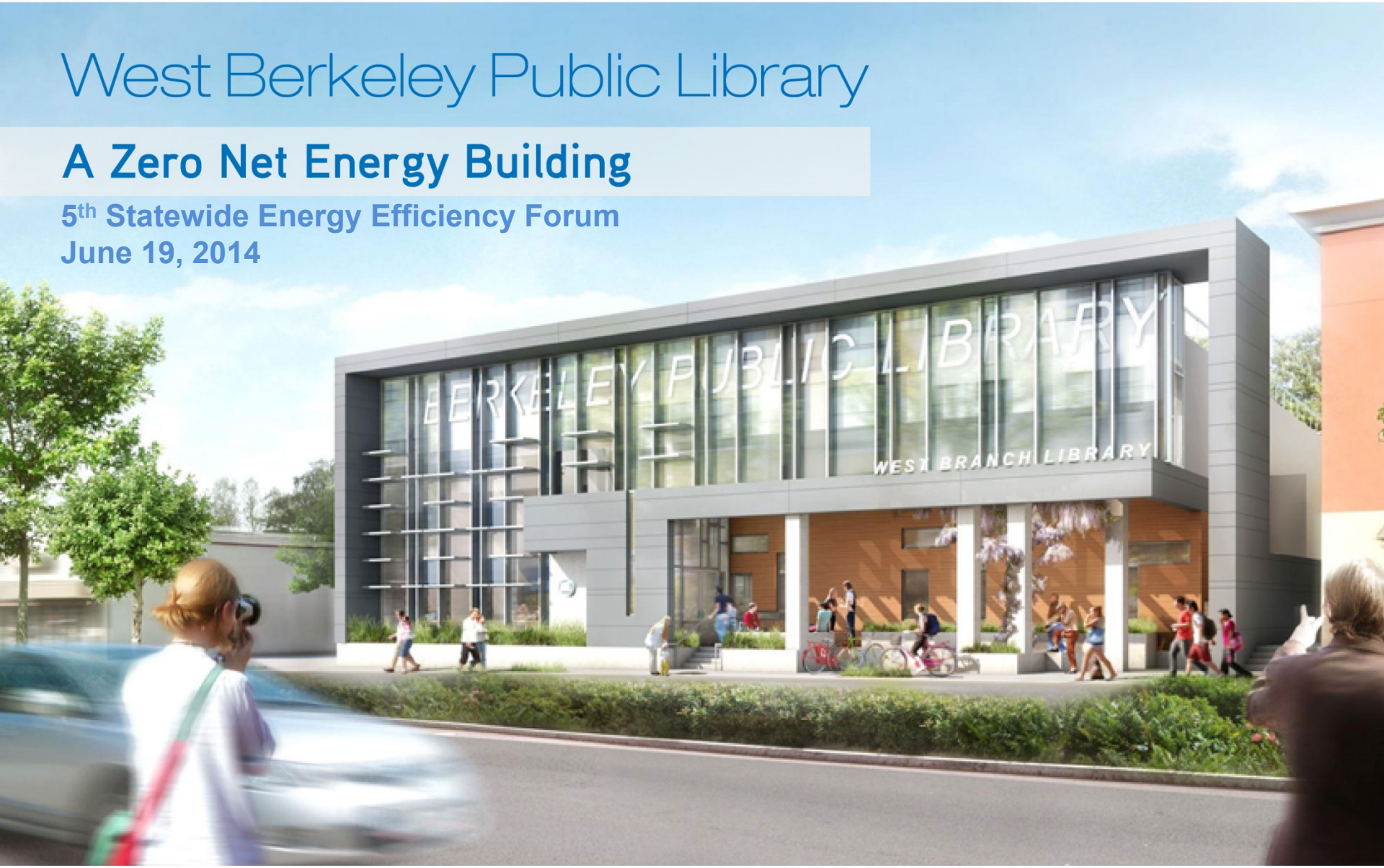
West Berkeley Public Library

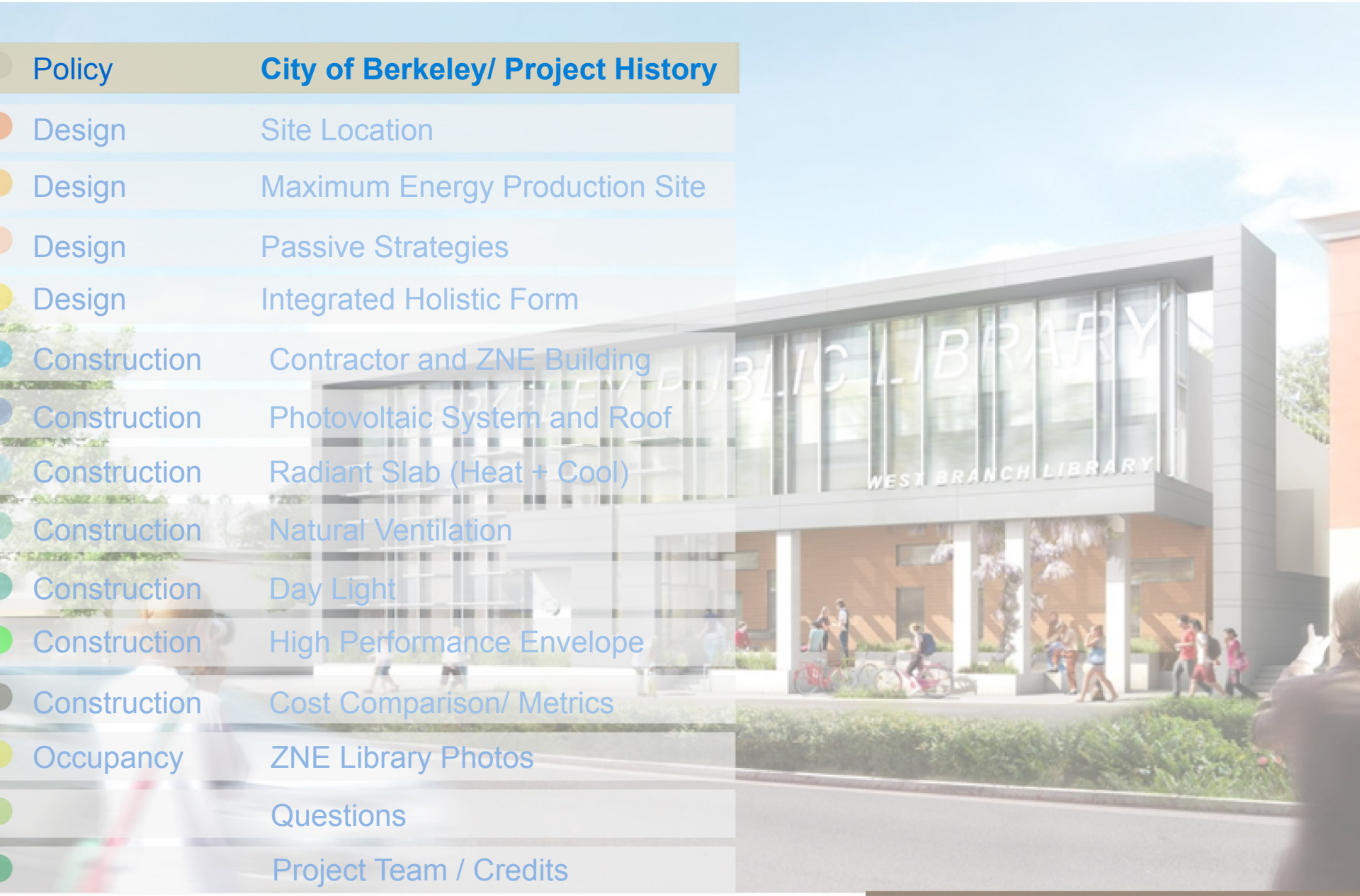
A Zero Net Energy Building

5th Statewide Energy Efficiency Forum
June 19, 2014



HARLEY ELLIS DEVEREAUX
GREENWORKSSTUDIO

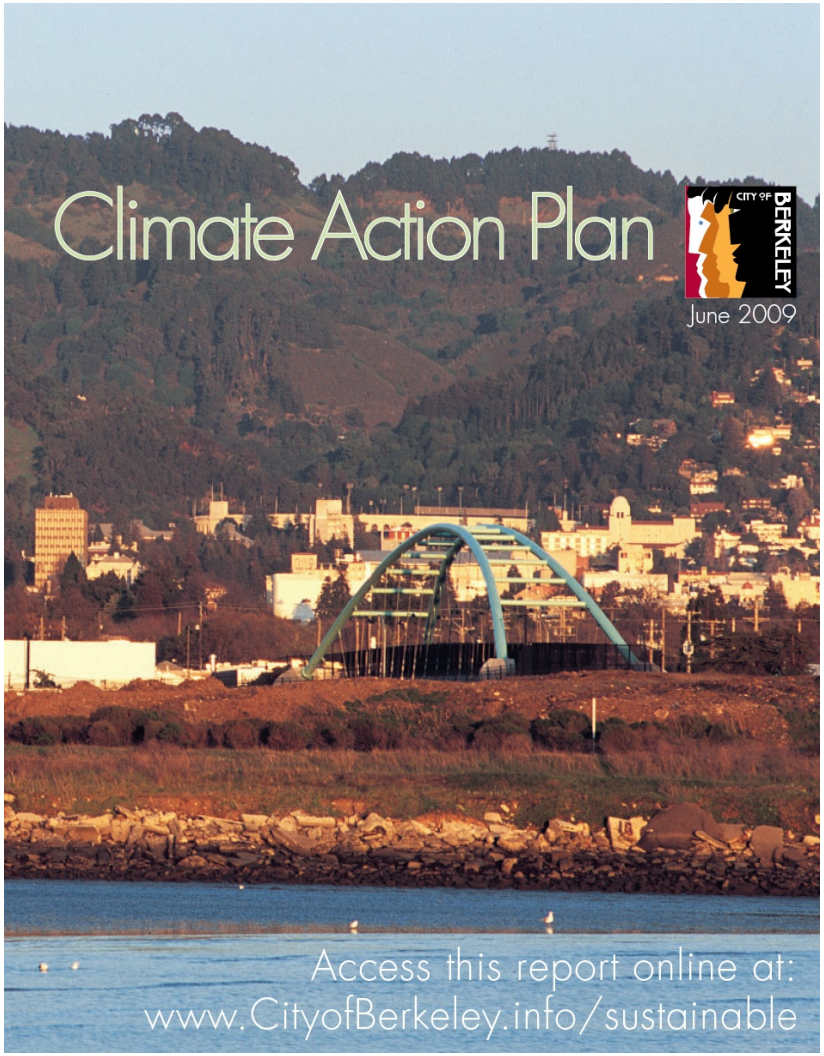
Policy	City of Berkeley/ Project History
Design	Site Location
Design	Maximum Energy Production Site
Design	Passive Strategies
Design	Integrated Holistic Form
Construction	Contractor and ZNE Building
Construction	Photovoltaic System and Roof
Construction	Radiant Slab (Heat + Cool)
Construction	Natural Ventilation
Construction	Day Light
Construction	High Performance Envelope
Construction	Cost Comparison/ Metrics
Occupancy	ZNE Library Photos
	Questions
	Project Team / Credits



West Berkeley Library

Berkeley Public Library

- Main Library and four branches
- 1.1 million annual visits
- 1.76 million checkouts annually (19.25 per capita)
- 140,000 square feet of conditioned floor space
- ~$14 million expenditure budget
- ~$220,000 annual energy expenses



City Of Berkeley

Policy Drivers

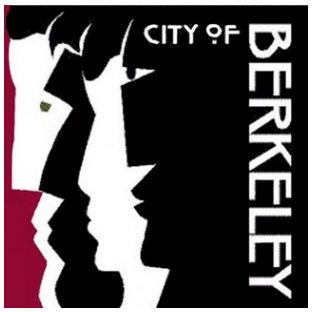
- **2009 Climate Action Plan Adopted**
  - **33% CO2 reduction below 2000 level by 2020**
  - **LEED Silver for all construction and renovation**

Measure FF –
Berkeley Public Library Bond

- $26M bond authorized by voters in 2008 for branch library improvements
  - Seismic
  - ADA improvements
  - Physical space and operations improvements

Procurement

- RFP for West Berkeley design team in 2009:
- Proposal from Harley Ellis Devereaux/Green Works Studio
  - Referenced City policies
  - Referenced National 2030 Challenge and CA NZE Policy
  - Proposed ZNE building
  - Proposed leveraging incremental design cost



HARLEY ELLIS DEVEREAUX

Pacific Gas and Electric Company®

Savings By Design

GREENWORKS STUDIO

ZNE Team Effort

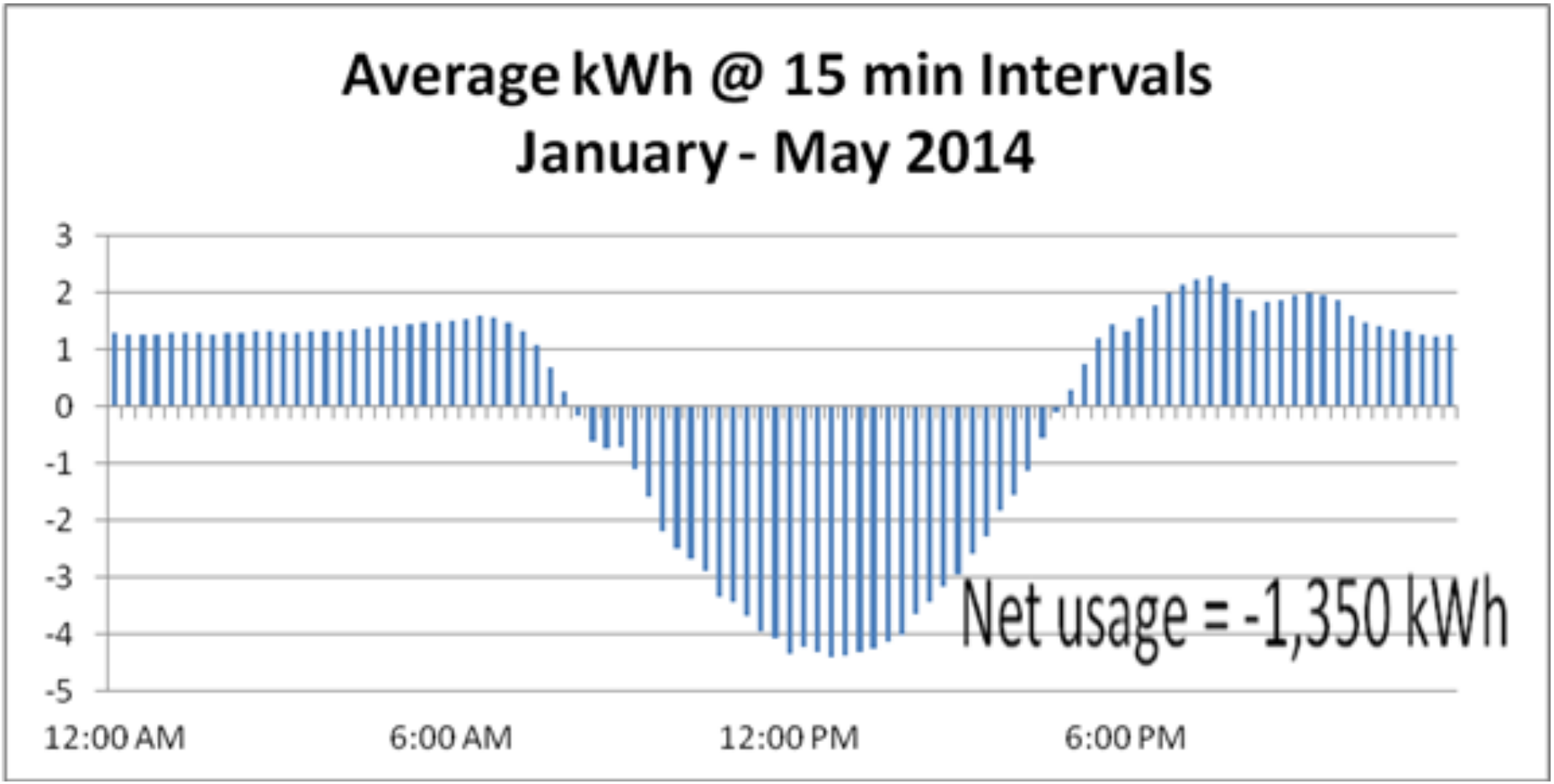
- **Savings By Design program**
  - Provided design assist grant
  - It is not meant to cover the entire cost of ZNE analysis
  - Design effort far exceeded the grant

- **ZNE Pilot Program**
  - Case study for PG&E ZNE pilot program
  - PG&E tracked design effort and assisted with final EnergyPro modeling for LEED and Title 24

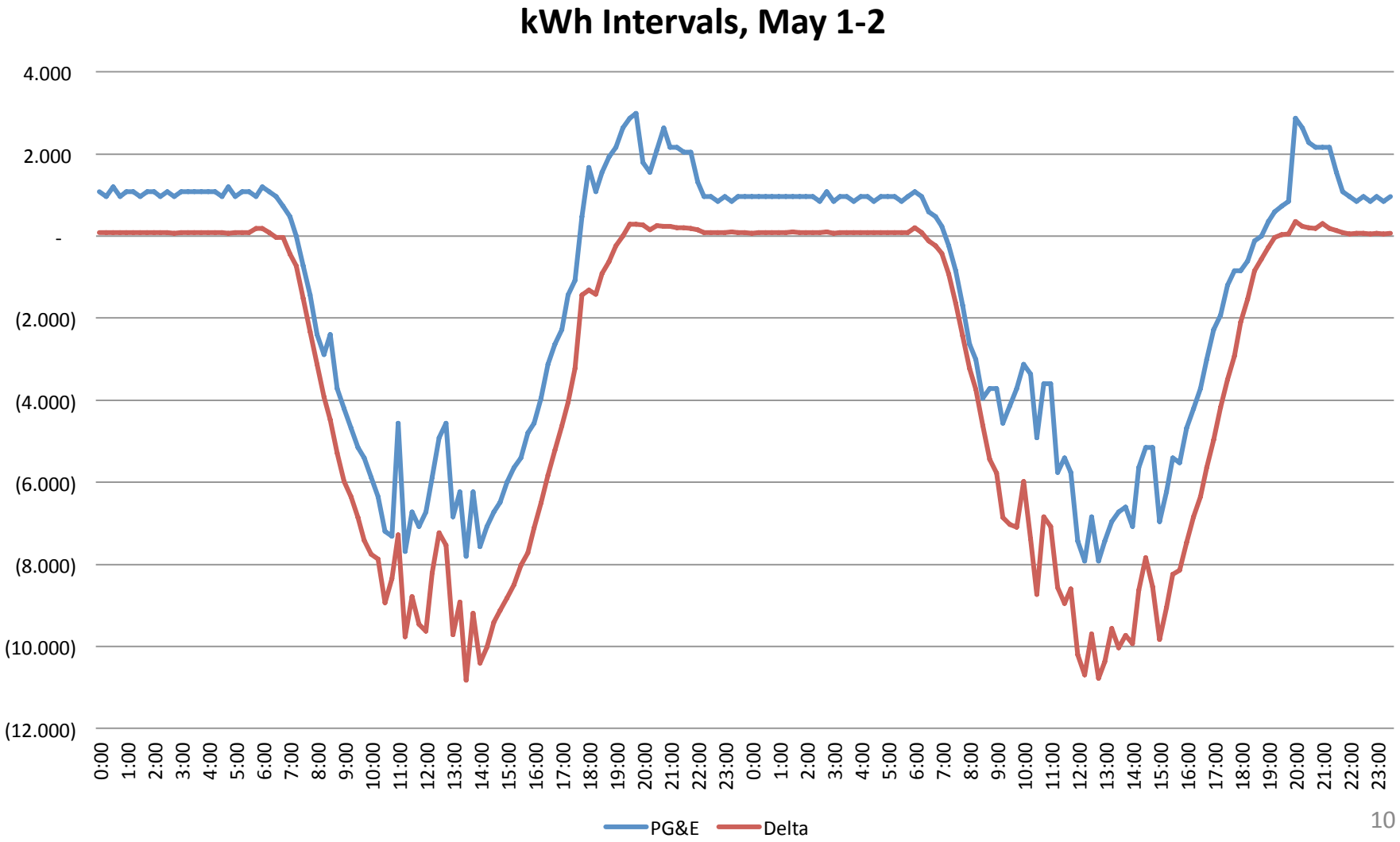
Budget Impacts

- $7.5 M total budget
- $60,000 incremental ZNE design cost
  - Offset by PG&E Savings by Design
- ~$250,000 incremental ZNE capital cost
- Initial cost estimates over budget
- Options
  - Considered CEC loan
  - Considered dropping solar

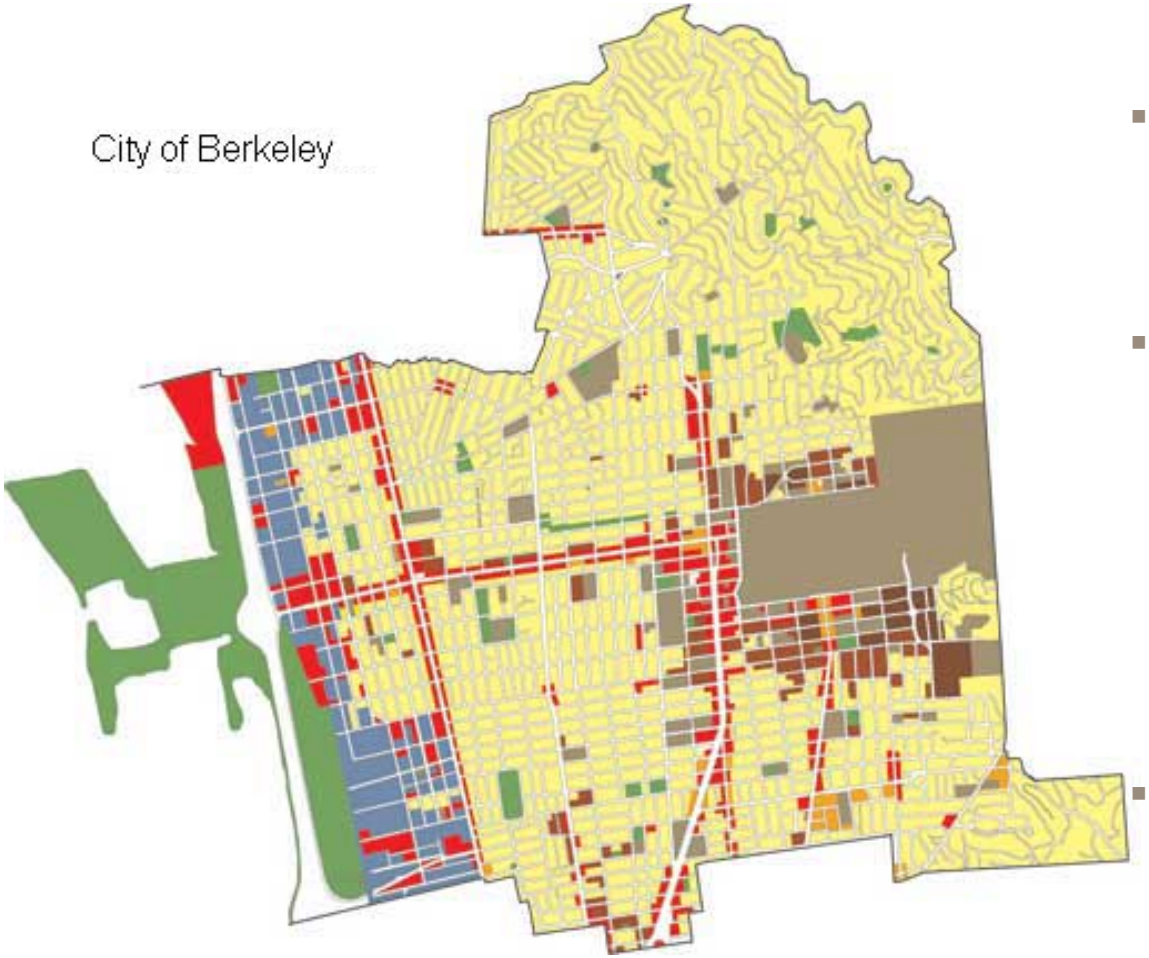
Building Metrics



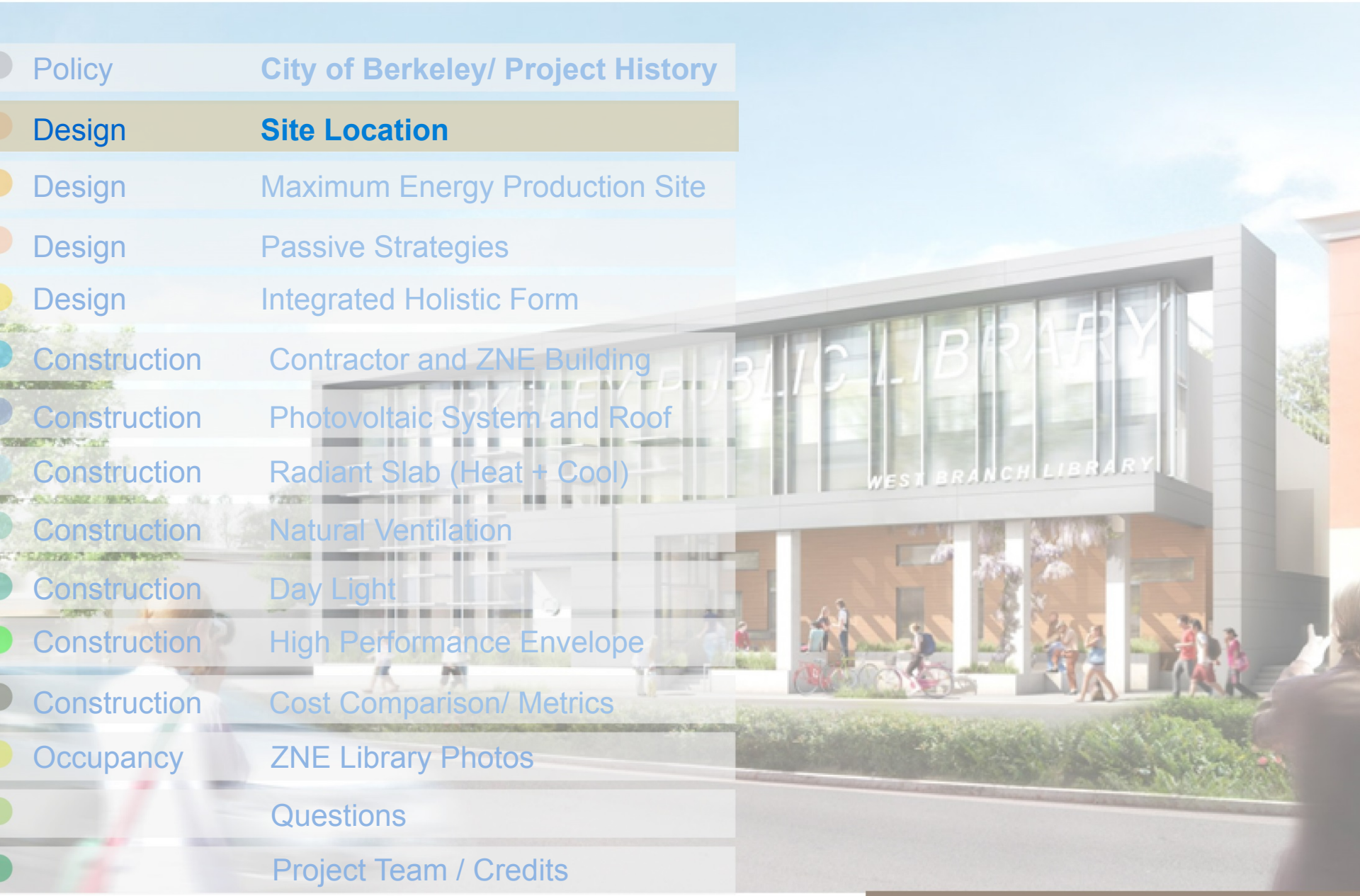
Building Metrics

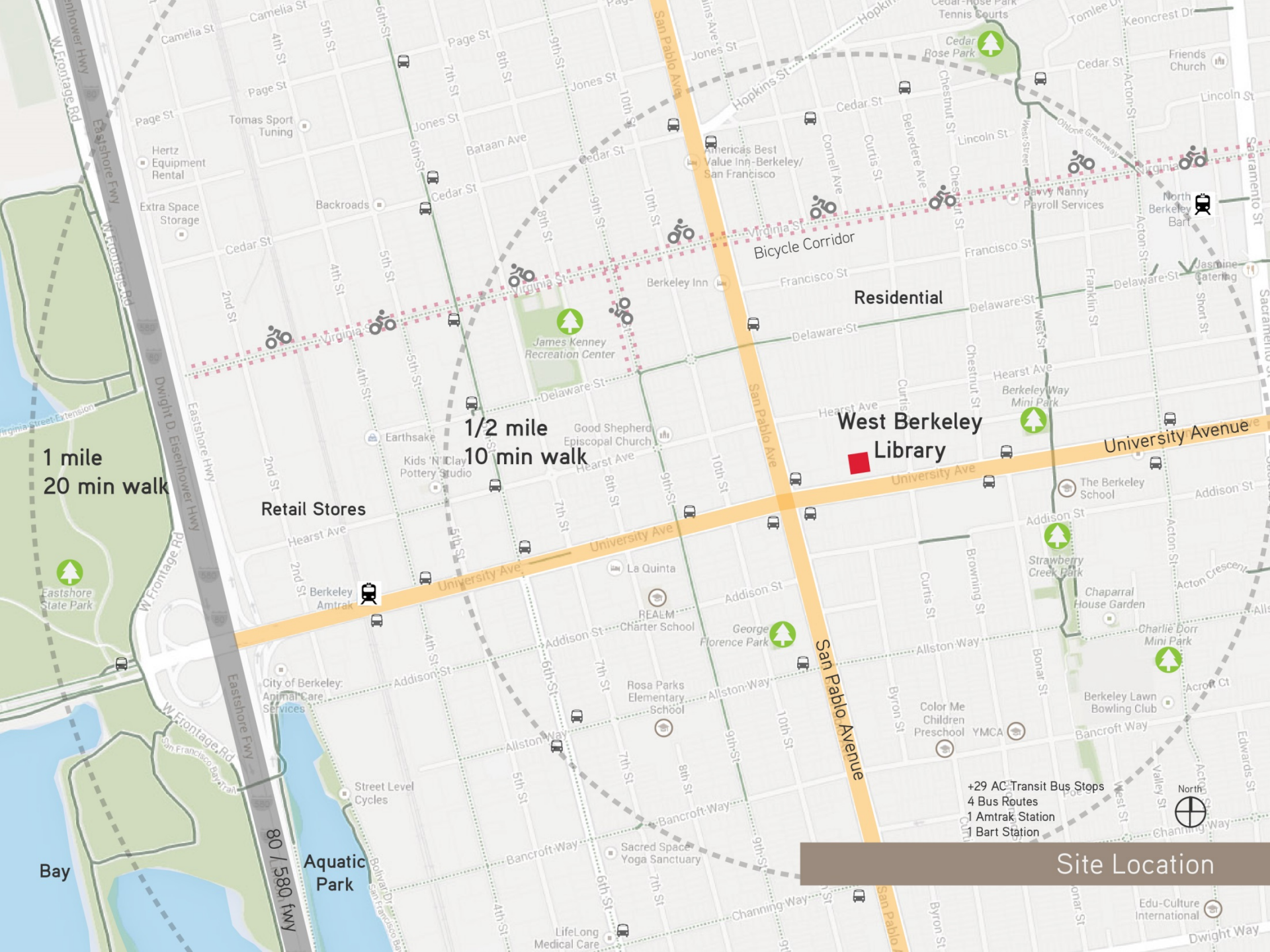


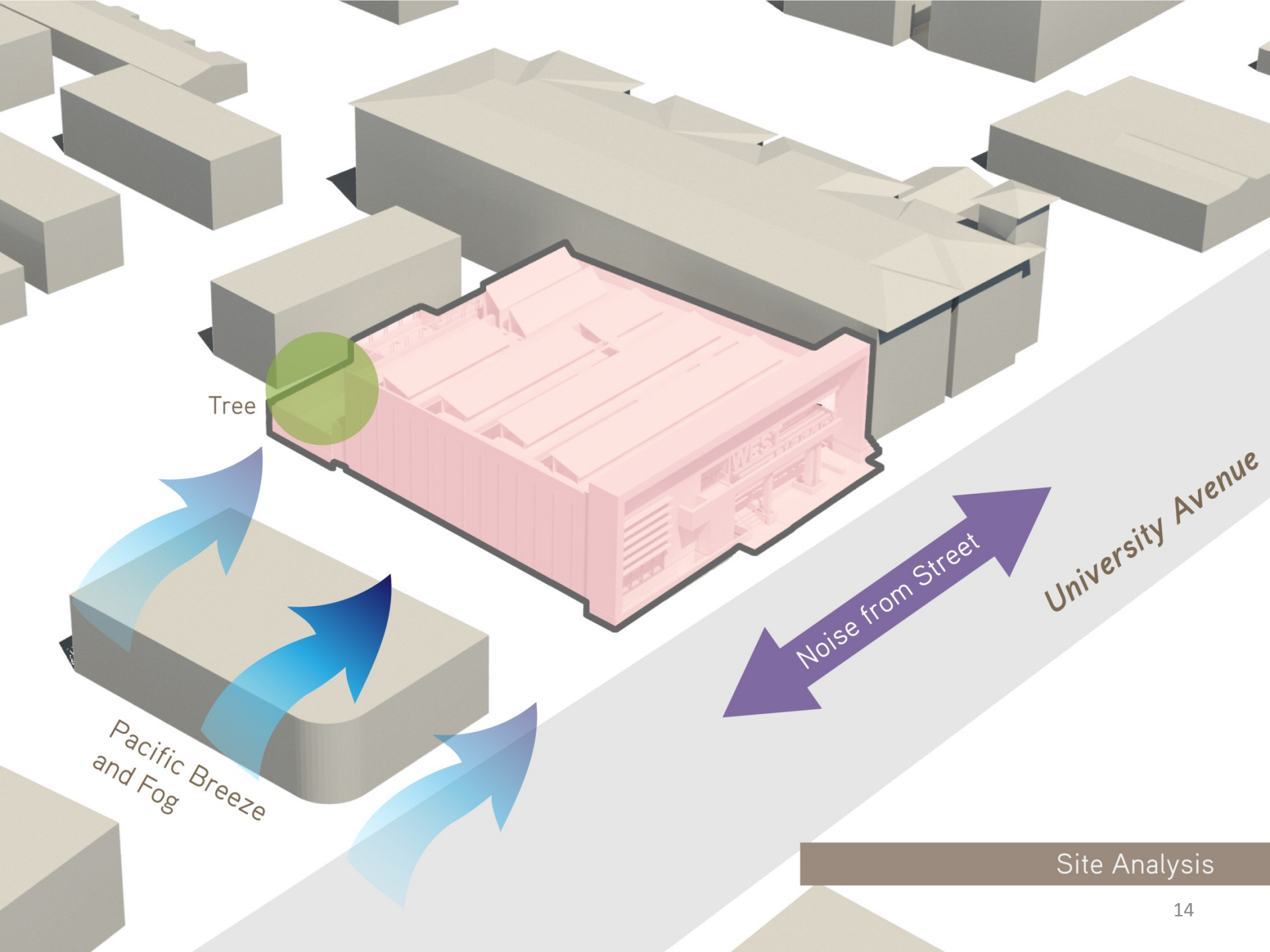
City of Berkeley
Lessons Learned



- **Climate Action Plan and LEED policy drivers were critical**
- **A Need for Institutional Improvements**
  - Relied too heavily on favorable bid
- **Policies For Consideration**
  - Life Cycle Cost Analysis requirements
  - Leverage projected O&M savings into capital budget
  - Mitigation/Offsets for expansions
- **Measurement is Critical (and not that easy)**

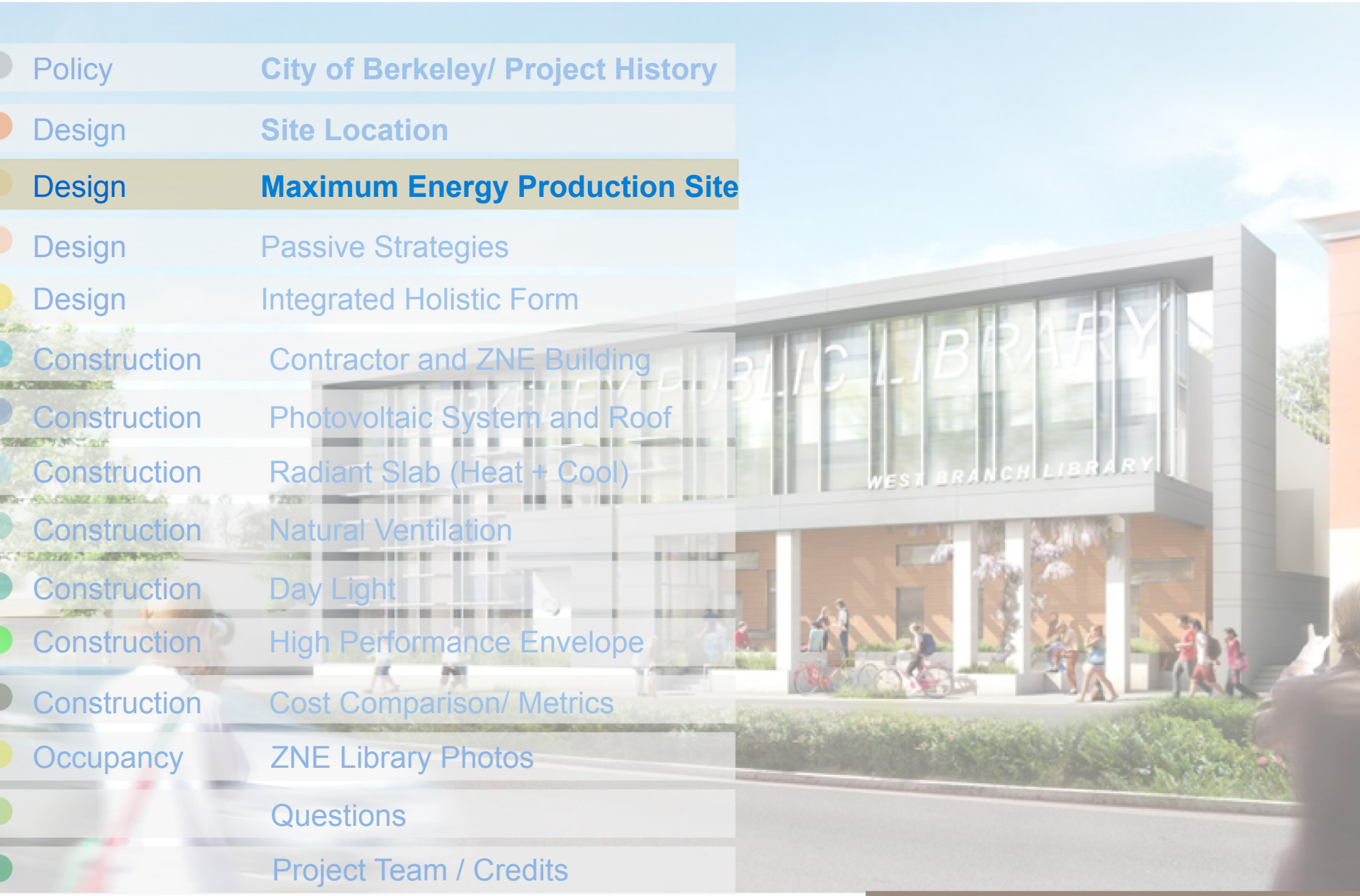


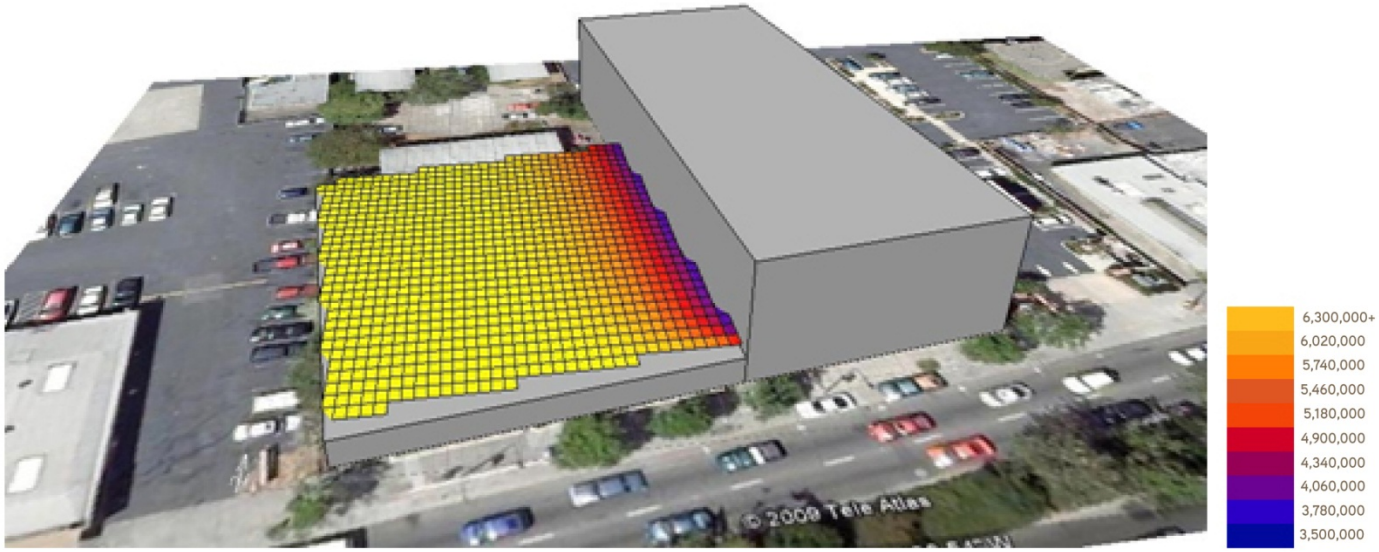

1 mile
20 min walk
1/2 mile
10 min walk
West Berkeley
Library
Residential
Retail Stores
Bicycle Corridor
University Avenue
San Pablo Avenue
+29 AC Transit Bus Stops
4 Bus Routes
1 Amtrak Station
1 Bart Station
Site Location
Bay
Aquatic
Park
80 / 580 fwy
North



Site Analysis

Site Photos- Existing Building



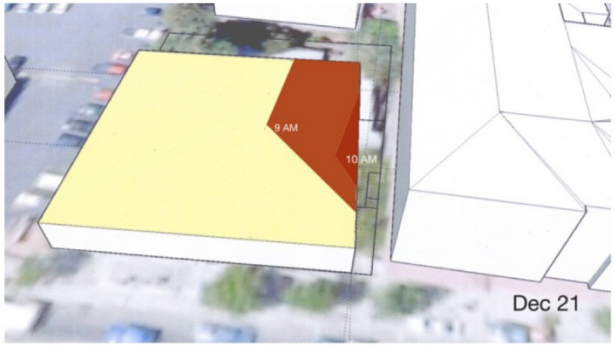


Insolation Analysis

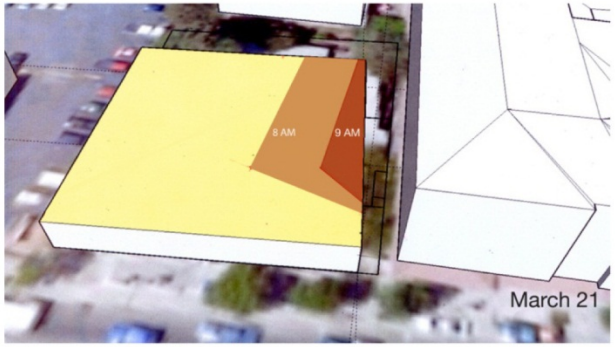
Total Radiation

Value Range: 3,500,000 - 6,300,000 Btu

"Every hour, ***the sun*** radiates more ***energy*** onto the ***earth*** than the entire human population ***uses*** in ***one*** whole ***year.***"



December 21



March 21

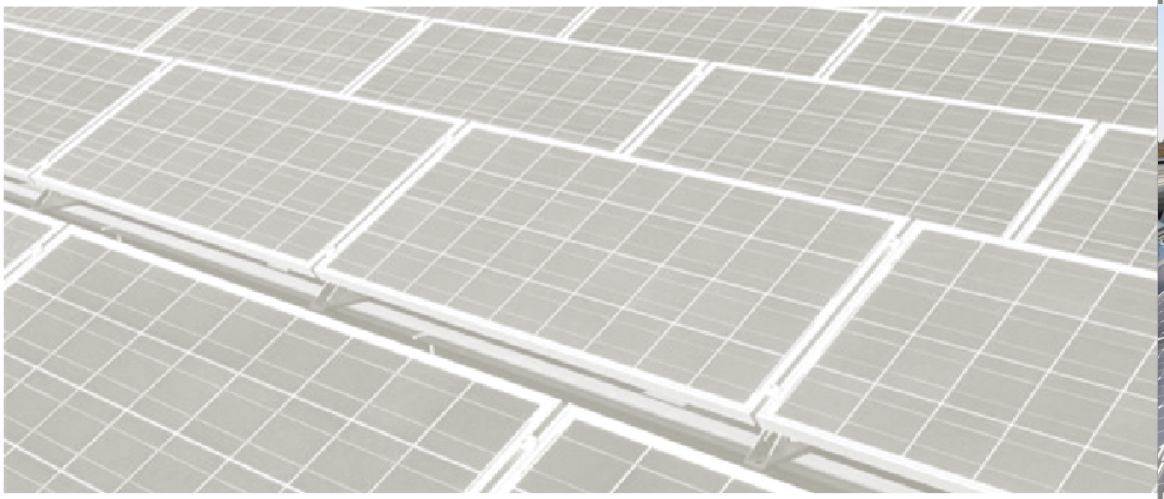
June 21

Roof Height: 12'-0"

Roof Height: 24'-0"

Solar Access – Optimum Roof Height

Early Power Generation Models



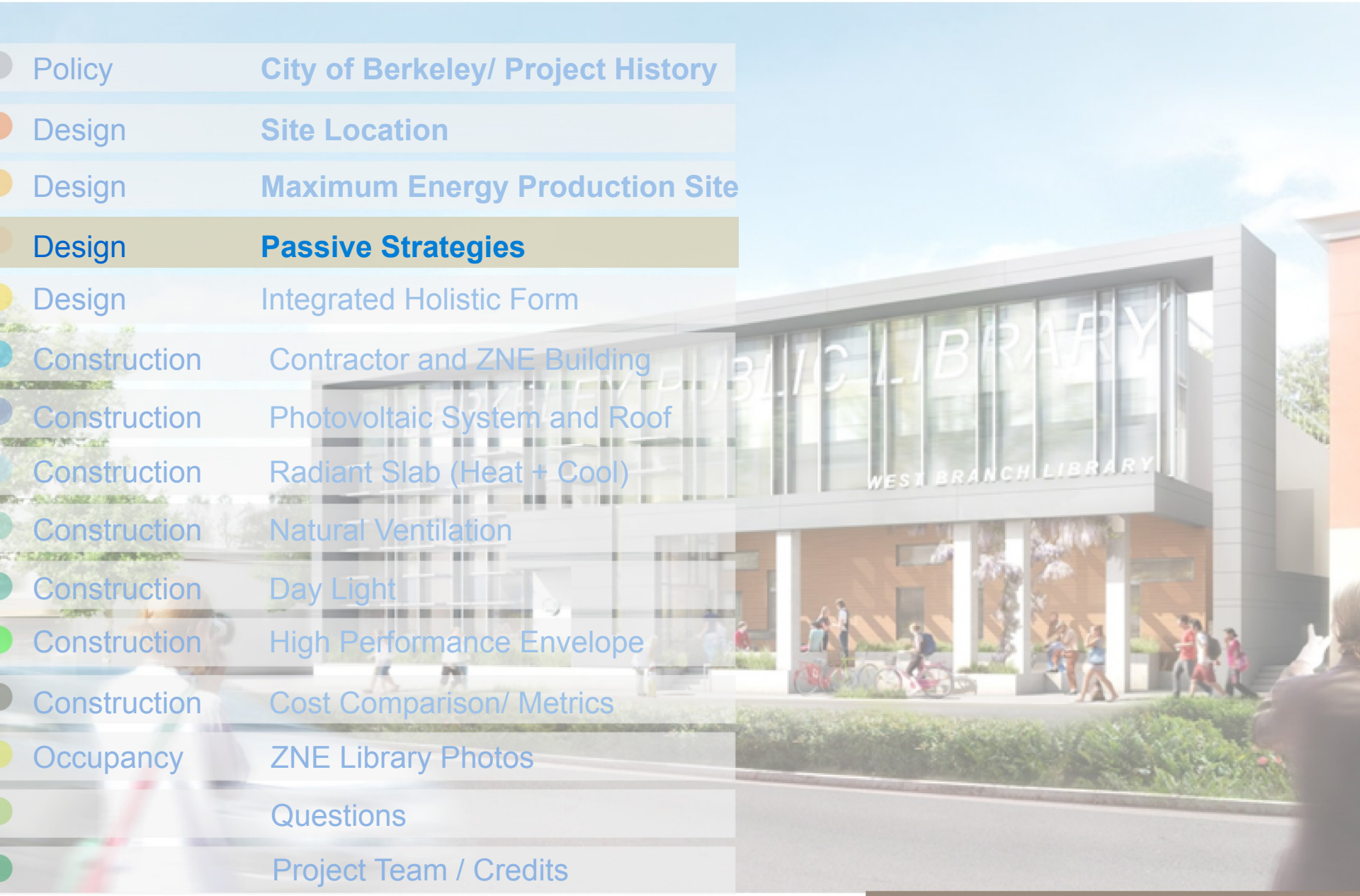
Built

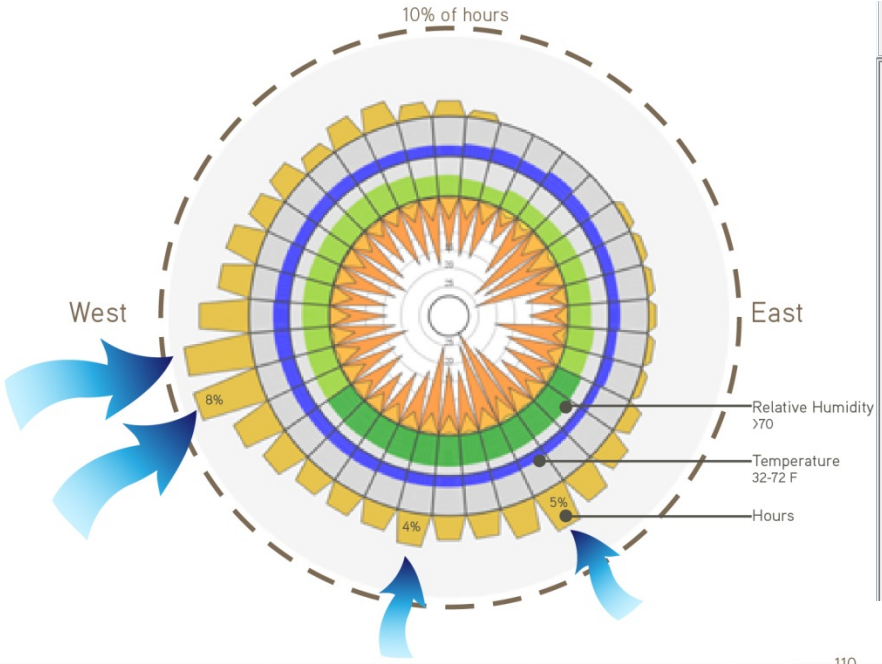
			Project PV	Project Solar Thermal
Photovoltaic Panel Design Power Capacity	235 watts/panels	305 watts/panel	435 watts/panel	
Number of Panels	160	160	120	16
Total PV System Power Capacity	37.6 kW	48.8kW	52 kW	
Total Electrical Energy Delivered Per Year	48,880 kWhr	63,440 kWhr	75,596 kWhr	
Gross Building Conditioned Area	9,600 sqft	9,600 sqft	9,400 sqft	
Max Building EUI for a ZNE Design	17.4 kBtu/sf-year	22.6 kBtu/sf-year	27.4 kBtu/sf-year	8.4 kBtu/sf-year
		Total	36.1 kBtu/sf-year	

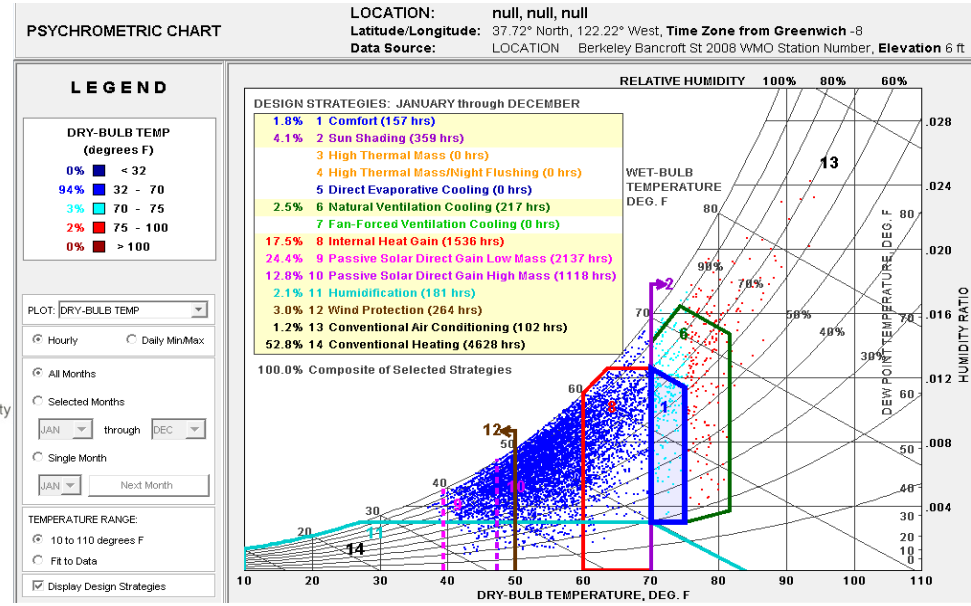
Power Generation Design Model

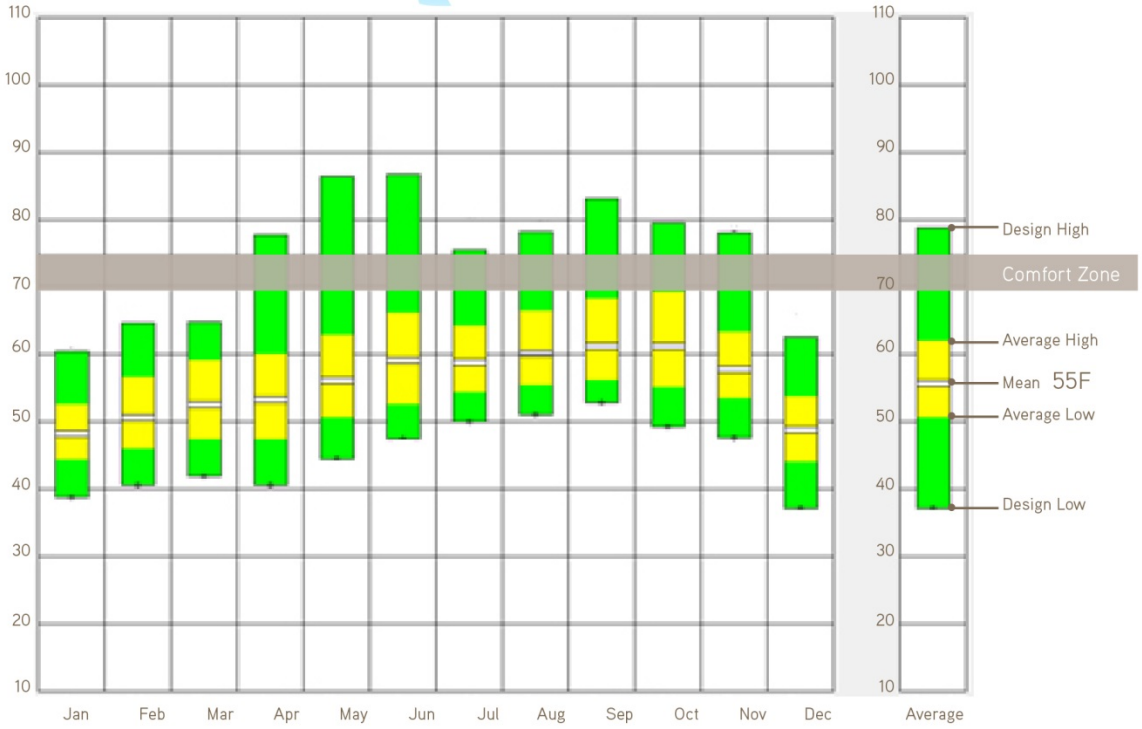
Early Design Assumptions: 17.4 kBtu/sf/yr
Note: During the intervening period PV panels increased in efficiency and reduced the costs.
Final PV and Solar Thermal Array As Built = 36.1 kBtu/sf/yr

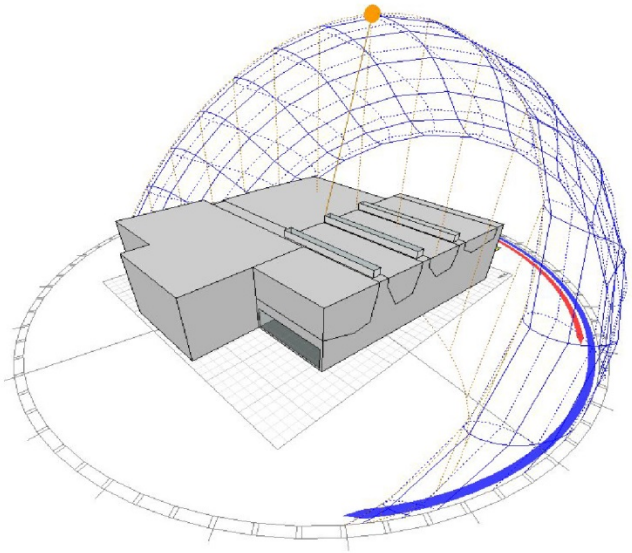
Renewable On-site Energy Supply



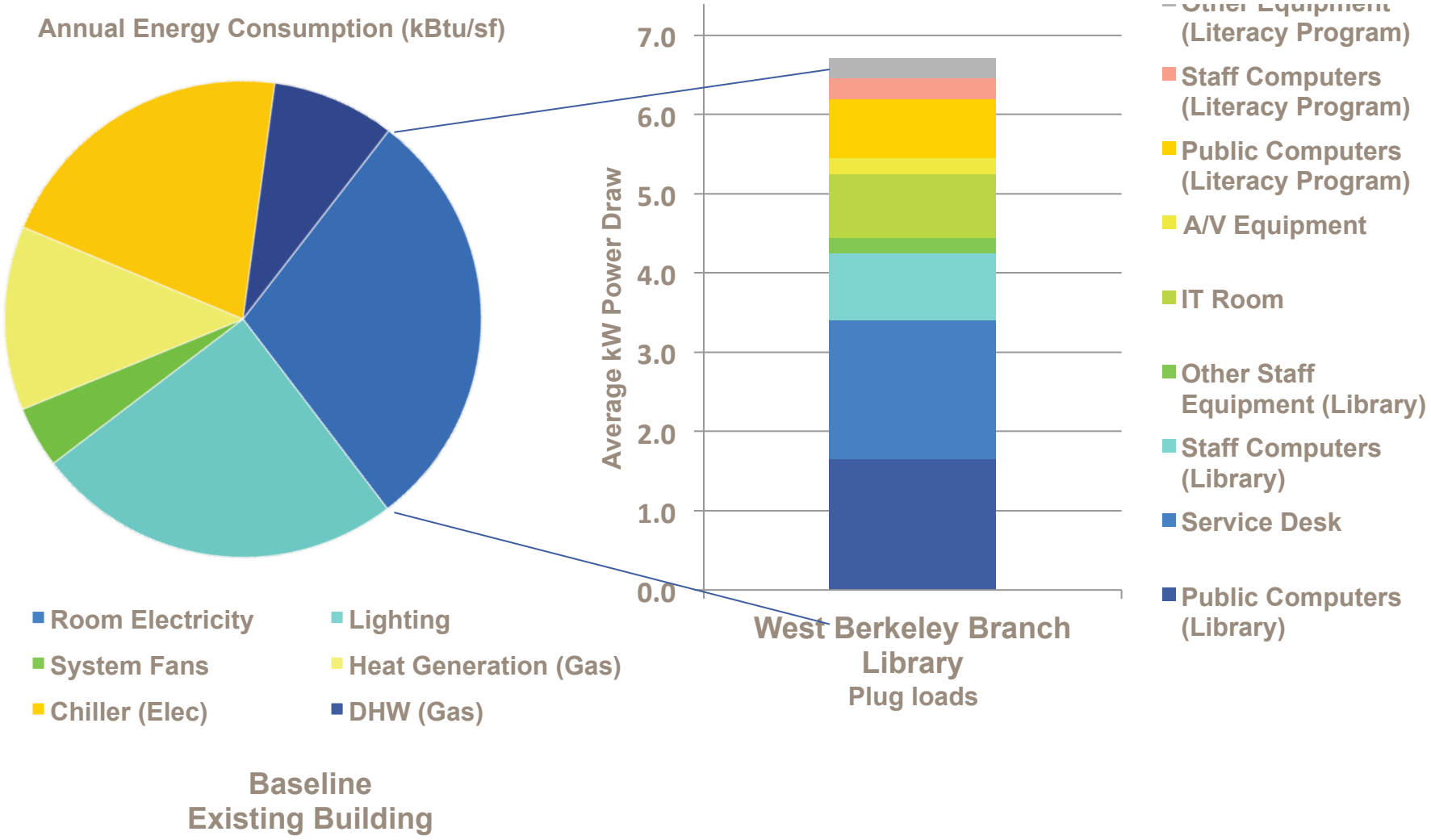




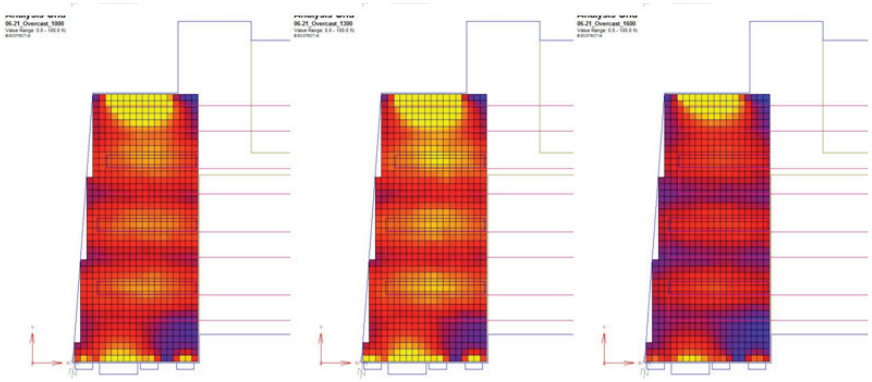




Local Climate Analysis

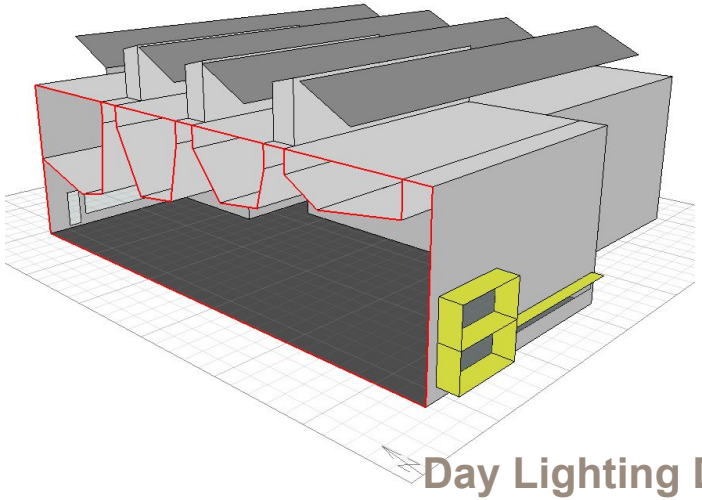


Plug Load Analysis



Floor Plan – Overcast Sky

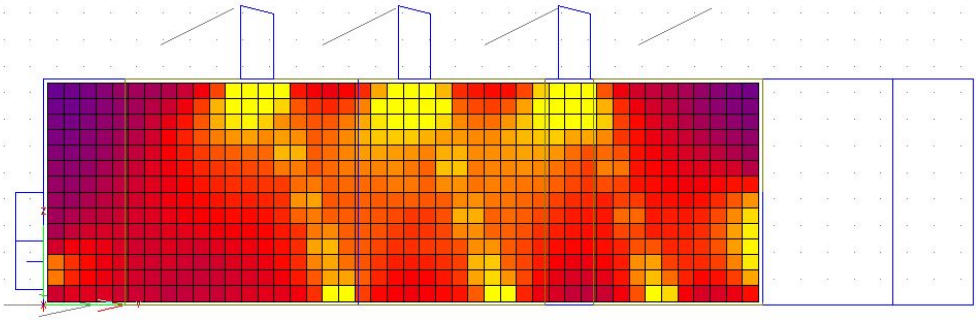
JUNE 21

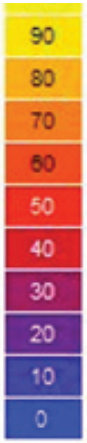


Day Lighting Design Tools

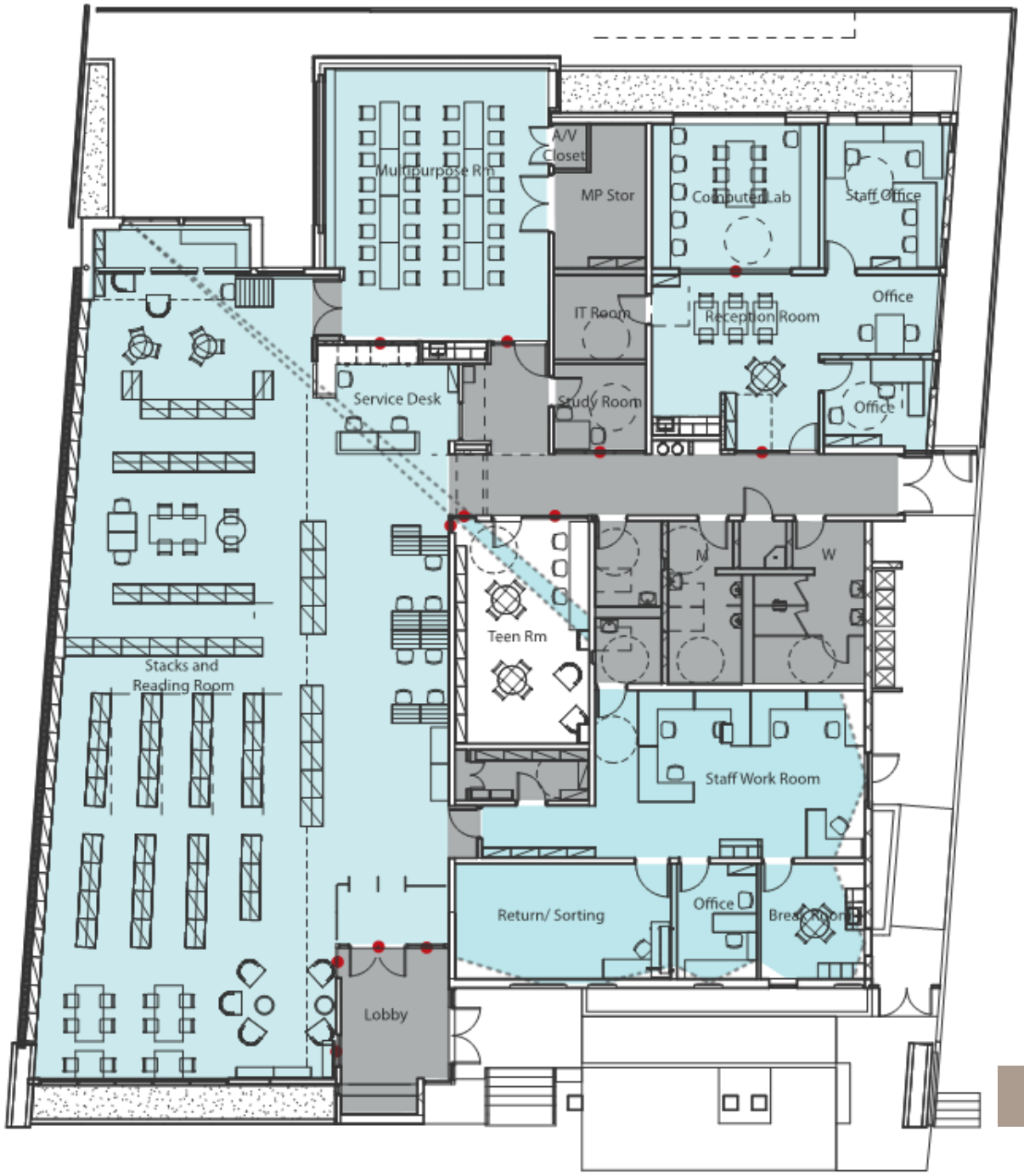
- **Daysim- annual daylighting analysis with weather data**
- **Radiance – illuminance maps based on specific times**
- **Use the right tool**
- **Daysim was more user friendly in early design phases**

Analysis Grid
06-21 Clear 1200 Falloffs
Value Range: 0.00-200 fc



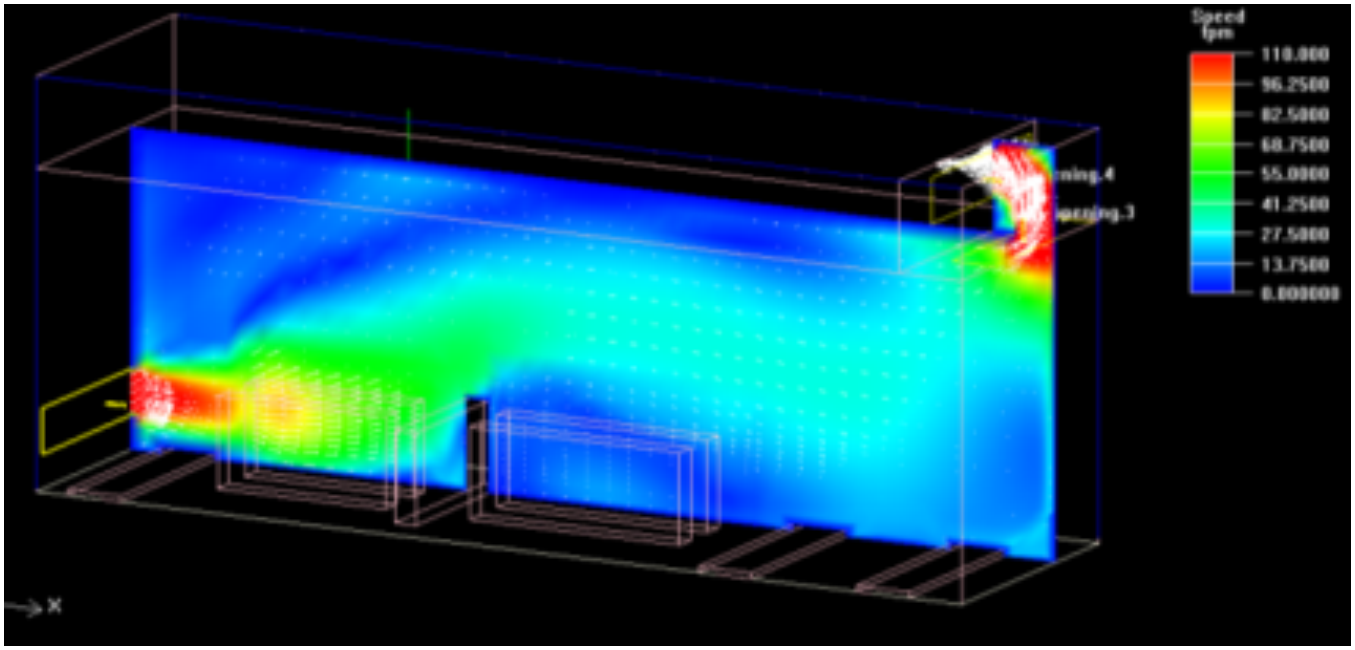


Building Section



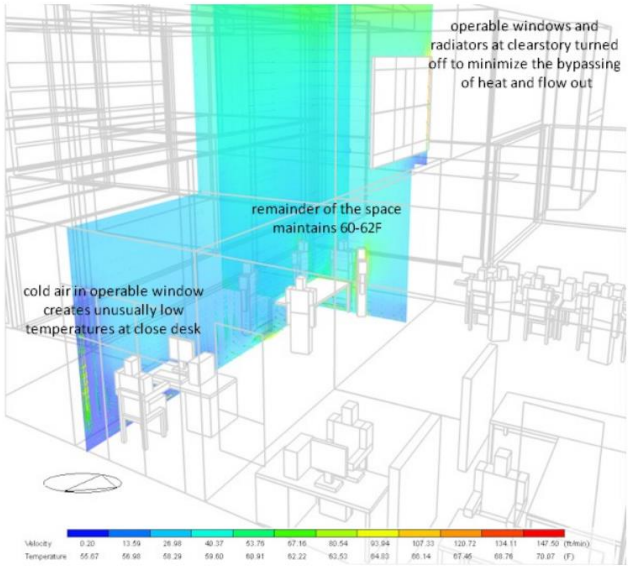
- Area with no views
- Area with views 90%
- Non-regularly occupied areas
- Interior Glazing

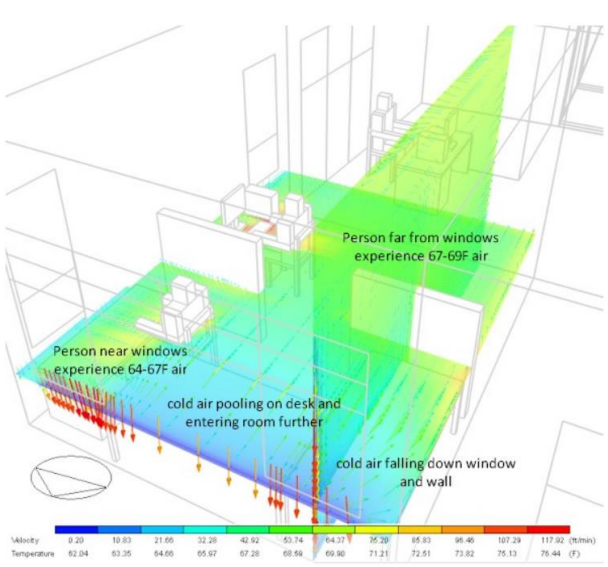
Views & Daylighting



Natural Ventilation – Computational Fluid Dynamics (CFD) Studies

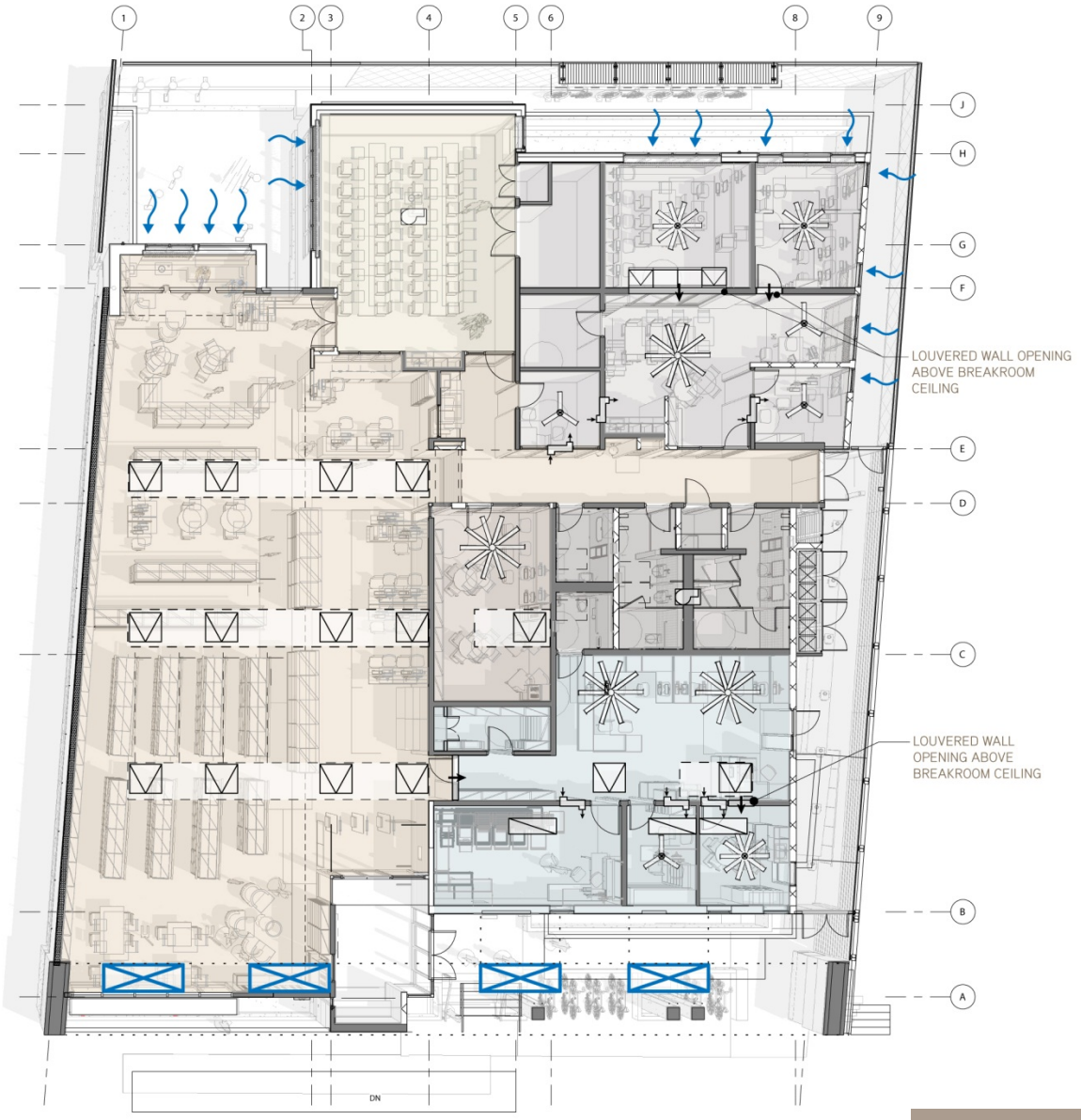
- Fluent (Ansys Airpak)
- Various ceiling configurations and shapes were analyzed
- CFD analysis indicated - horizontal ceiling plane works as well as a sloped ceiling
- Comfort Verification Studies – Additional CFD analysis was done during late design for verification purposes





Comfort verification studies by Capital Engineering/ SEED Inc.

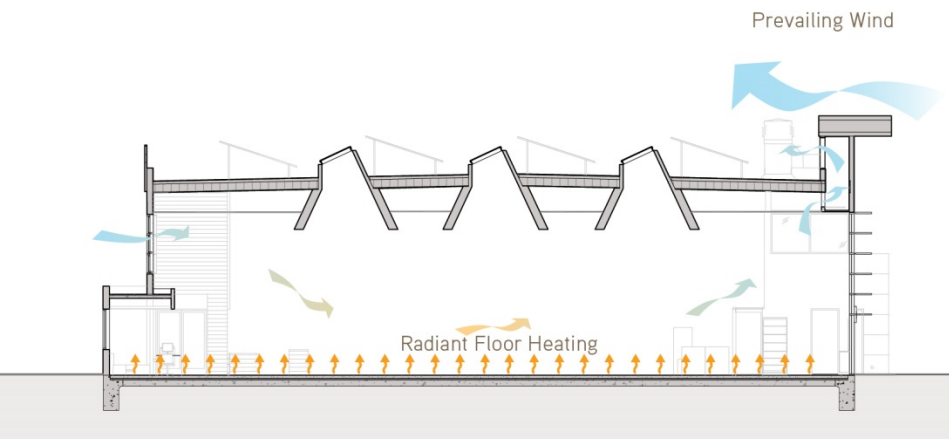
Natural Ventilation Analysis



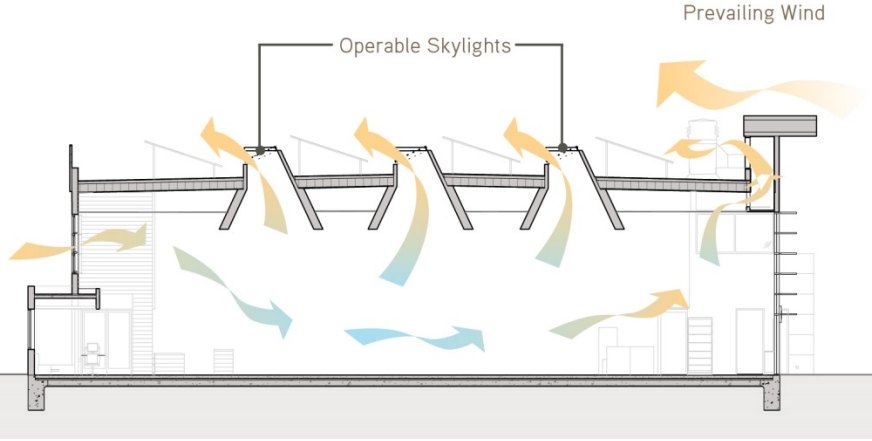
- Book Stacks
- Multipurpose Room
- Office Area
- Janitor and Restrooms
- Teen Room
- Staff Area

- Wind Chimney
- Skylight
- Operable Skylight
- Air Inlet
- Sound Trap (Wall or Ceiling)
- Direct Opening
- B.A. Fan
- Fan
- Clerestory Window
- Exhaust Fan Unit
- Ceiling Exahust Grille to Air Chase

Floor Plan – Ventilation Systems



Heating Season



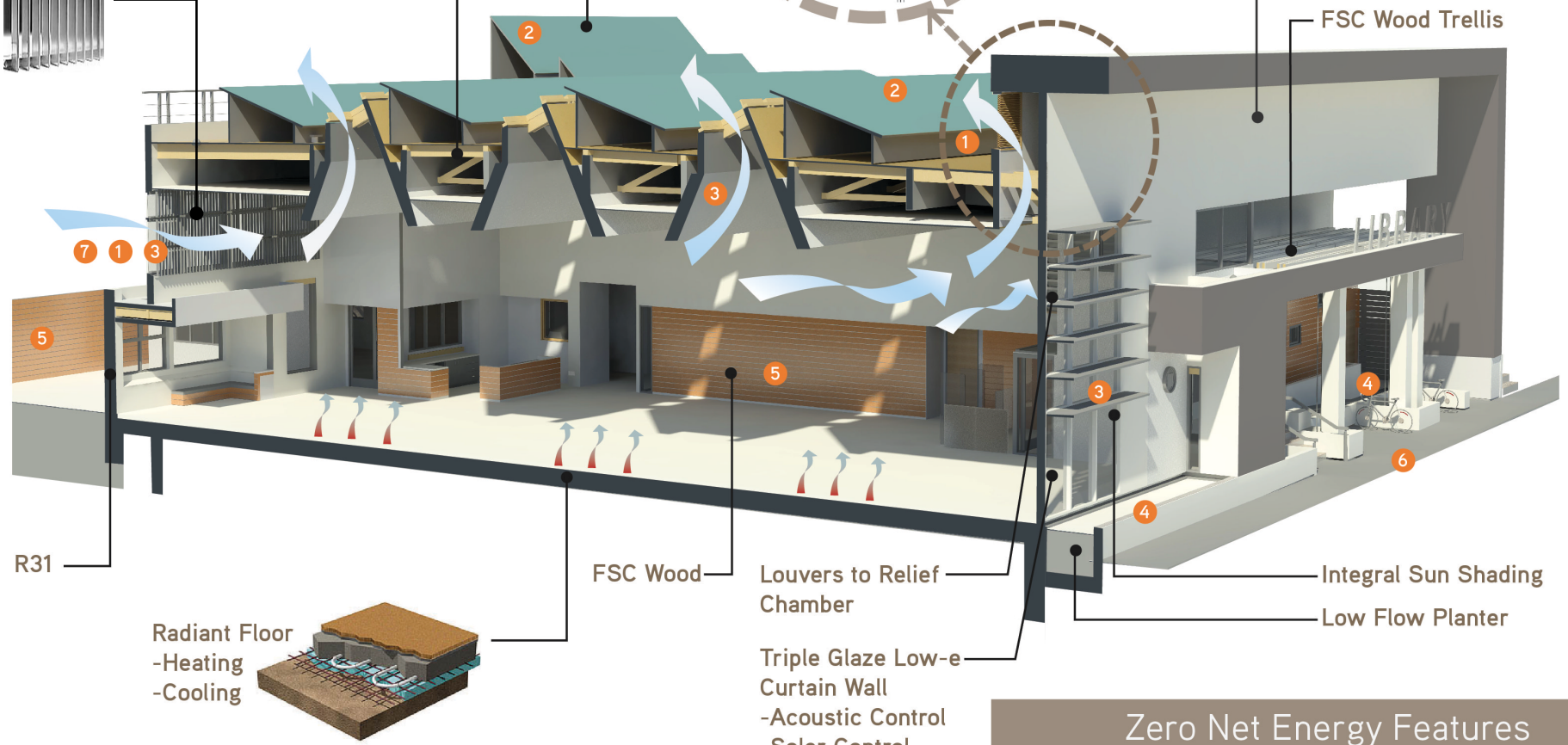
Early Cooling Season

Cooling Season

Peak Cooling Events

Mixed-Mode Operating System

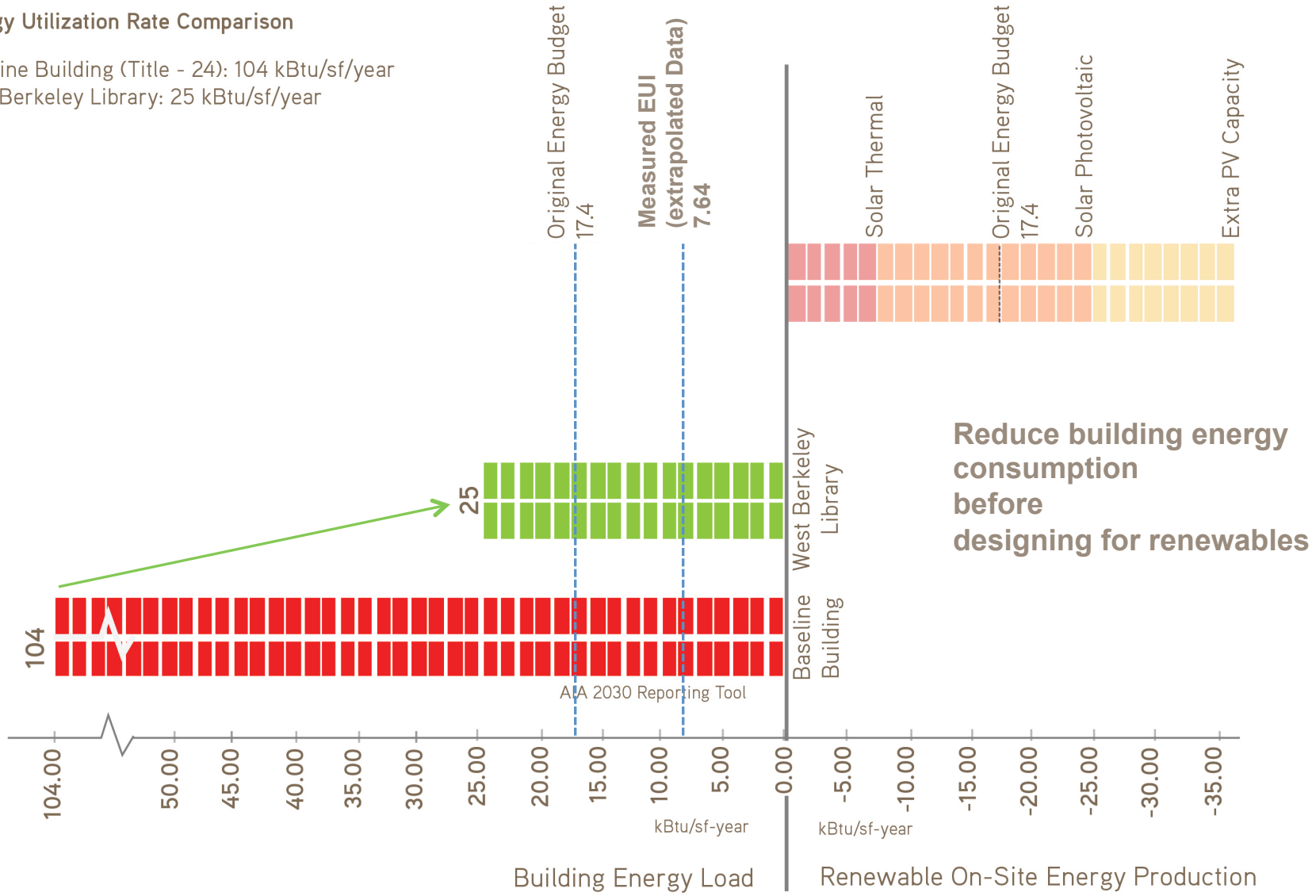
1 Natural Ventilation / Mix Mode
2 On Site Energy Generation
3 Daylighting- 90% of Spaces is Daylit
4 On Site Storm Water Technology
5 FSC Certified Wood
6 Dense Urban Site / Site Selection
7 Runtal Radiators



Zero Net Energy Features

Energy Utilization Rate Comparison

Baseline Building (Title - 24): 104 kBtu/sf/year
West Berkeley Library: 25 kBtu/sf/year



Whole Building Energy Analysis

West Berkeley Library

Floor Plan

- Book Stacks
- Multipurpose Room
- Office Area
- Janitor and Restrooms
- Teen Room
- Staff Area

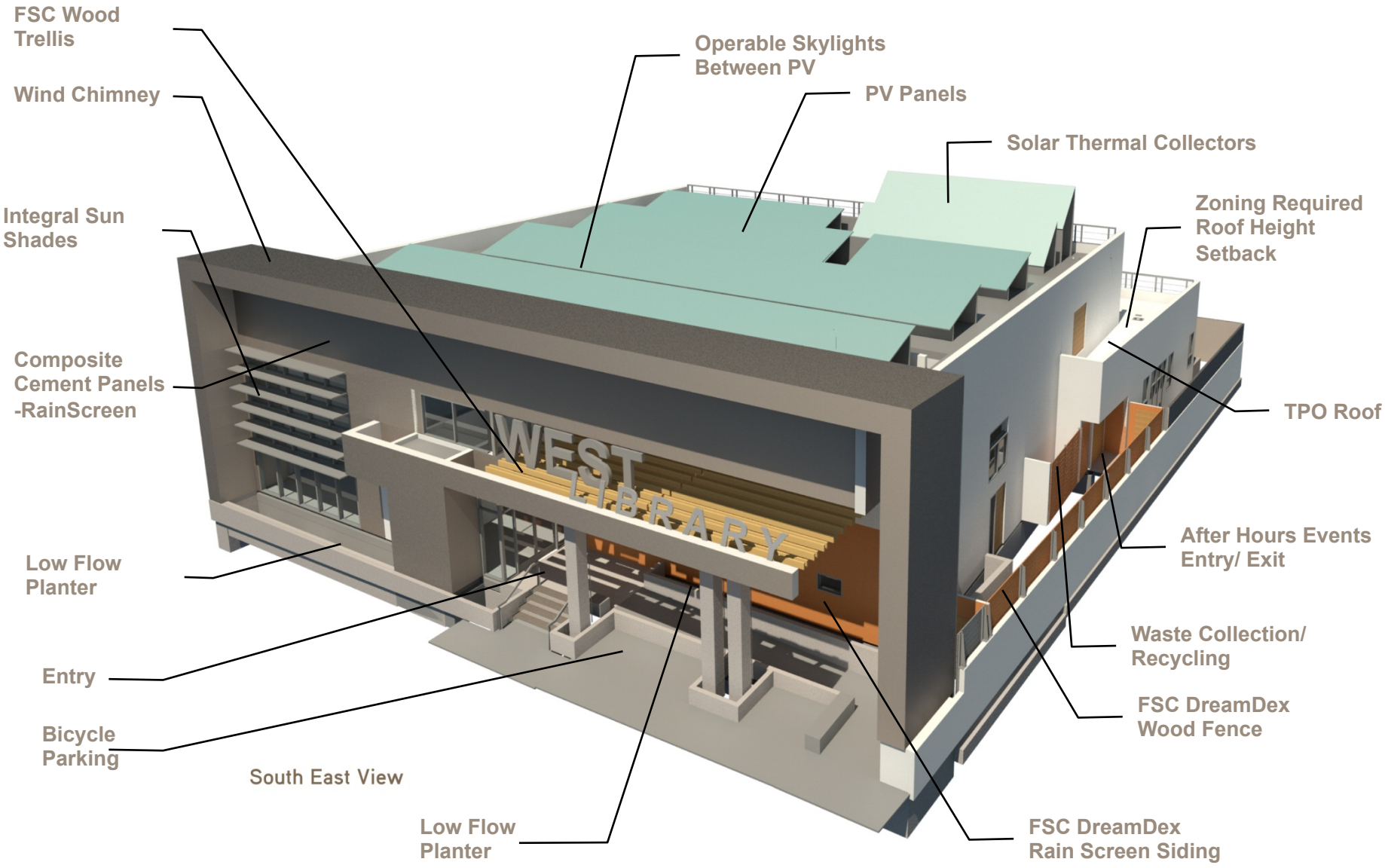
Site Plan Features

A Garden Courtyard w/ Specimen Oak Tree and Native Plants
B Trellised Entry Courtyard
C Bicycle Parking
D Flow-Through Planters w/ Native Plants
E Accessible Parking
F Loading Zone
G Security Gate
H After-Hours Public Access
I New Honeylocust Street Trees

North

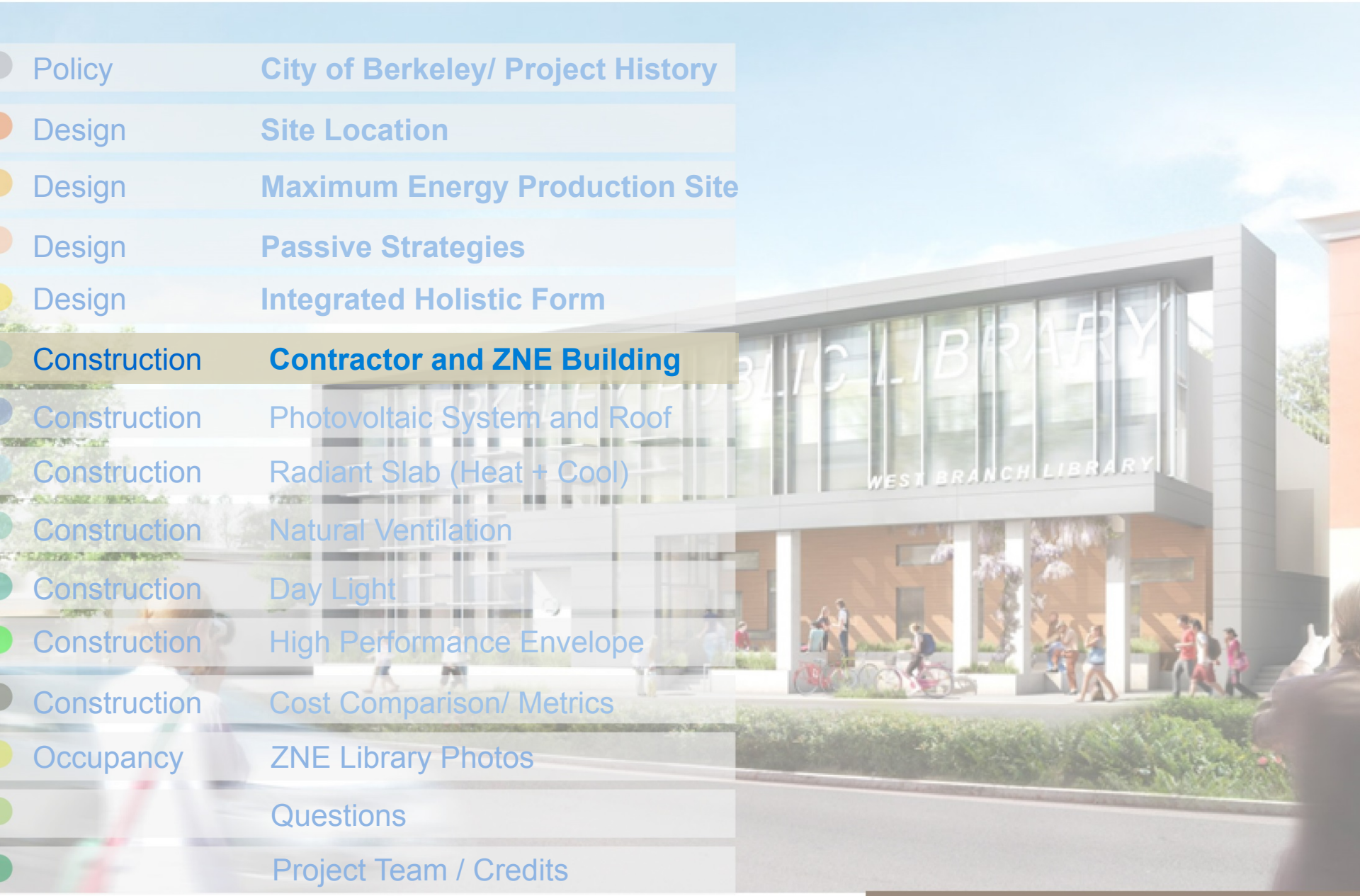
0 10 20 30

Site and Program Plan



South East View

Integrated Forms



West Berkeley Library

Public Procurement – Lessons Learned

- Few Built ZNE public Buildings
- FEAR of unknown is a hurdle
- Recall early days of LEED with 30% premium projects
- Costs Estimates may not be reflective of true costs
- There are ZNE and then there are ZNE projects
- HED relied on proven and reliable technology
- Passive Design has been around for centuries

Public Low Bid

Public Procurement – Lessons Learned

- Public Low Bid Requirement
- Limited Number of General Contractors with ZNE Experience
- Has to be a Collaborative Process
- Project Kick Off is Key
- PM/CM/PA/Builder/ Client Relationship is Crucial
- PA Needs to Educate
- PA Needs to Collaborate and Develop Trust
- COMMUNICATION!

Public Low Bid

- Coordination
- Quick turn around on RFIs/ Submittals
- Be Flexible
- Work as a Team to Identify Savings and Opportunities
- Concepts that apply to all projects

Policy	City of Berkeley/ Project History
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Occupancy	ZNE Library Photos
	Questions
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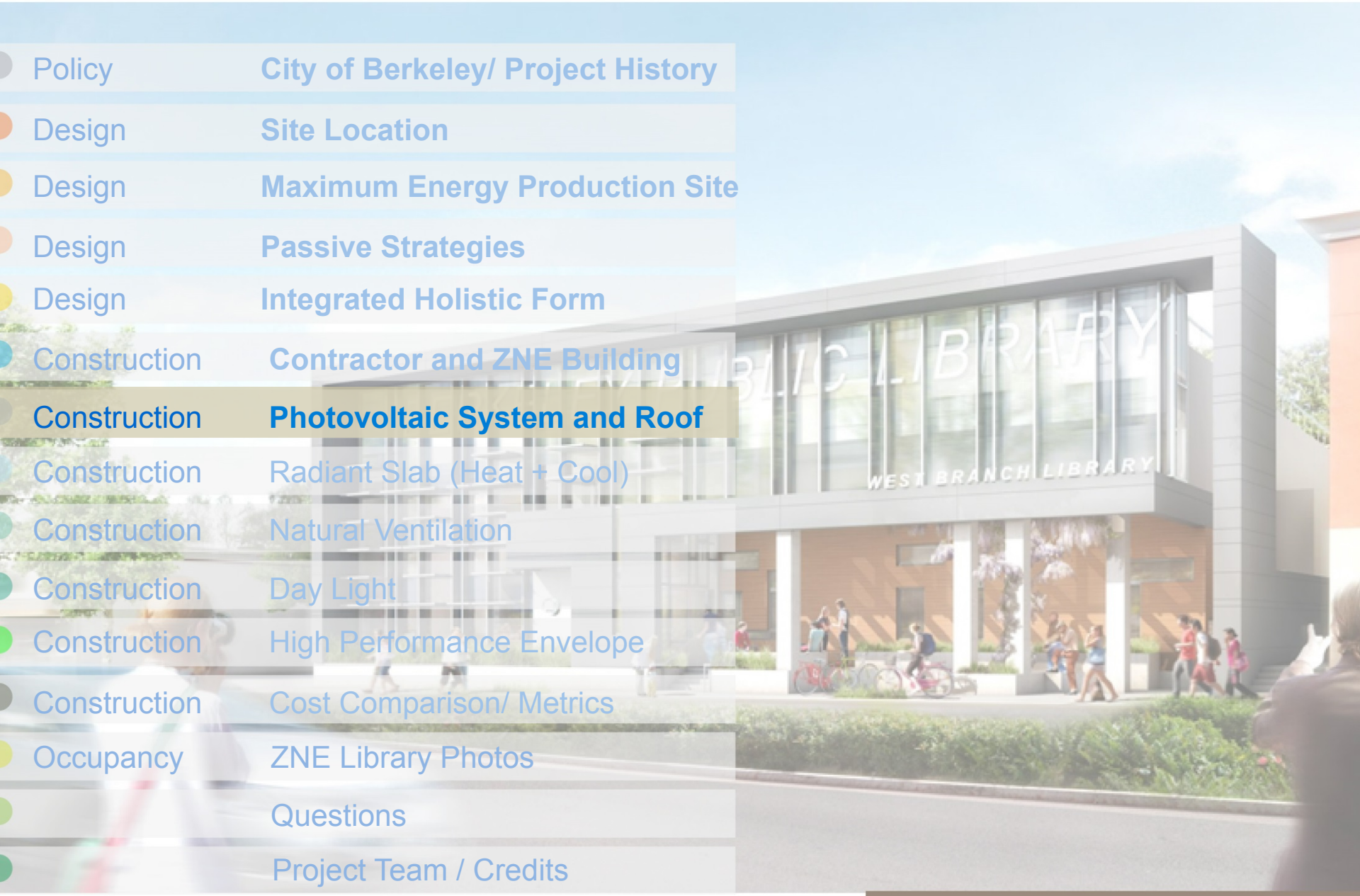


Unseen But Important -Roof

- Basis of Design/ Performance requirements
- PV Subs want to Install Off the Rack Systems
- Be Aware of System Conflicts
- PA Needs to Resolve Issues, Find Solutions and Be Aware of ZNE at all times
- Integrated Designs Are Not Friendly Towards Field Changes

PV & Solar Thermal

- Learning curve
- Not your standard electrical/ mechanical room
- Plan for issues in the field where Design Build systems are concerned
- Structure needs to have factored in design load
- PV emergency shut off -within 10’ of Main Switch Gear (MSB)
- Clearances?

Lessons In The Field

PV & Solar Thermal

- Do not exceed zoning height limitations
- Low slope roofs – HED detailed for stanchions.
- Standard wood curbs preferred by subs can impede flow and affect collector plate angles
- Stanchions allow for future technology, reroofing, ease of maintenance.

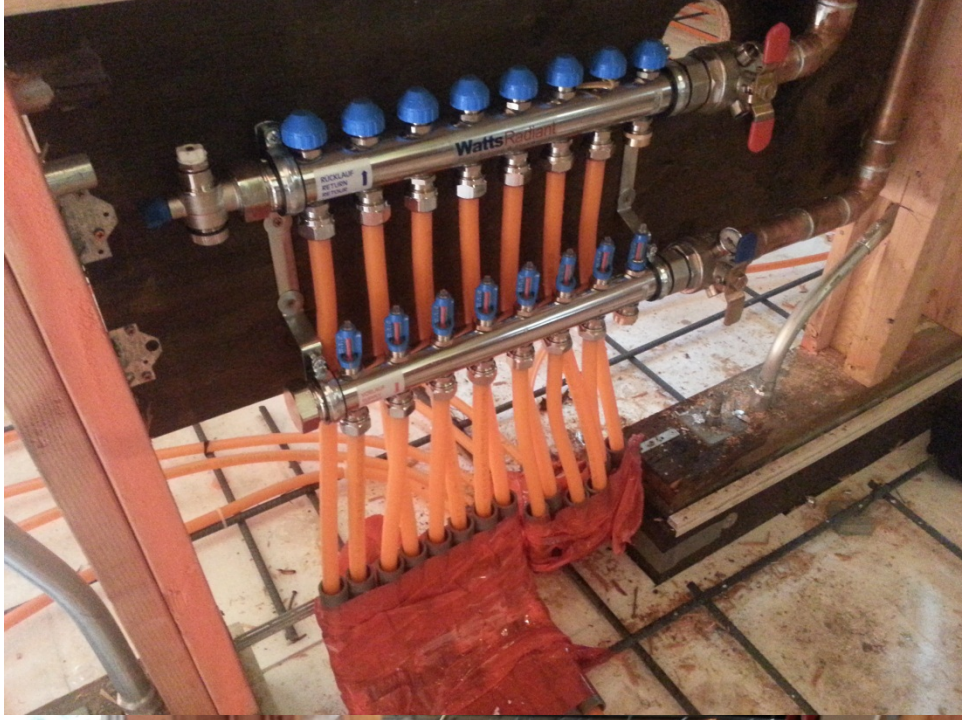
PV & Solar Thermal

- Structure needs to be conservative to accommodate solar thermal
- Review of submittals from joist and solar thermal should be concurrent
- Collector plate dead and live loads
- Scrutinize the performance, efficiency and proposed angles of collectors in submittals

West Berkeley Library

Radiant Slab

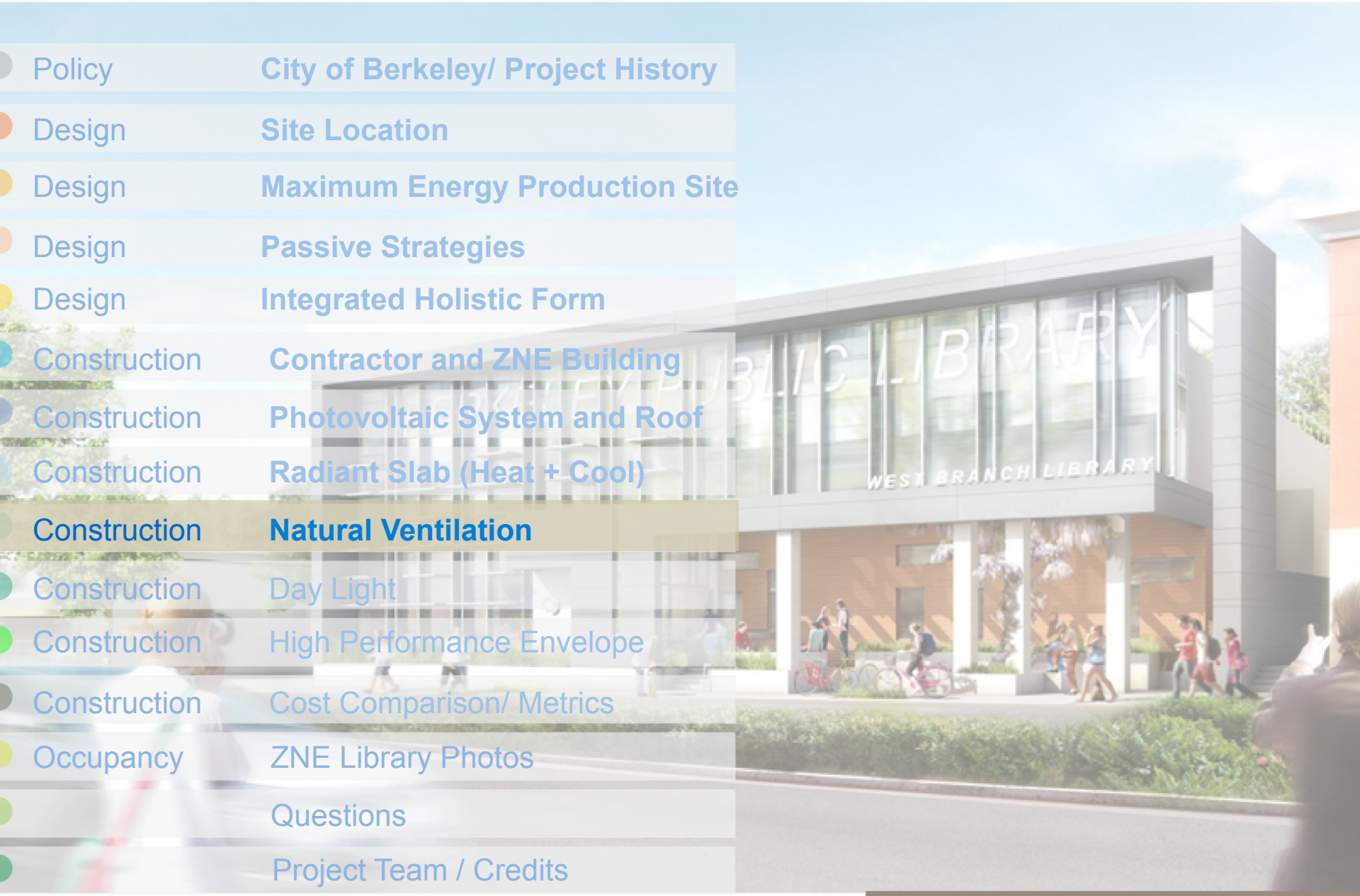
- Triple Wall Radiant Tubing
- 4” of Radiant Concrete Slab over 2” of Rigid Insulation
- Engineer has to check manifold design and tubing layout to ensure proper zoning
- Template Layout -avoid punctures
- Educating the **other** subcontractors is **KEY**
- Install protection plates under doors or at penetrations



Radiant Slab

- Tight Urban Site provided no laydown space.
- Everything is stored within the building.
- Slab pours -carefully phased to allow materials to be relocated
- 6” concrete curbs at all interior partitions
- Curb cutouts need to be planned for manifolds and for construction access- cherry pickers, etc.


solarskies
engaging the sun
solarskies



Natural Ventilation

- Interior of chimney has to be lined with acoustic board
- Provide for access to service and maintain
- Patrons standard comment is usually about how quiet the building is!
- CFD studies were worth it. No discomfort reported

Natural Ventilation

- Operable windows are tied to BMS
- Some manual operable windows provided at staff offices
- Window actuator looks like a handle – one operable window at standard height broken by patron
- Runtal missed at one automatic window

Wind Chimney

Runtal Radiators

- Provides preheating of fresh air in the winter
- Long lead time 6-8 weeks
- Concerns about appearance and perception
- Standard Runtal heights are limited
- HED worked with fabricator to increase fin spacing & revised pressure and flow design


EXIT

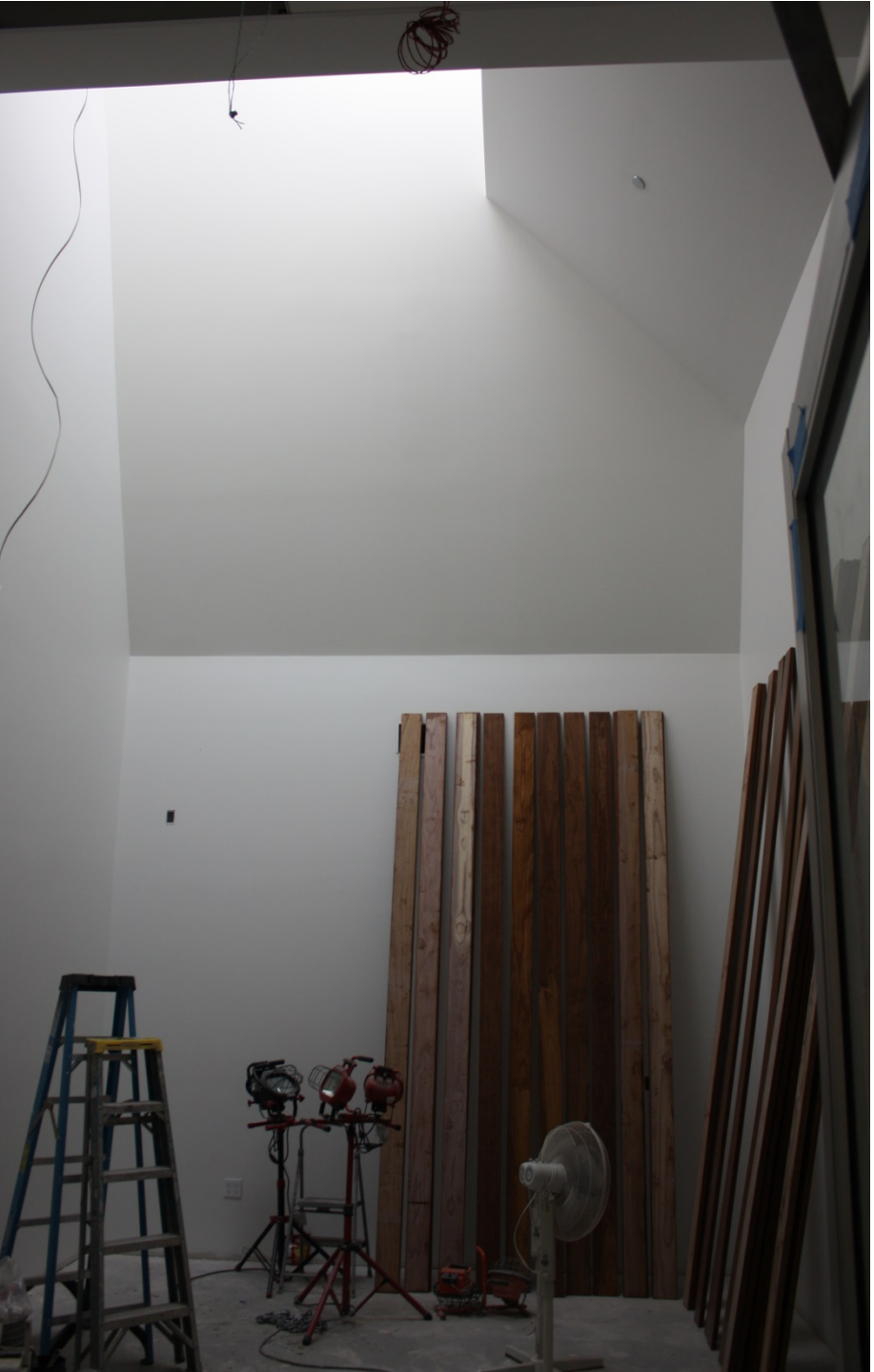

Genie GS-2632

Skylights

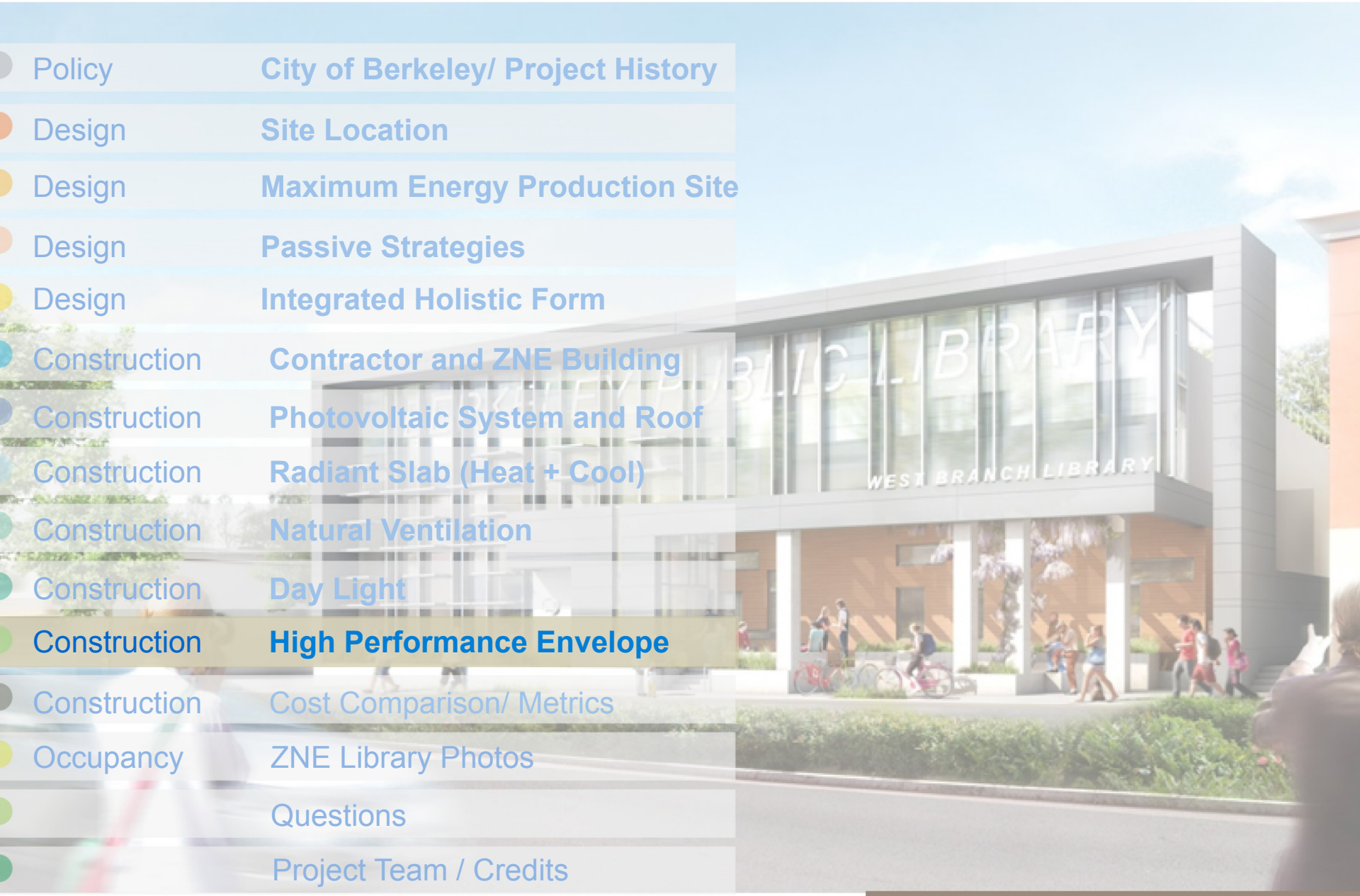
- Abundance of light-covered up skylights during construction
- Note the Roxul- rock wool insulation
- Note the radiant tubing layout over rigid insulation
- Layout of floor boxes
- Note the construction lights

Skylights

- Both fixed and operable
- Operable skylight controls were difficult to get to communicate with BMS
- Value engineering exercise had removed integral blinds- added back during construction
- Skylight blinds have solar cell- self powered and automatic



Quality of Light



West Berkeley Library

- High Performance Rain Screen System
- 14 Week Lead time from Switzerland – No comparable local product
- HED arranged for contractor to obtain manufacturer certification
- HED revised details to reduce steel furring use by 30%
- Reduced material use, errors, labor and possibility for breakage during installation

Cement Composite Panel Rain Screen

- Attention to detail at intersections of different assemblies
- Crucial during field work
- Care on the part of the GC is just as important
- Shout out to Pat Chavez & Paul Ubaldi- WBB Project Engineer & Site superintendent/ carpenter

Cement Composite Panel Rain Screen

- 3x8 wood studs @ 24” on center
- Wood is thermally efficient vs. steel stud
- 7 ¼” of wall cavity filled with rock wool insulation = R30
- 2 layers of Roxul in roof/ ceiling =R41
- 5 week lead time from Canada
- Good acoustics, high thermal & hygrothermal
- performance, fire protection, moisture & mold resistant and will not sag

Roxul Rock Wool Insulation

- 1” x 6” Radiata pine siding impregnated with resin
- FSC, dense, mold and insect resistant, weathers well – alternative to tropical hardwoods
- Designed as a rain screen system
- Dreamdex is restructuring – product unavailable
- City purchased available stock at start of construction and kept off site
- HED worked with contractor to avoid wastage

DreamDex Wood Siding


LIBRARY
1125

Policy	City of Berkeley/ Project History
Design	Site Location
Design	Maximum Energy Production Site
Design	Passive Strategies
Design	Integrated Holistic Form
Construction	Contractor and ZNE Building
Construction	Photovoltaic System and Roof
Construction	Radiant Slab (Heat + Cool)
Construction	Natural Ventilation
Construction	Day Light
Construction	High Performance Envelope
Construction	**Cost Comparison/ Metrics**
Occupancy	ZNE Library Photos
	Questions
	Project Team / Credits

West Berkeley Library

Costs Comparisons - Recently Completed Libraries in California

Date: 5/22/2014

Library	Gilroy Library*1	West Berkeley Library	Santa Monica Pico Branch Library*2	Berkeley Claremont Branch library *3	Berkeley North branch *4	Berkeley South Branch *5
ZNE (zero net energy)	No	Yes	No	No	No	No
LEED	Gold	Gold*	Platinum*	Silver	Silver	Silver
New/ Remodel	New	New	New	Remodel/ addition	Remodel/ addition	New
Completion Date	April, 2012	Dec-13	Jun-14	2012	2012	May,2013
Area (sf)	52,600	9,399	8,690	7,800	9,900	8,700
Estimate	$18,200,000	$7,500,000	$6,900,000	$3,230,000	$4,560,000	$4,300,000
Bid	$18,177,226	$5,495,000	$6,915,020	$3,300,000	$4,360,000	$4,963,000
Final Construction costs	$19,200,000	$5,567,000	$7,278,020	$4,600,000	$5,900,000	$5,000,000
costs/sf	$365	$592.30	$837.52	$589.74	$595.96	$574.71

$17.59/sf premium

*1 - includes $700,000 owner related increases. There are efficiencies in larger buildings and typically cost per square feet will appear lower.

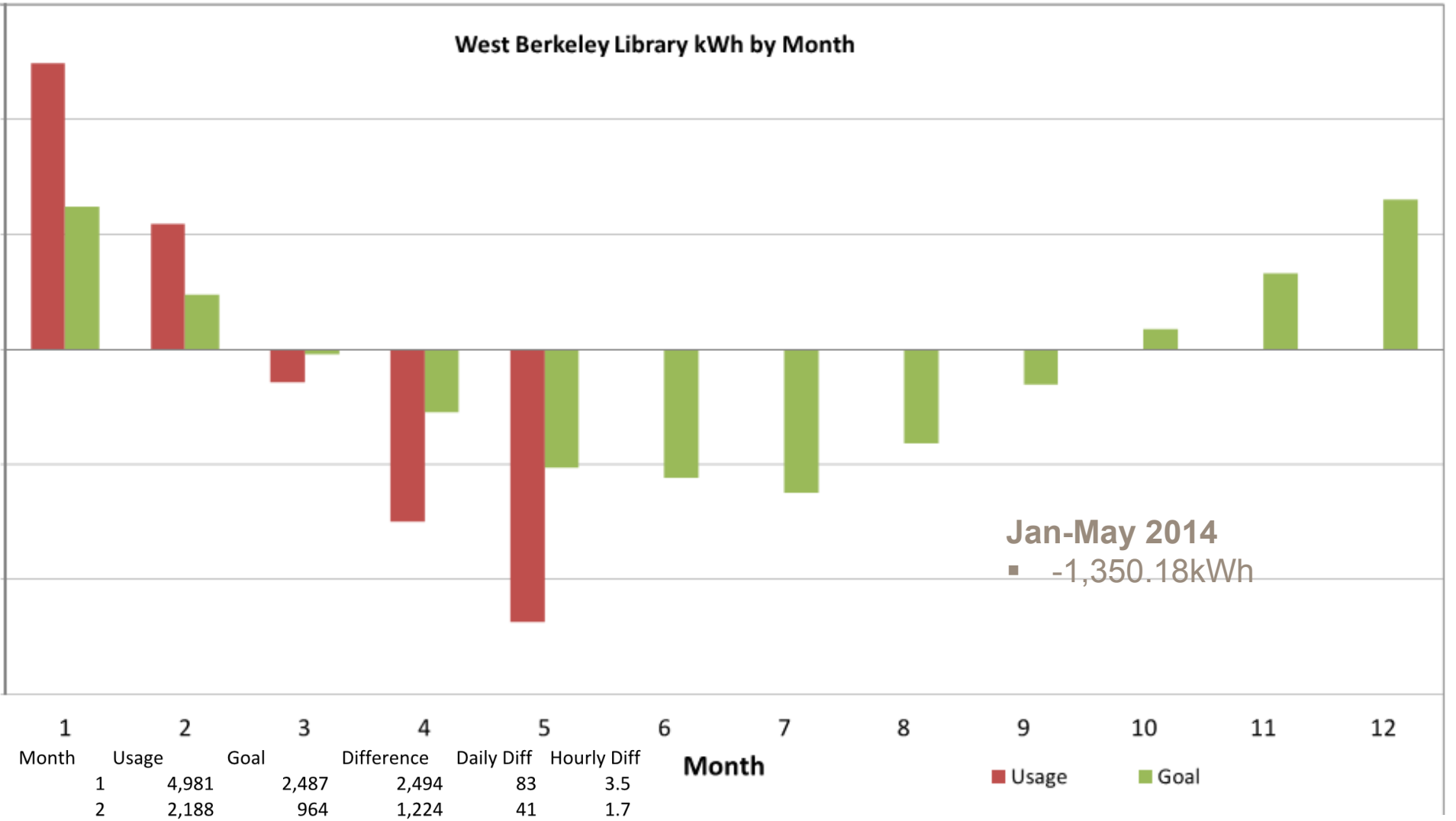
*2 - As of August 2013 as approved by city council- construction is ongoing.

*3 - Existing building with 380sf addition-interiors only

*4 - Existing building with 4,000sf two storey addition

*5 - Final project costs of $6.5M includes FF&E.

True Costs Comparisons



Month	Usage	Goal	Difference	Daily Diff	Hourly Diff
1	4,981	2,487	2,494	83	3.5
2	2,188	964	1,224	41	1.7
3	(563)	(74)	(489)	(16)	(0.7)
4	(2,991)	(1,079)	(1,912)	(64)	(2.7)
5	(4,731)	(2,050)	(2,681)	(89)	(3.7)
6	#N/A	(2,223)	#N/A	#N/A	#N/A
7	#N/A	(2,491)	#N/A	#N/A	#N/A
8	#N/A	(1,624)	#N/A	#N/A	#N/A
9	#N/A	(609)	#N/A	#N/A	#N/A
10	#N/A	358	#N/A	#N/A	#N/A
11	#N/A	1,333	#N/A	#N/A	#N/A
12	#N/A	2,617	#N/A	#N/A	#N/A

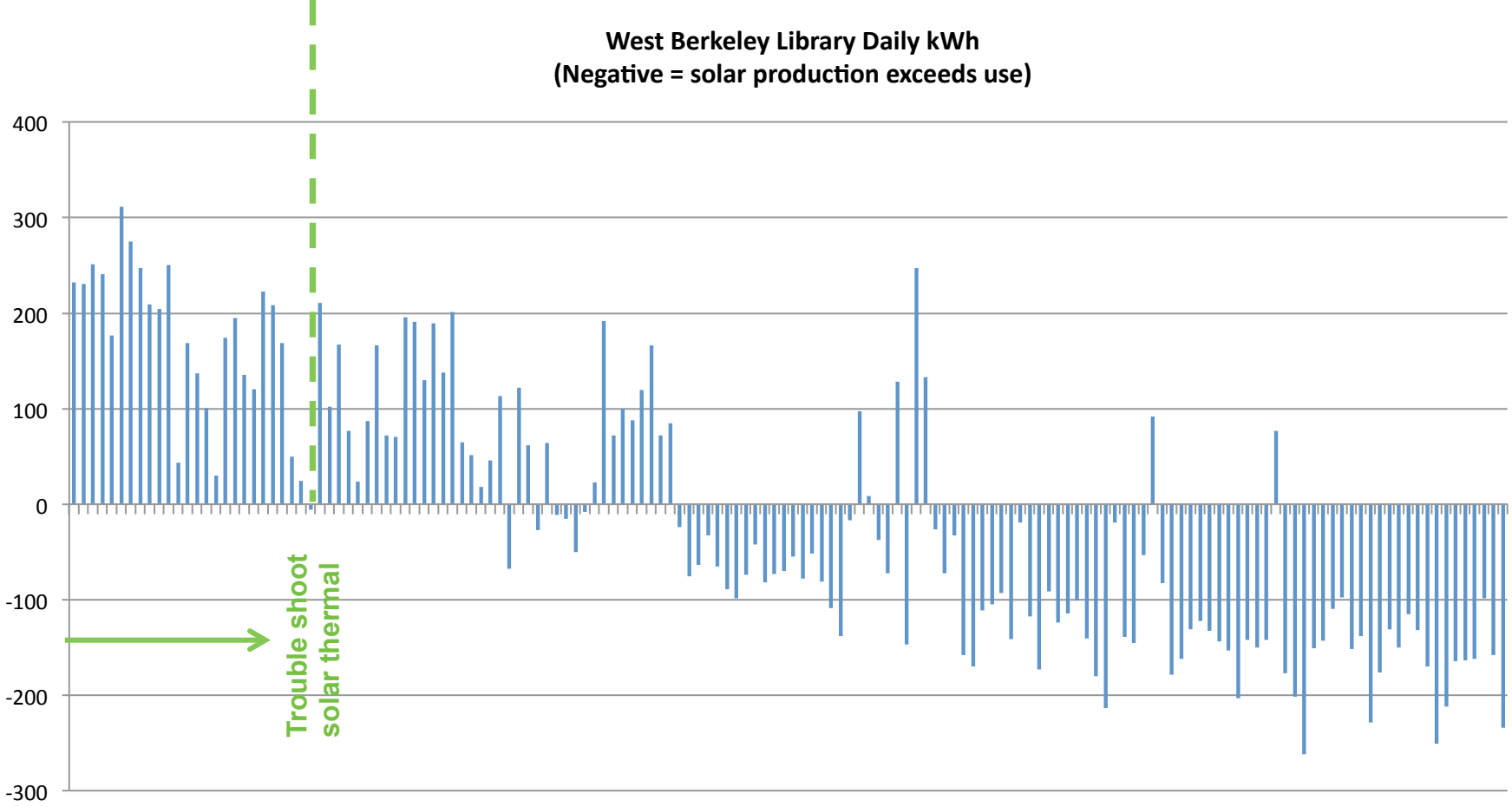
Jan-May 2014

- -1,350.18kWh

Energy Tracking

- Building appears to be on track for ZNE

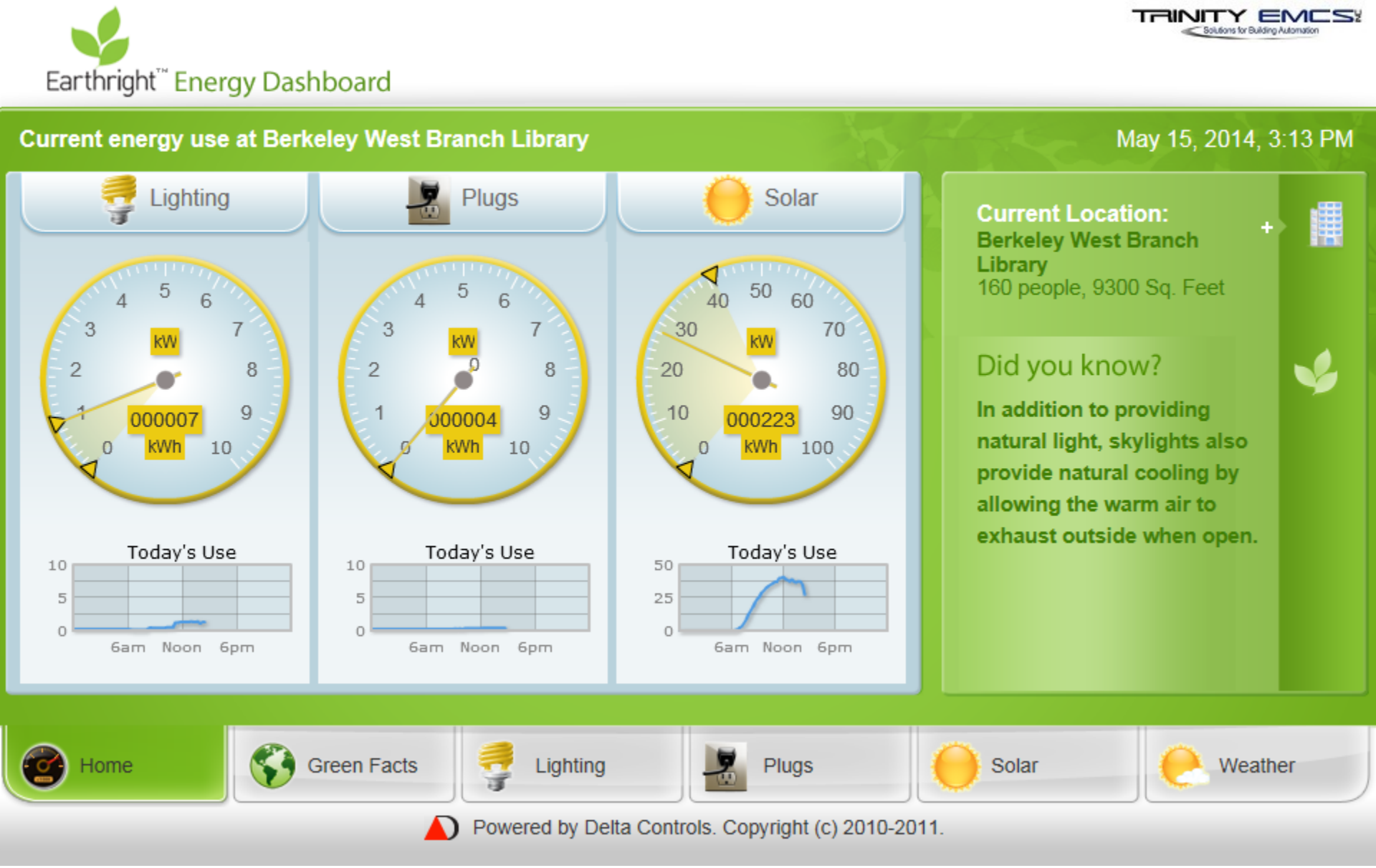
Trending Data



Energy Tracking

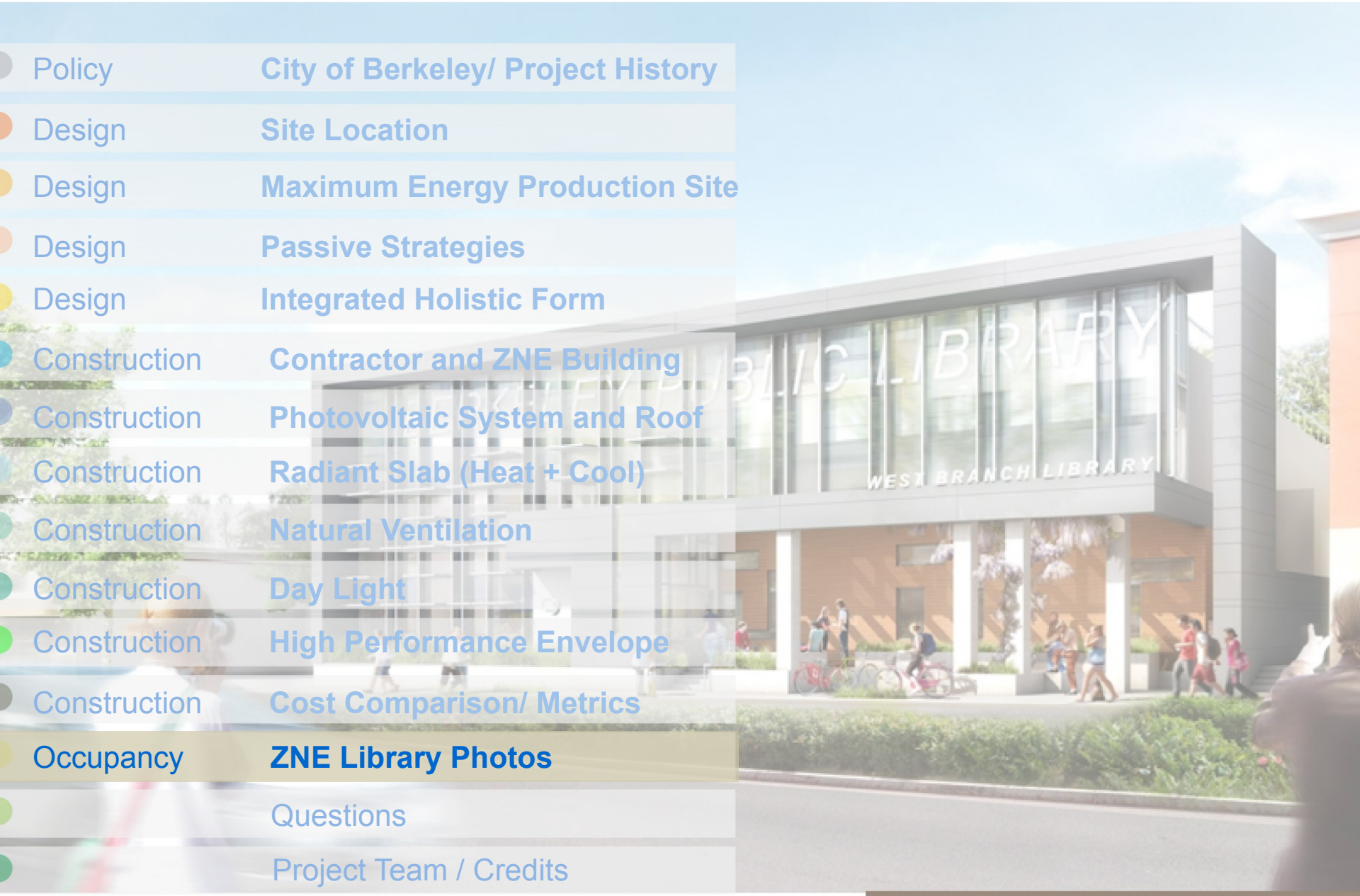
- Building appears to be on track for ZNE performance
- No flow meters

Trending Data



http://westenergy.berkeley-public.org/berkeley-west-branch-library/

Energy Dashboard



West Berkeley Library

University Avenue View

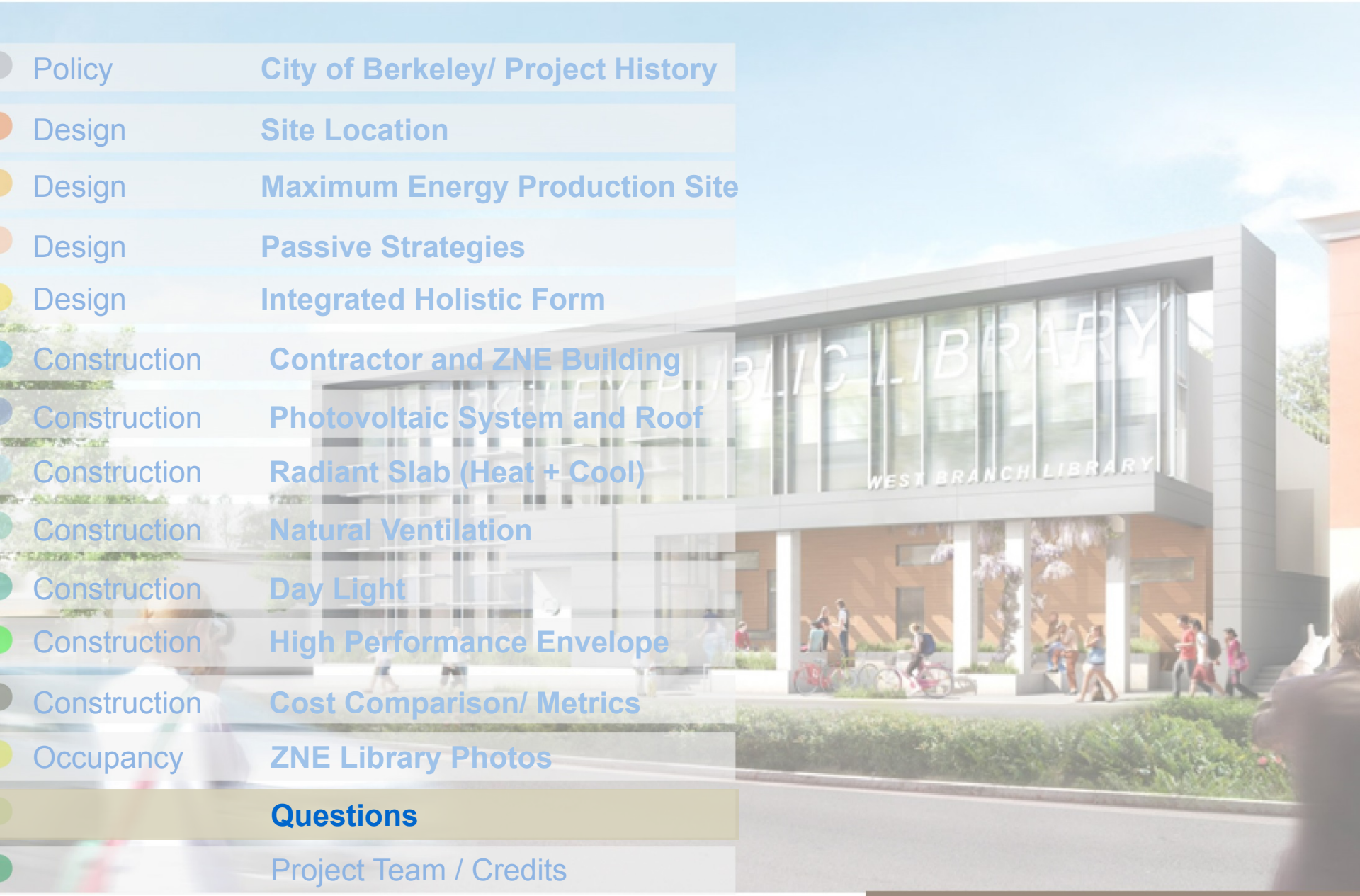

LIBRARY
1125


non-
fiction

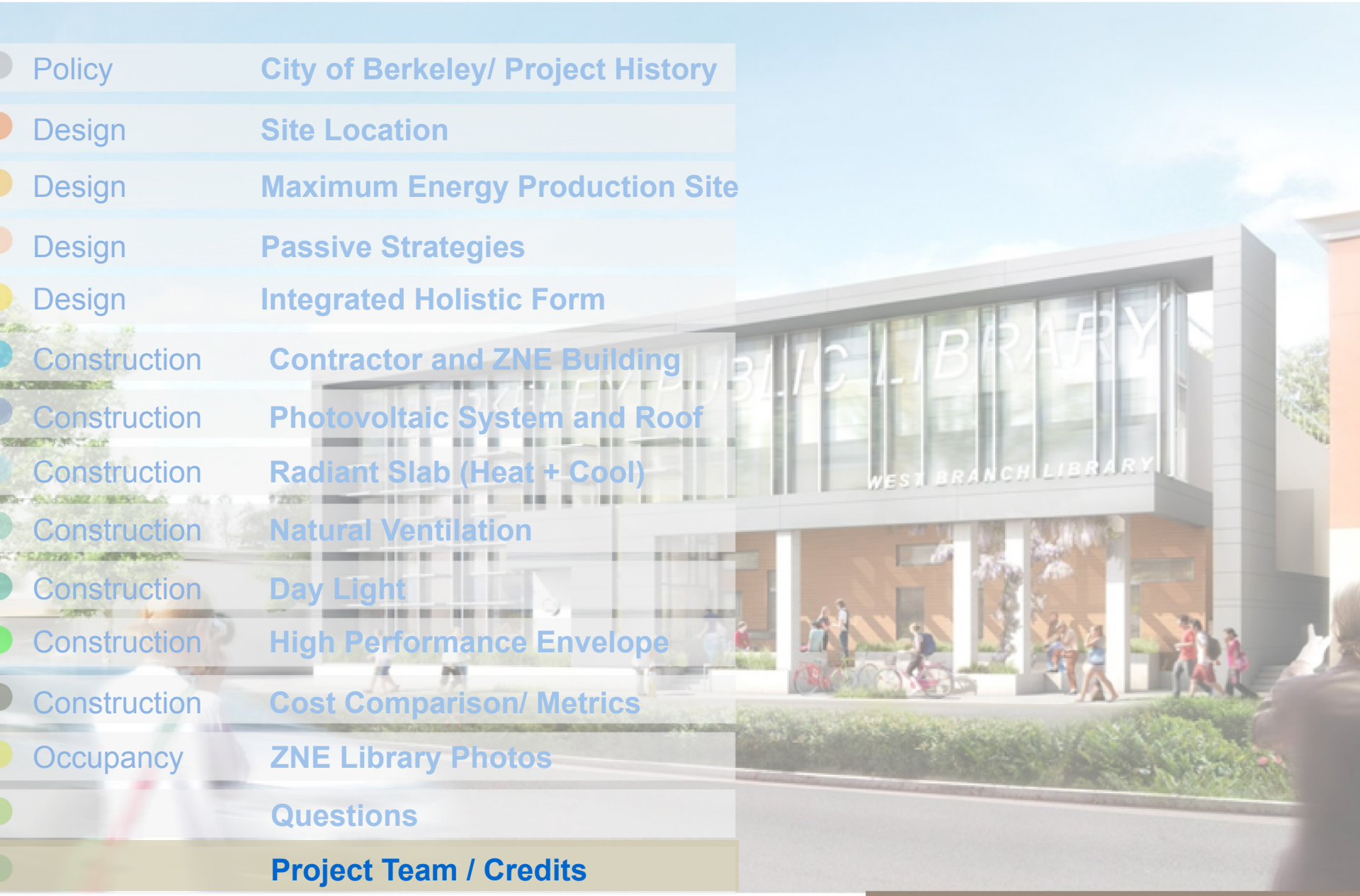

community room


children
fiction


fiction



West Berkeley Library



West Berkeley Library

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gklee@hedev.com

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Const Manager:	Kitchell CEM
Civil:	Moran Engineering
Landscape:	John Northmore Roberts and Associates
Structural:	Tipping Mar
MEP:	Timmons Design / Harley Ellis Devereaux
Sustainability:	Greenworks Studio
Audio Visual:	Smith, Fause and McDonald Inc
Contractor:	West Bay Builders