



Worcester North
High School



Worcester North High School

Adam Trumbour

2010 AE | CM

Introduction

Building Overview

Thesis Overview

Breadth Analysis 1: CHPS Study

Breadth Analysis 2: Green Roof

Breadth Analysis 3: Solar PV System

Conclusions

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Closing Remarks

Project At A Glance

Location: Worcester, Massachusetts

Size: 195,000 Square-Foot Educational Facility

Replacing Existing 75,000 SF Building

1,200 Students

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Project At A Glance

Guaranteed Maximum Price: \$54 Million

Duration: 29 Months

April 2009 – September 2011

CM-at-Risk: Gilbane Building Co.



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Overview: Thesis Efforts

Common Thread: Sustainability

How can this building's efficiency be improved?

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How can this building's efficiency be improved?

Analyses:

I. CHPS Rating (Collaborative for High-Performance Schools)

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- I. CHPS Rating (Collaborative for High-Performance Schools)
- II. Green Roof



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- II. Green Roof
- III. Solar PV System



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Analyses:

- I. CHPS Rating (Collaborative for High-Performance Schools)
- II. Green Roof
- III. Solar PV System
- IV. LED Luminaire Implementation



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III. Solar PV System

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CHPS Study: Probing Questions

How do CHPS and/or LEED affect the construction industry and building process?

What can be done to improve the quality and efficiency of the rating system?

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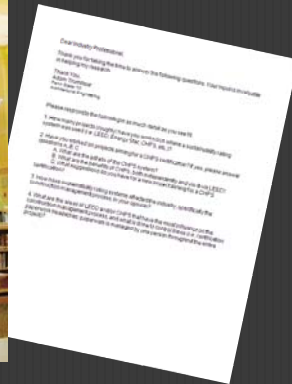
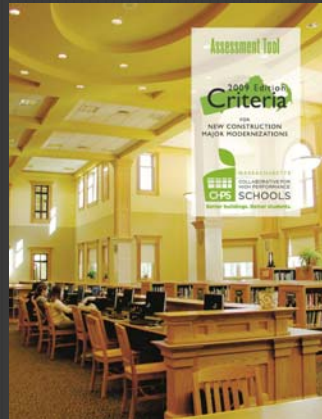
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CHPS Study: Research Methods

- Personal review of the rating system
- Surveys of professionals



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CHPS Study: Background

- Established in California, 1999
- Region-specific programs in 11 states
CA, WA, NY, MA, ME, NH, VT, CT, RI, CO, TX
- Over 225 organizations are currently members
(Schools, Utilities, Design firms, etc.)

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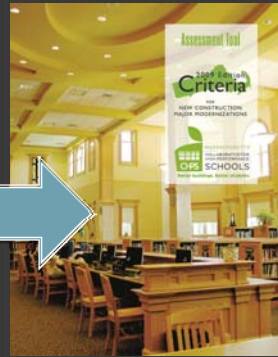
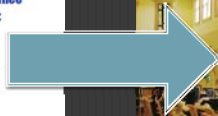
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CHPS Study: Background

Massachusetts:

- Version 1.0 in 2006
- Version 2009 second and current version
- Standard for all new schools in Massachusetts
- 23 Prerequisite credits
- 125 possible points:
 - + Minimum of 40 points to be "Verified"
 - + Minimum of 50 points to be "Verified Leader"



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Category	ID	Title
STRATEGY		Integration and Innovation
	II.P1	Integrated Design
	II.P2	Educational Display
DESIGN		Indoor Environmental Quality
	EQ.P1	HVAC Design - ASHRAE 62.1
	EQ.P2	Construction IAQ Management
	EQ.P3	Pollutant and Chemical Source Control
	EQ.P4	Moisture Management
	EQ.P5	Minimum Filtration
	EQ.P6	Thermal Comfort - ASHRAE 55
	EQ.P7	View Windows, 70%
	EQ.P8	Eliminate Glare
	EQ.P9	Minimum Acoustical Performance
EQ.P10	Minimum Low Emitting Materials	
DESIGN		Energy
	EE.P1	Minimum Energy Performance, 20%
	EE.P2	Commissioning
EE.P3	Facility Staff & Occupant Training	
DESIGN		Water
	WE.P1	Irrigation System Performance on Recreational Fields
WE.P2	Indoor Water Use Reduction, 20%	
DESIGN		Site
SS.P1	Joint Use of Facilities and Parks	
DESIGN		Materials & Waste Management
	MW.P1	Storage and Collection of Recyclables
MW.P2	Minimum Construction Site Waste Management, 75%	
PERFORMANCE		Operations and Maintenance
	OM.P1	Maintenance Plan
	OM.P2	Anti-Idling Measures
OM.P3	Green Cleaning	

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CHPS Study: Findings

- LEED difficult on limited budgets
- Closer relationships: CM, Designers, Owner
- CHPS is a smaller organization than LEED
- Need for lessons learned database
- No drastic change to CM by CHPS
- North High School will be CHPS Verified



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CHPS Study: Recommendations

- CHPS is better for MA schools than LEED
- Need for training professionals in CHPS
- Create lessons-learned database for CHPS projects
- Increase capabilities of regional offices
- Glean input from students and administration

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Green Roof Study: Intent

Evaluate the implementation of a green roof on North

High school, considering structural effects.

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Green Roof Study: Background

- Reduced storm water runoff
- Reduced heat-island effects
- Increased aesthetic quality
- Increased life of roof membrane
- Incremental addition to roof R-value
- Possible addition to CHPS score



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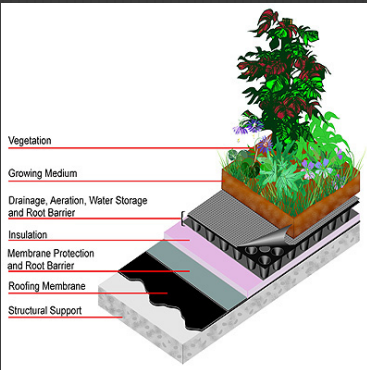
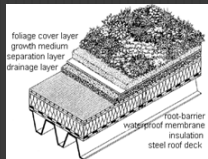
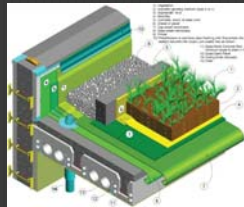
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Green Roof Study: Analysis Method

1. **Research available green roof systems**
2. Assemble weight data
3. Choose most economical option
4. Evaluate structural capacity



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Green Roof Study: Analysis Method

1. Research available green roof systems
2. **Assemble weight data**
3. Choose most economical option
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Manufacturer	Size	Soil Depth	Saturated Weight
Roofscapes Roofmeadow	No module size (mat-type)	3" – 5"	20 – 34 PSF
ZinCo	No module size (mat-type)	4.5"	22 PSF
Hydrotech USA	No module size (mat-type)	2" – 6"	17 – 41 PSF
GreenGrid	2' x 2', 2' x 4', 1.5' x 2'	4"	18 – 25 PSF
LiveRoof	1' x 2'	4" – 4.25"	15 – 29 PSF
Barrett Company	No module size (mat-type)		21 PSF

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GreenGrid	2' x 2', 2' x 4', 1.5' x 2'	4"	18 – 25 PSF
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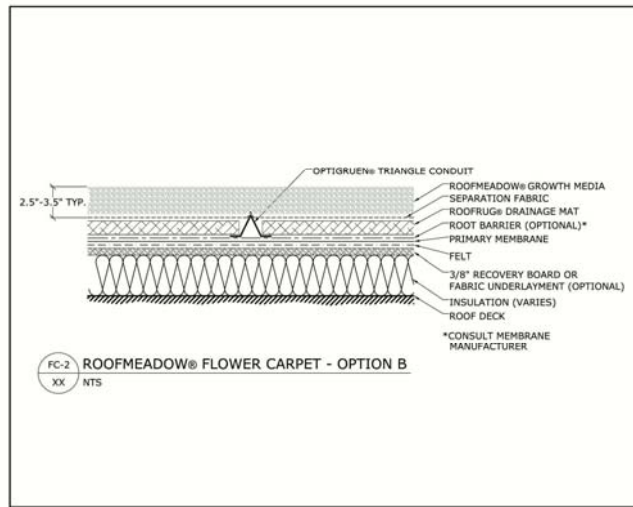
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Green Roof Study: Findings

- Extensive roof appropriate option
- Minimum 15 PSF, Maximum 41 PSF
- Use 3" system with 23 PSF rating
- Maximum area is 51,000 SF
- Maximum moment, shear and deflection within allowable limits
- Added cost: \$522,750
- No schedule delay; not on critical path



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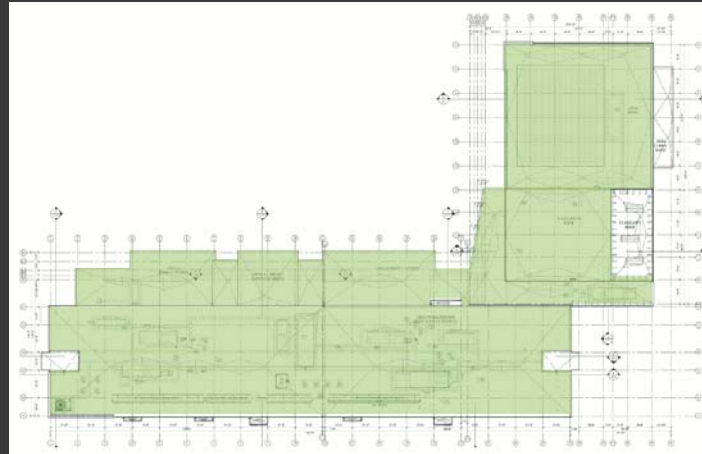
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Green Roof Study: Recommendation

- Install green roof
- Use Roofscapes™ assembly: Primarily sedum
- 51,000 square-feet will cost \$522,750
- Cost may be recouped after 50 year maintenance is deferred
- 1 Point addition to CHPS score



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Solar PV: Intent

Design a roof mounted solar photovoltaic system,
meeting the given \$250,000 allowance.

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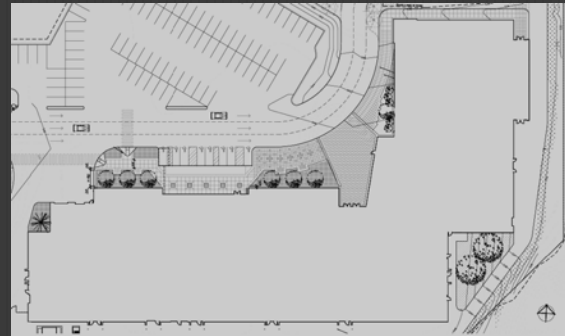
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Solar PV: Background

- \$250,000 allowance in budget, unused
- System has the ability to provide sustainable power to North High School
- Potential credit to CHPS score
- System design is project-specific



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Solar PV: Method

1. Research system types and components, costs

2. Design 2 options:

Meet full \$250,000 allowance

Fill allotted roof space

3. Calculate Payback

Source	Cost per Watt	Source	Average Cost per Watt
Estimation Cost Data		Newspaper Articles	\$5.46
RSMeans 2009 Cost Data	\$11.70	Online Estimates	\$6.02
Newspaper Articles		Cold Call	\$8.00
Alteris Renewables	\$5.87	Total Average:	\$5.98
Ostrow Electric	\$5.39		
Fall River Electrical Associates	\$4.72		
Waterline Industries, Corp.	\$5.86		
Online Estimation Tools			
BP Solar Estimator:	\$6.00		
Solar-Estimate.org:	\$6.03		
Cold Calls			
Zapotec Solar	\$8.00		

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Solar PV: Method

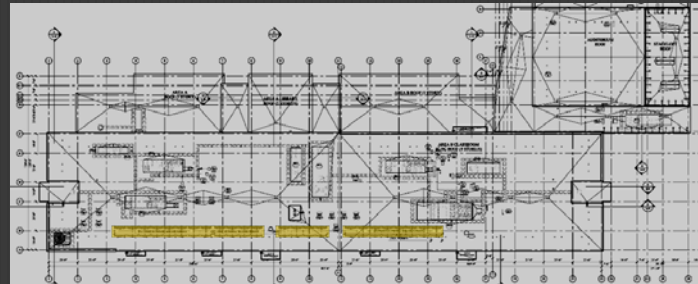
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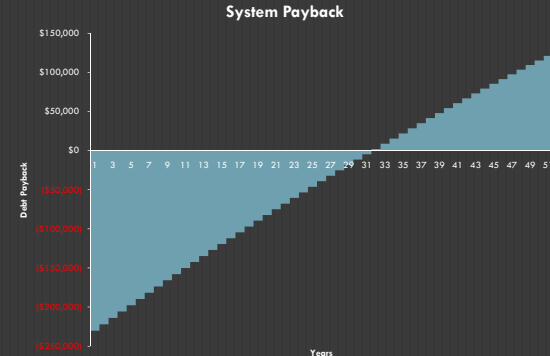
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Solar PV: \$250,000 System

Maximum Power: 38,640 Watts (38.64 kW)

(3) 12.88kW arrays comprise the 38.64 kW system:

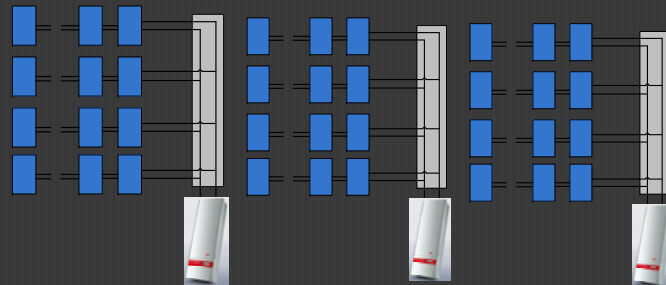
Solar Panels: (56) BP Solar 3230T, 230W each

Inverter: (1) Fronius IG Plus, 13.8 kW

Combiner Box: (1) SMA SBCB-6

Wiring: (4) Strings in Parallel
(1) string = 14 panels in series

Area Required: 3,000 Square Feet



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Solar PV: 600 SF of Roof Space

Maximum Power: 7,590 Watts (7.59 kW)

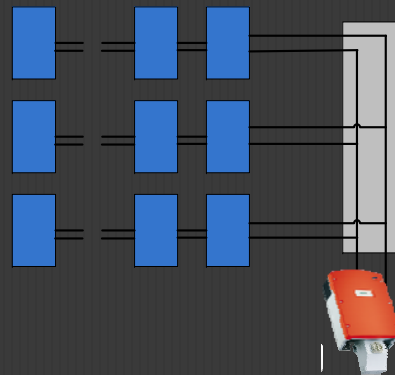
Solar Panels: (33) BP Solar 3230T, 230W each

Inverter: (1) SMA Sunny Boy SB7000US, 8.75 kW

Combiner Box: (1) SMA SBCB-6

Wiring : (3) Strings in Parallel
(1) String = 11 panels wired in series

Area Required: 592.68 Square Feet



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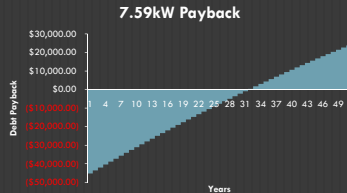
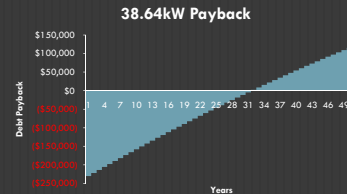
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Solar PV: Recommendation

- Both systems show a payback of 31 years (cash financing)
- Implement smaller array to reduce structural impact
- Implement larger array if funds are available and gymnasium can support array
- Up to 5 credits added by PV system



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CHPS

- Good regional system for schools
- Needs improvement in knowledge transfer

Green Roof

- Feasible with current roof and 23 PSF assembly
- Cost: \$ 522,750
- Could pay itself back in 50 years

Solar PV System

- Two options for owner
- Both pay back after 31 years
- Acts as a learning tool for students

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Lessons Learned

- Good input is hard to get!
- More research is needed on the effects of sustainability ratings on the construction management process.
- “Greening” a typical building produces large benefits; making a green building greener presents incremental benefits .
- Payback is not as immediate as you’d think.
- Great learning experience.

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Questions?

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