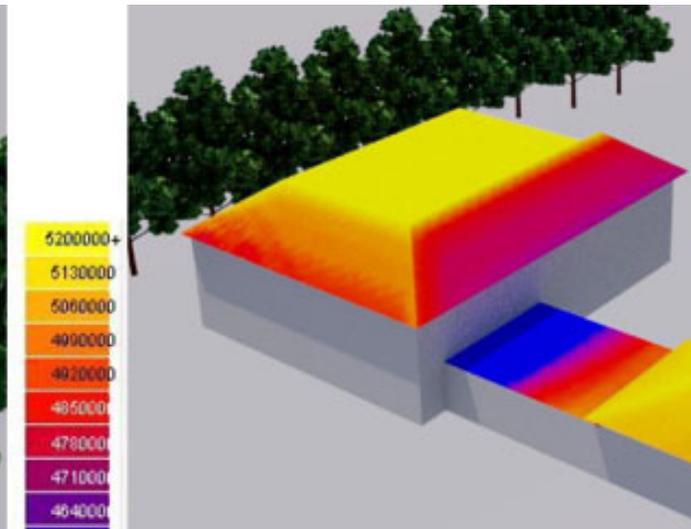
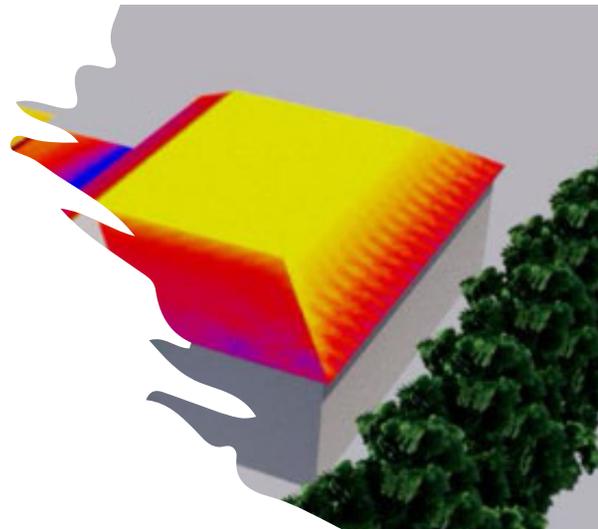
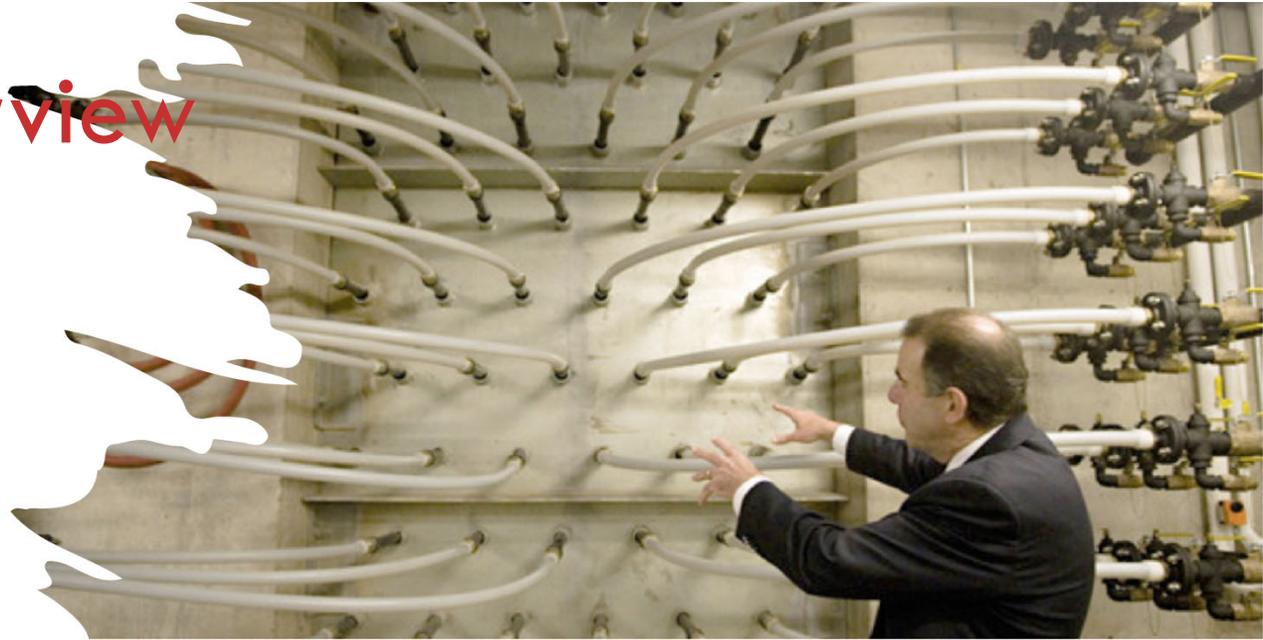
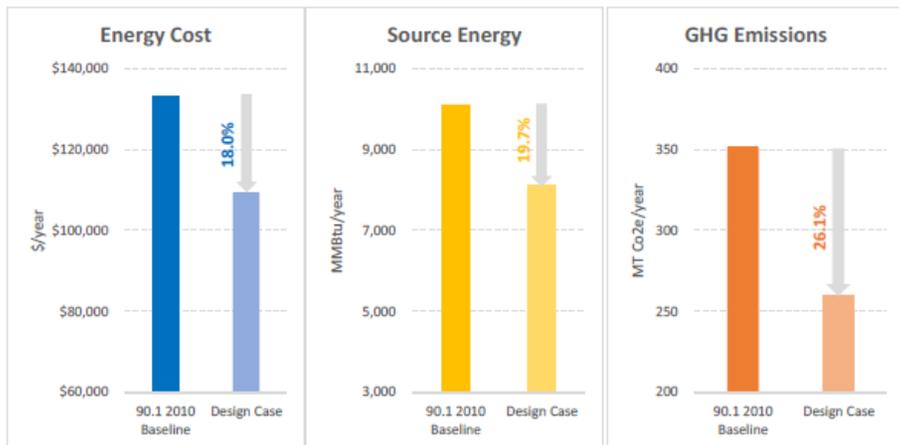


# Sustainability Overview

## Energy Efficiency Strategy for Success

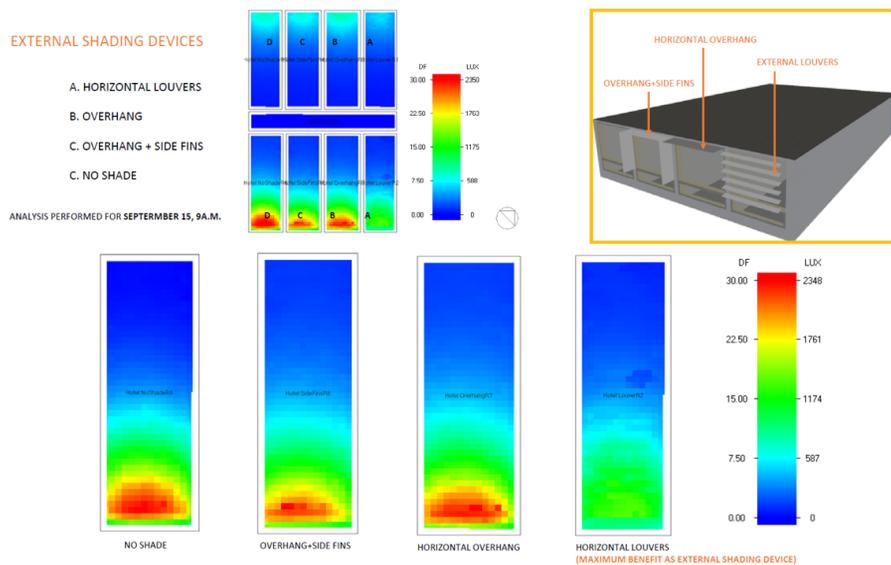
- 1) Reduce Demand
- 2) Harvest Site Energy
- 3) Maximize Efficiency
- 4) Building Commissioning
- 5) Operations and Maintenance
- 6) Renewables



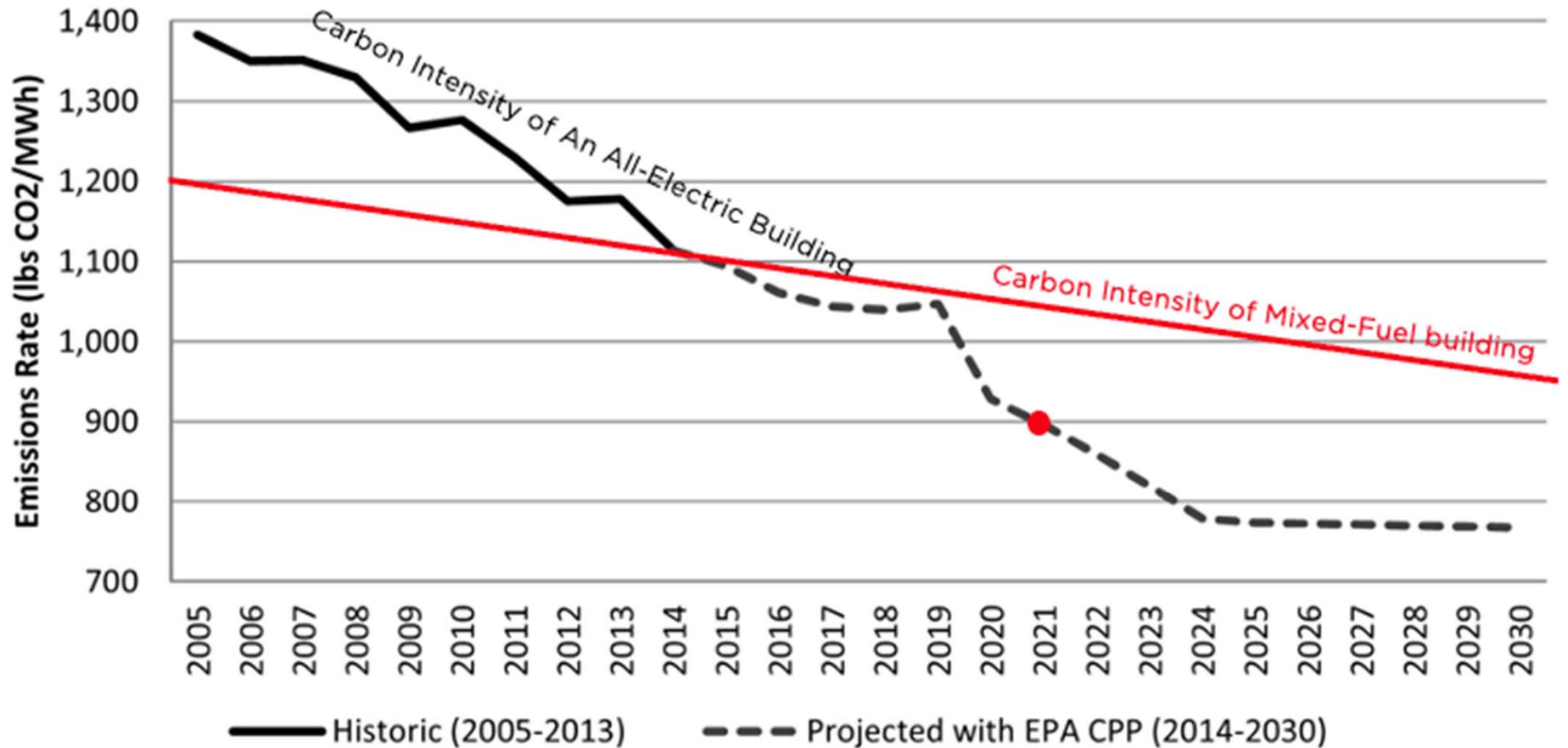


## Common Themes of Successful Low Energy Projects

- Energy targets established early
- Focus on reducing loads – building envelope, right-sizing
- Non-typical HVAC systems – heat pumps, chilled beams, displacement ventilation to be considered
- Modeling used to test alternatives
- Decision to eliminate fossil fuels is critical and difficult
- Third-party ownership of renewables

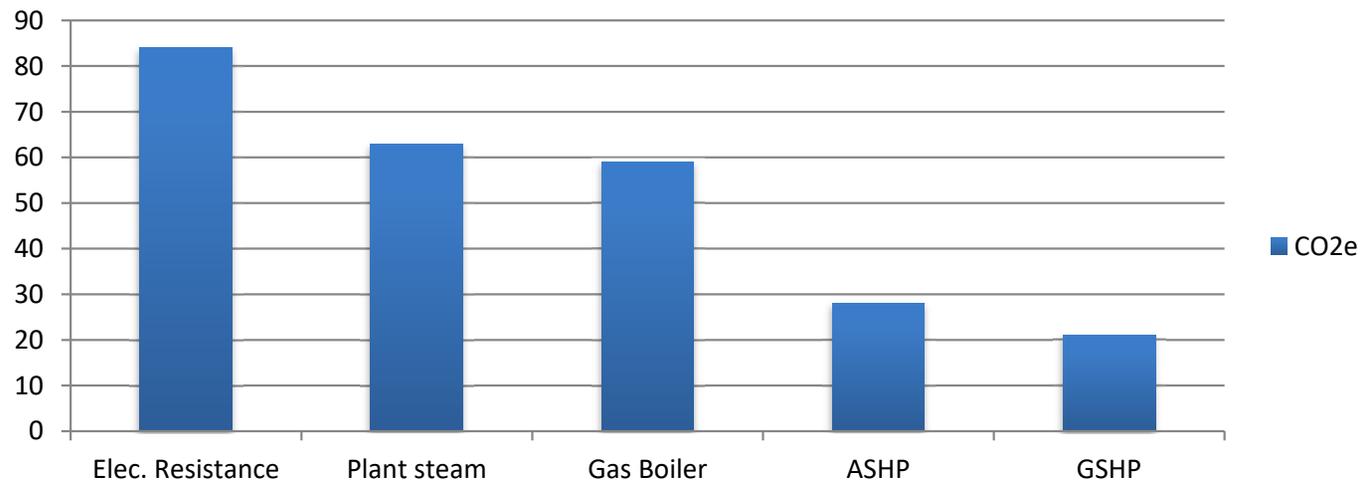


# All Electric Buildings Reduce CO<sub>2</sub> Over Time



# Decarbonize Heat

CO<sub>2</sub>e



## Analysis from a recent campus climate plan

- Electric Resistance – 84 kgCO<sub>2</sub>e/MBTU
- Steam from plant – 63 kgCO<sub>2</sub>e/MBTU
- Gas Fired Condensing Boiler – 59 kgCO<sub>2</sub>e/MBTU
- ASHP – 28 kgCO<sub>2</sub>e/MBTU
- GSHP – 21 kgCO<sub>2</sub>e/MBTU

# Pathways to Net Zero



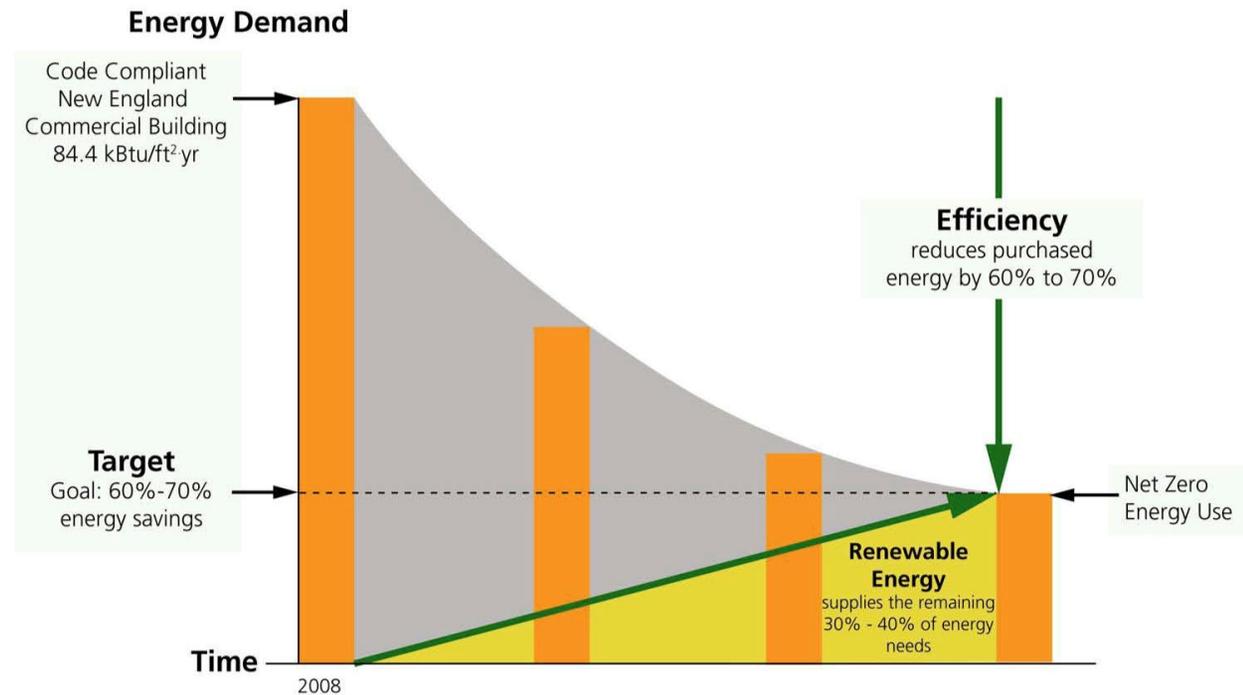
Low EUI

Decarbonization of heat

Solar on Site

Community Renewables

# General Approach



Source: Federal R&D Agenda for Zero-Net Energy high Performance Green Buildings, National Science and Technology Council, October 2008

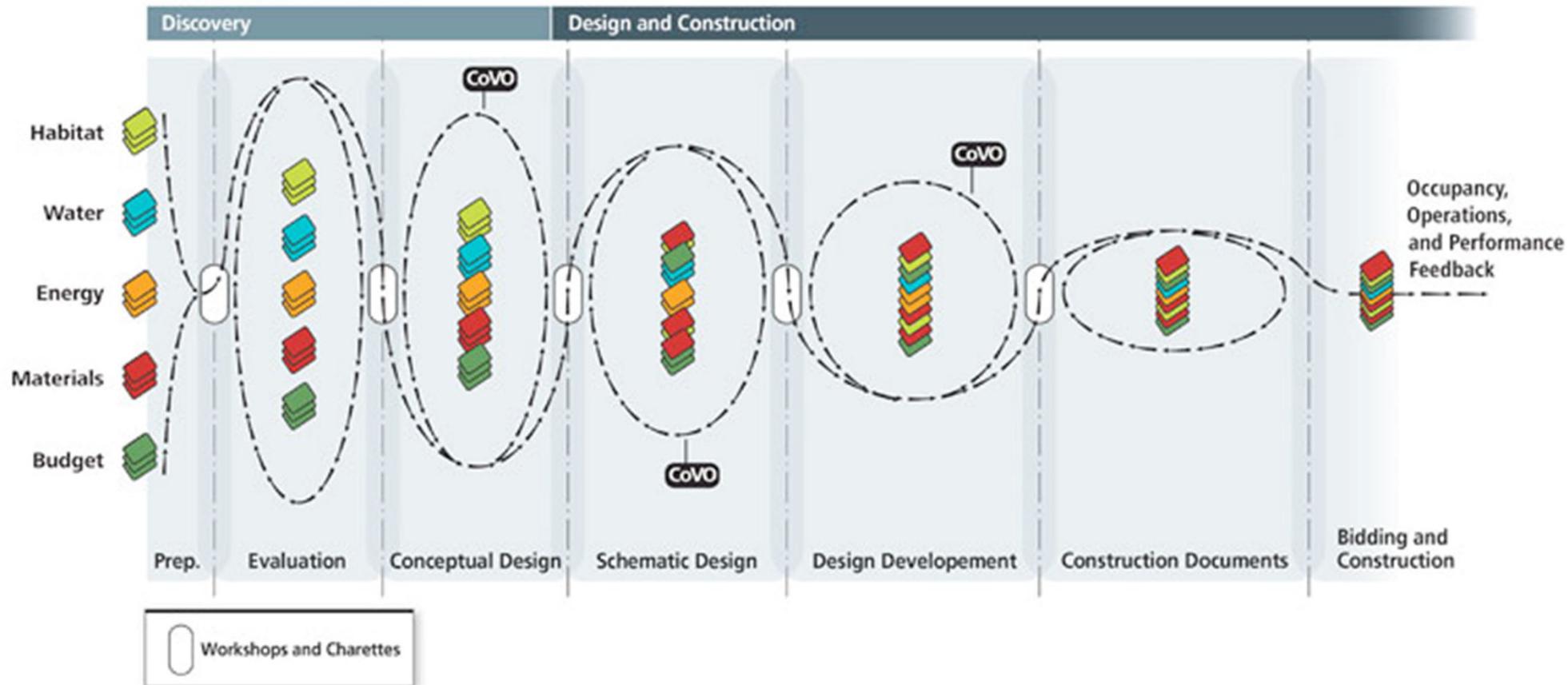
# Zero Net Energy Building Types (ZNEB)

- Class A – renewables with building footprint
- Class B – renewables on building site
- Class C – off site renewables
- Class D – RECs or renewable energy purchased



<https://www.ge.com/reports/size-matters-next-big-thing-wind-turbines/>

# Integrative Process





**Hanlon Elementary School - Mechanical System Payback Summary**

Baseline	System	Gross Capital Investment*	Annual Elec. Cons. (kWh)	Annual Gas Cons. (MBTU)	Annual Electric Cost	Annual Gas Cost	Combined Utility Cost	Annual Utility \$/s.f.	Annual kBTU/s.f. (EUI)	Annual Maint. Cost	20 Year Exterior Equipment Replacement Cost	Combined Annual Expense	Combined Expense Savings**	Total Life-Cycle Savings***	Discounted Payback (Years)****
Code Baseline	1. Hot water coil heating/chilled water coil cooling VAV AHU system with energy recovery and terminal VAV boxes with hot water reheat coils 2. Code-efficient gas-fired non-condensing boiler plant 3. High-efficiency (code) water-cooled chiller plant with cooling tower	\$7,065,144	542,150	1,784.8	\$108,430	\$22,489	\$130,919	\$1.16	32.1	\$132,704	\$1,469,500	\$263,623	-	-	-

Option	System	Gross Capital Investment*	Annual Elec. Cons. (kWh)	Annual Gas Cons. (MBTU)	Annual Electric Cost	Annual Gas Cost	Combined Utility Cost	Annual Utility \$/s.f.	Annual kBTU/s.f. (EUI)	Annual Maint. Cost	20 Year Exterior Equipment Replacement Cost	Combined Annual Expense	Combined Expense Savings**	Total Life-Cycle Savings***	Discounted Payback (Years)****
Base Design	1. Dehumidification displacement ventilation diffusers with radiant heating panels 2. Gas-fired heating/dx cooling VAV ventilating units with energy recovery with terminal VAV boxes with CO2 controls 3. High efficiency gas-fired condensing boiler plant	\$6,026,583	511,760	1,561.7	\$102,353	\$19,678	\$122,031	\$1.08	29.2	\$130,279	\$919,850	\$252,310	\$11,313	\$1,856,606	Instant *****
Tier 1	1. Dehumidification displacement ventilation diffusers with radiant heating panels 2. Hot water coil heating/chilled water cooling VAV ventilating units with energy recovery with terminal VAV boxes with CO2 controls 3. High efficiency water-cooled chiller plant with dry cooler 4. Supplemental electric boiler plant	\$7,666,934	887,380	0.0	\$175,476	\$0	\$175,476	\$1.55	26.8	\$122,079	\$330,000	\$297,555	-\$33,932	-\$685,229	Not Reached *****
Tier 2	1. Dehumidification displacement diffusers with radiant heating panels 2. Hot water coil heating/chilled water cooling VAV ventilating units with energy recovery with terminal VAV boxes with CO2 controls 3. Geothermal wells with high-efficiency water-to-water source heat pump chillers	\$10,917,434	667,000	0.0	\$133,400	\$0	\$133,400	\$1.18	20.1	\$121,079	\$0	\$254,479	\$9,144	-\$2,307,572	Not Reached *****
Tier 3	1. Dehumidification displacement diffusers with radiant heating panels 2. Hot water coil heating/chilled water cooling VAV ventilating units with energy recovery with terminal VAV boxes with CO2 controls 3. Geothermal wells with high-efficiency water-to-water source heat pump chillers 4. Supplemental electric boiler plant	\$10,459,048	754,620	0.0	\$150,923	\$0	\$150,923	\$1.33	22.8	\$122,079	\$0	\$273,002	-\$9,379	-\$2,396,360	Not Reached *****

# What Some MSBA Projects are Doing



Massachusetts School Building Authority

*Funding Affordable, Sustainable, and Efficient Schools in Partnership with Local Communities*

- **Lexington** – Net Zero on site, 100% electric GSHP – Built
- **Worcester** – switched to hybrid electric after public pressure – under construction
- **Ashland** – Hybrid GSHP/Gas Boiler, future solar – in CDs
- **Westwood** – 100% electric GSHP (considering supplemental elec. Boilers – SD, looking at solar
- **Groton** - All electric, ASHP, PV provided by Municipal Light Plant - DD



## Commercial New Construction or Major Renovation Path 1: Zero-Net Energy / Deep Energy Savings



### Get to Net Zero with Help from Mass Save

Partner with the Sponsors of Mass Save for help reaching your team's zero net energy (ZNE) goals while getting the project on a path to minimize future overall energy use.

If you are planning a ZNE commercial or industrial building project, receive the highest level of incentives to offset project costs, as well as

### Project Eligibility Requirements\*

1. Commit to a ZNE, ZNE ready or Passive House (as a path to zero) project
2. Target a goal of 25 EUI or less \*\*
3. Minimum of 20,000 square feet (sf) of heated and cooled space
4. Must anticipate year-round occupancy
5. Engage your Mass Save Sponsor(s) before 50% schematic design
6. Include ZNE or ZNE ready goal and EUI target in project documents
7. Commit to building commissioning

# Potential Goals for Foster Elementary

- Energy efficient building per MSBA – 20% better than code, EUI 35 - 45
- “Net Zero Ready” – EUI of 25 or less
- All Electric – fossil fuel only as back up
- Net Zero Energy - Renewables either on site or off site, EUI  $\leq 0$

EUI – Energy Utilization Index – energy per square foot, usually in kBTU/sf/yr

