Integrated Design on the Path to Commercial ZNE

Zero Net Energy Redwood Retreat
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Outline and Key Concepts

- My background: Research → Practice → Policy
  - MS Building Science, UCB
  - 10+ years commercial building mechanical design & whole building energy analysis, Taylor Engineering
  - Recently switched focus to policy and the market adoption challenge: Emerging Solutions and Codes and Standards, TRC
- Key Concepts
  - Advanced practices can inform policy
  - Achieving deep efficiency cost effectively requires a different process and integrated design is important
    - life cycle cost analysis
    - cost optimization
  - Challenging to accelerate market adoption of advanced practices
- Presentation Outline
  - Examples projects from my design experience
  - Results from a PG&E funded study of 29 advanced buildings

Orinda City Hall

12,000 ft^2
LEED Gold

Mixed-mode

- Natural ventilation
- HVAC
- Controls integration with occupant communication (“open windows” light)

Compressorless cooling

- Direct-Indirect evaporative cooling
- Required peak load reduction
- Required occupant based comfort solution

Peak Load Reduction

- Aggressive solar shading
- Reduced computer loads

Occupant comfort

- Ceiling fans provide 4°F cooling
- Personal control (fans & windows)

Chartwell School

- Private School for children with language learning challenges
- Superior learning environment
- LEED Platinum
- Zero net electricity

Chartwell School
Life Cycle Cost Analysis

Run	Description	Life Cycle Cost [present dollars]	Life Cycle Rank	Life Cycle Cost Difference [compared to base case]
0A	Base Case	$301,094	8	
0B	Base Case - Electricity Neutral	$375,640	10	$74,546
0C	Base Case - Energy Neutral	$469,140	14	$168,046
1A	Worse Opaque Envelope	$305,387	9	$4,293
2A	Better Opaque Envelope	$300,362	5	($732)
3A	Worse Glazing	$300,767	6	($328)
4A	Better Glazing	$301,046	7	($48)
5A	Daylighting	$236,260	1	($64,834)
5B	Daylighting - Electricity Neutral	$278,372	2	($22,723)
5C	Daylighting - Energy Neutral	$393,872	12	$92,777
6B	Daylighting + Classroom ERV - Electricity Neutral	$298,895	4	($2,199)
6C	Daylighting + Classroom ERV - Energy Neutral	$408,895	13	$107,801
7B	Daylighting + Multipurpose ERV - Electricity Neutral	$293,174	3	($7,921)
7C	Daylighting + Multipurpose ERV - Energy Neutral	$386,674	11	$85,579

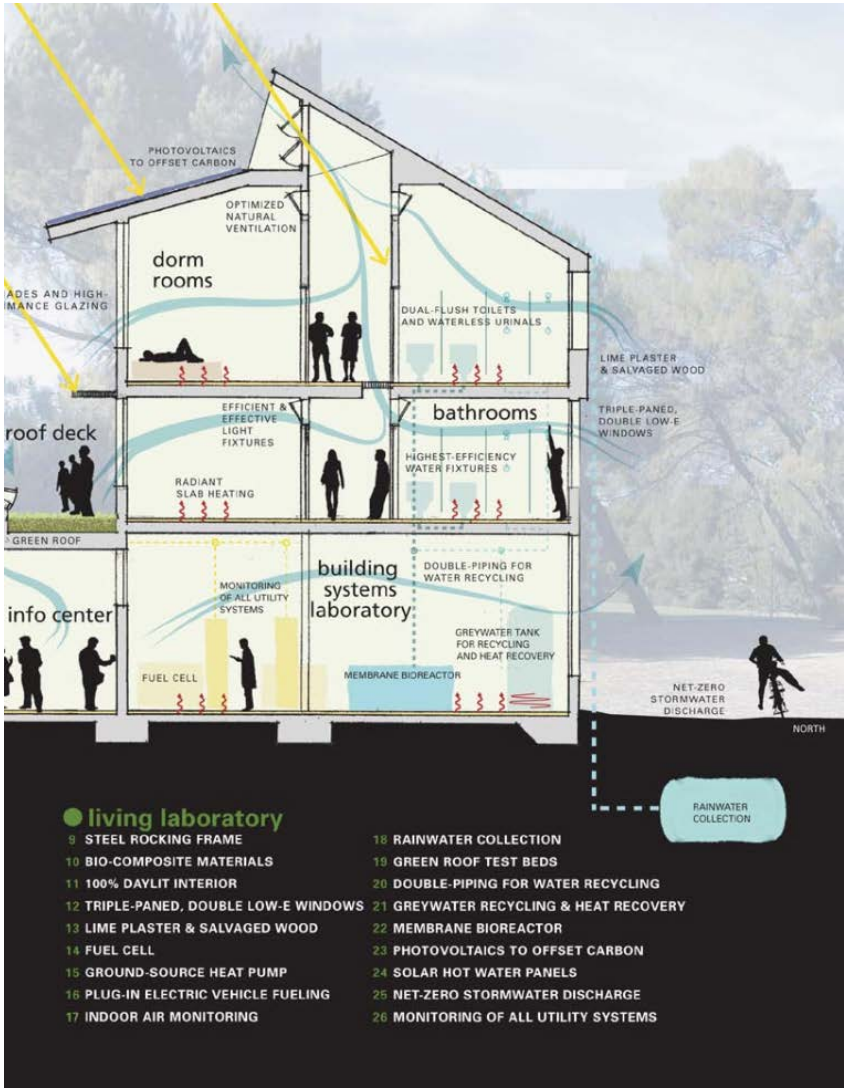
General Analysis Parameters

Study Life	25 years
General Inflation Rate	2.0%
Owner Discount Rate (Nominal)	6.0%
Real Discount Rate	3.9%

Annual Escalation Rates

	Nominal	Real
Maintenance	2.5%	0.49%
Materials	2.5%	0.49%
Fuel	3.5%	1.47%
Electricity	3.5%	1.47%

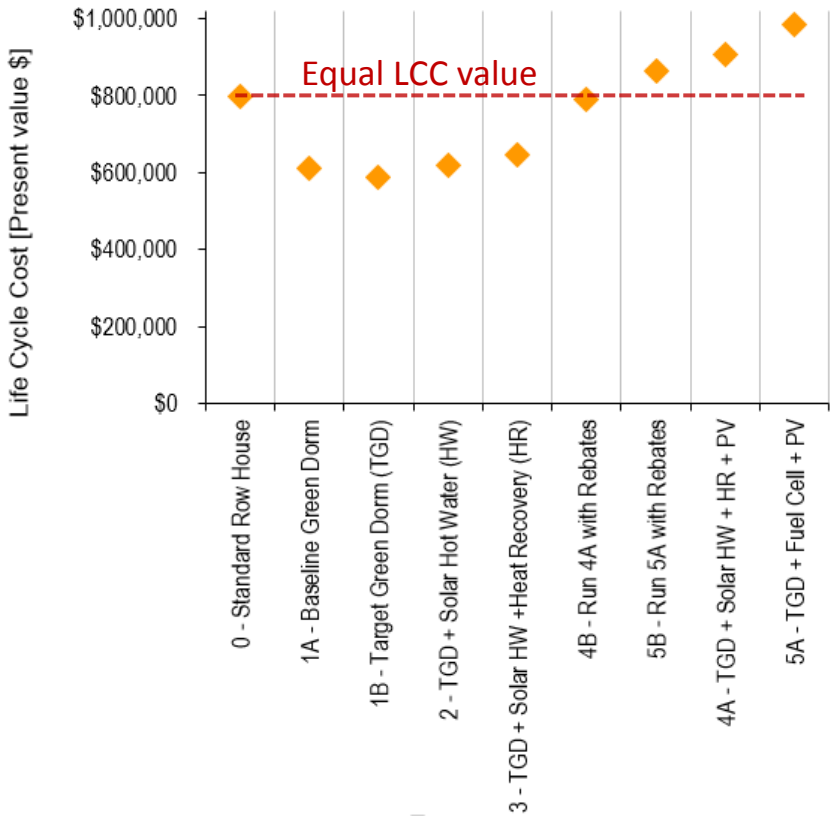
Stanford Green Dorm Feasibility Study



- Zero Carbon
- Closed Water Cycle
- Optimizing Material Resources

Stanford Green Dorm Life Cycle Cost Analysis

Life Cycle Cost (present value) for each option

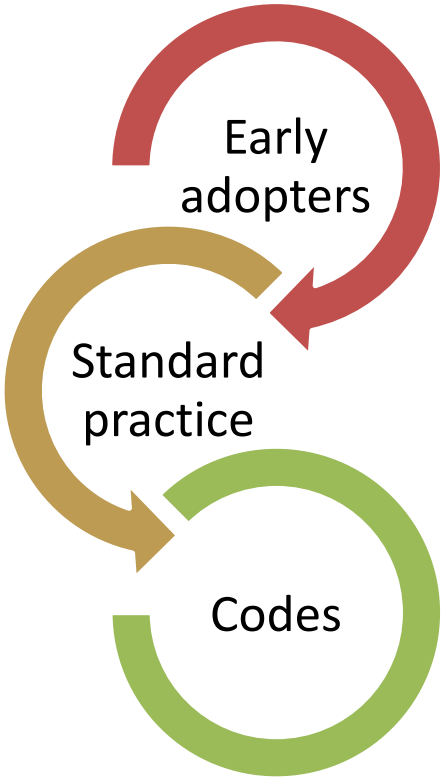


1. Identify cost effective efficiency
2. Use "equal value" concept to tunnel through cost barrier

Advanced Building Characteristics Study

More result in ACEEE Summer Study 2016 Proceedings
Funded by PG&E Codes and Standards

- Purpose
  - Use market to guide policy & research
  - Identify advanced features/strategies in ZNE & near ZNE commercial buildings
  - Identify barriers and opportunities
- Outcomes
  - Catalog measures and integrated design packages (IDP)
  - Recommend opportunities for emerging technology research, incentive programs, and code readiness

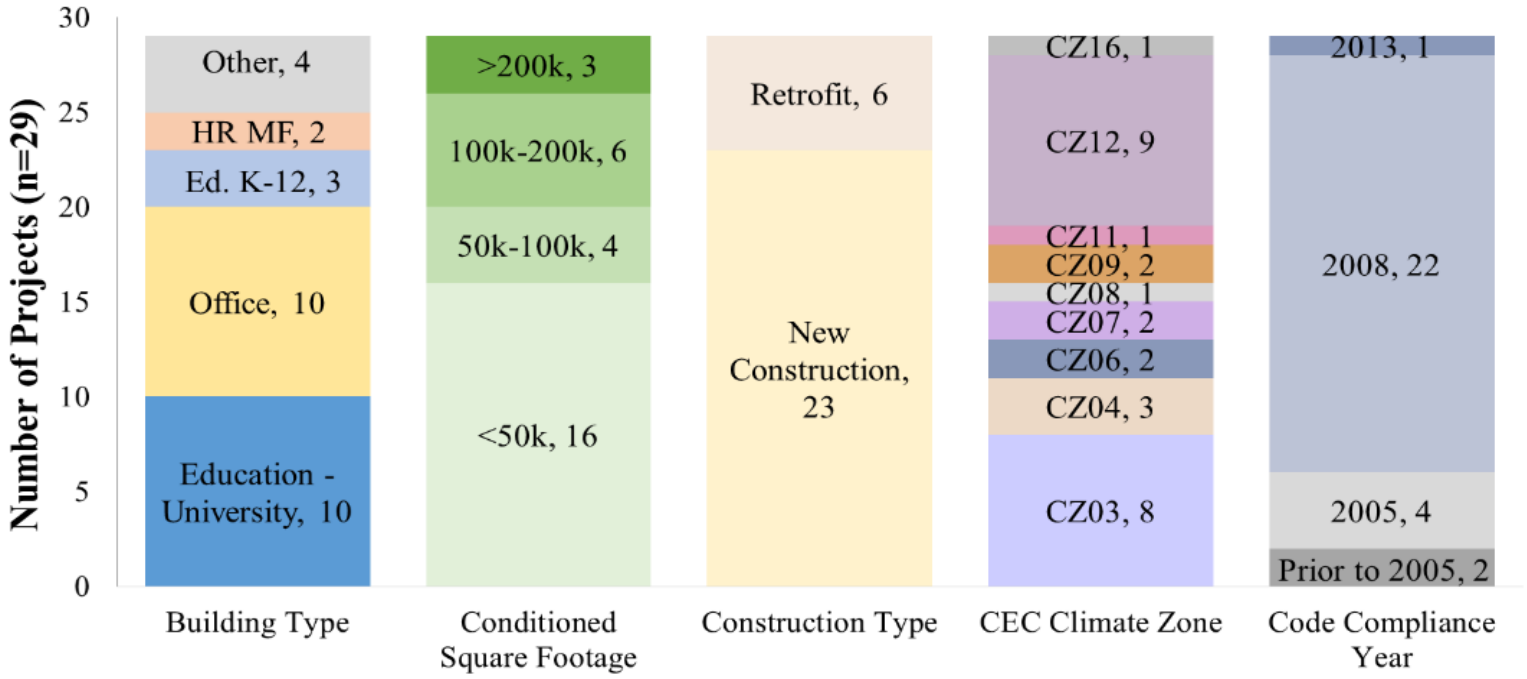


Advanced Building Surveyed

29 California buildings with ZNE or near-ZNE goal - average modeled EUI < 40 kBtu/ft^2

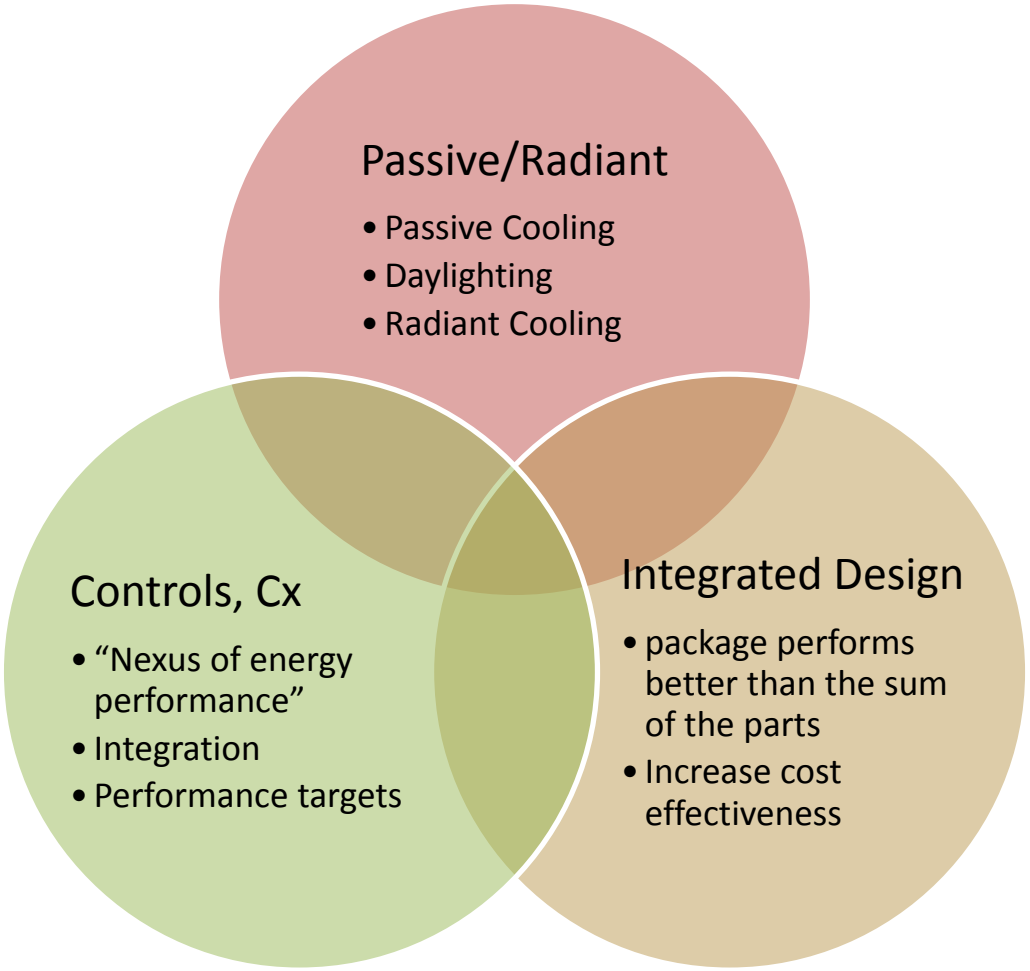
39 interviews: engineer, architect, contractor, owner

Review models and design drawings



Study limitation: Focused on leaders pushing the envelope. Small sample size.

Key Themes



Load Reduction

- Enables passive/radiant
- Solar & plug load reduction

Occupant Centric Solutions

- *"provide service for the occupant rather than the building"*
- Addresses variability of passive systems & enables mixed-mode
- Ceiling/desk fans, task-ambient lighting, operable windows, etc.

Integrated Design Packages (IDPs)

Passive (natural) and Mixed-Mode Cooling IDPs (n=18)

Common Essential Elements

- solar control
- reduce plug load
- mass
- ceiling fans

Alternatives/Variations

- night pre-cooling
- automated window or louver
- narrow floor plate

Radiant Cooling IDPs (n=11)

Common Essential Elements

- Solar control
- Reduce plug loads
- Evap cooled water (compressorless)

Alternatives/Variations

- Mixed-mode: Passive cooling+Radiant
- Ceiling fans
- Thermal energy storage
- Night pre-cooling
- Heat pump (bay water, geothermal)

Daylighting and Lighting Controls IDPs (n=27)

Common Essential Elements

- Solar control
- Light shelves or clerestories
- High efficacy lighting
- Controls

Alternatives/Variations

- Occupant response controls
- Skylights
- Narrow floor plate

Barriers and Opportunities

- Knowledge gaps:
  - Engineering fundamentals
  - Design tools to decrease transaction cost and risk
  - Controls integration and ongoing commissioning
  - Contractor and/or operator experience
- Integrated Design (ID) challenges:
  - ID is a process, not a solution, with more complexity
  - Lack of knowledge and tools to support ID
  - Simulation critical, but bugs and multiple tools are time consuming ($$$$)
- Difficult to predict PV size for ZNE

Recommendations

- Candidates for research and Incentive Programs to support market adoption
  - Integration and scalability is critical to move these measures into standard practice
- Support and enable integrated design (ID)
  - ID process and packages of measures important for achieving deep efficiency cost effectively
  - Identify ID packages and best practices
  - Develop ID analysis tools – e.g. pre-defined parametric analysis including cost effectiveness
- Improve energy predictions to size PV for ZNE
  - Benchmarking
  - Plug load and behavior libraries closer to reality

Natural ventilation design
Mixed-mode systems
Comfort performance simulation
Radiant cooling design
Daylighting design and control
Task-ambient strategies
Occupant responsive controls
Controls integration/optimization
Ongoing Commissioning & EIS

Thank you

Questions?

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