Defining the "Smart" Energy Retrofit

Through a Feasibility Study of Two 1960s Residence Halls

2020 AIA/ACSA INTERSECTIONS RESEARCH CONFERENCE: CARBON

GOODY CLANCY

ARCHITECTURE / PLANNING / PRESERVATION

Introductions

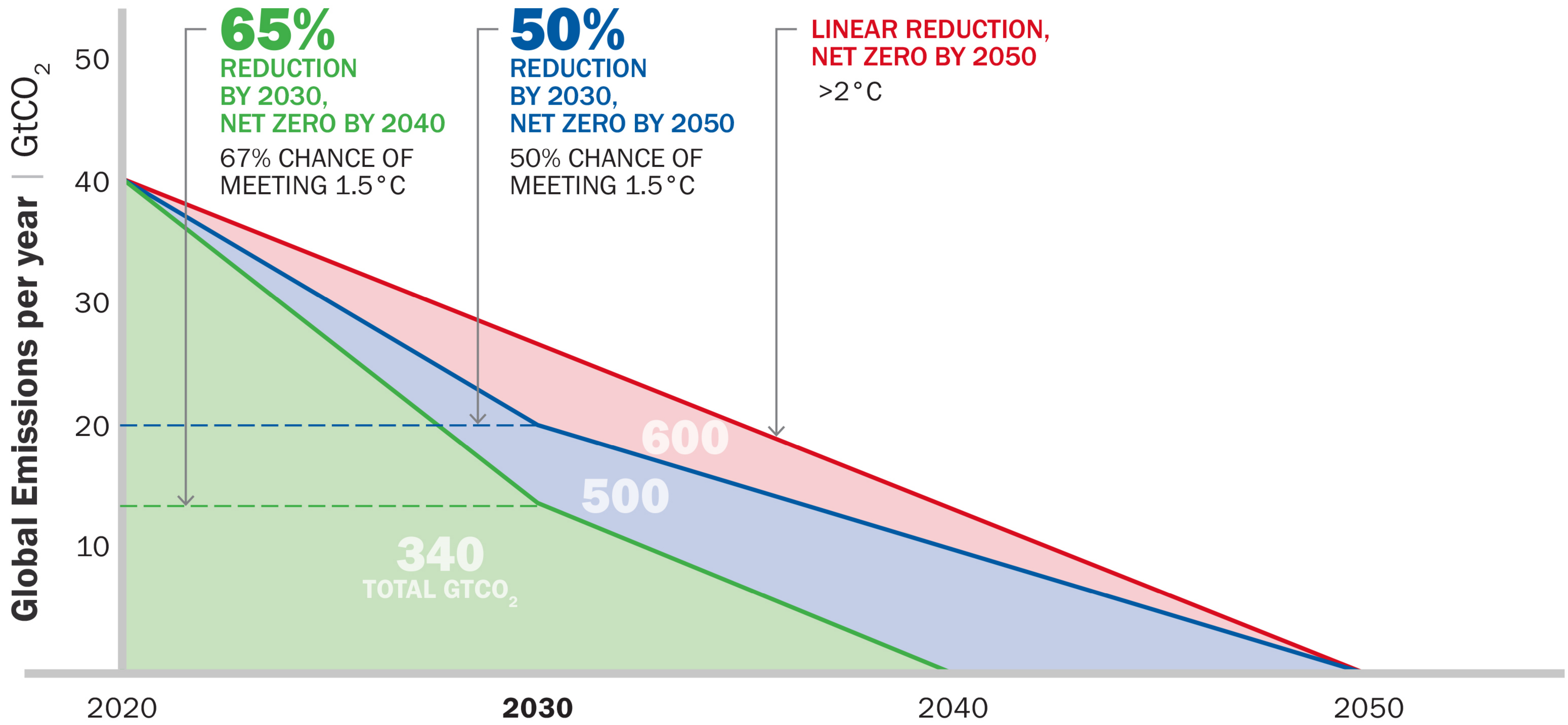
Lori Ferriss, AIA, PE, LEED AP
Director of Sustainability and Climate Action

Elaine Hoffman, AIA, CPHC, LEED AP
Associate

Outline

- Context – the case for “smart” energy retrofits
- Case study introduction
- Analysis findings
- Conclusions

The Next Decade is Critical for Climate Action



DATA SOURCE: ARCHITECTURE 2030

A Deep Energy Retrofit…

- "…is a whole-building analysis and construction process that achieves much larger **energy cost savings**—sometimes more than **50% reduction**—than those of simpler energy retrofits…"

  -Rocky Mountain Institute

- "…is a retrofit project that achieves at least **30% energy savings** in a building

  -New Buildings Institute

A "Smart" Energy Retrofit...

- **Saves more carbon than it spends by the year 2030**
- Accounts for embodied, operational, and end-of-life carbon emissions
- Strategically improves building energy performance through minimal addition of new material
- Positions the building within the bigger picture of the greening grid and utility upgrades to maximize carbon reductions over time

CASE STUDY

Energy Retrofit Project Team

- *Architect: Goody Clancy*
- *Building analytics and envelope: Thornton Tomasetti*
- *MEP engineering: Van Zelm Engineers*

Study Methodology

- Identify project goals
- Establish evaluation criteria
- Create list of potential scope items
- Analyze scope items relative to established criteria
- Propose phasing/bundling of scope
- Conclusions

Study Objectives

- Establish method for designing a "smart" energy retrofit project
- Understand which interventions have the best financial and carbon ROI
- Draw conclusions about energy retrofit approaches that are broadly applicable
- Create a project that supports the campus' carbon neutrality goals within constraints of budget, schedule, and deferred maintenance

Scope Evaluation Criteria

- **Operational Energy Impact**
  Operational energy use reductions – cost and carbon metrics
- **Embodied Carbon Impact**
  Embodied carbon of new materials for envelope interventions
- **Thermal Comfort**
  Benefits to occupant thermal comfort
- **User Control**
  Level of control individual occupants have within their space
- **Applicability to Other Campus Buildings**
  Relevance of energy conservation measure to retrofit of other campus buildings
- **Accessibility**
  Inclusivity of access to spaces for all community members
- **Maintenance Implications**
  Impact on routine maintenance and material replacement cycle

Scope Item Categories

- 125 Scope Items
- 50 energy conservation measures (ECMs)

Envelope End-of-Life Replacements

- Window replacement
- Reroofing

Zone-Level HVAC Upgrades

- Retrofit existing system
- Radiant ceilings
- VRF
- Ventilation air

Envelope Upgrades

- Wall insulation
- Overcladding

Primary Energy Source

- Existing campus hot water
- Geothermal High-efficiency gas boilers

Energy Conservation Measure Categories

Envelope

- Window replacement
- Roof Insulation
- Wall Insulation

HVAC

- Retrofit/replace in kind existing system
- Radiant ceilings
- VRF
- Ventilation air

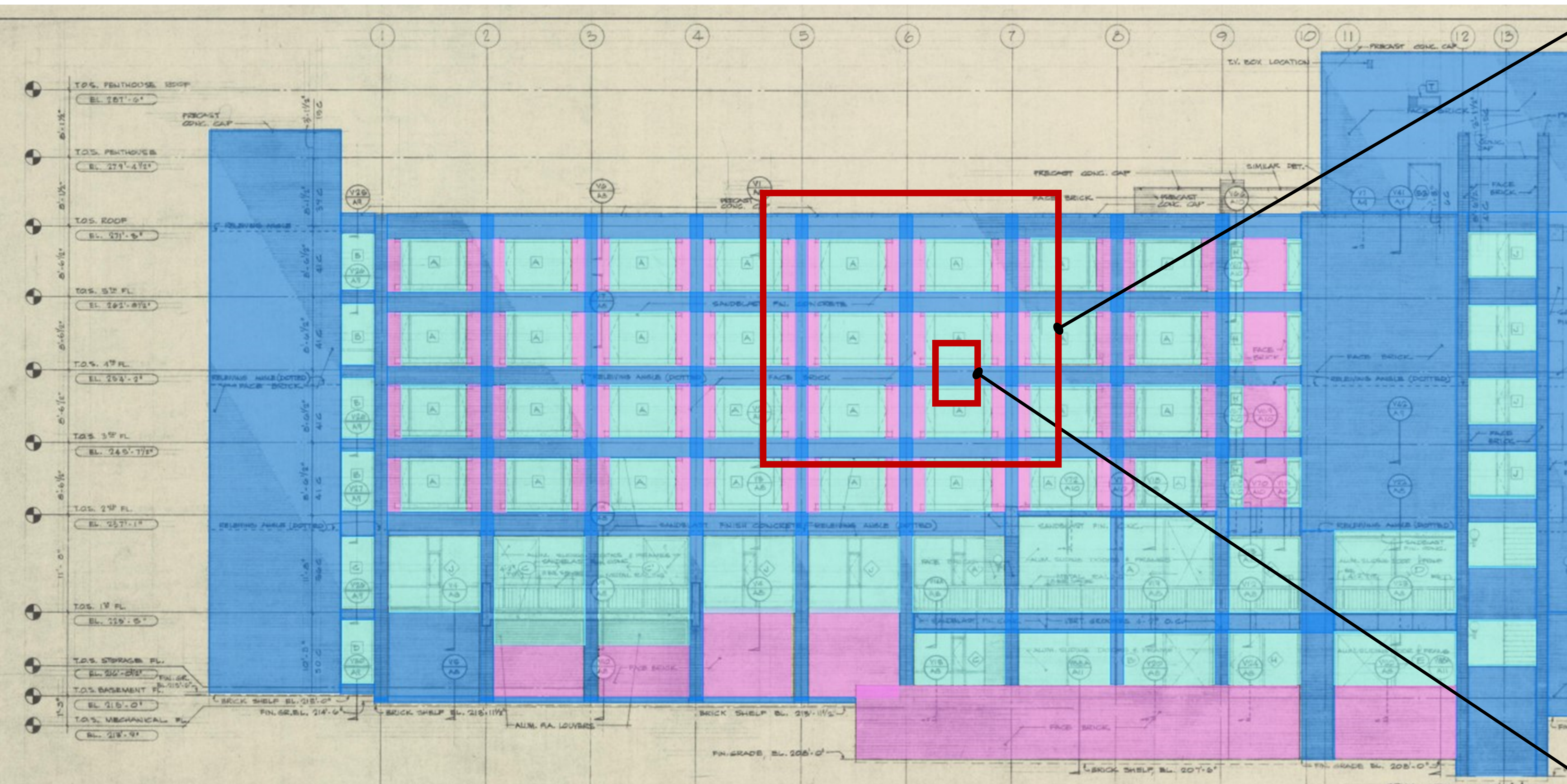
Primary Utility

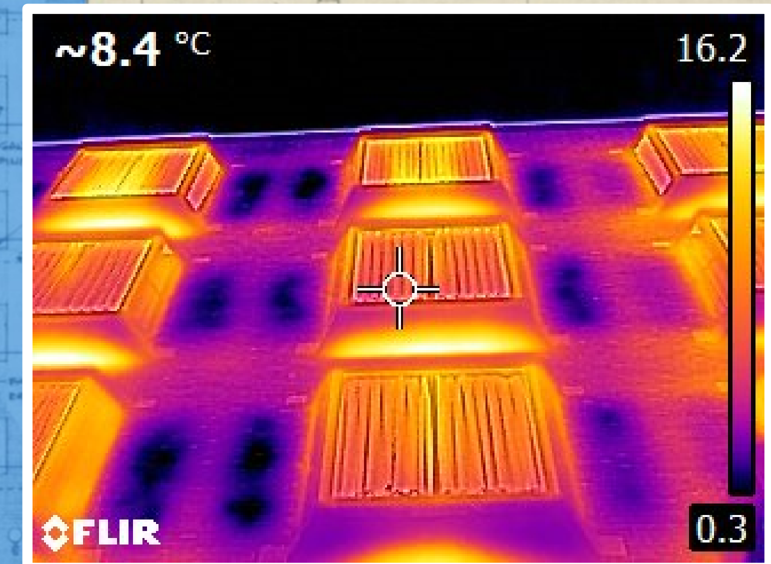
- Existing campus hot water
- Geothermal system
- High-efficiency gas boilers

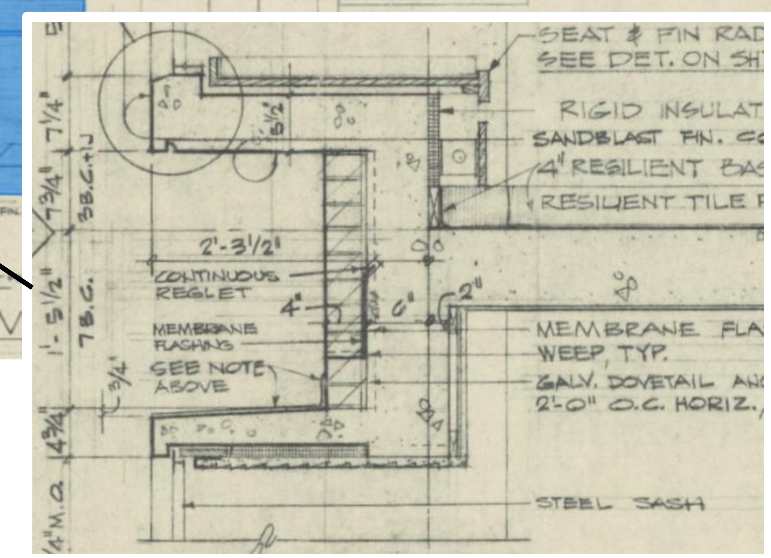
Scope Evaluation Process

Forensics	*Analysis*	*Bundling*	*Phasing*
Investigate existing conditions:	**Evaluate impact of individual scope items:**	**Determine impact of bundled scope items:**	**Establish scope priorities for current and future work:**
▪ Exterior probes ▪ Exterior & building systems survey ▪ Blower door testing ▪ Laser scan	▪ Thermal modeling ▪ Energy modeling ▪ Comfort modeling ▪ Life cycle assessment	▪ Operational energy ▪ Occupant comfort ▪ Embodied carbon	▪ Build project scope that enables future upgrades for additional savings

Validating Existing Conditions







Window/Louver | Uninsulated opaque wall | Insulated opaque wall

Analysis Round 1: Identify Opportunities for Greatest Impact

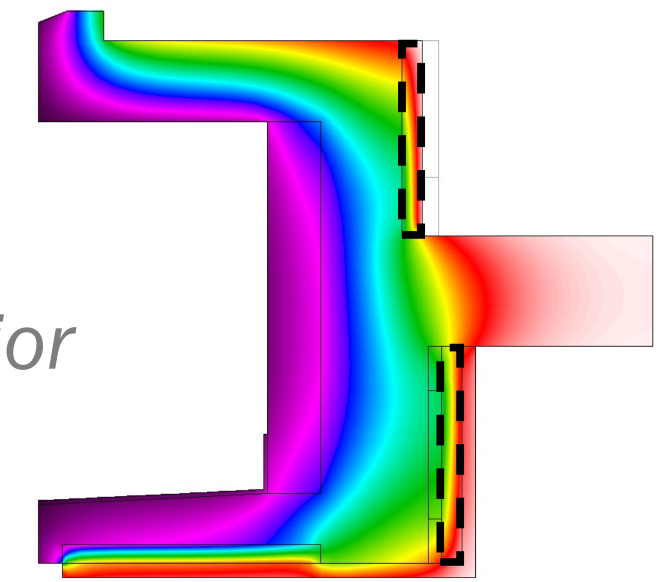
- **Thermal modeling *(Tool: THERM)***
  - *Model existing thermal bridges*
  - *Test various insulation configurations*
  - *Establish best case improvements in R-value*
- **Full building energy modeling *(Tool: Open Studio)***
  - *Calibrate existing conditions model*
  - *Analyze 50 energy conservation measures representing full range of options*
  - *Understand relative impacts of each intervention*
  - *Quickly establish highest possible energy and carbon reductions*

THERM Analysis of Bay Window Retrofit Options

ECM A

Add 1½" vertical insulation at interior

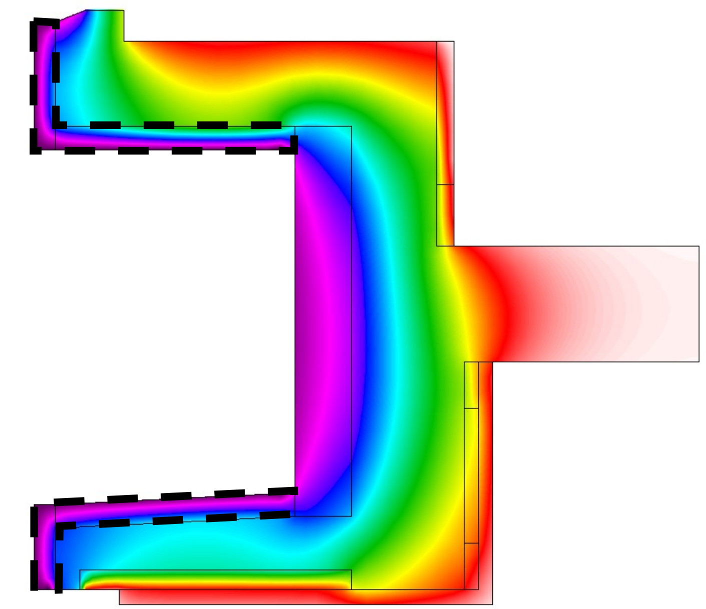
R-value: 2.1



ECM C

Overclad 1½" at exterior concrete

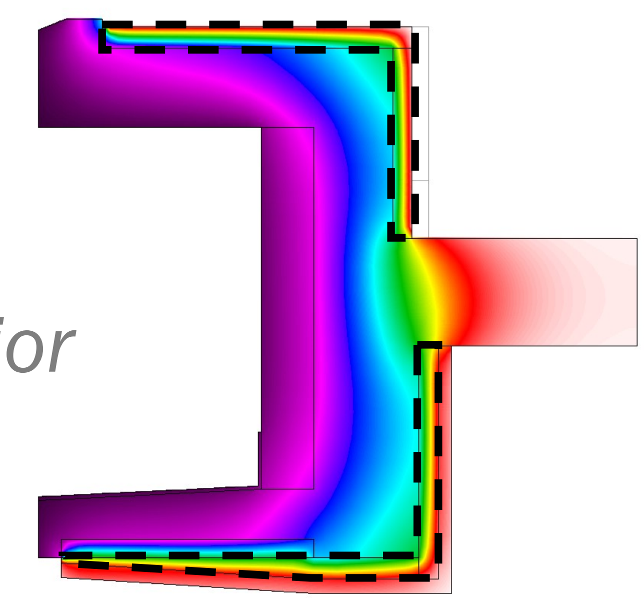
R-value: 2.5



ECM B

Wrap 1½" insulation at interior

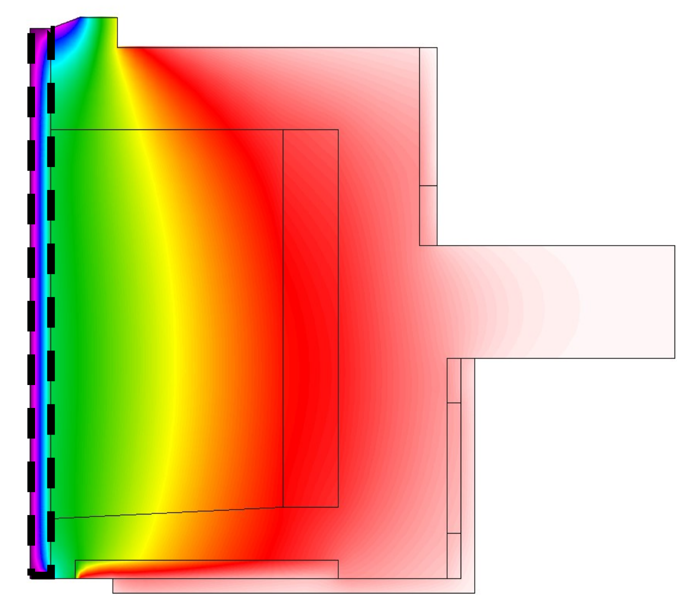
R-value: 3.6



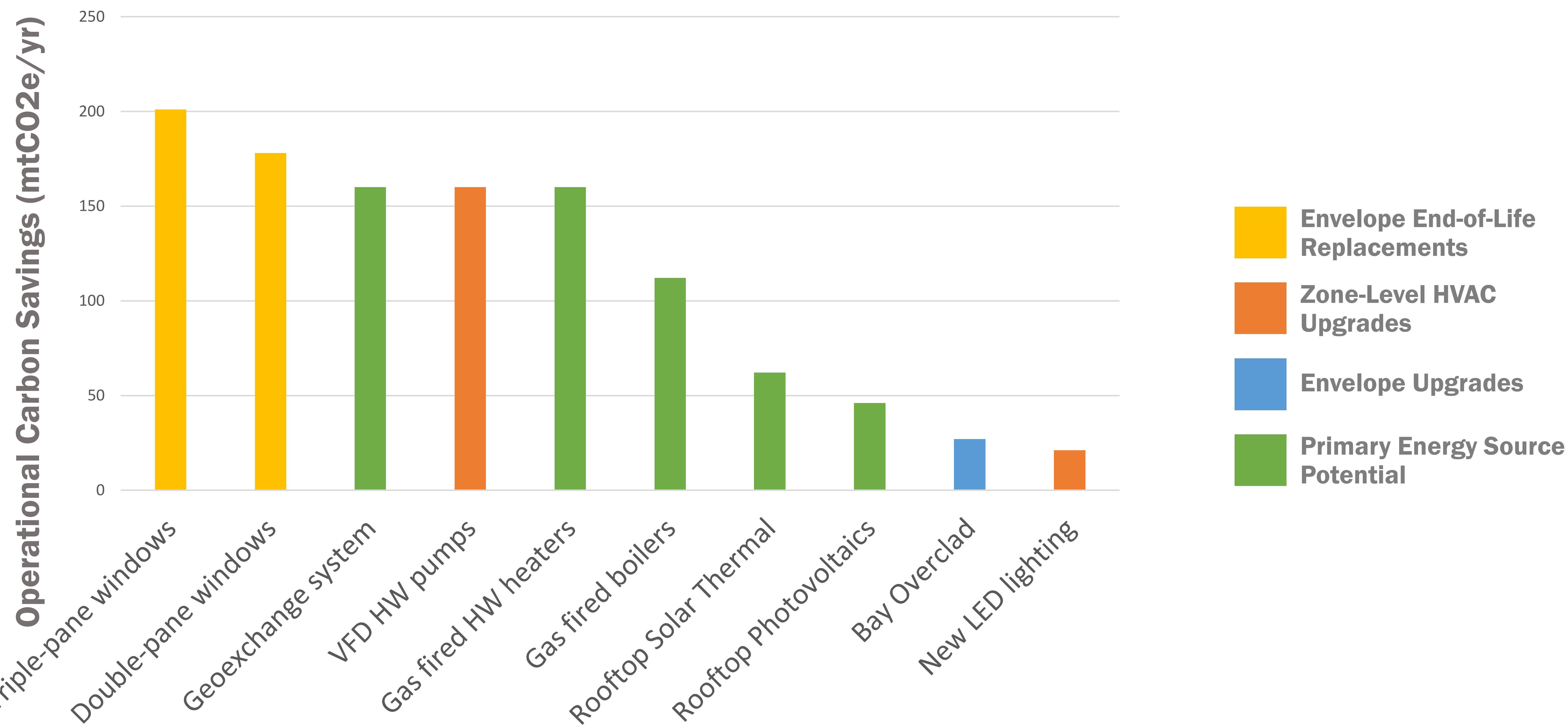
ECM D

Overclad 1½" at concrete and spandrel

R-value: 7.5



Top Ten Operational Carbon Savings Measures



Analysis Round 2: Understand Interrelationships of ECMs and Environmental Impacts

- **Parametric energy modeling *(Tool: Open Studio)***
  - *Analyze 240 combinations of ECMs*
  - *Assess interrelationships*
  - *Optimize for energy use, carbon emissions, and cost reduction*
- **Life cycle assessment *(Tool: Tally)***
  - *Quantify embodied carbon emissions of envelope options*
  - *Understand carbon storing potential of biogenic materials*
- **Summer comfort**
  - *Evaluated with current data (TMY3) and predicted 2080 meteorological data*
  - *Annual hours above 78F for each condition to determine cooling need*

Carbon Savings of Combined Measures

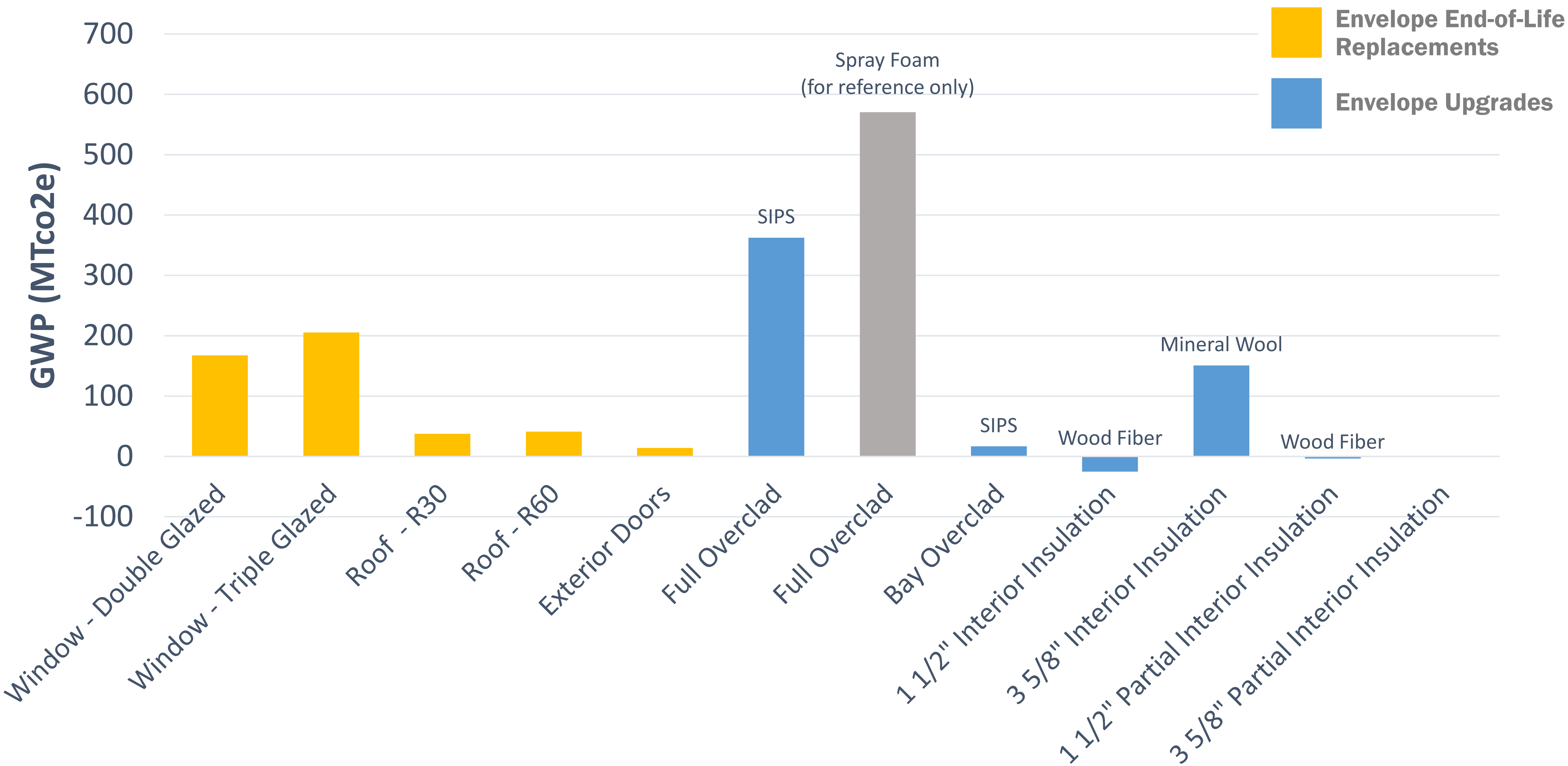
	Hot water heat exchangers	Gas fired boilers	Geo-exchange system
New VFD HW Pumps	171		
Runtal radiators	185	227	331
Radiant heating panels	179	224	331
Radiant heating and cooling panels	87	137	331

Primary Energy Source Potential

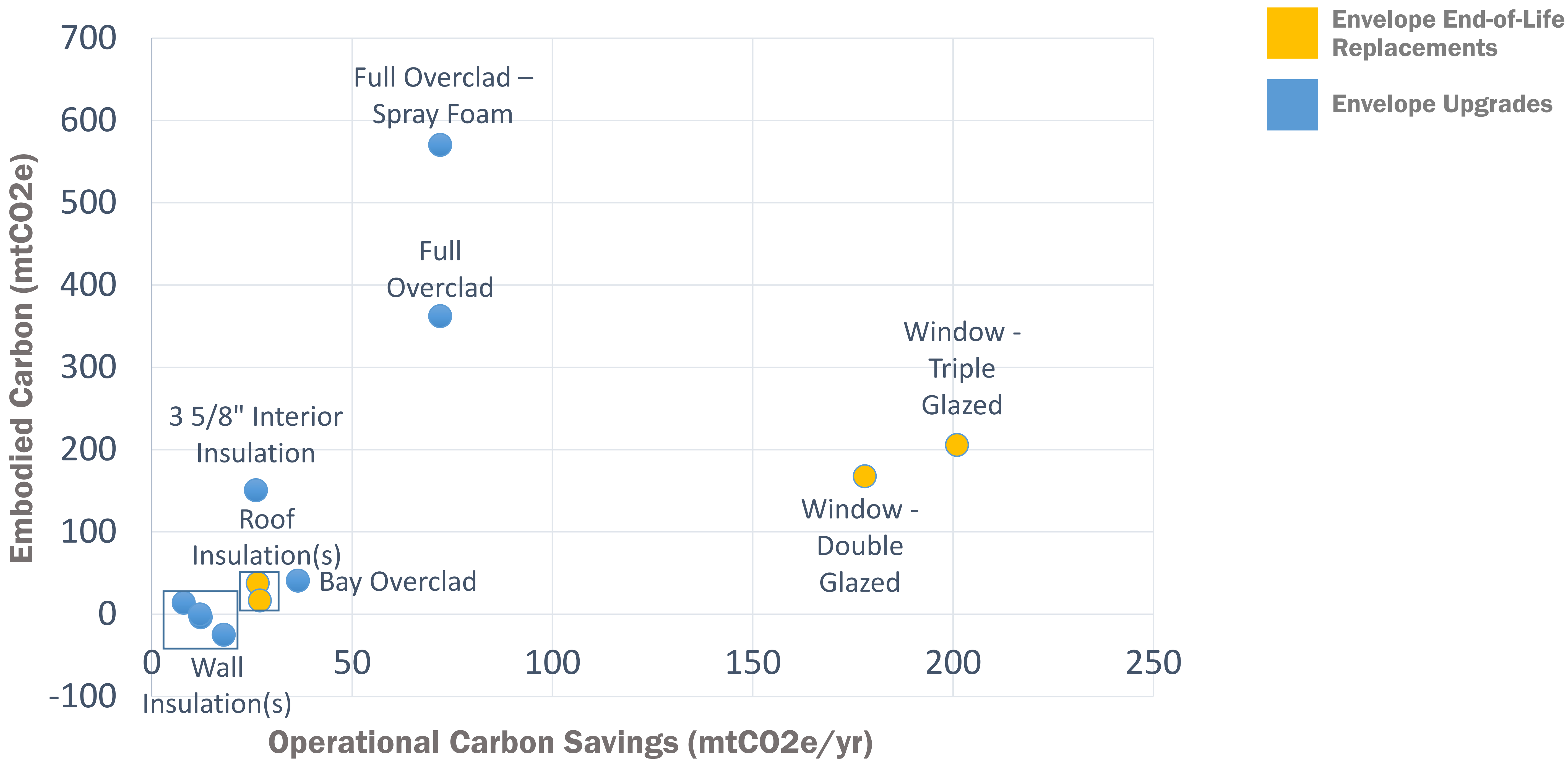
Zone-Level HVAC Upgrades

Combined Operational Carbon Savings (mtCO2e/yr)	

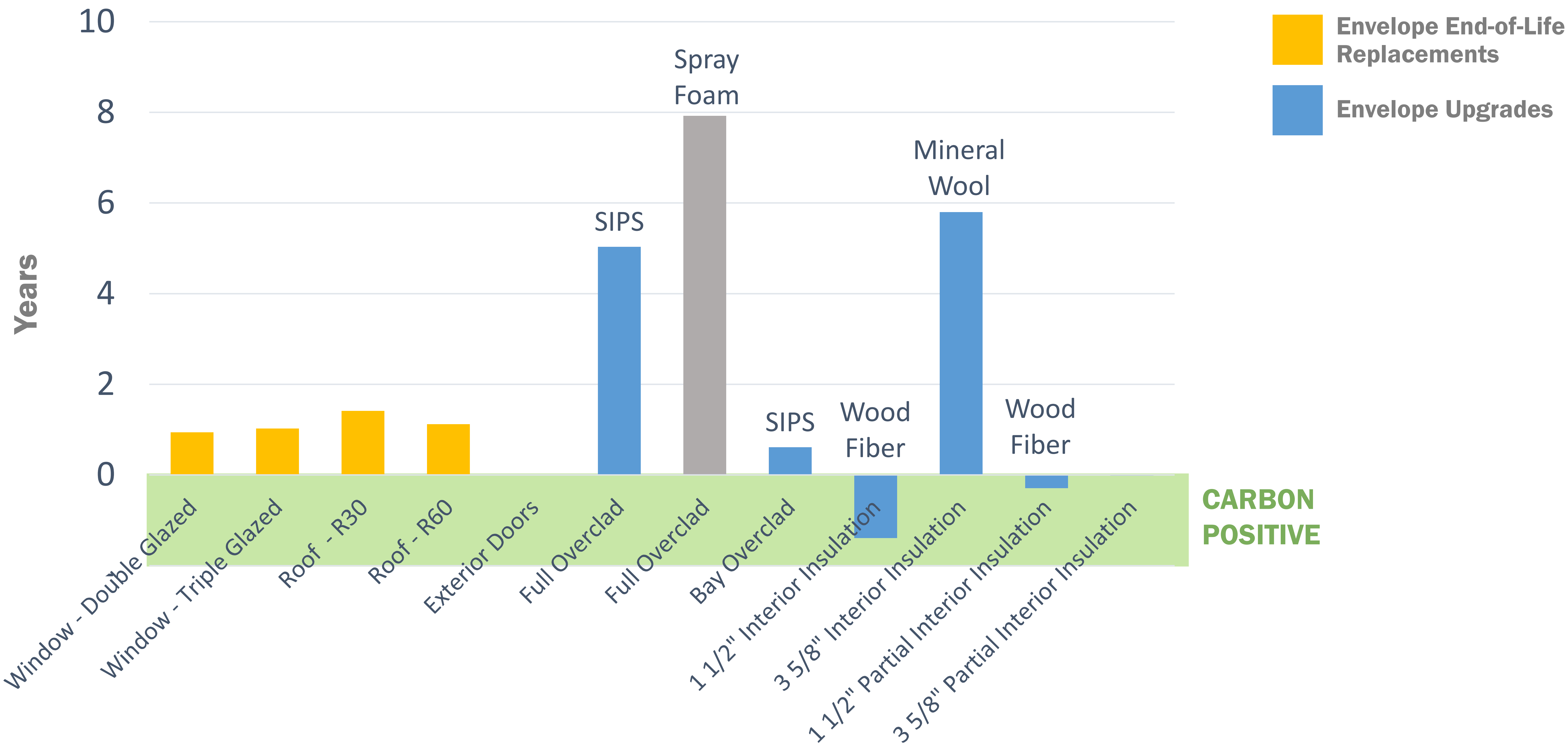
Embodied Carbon of Selected Scope Items



Balancing Operational and Embodied Carbon



Carbon Payback Period



CONCLUSIONS

Lessons Learned about the “Smart” Energy Retrofit

- **Maintaining the building envelope plays a significant role in reducing energy consumption**
- **Superinsulating existing buildings does not always yield dramatic energy savings**
- **Carbon reduction potential is limited at the building scale. Building retrofits must be designed for compatibility with greening energy sources to maximize carbon savings.**

How to Make All Retrofits Smarter

- Establish maximum carbon return on investment as a project criterion
- Measure total life cycle carbon
- Optimize carbon payback for envelope end-of-life replacement/refurbishment measures
- Evaluate retrofit interventions at envelope weak points for effective reductions in energy use
- Look for opportunities to store carbon through new materials

THANK YOU!

Lori Ferriss: lori.ferriss@goodyclancy.com
Elaine Hoffman: elaine.hoffman@goodyclancy.com