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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
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

Average kWh @ 15 min Intervals
January - May 2014

Net usage = -1,350 kWh
Building Metrics

kWh Intervals, May 1-2

- PG&E
- Delta
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)
Design
- Site Location
- Maximum Energy Production Site
- Passive Strategies
- Integrated Holistic Form

Construction
- Contractor and ZNE Building
- Photovoltaic System and Roof
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- ZNE Library Photos

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Project Team / Credits

West Berkeley Library
1/2 mile 10 min. walk
1 mile 20 min walk

West Berkeley Library

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

Insolation Analysis
Total Radiation
Value Range: 3,500,000 - 6,300,000 Btu
Solar Access – Optimum Roof Height

- **December 21**: Roof Height: 12’-0”
- **March 21**: Roof Height: 24’-0”
- **June 21**: Roof Height: 24’-0”
### Early Power Generation Models

<table>
<thead>
<tr>
<th>Photovoltaic Panel Design Power Capacity</th>
<th>235 watts/panels</th>
<th>305 watts/panel</th>
<th>435 watts/panel</th>
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<tbody>
<tr>
<td>Number of Panels</td>
<td>160</td>
<td>160</td>
<td>120</td>
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<tr>
<td>Total PV System Power Capacity</td>
<td>37.6 kW</td>
<td>48.8 kW</td>
<td>52 kW</td>
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<tr>
<td>Total Electrical Energy Delivered Per Year</td>
<td>48,880 kWh</td>
<td>63,440 kWh</td>
<td>75,596 kWh</td>
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<tr>
<td>Gross Building Conditioned Area</td>
<td>9,600 sqft</td>
<td>9,600 sqft</td>
<td>9,400 sqft</td>
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<td>Max Building EUI for a ZNE Design</td>
<td><strong>17.4 kBtu/sf-year</strong></td>
<td>22.6 kBtu/sf-year</td>
<td><strong>27.4 kBtu/sf-year</strong></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td><strong>8.4 kBtu/sf-year</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>36.1 kBtu/sf-year</strong></td>
</tr>
</tbody>
</table>

#### 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**
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
Plug Load Analysis

Baseline
Existing Building

Annual Energy Consumption (kBtu/sf)

Average kW Power Draw

West Berkeley Branch Library
Plug loads

Other Equipment (Literacy Program)
Staff Computers (Literacy Program)
Public Computers (Literacy Program)
A/V Equipment
IT Room
Other Staff Equipment (Library)
Staff Computers (Library)
Service Desk
Public Computers (Library)
Daylight Modeling

Floor Plan – Overcast Sky

JUNE 21

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

Building Section

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

Daysim was more user friendly in early design phases
94%
Area with no views

90%
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.
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

1. Thermal Chimney
2. Prevailing Wind
3. Operable Vent
4. System Fan Assist
5. Traffic Noise
6. Grille
7. High Performance Rain Screen (R30)
8. FSC Wood Trellis
9. Integral Sun Shading
10. Low Flow Planter
11. Radiant Floor - Heating - Cooling
12. FSC Wood
13. Louvers to Relief Chamber
14. Triple Glaze Low-e Curtain Wall - Acoustic Control - Solar Control
Energy Utilization Rate Comparison

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

Reduce building energy consumption before designing for renewables.
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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
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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 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!
- Coordination
- Quick turn around on RFIs/Submittals
- Be Flexible
- Work as a Team to Identify Savings and Opportunities
- Concepts that apply to all projects
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

Lessons In The Field
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
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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.
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Project Team / Credits

West Berkeley Library
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
Wind Chimney

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
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
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West Berkeley Library
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
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Occupancy
ZNE Library Photos

Questions

Project Team / Credits
- 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
- 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
- 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
DreamDex Wood Siding

- 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
Policy

City of Berkeley/ Project History

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ZNE Library Photos

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Project Team / Credits

West Berkeley Library
## Costs Comparisons - Recently Completed Libraries in California

**Date:** 5/22/2014

<table>
<thead>
<tr>
<th>Library</th>
<th>Gilroy Library*1</th>
<th>West Berkeley Library</th>
<th>Santa Monica Pico Branch Library*2</th>
<th>Berkeley Claremont Branch library *3</th>
<th>Berkeley North branch *4</th>
<th>Berkeley South Branch *5</th>
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<td>ZNE (zero net energy)</td>
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<td>Yes</td>
<td>No</td>
<td>No</td>
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<tr>
<td>LEED</td>
<td>Gold</td>
<td>Gold*</td>
<td>Platinum*</td>
<td>Silver</td>
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<td>New/ Remodel</td>
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<td>Completion Date</td>
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<td>Dec-13</td>
<td>Jun-14</td>
<td>2012</td>
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<td>Area (sf)</td>
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<td>$589.74</td>
<td>$595.96</td>
<td>$574.71</td>
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</table>

$17.59/sf premium

*1 - includes $700,000 owner related increases. There are efficiencies in larger building 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.
Energy Tracking
- Building appears to be on track for ZNE

Jan-May 2014
- -1,350.18kWh

West Berkeley Library kWh by Month

<table>
<thead>
<tr>
<th>Month</th>
<th>Usage</th>
<th>Goal</th>
<th>Difference</th>
<th>Daily Diff</th>
<th>Hourly Diff</th>
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<tbody>
<tr>
<td>1</td>
<td>4,981</td>
<td>2,487</td>
<td>2,494</td>
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<tr>
<td>2</td>
<td>2,188</td>
<td>964</td>
<td>1,224</td>
<td>41</td>
<td>1.7</td>
</tr>
<tr>
<td>3</td>
<td>(563)</td>
<td>(74 )</td>
<td>(489)</td>
<td>(16)</td>
<td>(0.7)</td>
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<tr>
<td>4</td>
<td>(2,991)</td>
<td>(1,079)</td>
<td>(1,912)</td>
<td>(64)</td>
<td>(2.7)</td>
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<td>(4,731)</td>
<td>(2,050)</td>
<td>(2,681)</td>
<td>(89)</td>
<td>(3.7)</td>
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Trending Data
Energy Tracking

- Building appears to be on track for ZNE performance
- No flow meters
Current energy use at Berkeley West Branch Library

- Lighting: 0.000007 kWh
- Plugs: 0.000004 kWh
- Solar: 0.000223 kWh

Current Location:
Berkeley West Branch Library
160 people, 9300 Sq. Feet

Did you know?
In addition to providing natural light, skylights also provide natural cooling by allowing the warm air to exhaust outside when open.

http://westenergy.berkeley-public.org/berkeley-west-branch-library/
<table>
<thead>
<tr>
<th>Policy</th>
<th>City of Berkeley/ Project History</th>
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<tr>
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<td>Passive Strategies</td>
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<td>Day Light</td>
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<tr>
<td>Construction</td>
<td>High Performance Envelope</td>
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<td>Construction</td>
<td>Cost Comparison/ Metrics</td>
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<tr>
<td>Occupancy</td>
<td>ZNE Library Photos</td>
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<td></td>
<td>Questions</td>
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**West Berkeley Library**
Architect: Harley Ellis Devereaux
360 17th Street, Suite 210
Oakland Ca 94612

Contact: Gerard Lee, AIA LEED BD+C
gklee@hedeve.com

Client: City of Berkeley
Architect: Harley Ellis Devereaux
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