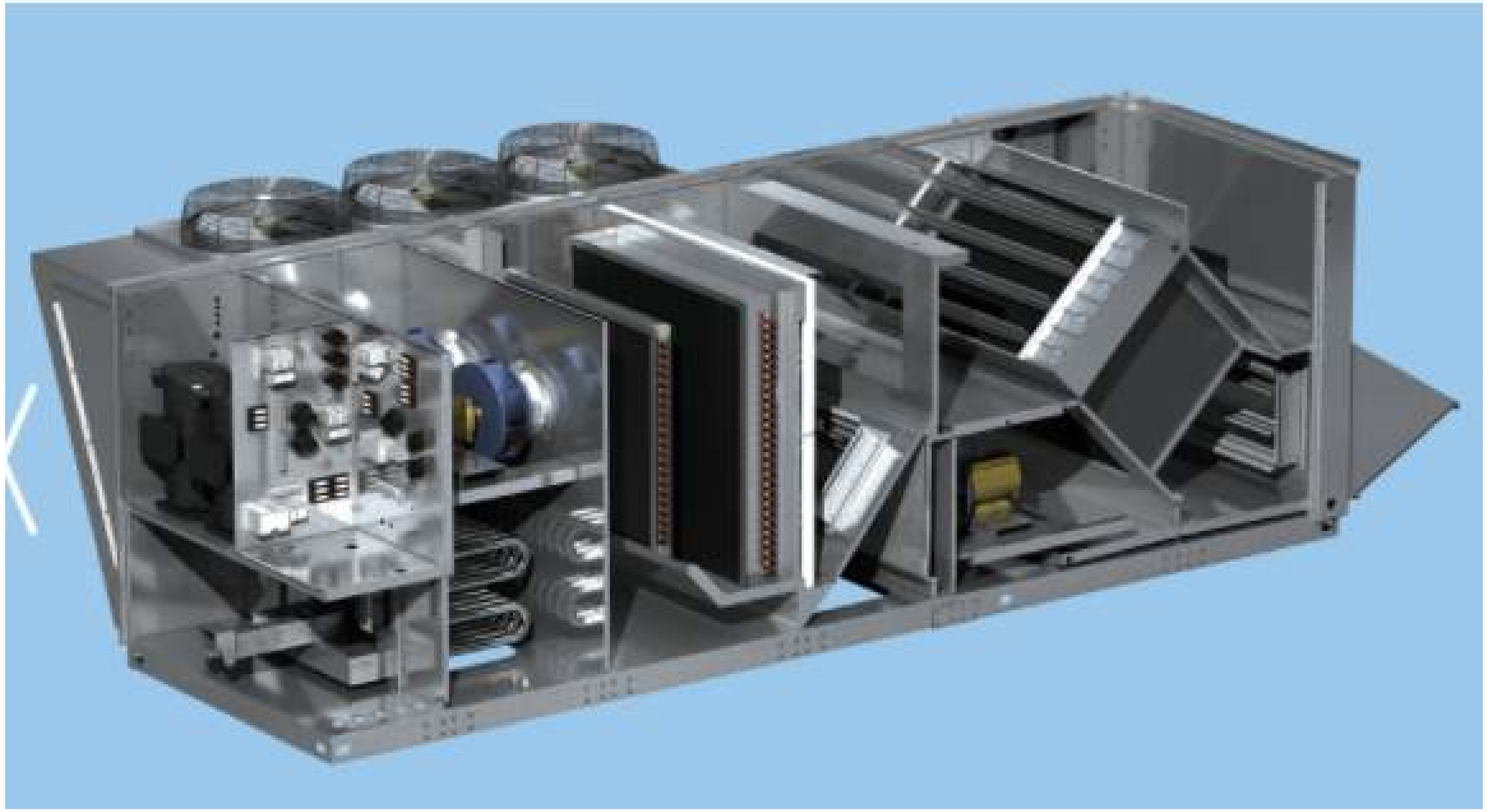
ELECTRIC HEAT RECOVERY CHILLER/HEATER

- Generates both chilled water and hot water simultaneously
- Operation down to 0F outdoor with 130F hot water as air to water heat pump and -20F as heat recovery chiller/heater
- Multiple 30-ton modules (est. 150-ton+)



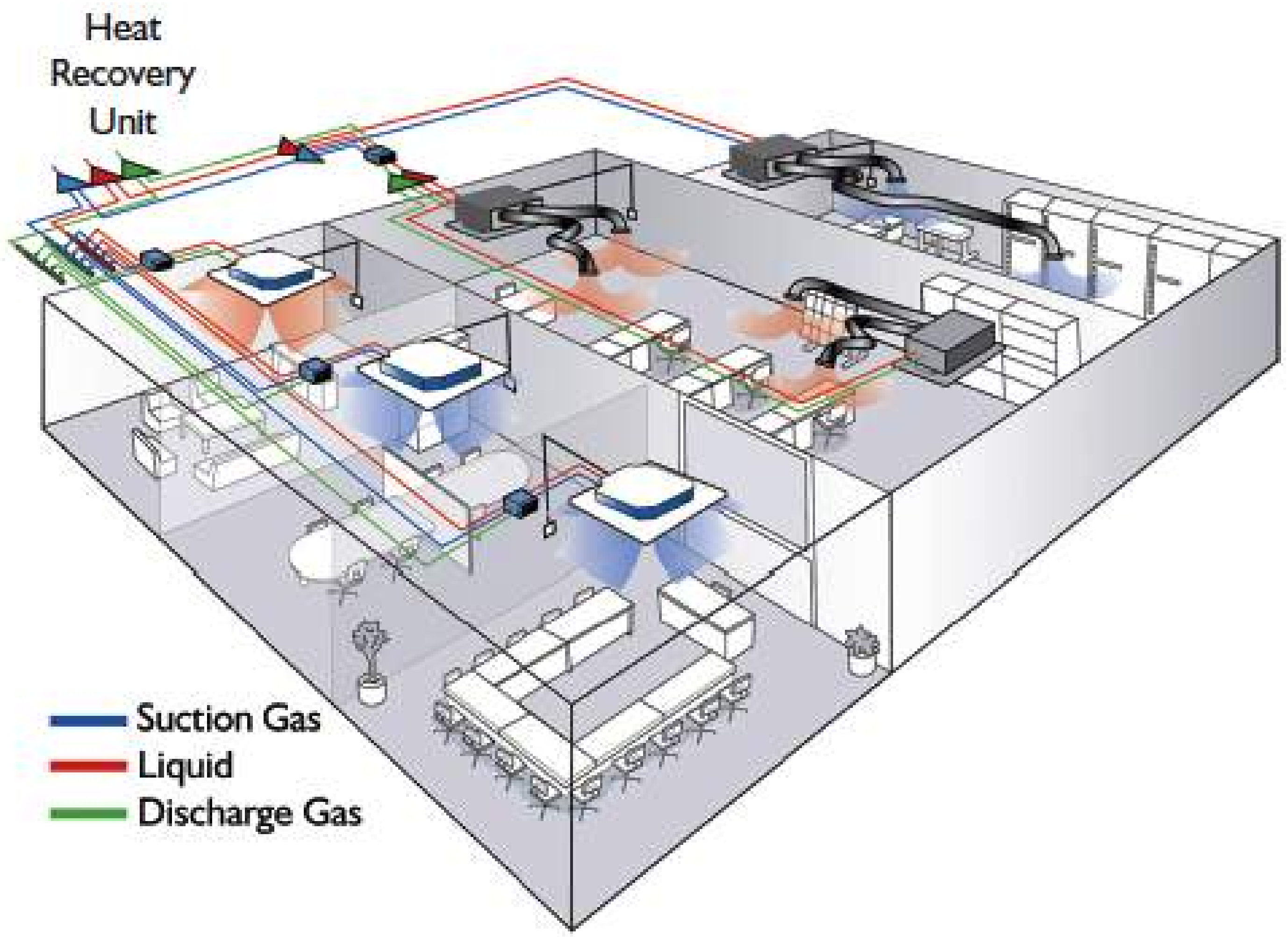
ELECTRIC AIR SOURCE HEAT PUMP RTU'S

- Inverter Compressors
- ERV Wheel or Core
- Hot Water Back-up heat Option
- Uses electricity for heat instead of gas

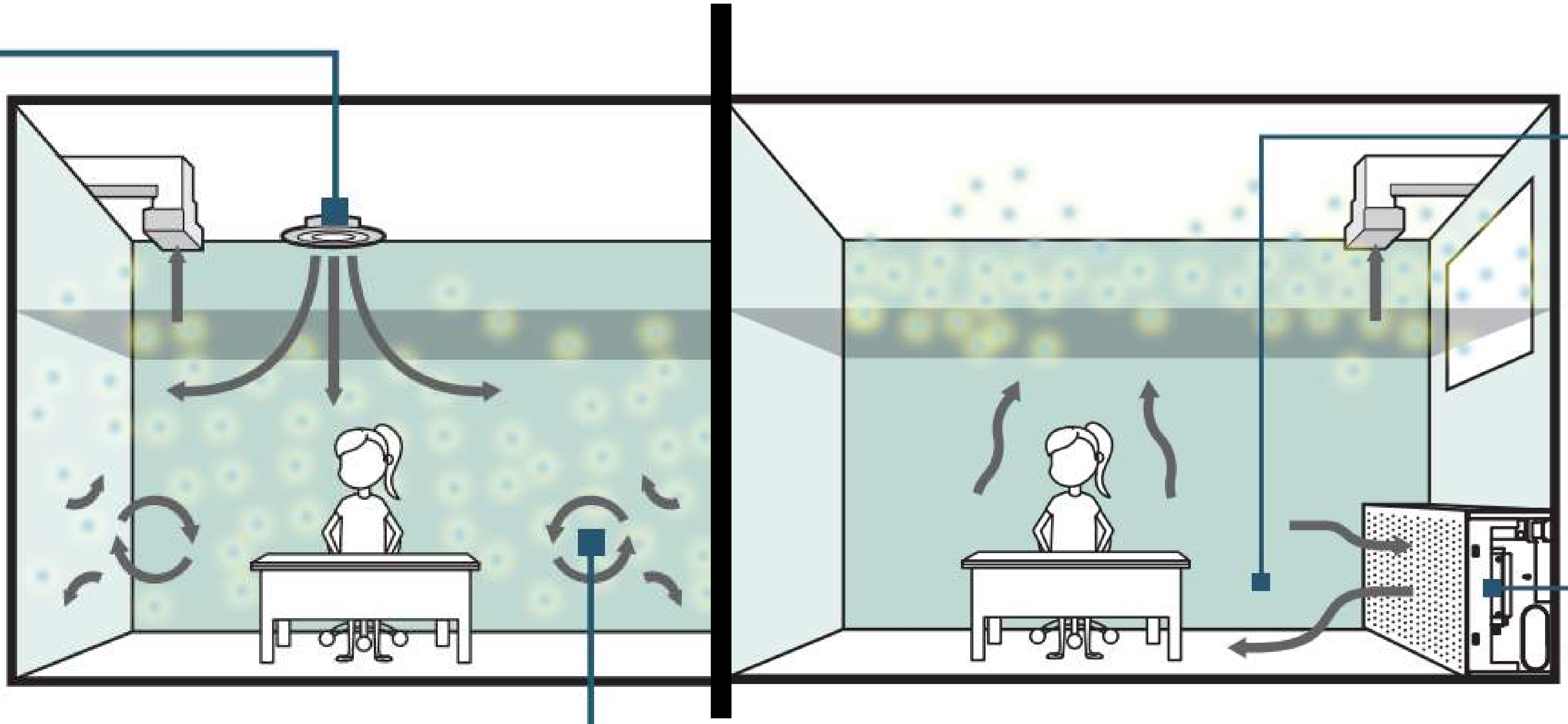


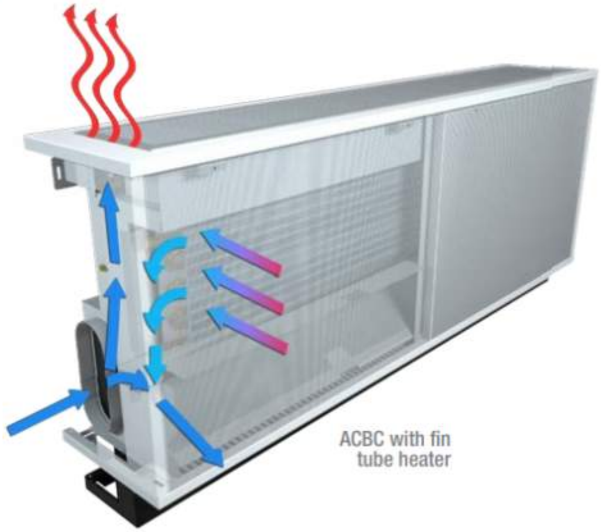
VRF HEAT PUMP SYSTEM

ELECTRIC VRF HEAT RECOVERY HEAT PUMP SYSTEM



DISPLACEMENT CHILLED BEAM CABINETS



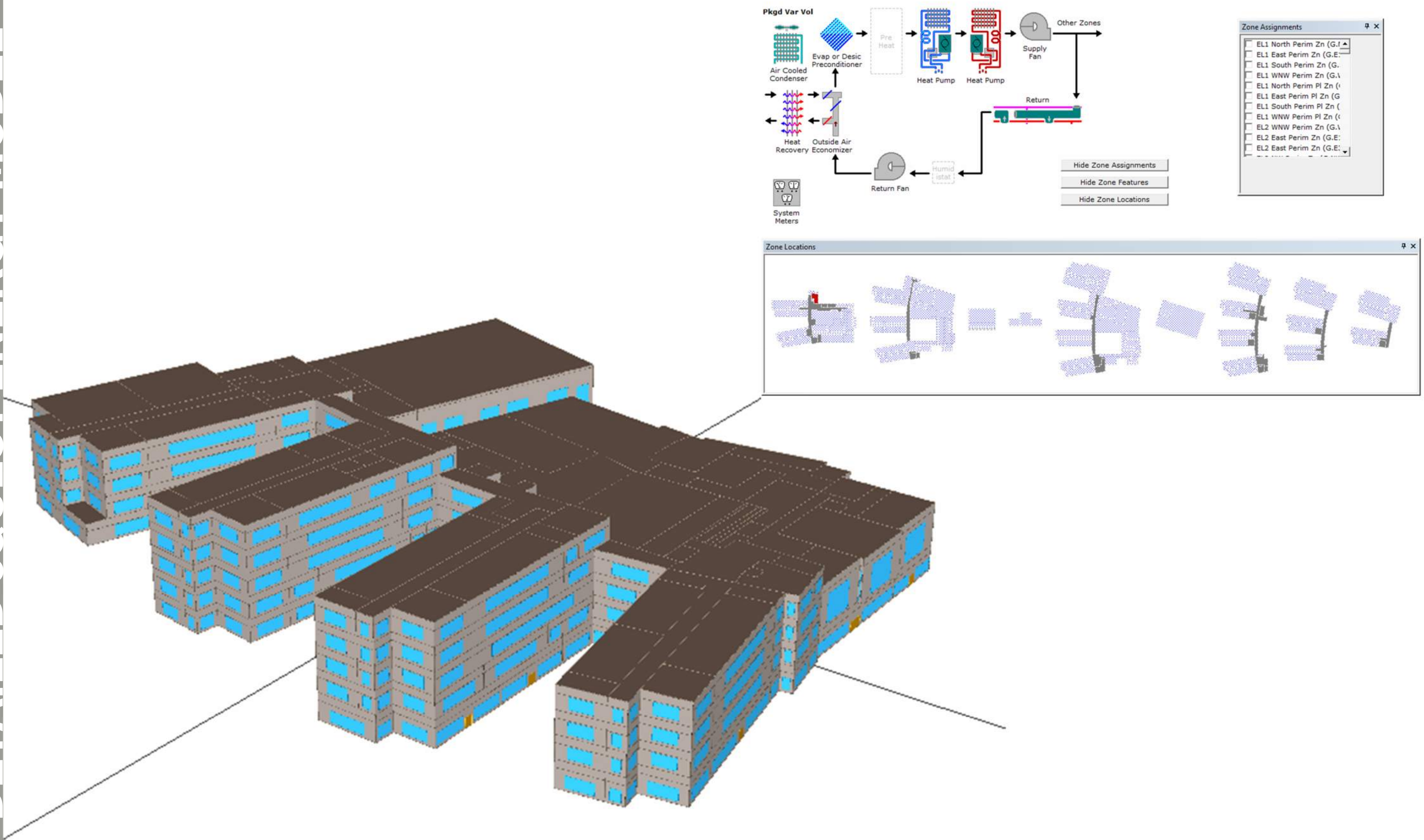


- ✓ EASE OF MAINTENANCE
- ✓ FRESH AIR IN BREATHING ZONE
- ✓ SUPERIOR ACOUSTICS
- ✓ LESS DUCTWORK REQUIRED FOR LOW VELOCITY AIR

Slide Info. from Price Industries

DISPLACEMENT VENTILATION

DETAILED eQUEST ENERGY MODEL



100% CD PROJECTIONS

	CODE BASELINE	100% CONSTRUCTION DOCUMENTS
Natural Gas Cost ($)	$136,669	$ 39,127
Electricity Cost ($)	$600,455	$ 447,876
Total Annual Energy Cost ($)	**$737,124**	**$ 487,003**
Electricity Consumption (kWh)	3,639,123	2,714,401
Gas Consumption (therms)	112,300	32,150
GHG Emissions (MTCO2e) Energy Star Carbon Factors	**1,467**	**820**
Site EUI (kBTU/SF)	**53.9**	**28.8**

BOTTOM LINE

647 MTC02 IS THE EQUIVALENT OF

72,803

GALLONS OF GASOLINE CONSUMED

BOTTOM LINE

BASELINE SUSTAINABLE ENVELOPE / SYSTEMS

+ HEAT RECOVERY CHILLER
+ VRF HEAT PUMPS
+ AIR SOURCE HEAT PUMP RTU'S

70% REDUCTION

IN PROJECTED FOSSIL FUEL USE

SUMMARY

- **EARLY DECISION MAKING IS CRITICAL**

SUMMARY

- EARLY DECISION MAKING IS CRITICAL
- NATURAL GAS /ELECTRICITY IN ENERGY MODELS

SUMMARY

- EARLY DECISION MAKING IS CRITICAL
- NATURAL GAS /ELECTRICITY IN ENERGY MODELS
- IMPACT OF CLIMATE ACT LEGISLATION

SUMMARY

- EARLY DECISION MAKING IS CRITICAL
- NATURAL GAS /ELECTRICITY IN ENERGY MODELS
- IMPACT OF CLIMATE ACT LEGISLATION
- EXTENDED COMMISSIONING SERVICES

SUMMARY

- EARLY DECISION MAKING IS CRITICAL
- NATURAL GAS /ELECTRICITY IN ENERGY MODELS
- IMPACT OF CLIMATE ACT LEGISLATION
- EXTENDED COMMISSIONING SERVICES
- CAREER OPPORTUNITIES

Massachusetts School
Building Authority

SEAMAN
ENGINEERING CORPORATION

The Green Engineer
Sustainable Design Consulting

LPA|A