ZNE or Bust, Warts and All Zero Net Energy Schools (almost)

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- What is a Zero Net Energy building (ZNE/NZE) and a near-ZEN building?
- What are the relationships between ZNE/NZE buildings and occupancy type and density, and renewable source cost and capacity?
- Can ZNE schools be appealing at the cost of everyday buildings?
- A few lessons learned from two+ schools.

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Project	Area	People	Pop. Density	kBTU/sf/yr
Base Case (code)				39-58
Putney Field House	17,000	Varies	Varies	10
Leopold Center	12,000	12	1000 sf/p	12
RSA	**77,000**	**~500**	**150 sf/p**	**14**
Richardson Elementary	81,000	550	150 sf/p	18
Lady Bird Johnson	150,000	~1000	150 sf/p	19
Fort Huachuca M.S.	**96,000**	**~600**	**150 sf/p**	**20**
HOK/Weidt Office Prototype**	150,000	~500	300 sf/p	22
iDeAs	7,000	15	470 sf/p	22
31 Tannery	42,000	~150	300 sf/p	24
NREL Golden	222,000	~750	300 sf/p	35

*** Theoretical*

Near ZNE

REDDING SCHOOL FOR THE ARTS

TRILOGY ARCHITECTURE, REDDING, CA

Efficiency Vermont BBD BETTER BUILDINGS BY DESIGN

Conference theme: NET ZERO by 2030

RSA Energy Use

Annual Total 313,000 kWh/14 kBTU/sf/yr

Disaggregated

Load	kWh/yr
Lighting	
• Main Level (9.9%)	31,000
• Upper Level (5.6%)	17,500
• Exterior (0.5%)	1,600
• Stairs & Exits (0.6%)	1,800
• LED (<.1%)	100
Base Load	
• Transformer Loss (3.2%)	10,000
• Plug, IT, circulation pump and refrigeration (40.5%)	127,000
• Cart charging (1.6%)	5,000
TOTAL (62%)	194,000 9 kBTU/sf/yr

Aggregated

Load	kWh/yr
• HVAC • Amphitheater • Computers • Projectors • Video monitors • AV systems • Night events • Cooking	123,000 5 kBTU/sf/yr (38%)

PV Output 197,000 kWh/9kBTU/sf/yr
Wind 5,000 kWh/.1kBTU/sf/yr

DIFFERENCE ~ 5kBTU/sf/yr

Reaching for ZNE

Challenge	Impact
Reduce lighting load by 1/3	1.0 kBTU/sf/yr
Reduce base load by 1/3	1.9 kBTU/sf/yr
Reduce aggregated load by 1/3	1.7 kBTU/sf/yr
Solar cart charger	0.3 kBTU/sf/yr

Obvious Opportunities

- Lights on by day
- Night lights
- Video screens in lobby
- Portable space heaters
- IR lamps for aquariums and terrariums
- Non-energy star refrigeration
- Heat pump set points
- Area IR heaters

RSA from the Southwest

RSA Entry

RSA Circulation Main Level

RSA Upper Level Circulation

Classroom Entry

Typical Classroom

Classroom View

Library

Classrooms/Amphitheater

Classrooms/Amphitheater

Successes

- Very low energy use
- Interior lighting average LPD <0.4 w/sf @ 2500 hrs/yr
- Exterior lighting <1600 kWh/yr
- Ground source heat pump system
- Shift of program space to partly conditioned or outdoor space

Could Do Better

- Better metering and disaggregation
- Lighter colors in classrooms
- Classroom footprint – more area close to daylight source
- Classroom AV – always perpendicular to light
- LED theatrical lighting
- Higher SFR in stage/classrooms
- Complete summer shut down

ZNE or Near ZNE?

ZNE

- Energy use 14 kBTU/sf/y
- PV output 306,000 kWH per year
- PV size about 180 pKW
- PV cost about $1.1 million

Near ZNE

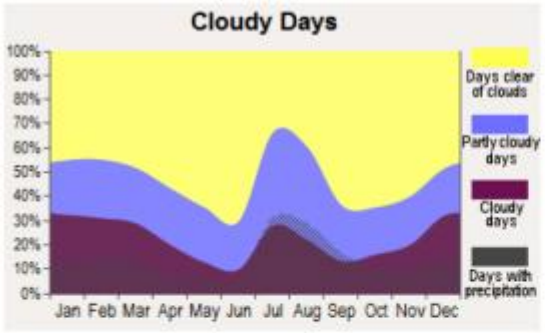
- Energy use 14 kBTU/sf/yr
- PV output 197,000 kWh per year
- PV size about 120 pKW
- PV cost about $0.6 million
- Save $0.5 million
- Energy cost per year ~$15,000 (120,000 kWh)
- Payback period >25 years from near ZNE to ZNE
- Maximum output when building is dormant

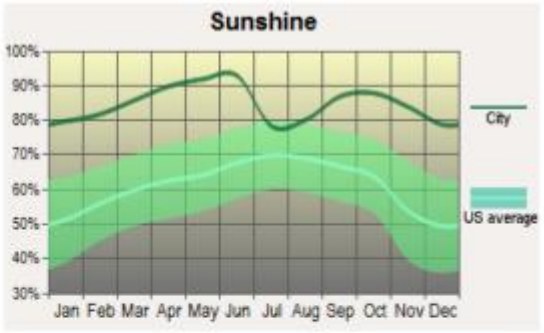
ZNE ready

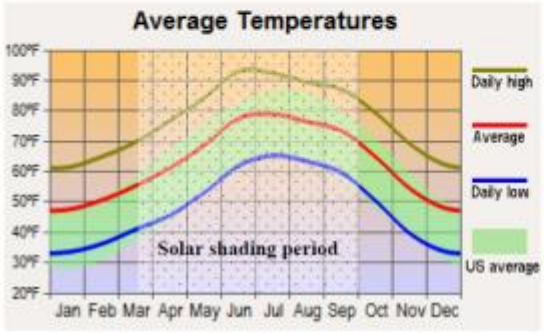
FORT HUACHUCA COLONEL SMITH MIDDLE SCHOOL

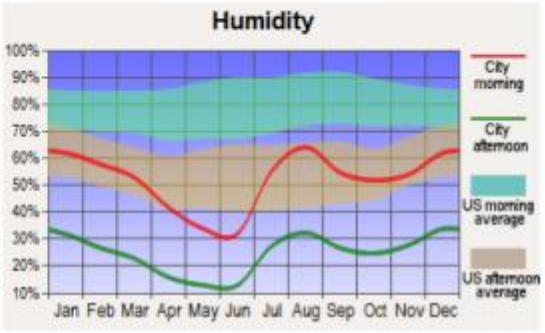
FANNING HOWEY AND EMC2, ARCHITECTS

Climate and Site Studies

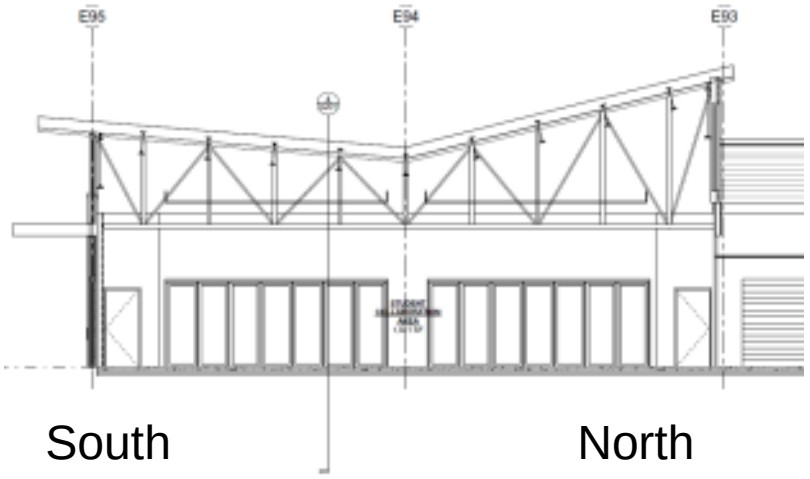


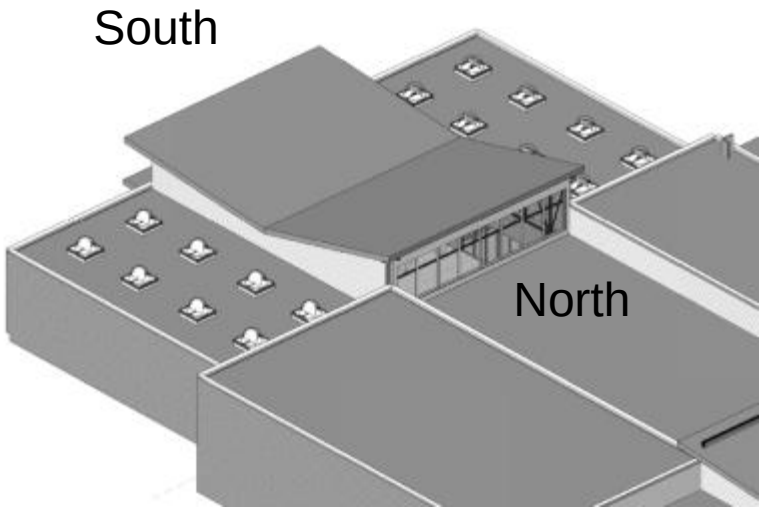






Schematic Design





Design Development

Entry North Facing (towards Cafetorium)

Entry South Facing Night and Day

Gymnasium

By night: 500 lux, 0.65 w/sf, 5 kwh/hr of lighting load, .65 w/sf of cooling load

By day: 200-1000 lux, 0.00 w/sf, 5 kwh/hr, .65 w/sf of cooling load from daylight

Classrooms

Classroom Pod

Day

- Cloudy day, 300-600 lux
- Sunny day 500-1000 lux
- Cooling load <.5 w/sf (summer)
- Passive heating > 1.5 w/sf (winter)

Night

- Light level 400-500 lux
- 0.65 w/sf lighting power
- 0.65 w/sf cooling load

Lessons Learned

- Nearly 100% daylight autonomy in regularly occupied spaces is possible
- Don’t (over) daylight spaces with part time occupancy
- Daylight factor can be less in circulation and non task spaces
- Layered daylighting (skylights + clerestories + view windows) is a good formula
- Complex lighting controls not needed if the daylighting is really good

The Prow

Site Lighting

Lessons Learned

- LED outdoor lighting can be low power and easily dimmed in any climate
- Hybrid LED lighting (warm white/amber) for dark skies
- Turn lights off most of the night
- Motion sensors can illuminate a part of a site to ward off “visitors”

Questions?

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