Green Gauges

A design methodology at Williams College

Learning Outcomes:

- Outline the Green Gauges framework and describe how it organizes complex design and sustainability information into a simple structure that can be communicated to leadership.
- Calculate and compare the carbon savings of specific design strategies and establish an acceptable savings and cost threshold.
- Define and contrast site and source energy use and its implications for carbon reductions.
- Discuss how to make informed decisions within the context of carbon reduction master planning.

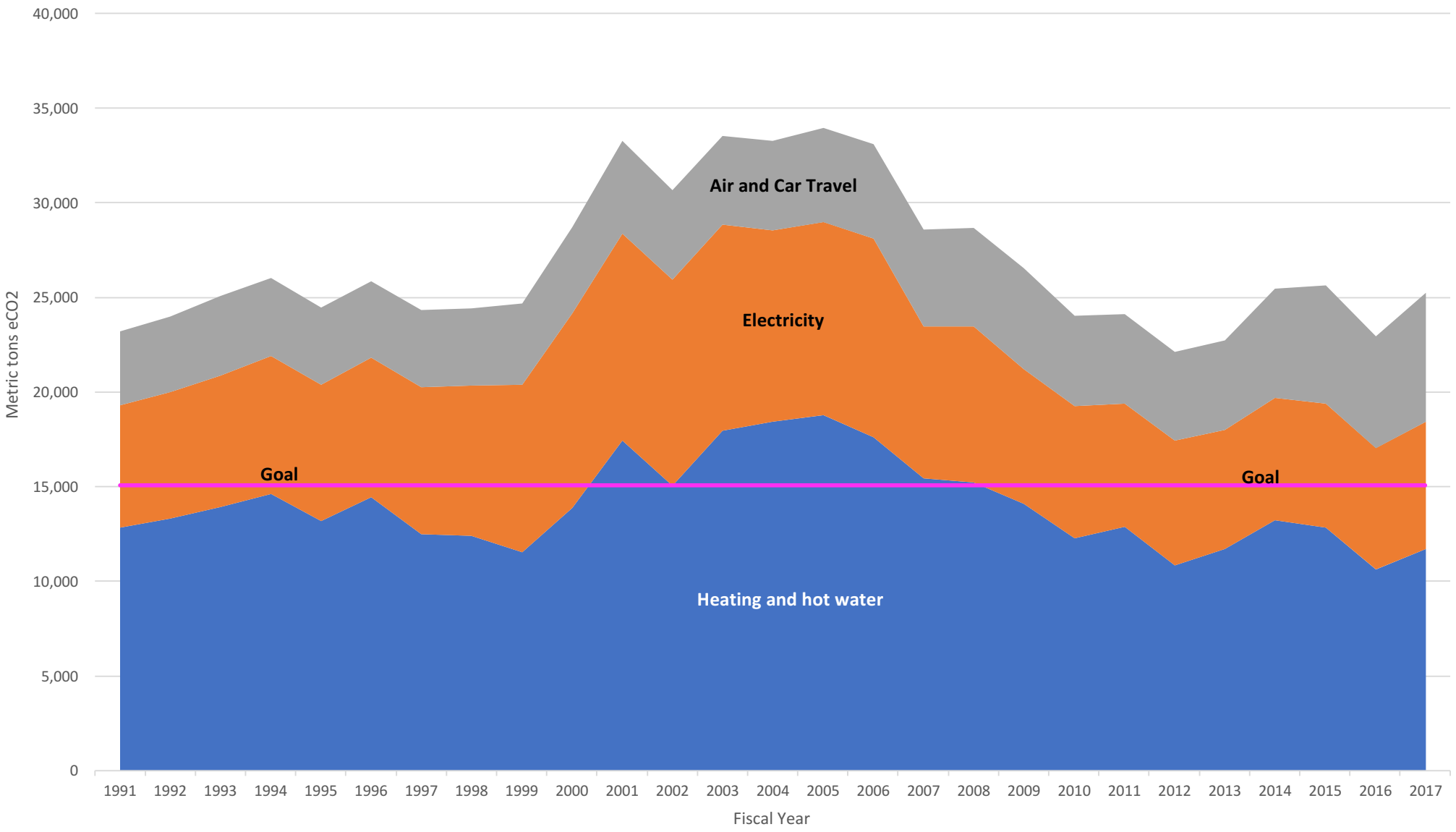
Who's in the audience?

Schedule:

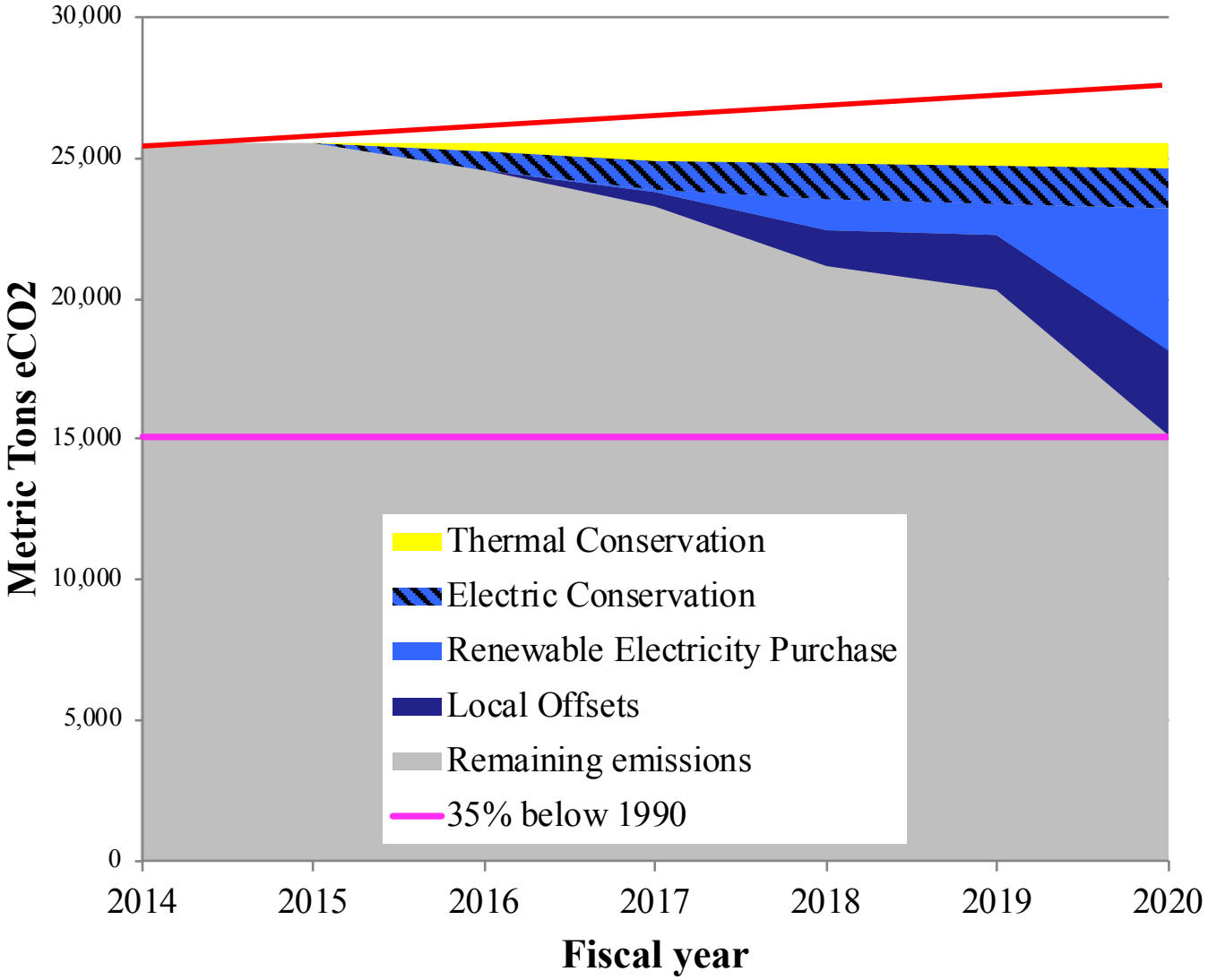
10 minutes	Amy	Introduction -Carbon Goals & Reductions to date
5	Tom	Green Gauges framework
5	Amy	Energy Use Intensity (EUI) Targets & Exemplars
20	Tom	Examples of Current and Ongoing project results
10	Amy	Site vs. Source EUI and Carbon
10		Wrap up and questions

Williams College

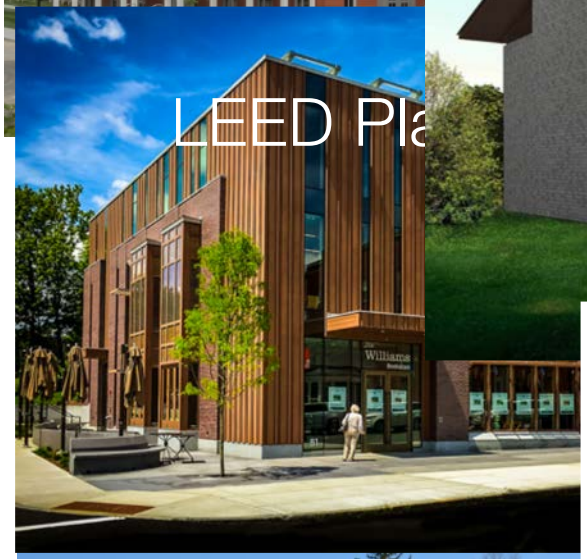
- Founded 1793
- 2000 undergraduates
- 110 buildings
- $2 billion endowment
- First GHG reduction goals in 2007
- Additional goals in 2010

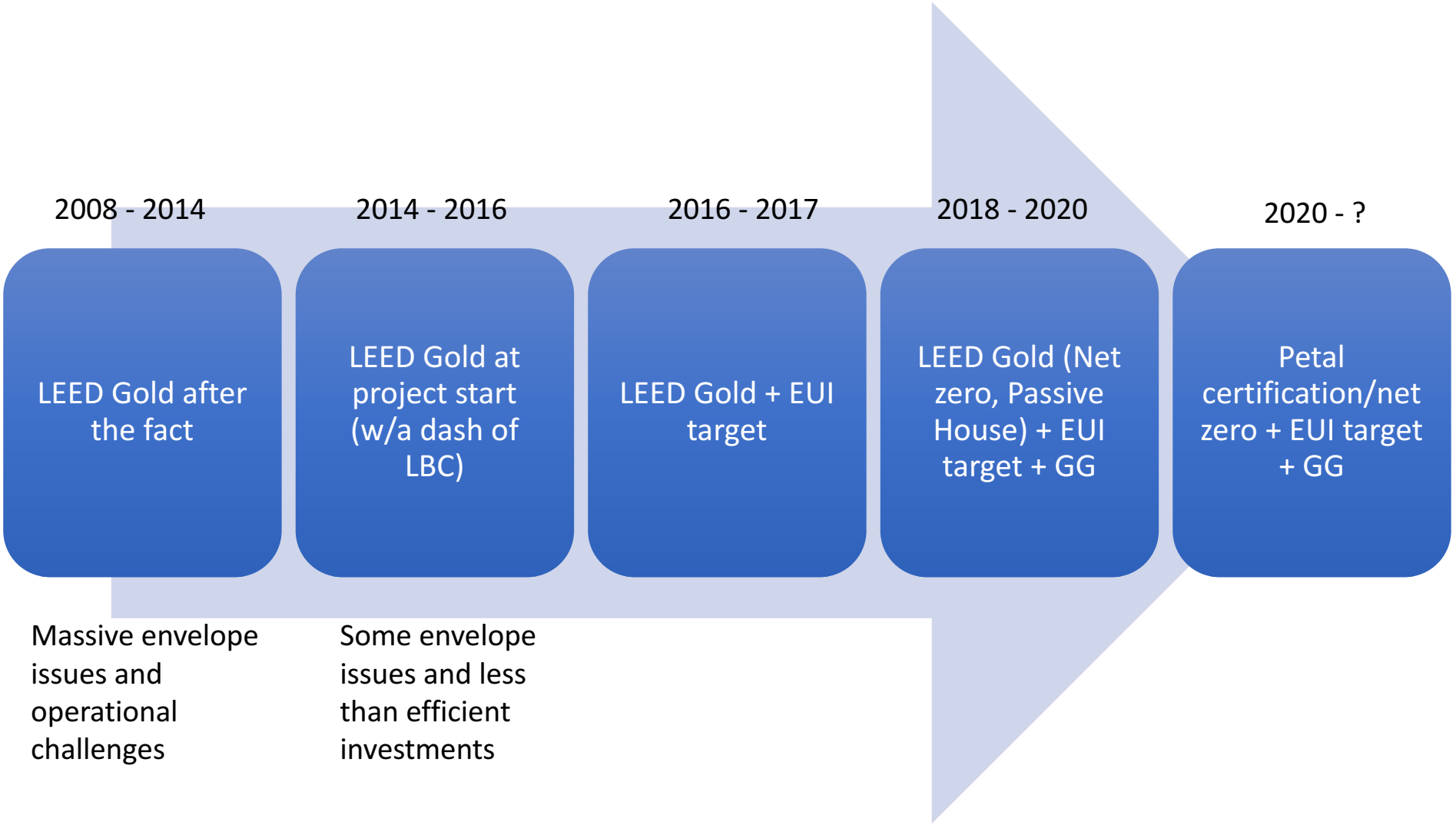


Williams College Emissions by Scope


30,000
25,000
20,000
15,000
10,000
5,000
0
Metric Tons eCO2
2014
2015
2016
2017
2018
2019
2020
Fiscal year
Thermal Conservation
Electric Conservation
Renewable Electricity Purchase
Local Offsets
Remaining emissions
35% below 1990

High performance buildings are important – but what are we getting for our investment?




2008 - 2014
2014 - 2016
2016 - 2017
2018 - 2020
2020 - ?
LEED Gold after the fact
LEED Gold at project start (w/a dash of LBC)
LEED Gold + EUI target
LEED Gold (Net zero, Passive House) + EUI target + GG
Petal certification/net zero + EUI target + GG
Massive envelope issues and operational challenges
Some envelope issues and less than efficient investments

What to measure?

- Incremental cost of high performance
- Benefit: carbon reduction
- Benefit: Energy cost savings
- Benefit: Operational cost savings

What's the baseline?

Site? Source? Lifetime? Annual?

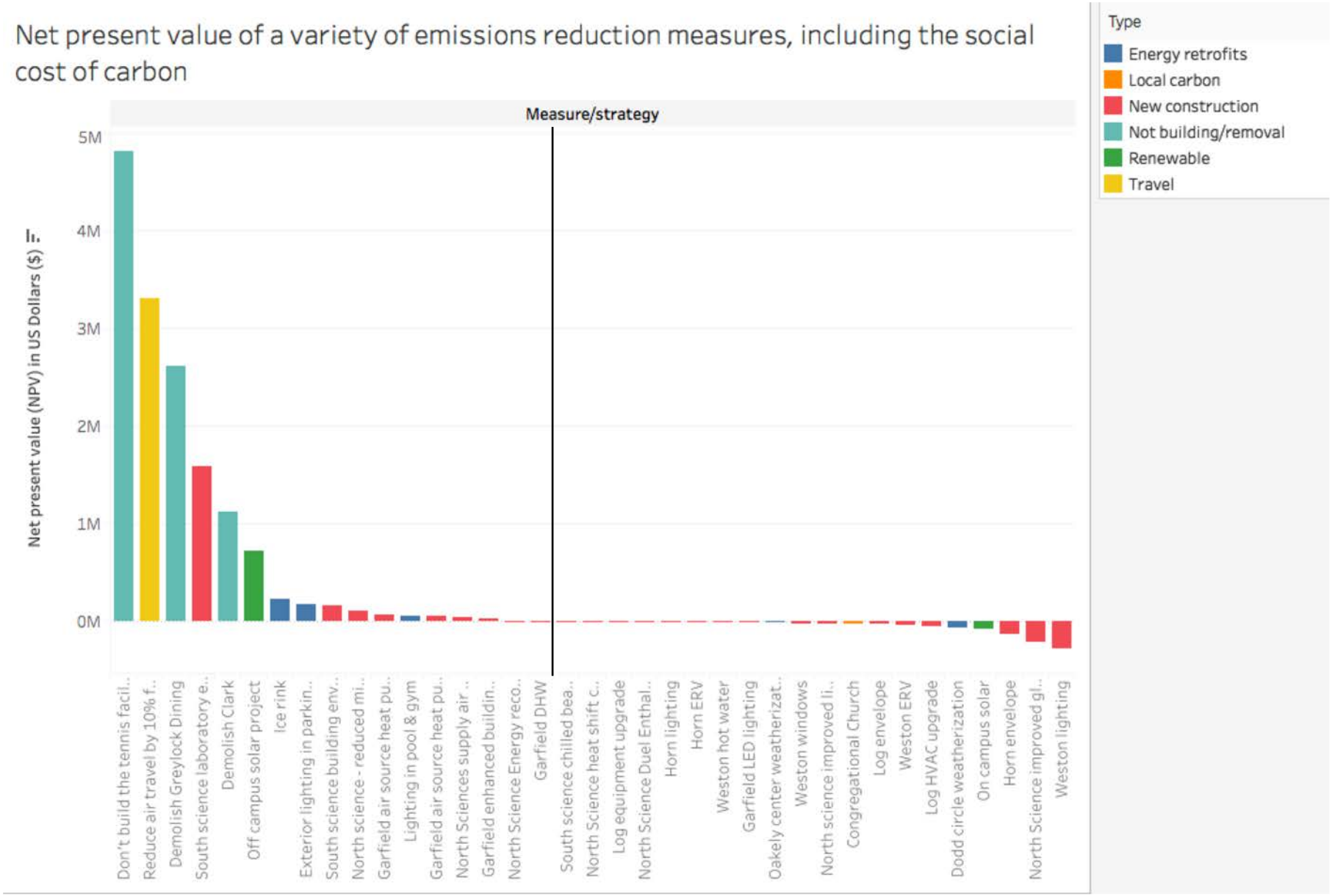
See above – what's the baseline?

- Then combine somehow into a unified metric!

Annual carbon/incremental cost?
Lifetime carbon/incremental cost?
Net present value/incremental cost?
??????

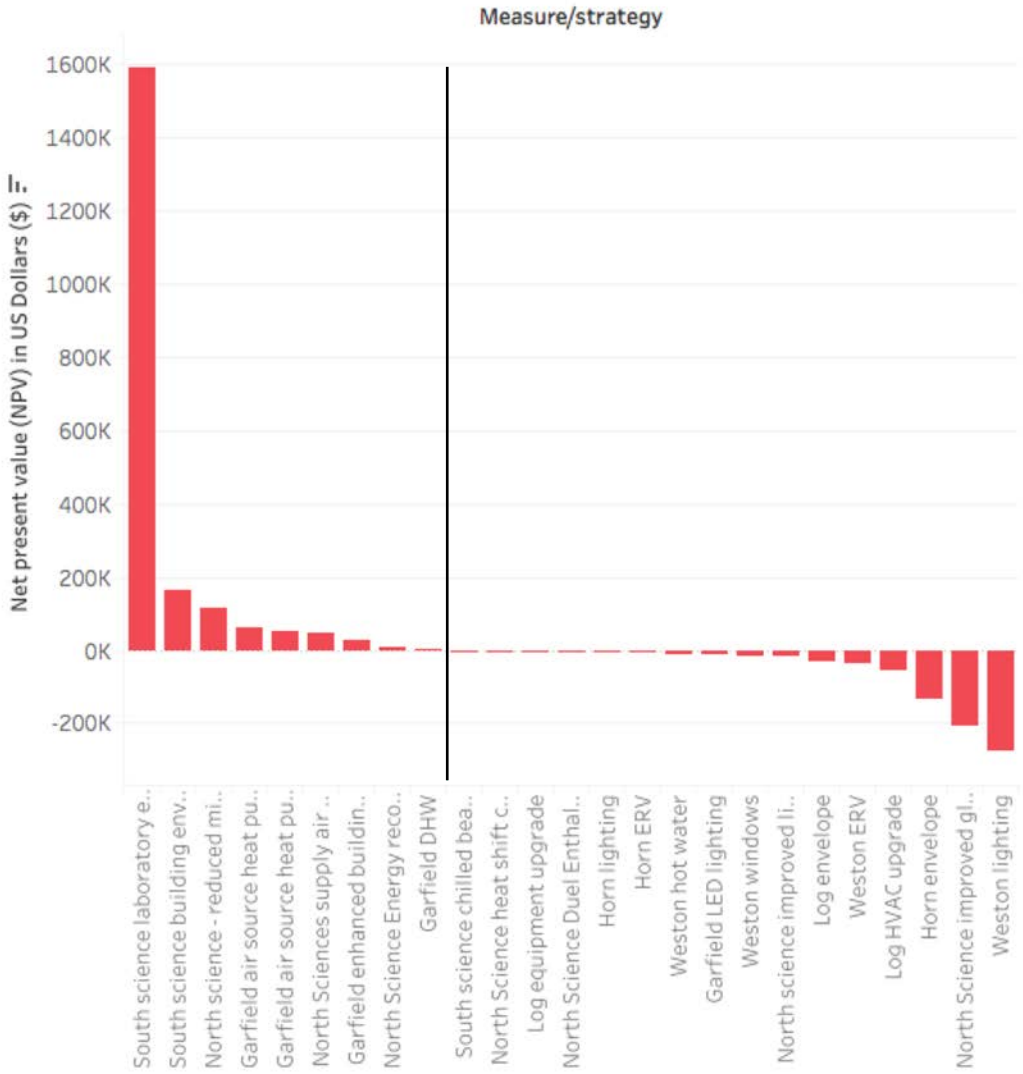
- ~~Easy, right?~~

Fun, though.

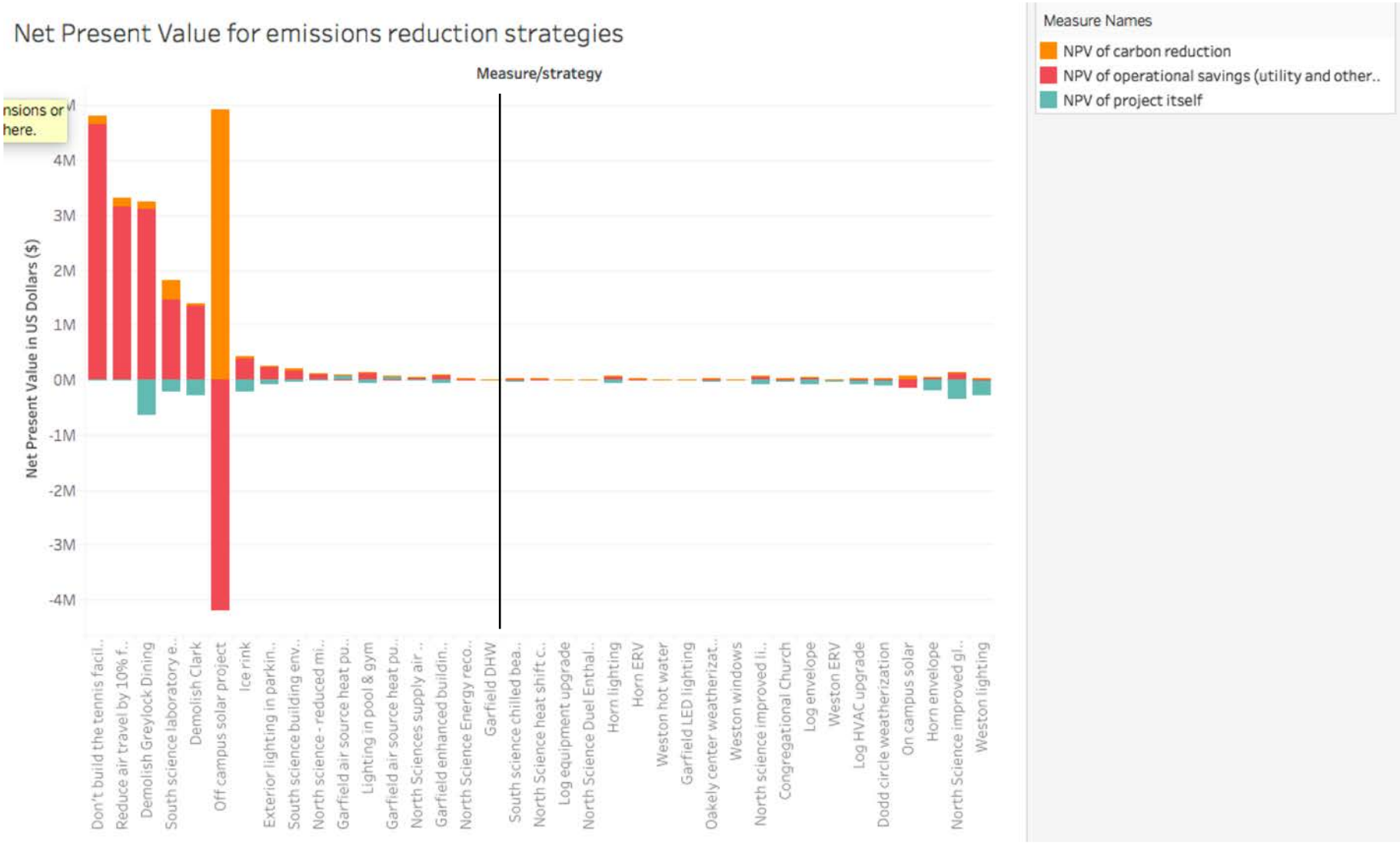


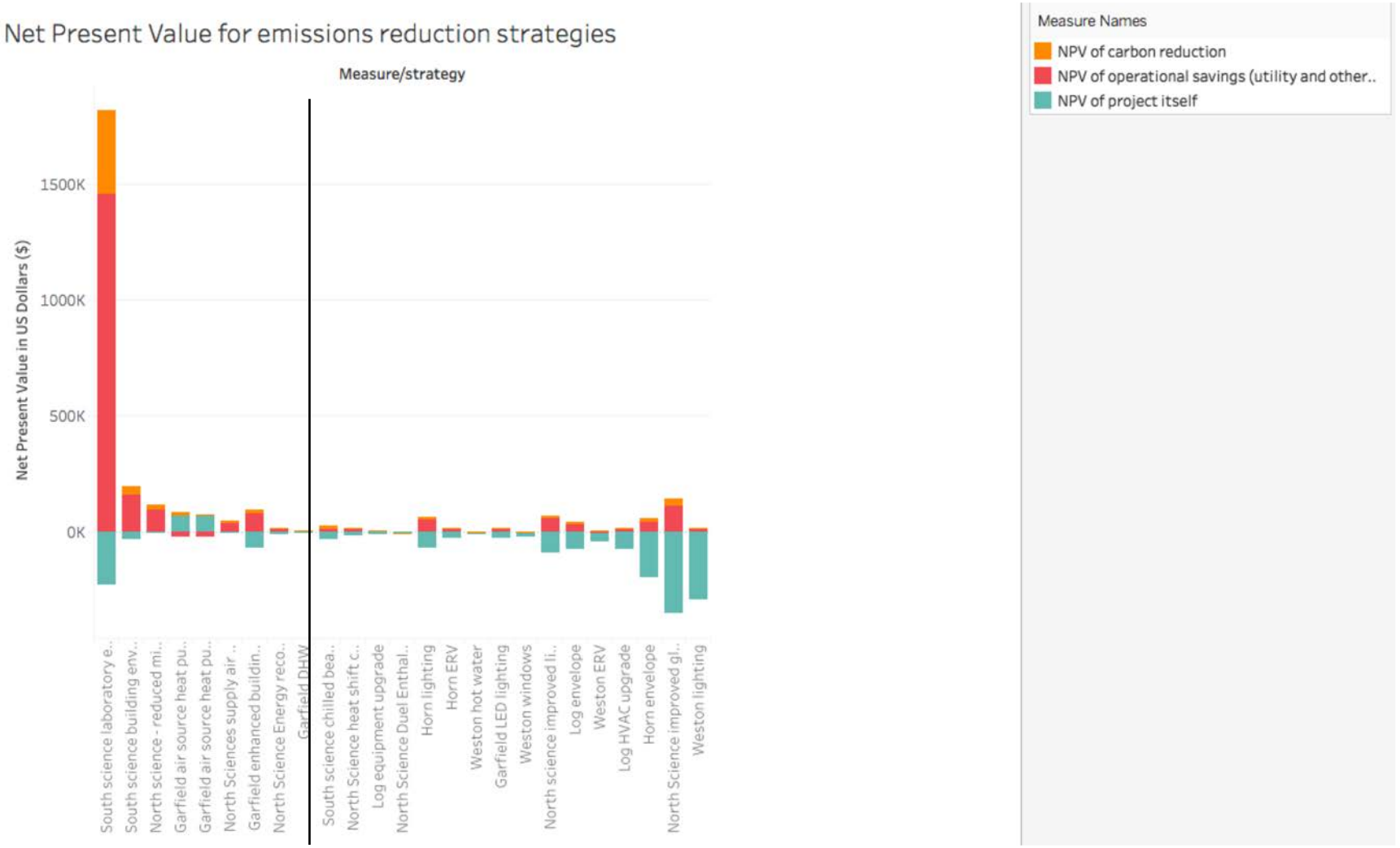
NPV including avoided social costs

Net present value of a variety of emissions reduction measures, including the social cost of carbon



NPV including avoided social costs


Net Present Value for emissions reduction strategies
Measure/strategy
Net Present Value in US Dollars ($)
4M
3M
2M
1M
0M
-1M
-2M
-3M
-4M
Don't build the tennis facil..
Reduce air travel by 10% f..
Demolish Greylock Dining
South science laboratory e..
Demolish Clark
Off campus solar project
Ice rink
Exterior lighting in parkin..
South science building env..
North science - reduced mi..
Garfield air source heat pu..
Lighting in pool & gym
Garfield air source heat pu..
North Sciences supply air ..
Garfield enhanced buildin..
North Science Energy reco..
Garfield DHW
South science chilled bea..
North Science heat shift c..
Log equipment upgrade
North Science Duel Enthal..
Horn lighting
Horn ERV
Weston hot water
Garfield LED lighting
Oakely center weatherizat..
Weston windows
North science improved li..
Congregational Church
Log envelope
Weston ERV
Log HVAC upgrade
Dodd circle weatherization
On campus solar
Horn envelope
North Science improved gl..
Weston lighting
Measure Names
NPV of carbon reduction
NPV of operational savings (utility and other..
NPV of project itself


Net Present Value for emissions reduction strategies
Measure/strategy
Net Present Value in US Dollars ($)
1500K
1000K
500K
0K
South science laboratory e..
South science building env..
North science - reduced mi..
Garfield air source heat pu..
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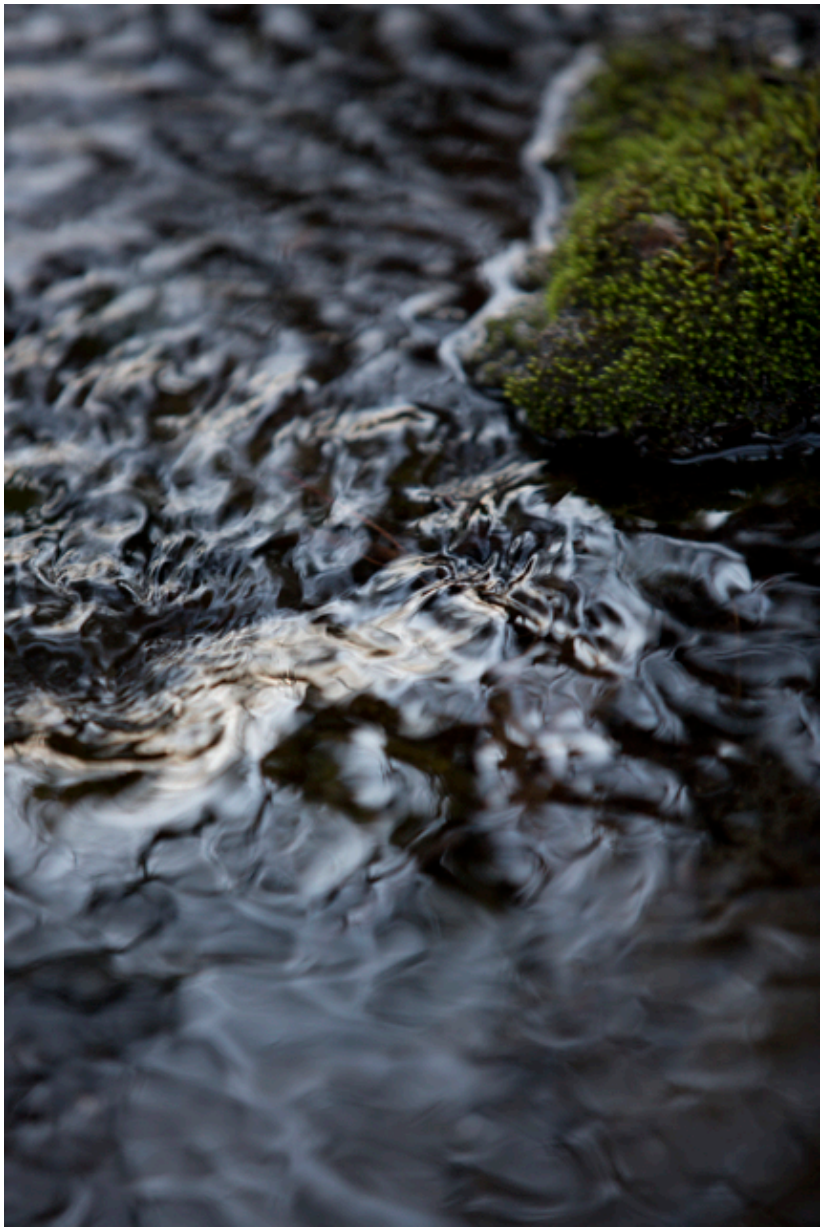


T- Biophilic moment- *all photos courtesy of Ethan Drinker Photography*

In the context of carbon reductions,

three questions are being asked:

1. What specifically is the College doing?
2. What does it cost?
3. What are the savings? ($ and CO2e)

The effort has been named Green Gauges:

gauge *|gāj|* *- an instrument or device for measuring the magnitude, amount, or contents of something, typically with a visual display of such information*

GREEN GAUGES

Green Gauges is a guided process developed by Williams College to communicate fundamental information about a project's green building characteristics. This process is employed in addition to—and interwoven with—the standard practice of architectural design and documentation.

The first part of Green Gauges allows the Design Team and Owner to evaluate various options early in the design phase, and make informed decisions as they relate to the Owner's cost and sustainability objectives. The next part of the process tracks the results of the built systems, to see whether the building is performing as intended.

Six contractual deliverables are required during design and construction. Each deliverable communicates specific information from the Design Team to the Owner about the fundamental building strategies being developed, and how those strategies impact cost, energy and operational carbon. The review of the deliverable by the Design Team and Owner provides the opportunity to evaluate key information, make decisions, and attain approval for the project's next steps.

The goal of Green Gauges is to help institutions clearly understand the measurable effectiveness of sustainable building strategies.

The information generated by the process shows what particular systems and approaches are being considered to achieve a sustainable building, and answers the basic questions:

"What does it cost?"
and
"What does it save?"

DELIVERABLE	WHEN DUE
1: ESTABLISH PROJECT GOALS FOR ENERGY USE	10% SCHEMATIC
2: SYSTEMS AND METERING NARRATIVE	30% SCHEMATIC
3: VALUE ASSESSMENT	25% DESIGN DEVELOPMENT
4: METERING DIAGRAM	50% DESIGN DEVELOPMENT
5: OCCUPANCY MONITORING NARRATIVE	CONSTRUCTION COMPLETION
6: VERIFICATION	11 & 18 MONTHS POST-OCCUPANCY

DELIVERABLE 1

ESTABLISH PROJECT GOALS FOR ENERGY USE

WHEN Occurs at 10% of Schematic Design

WHAT Define target Energy Use Intensity (EUI) for the building, and compare with similar building types to consider the feasibility of carbon reduction potential.

(See attached example)

WHY To make sure that the energy goals are appropriate to the building type (ie science lab versus dormitory) and that they are achievable.

DELIVERABLE 2

SYSTEMS AND METERING NARRATIVE

WHEN Occurs at 30% of Schematic Design

WHAT Provide clear, simple written descriptions of:

A) The proposed conceptual systems being considered for:

Site, envelope, active systems (MEP),passive systems, indoor air quality, resilient design, water, generation/off-sets, occupancy, monitoring, construction

B) The strategy for installing meters and collecting data.

Narrative will be reviewed by: Users, Operations, Commissioning Agents, and Contractor. Owner will then review and comment on each description, providing modification or approval of each strategy and/or system prior to the completion of Schematic Design.

(See attached example & template)

WHY To get early feedback from various stakeholders (Owners, Operations, Maintenance Staff) about the functionality, cost effectiveness, and carbon reduction of the strategies being proposed by the Design Team.

DELIVERABLE 3

VALUE ASSESSMENT

WHEN Occurs at 25% of Design Development

WHAT Identify primary building strategies to reduce energy and carbon use, and quantify how much these strategies cost & how much energy they save.

Together with the Owner, identify discrete design elements from the above strategies to be compared in terms of cost by the Design Team's cost estimator.

(See attached example & template)

WHY Provide clear summary of how much each option saves versus how much it costs, so that the Owner can decide where to spend their money to get the greatest energy return on their investment.

Green Gauges- Summary narrative

DELIVERABLE	WHEN DUE
1: ESTABLISH PROJECT GOALS FOR ENERGY USE	10% SCHEMATIC
2: SYSTEMS AND METERING NARRATIVE	30% SCHEMATIC
3: VALUE ASSESSMENT	25% DESIGN DEVELOPMENT
4: METERING DIAGRAM	50% DESIGN DEVELOPMENT
5: OCCUPANCY MONITORING NARRATIVE	CONSTRUCTION COMPLETION
6: VERIFICATION	11 & 18 MONTHS POST-OCCUPANCY

What is Green Gauges and Why?

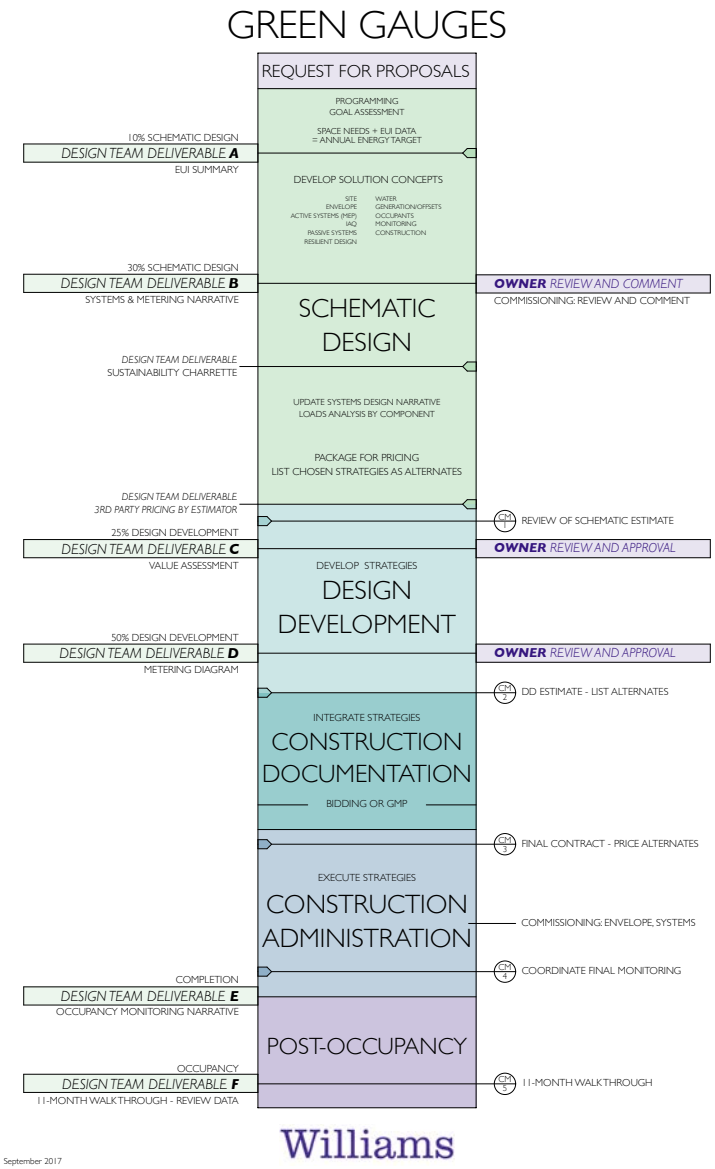


Diagram- overall

A- Biophilic moment

What is the BASELINE and What is the GOAL?

BASELINE

Peer group Baseline is LEED Silver (not energy specific)
Williams Baseline is MA Stretch Code

GOAL

- LEED GOLD or better
- 15-20% better than the Stretch Code (now IECC – 2015)
- Target EUI
- 35% campus wide carbon emission reduction of 1990 levels by 2020

*ENERGY USE INTENSITY or **EUI***

The total amount of energy used in the course of a year expressed in kbtu/sf.

at Williams, this value is NOT offset by renewables

EUI projections (kBtu/sf/year)

DELIVERABLE 1

ESTABLISH PROJECT GOALS FOR ENERGY USE

WHEN Occurs at 10% of Schematic Design

WHAT Define target Energy Use Intensity (EUI) for the building, and compare with similar building types to consider the feasibility of carbon reduction potential.

(See attached example)

WHY To make sure that the energy goals are appropriate to the building type (ie science lab versus dormitory) and that they are achievable.

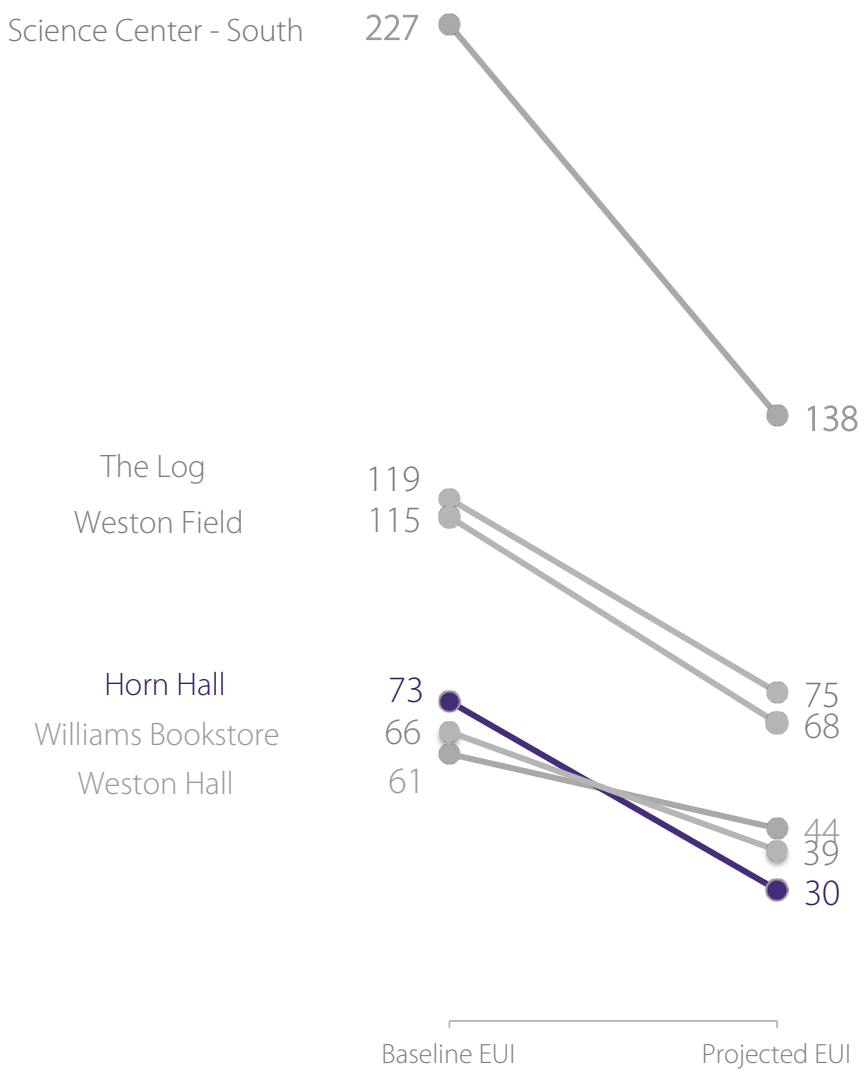
Project EUI- Code verses design in past projects

Williams

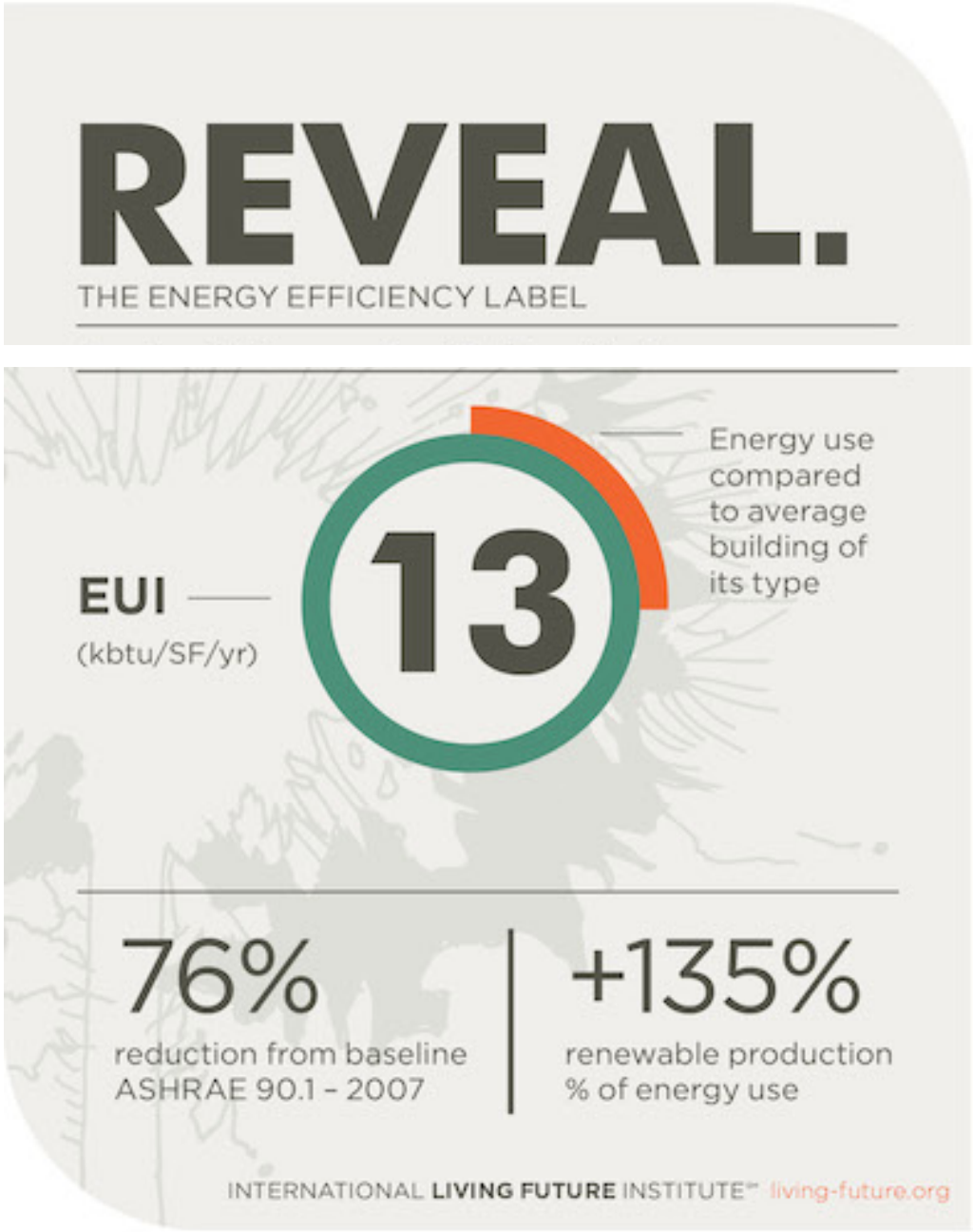
Green Gauges

EUI projections (kBtu/sf/year)

c&h architects



Project EUI- Code verses design in past projects



(EUI)- as reported by LBC, not 2030 Challenge

To be updated with yearly tracking rates	Conversion Factors				
					EUI
Property SDude	Property Address		Sq. Ft	Total Kbtu	Kbtu/SF/Yr
ABC House-58 Hoxey St.	58	Hoxsey Street	5,651	308,275.97	54.55
Bascom House-UD	33	Stetson Court	11,400	556,181.47	48.79
Bernhard Music Center-UD	54	Chapin Hall Drive	22,520	1,727,813.52	76.72
Brinsmade House-UD	71	Stetson Court	2,304	142,788.72	61.97
Bronfman Science Center-UD	18	Hoxsey Street	90,698	22,262,140.75	245.45
Chandler Athletic Center-UD	34	Spring Street	87,001	8,668,048.68	99.63
Chapin Hall-UD	62	Chapin Hall Drive	22,244	3,336,298.66	149.99
Childrens Center-UD	44	Whitman Street	9,300	550,476.83	59.19
Clark Hall-UD	947	Main Street	13,680	879,496.25	64.29
Class of 37 House/Childrens Center-UD	51	Park Street	5,863	306,585.43	52.29
Cole Field House-UD	85	Stetson Road	16,099	875,195.82	54.36
CTD-UD	1000	Main Street	106,000	10,238,950.58	96.59
Denison Gate House-UD	7	Denison Park Drive	2,526	197,429.02	78.16
Dropper House-UD	15	Park Street	1,496	164,186.11	109.75
Facilities	60	Latham Street	26,914	1,479,277.03	54.96
Griffin Hall-UD	844	Main Street	12,998	1,129,192.62	86.87
Hardy House-UD	20	Morley Drive	8,314	312,745.54	37.62
Hollander Hall	24	Hopkins Hall Drive	57,842	2,536,534.35	43.85
Hopkins Forest-UD	271	Northwest Hill Road	8,628	410,903.80	47.62
Hopkins Hall-UD	880	Main Street	43,700	2,335,256.82	53.44
Hopkins Observatory	829	Main Street	850	190,578.32	224.21
Jenness House-UD	10	Morley Drive	3,924	352,221.86	89.76

Existing campus EUI – **SITE** by type

Building Type	Existing EUI from 2016 campus EUI chart	Goal EUI	Sources of Site Energy Goals
Dormitory [1]	77	30	College of the Atlantic Dorm village, EUI=27, 50 beds 20,500 sq.ft.
Dormitory with AC		35	Putney School Gray Dorm DER modeling EUI=20, same building modeled to code EUI=48, 2 floors 30 occupants wood frame bldg
Houses (small dorms under 15 beds)	58	20	Waterfront Apartmens, 4 floors, 42 units, 45k sq.ft. EUI measured = 24
			Houses range of 20 to 35
Administrative	84	35	South Village small office project, EUI=33 and Mcalay offices EUI=29, very small office
Classrooms		50	Oakes Hall, Vt Law School, EUI=35 (22 if had ASHP)
Science [3]	235	138	138 based on model for Williams South Building
Sports	62	30	Putney School, Field House (14k sq.ft., light occupancy, sport facility, 60--ish avg temp) EUI=14
Dining Halls	151	120	Proctor Academy first year 88 kBtu/sq.ft.-yr

Exemplar EUI – **SITE** by type

WILLIAMS INN SCHEMATIC DESIGN | BENCHMARKING | BENCHMARKS AND TARGETS

BENCHMARK TARGETS

These graphs show how the Benchmarking Analysis described on the previous pages compares against other industry values.

The source of information for the existing Williams Inn in based on 2013 Utilities provided by Williams College.

The Benchmarking analysis shows that the current target of 60 kbtu/sf for the project is roughly 45% better than the existing Inn and about 37% better than existing buildings of comparable program.

For comparison, LEED and Architecture 2030 Targets are also shown. Since LEED uses energy costs instead of EUI, some approximation is necessary to provide a comparable target. Since LEED does not have a specific energy target, what is shown is the likely range of energy performance that will be required in order to achieve the desired level of LEED Gold (using the 2009 version of the Rating System).

Architecture 2030 uses the CBECS baseline and seeks to achieve Carbon Neutral design relative to 2003 CBECS data by the year 2030 though increasing savings year over year. The current goal is 70% reduction, or an EUI of approximately 29 relative to the program-weighted EUI.

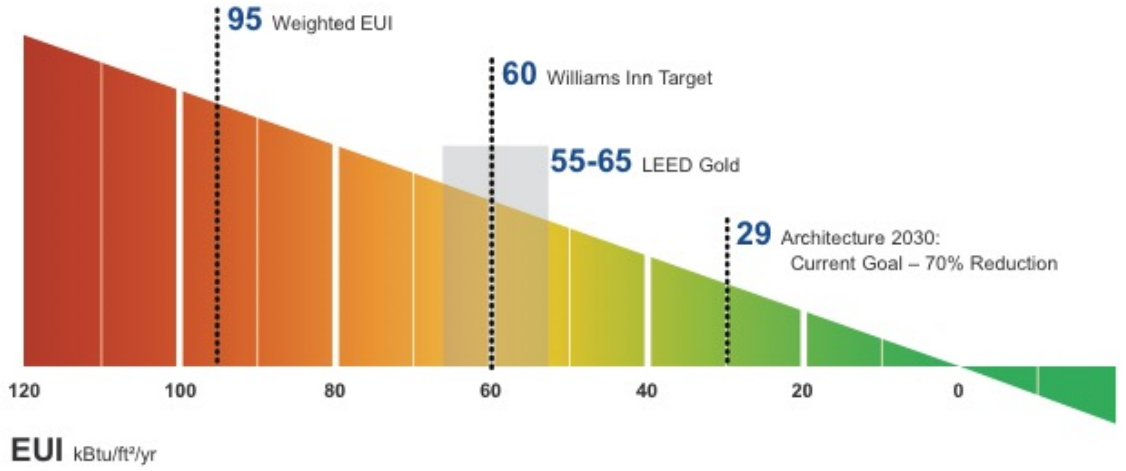
The above Benchmarking exercise therefore suggests that the current target of 60 kbtu/sf represents a moderately aggressive, yet realistic target.

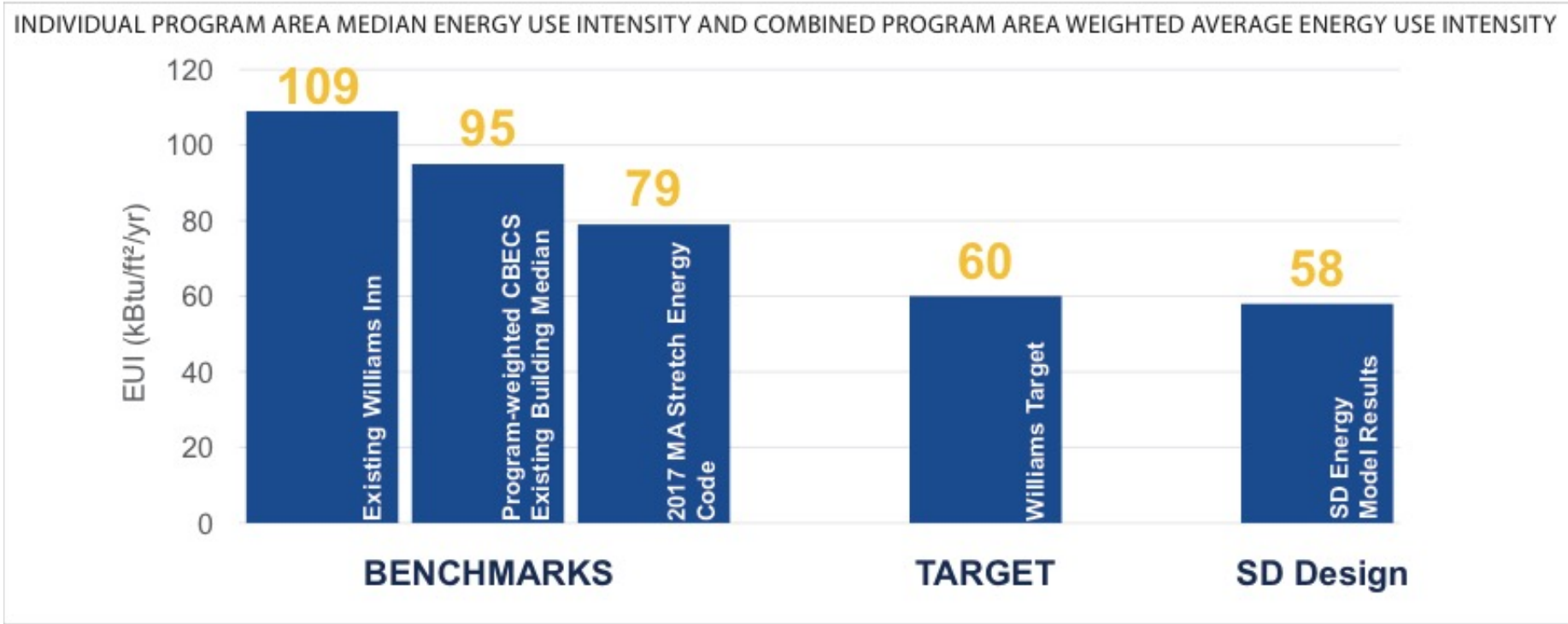
In addition to the EUI target and LEED Gold, the project is also required to meet the MA Stretch Energy Code.

The next sections of the report outlines strategies to achieve these targets.

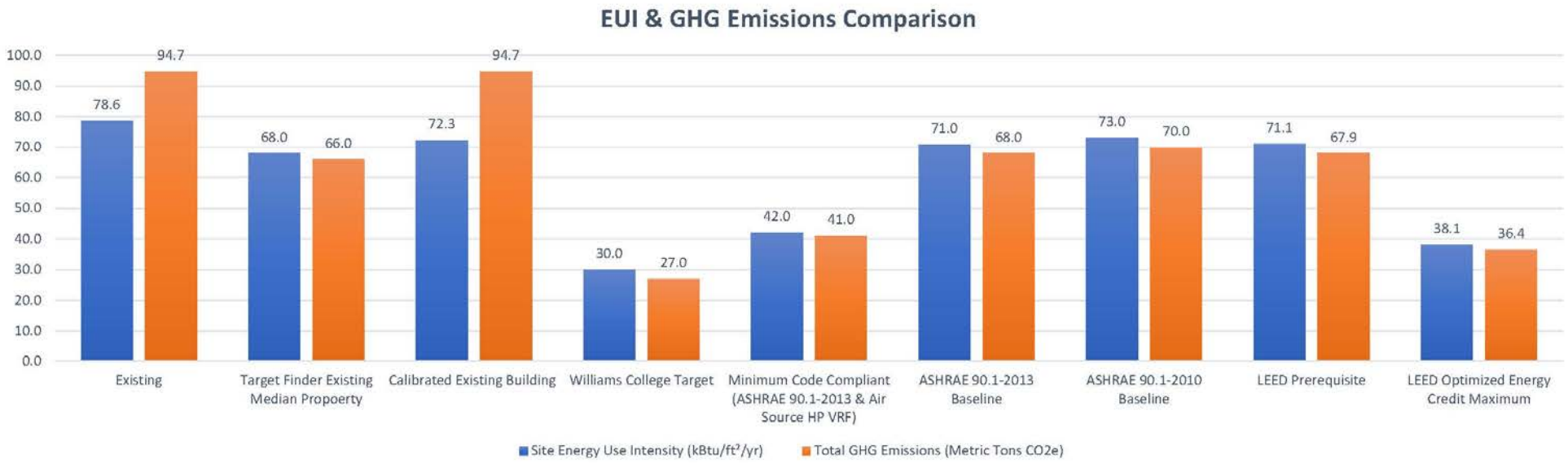
EUI BENCHMARKING EXISTING WILLIAMS INN, MEDIANS AND CURRENT TARGET

EUI BENCHMARKING COMPARISON, LEED GOLD AND ARCHITECTURE 2030

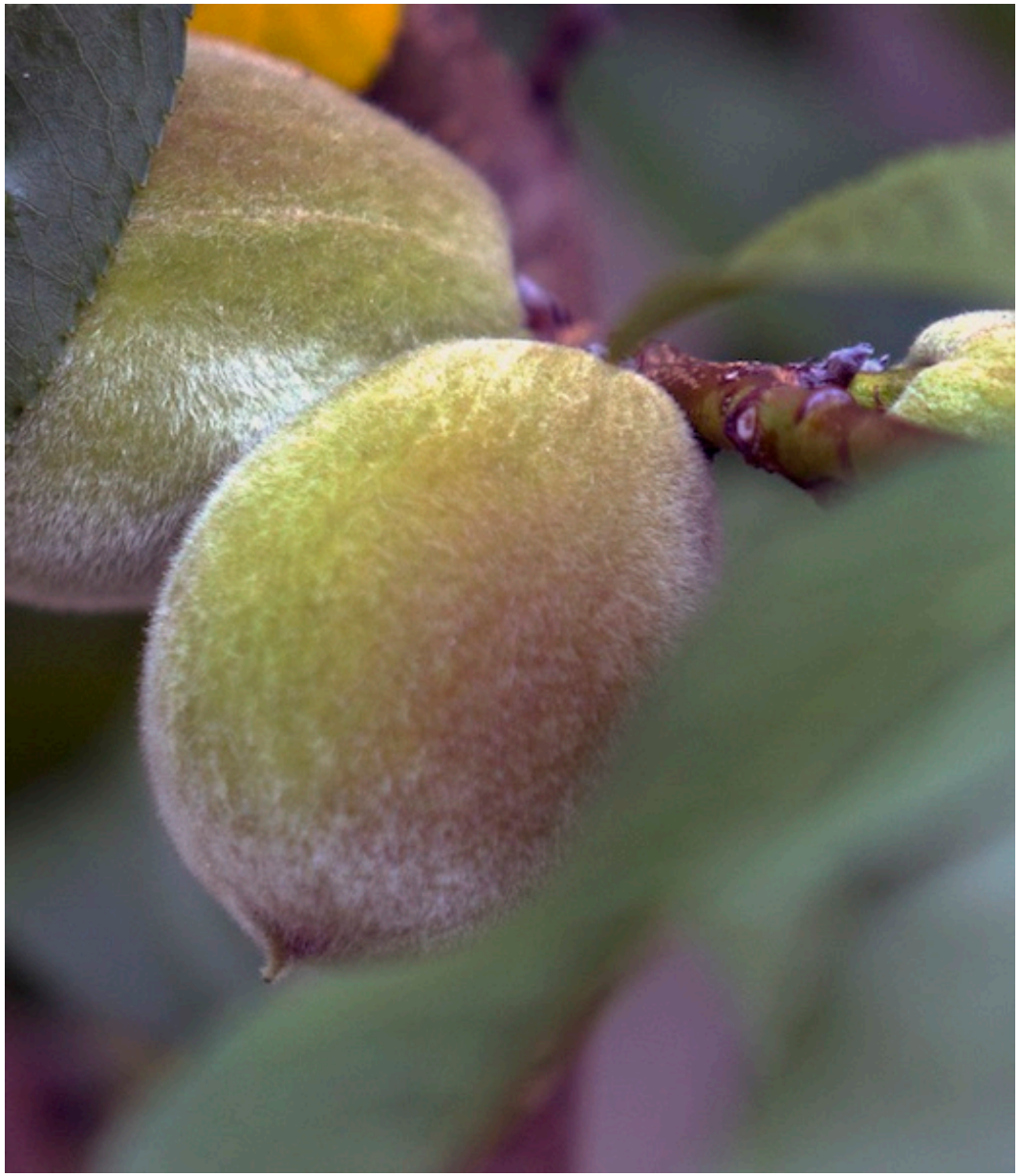



INDIVIDUAL PROGRAM AREA MEDIAN ENERGY USE INTENSITY AND COMBINED PROGRAM AREA WEIGHTED AVERAGE ENERGY USE INTENSITY
EUI (kBtu/ft²/yr)
120
100
80
60
40
20
0
109
95
79
60
58
Existing Williams Inn
Program-weighted CBECS Existing Building Median
2017 MA Stretch Energy Code
Williams Target
SD Energy Model Results
BENCHMARKS
TARGET
SD Design

Project Name: Renovation of Fort Hoosac
Date: October 17, 2018
Prepared by: A/Z Corporation, Mesick Cohen Wilson Baker Architects, LLP, Quantum Engineering Co. P.C., Sustainable Design Consulting, LLC



Fort Bradshaw Energy Use Intensity- Example



T- Biophilic moment

DELIVERABLE 2

SYSTEMS AND METERING NARRATIVE

WHEN Occurs at 30% of Schematic Design

WHAT Provide clear, simple written descriptions of:

A) The proposed conceptual systems being considered for:

Site, envelope, active systems (MEP),passive systems, indoor air quality, resilient design, water, generation/off-sets, occupancy, monitoring, construction

B) The strategy for installing meters and collecting data.

Narrative will be reviewed by: Users, Operations, Commissioning Agents, and Contractor. Owner will then review and comment on each description, providing modification or approval of each strategy and/or system prior to the completion of Schematic Design.

(See attached example & template)

WHY To get early feedback from various stakeholders (Owners, Operations, Maintenance Staff) about the functionality, cost effectiveness, and carbon reduction of the strategies being proposed by the Design Team.

The 2nd deliverable is a simple narrative that is organized to communicate with all members of the Project team.

Site
Envelope
Mechanical, Electrical & Plumbing
Indoor Air Quality
Passive Strategies
Resilient Strategies
Water
Generation & Offsets
Occupant engagement
Monitoring

To be reviewed and approved with the Owner at 30% of Schematic Design ***before*** the design is fully documented.

A consistent 20+ page narrative for Project Managers who are working with numerous design teams. For an integrated design process, this is easy.

B2- Envelope	System Description	Pros / Cons	Target / Goal	Owner Review & Comments
Sub-Slab	Basement Slabs: No Insulation Proposed There are no regularly occupied spaces in the basement. The basement is 8' below the outside finished grade, therefore heat loss is smallest in this area of the envelope.	(-) Colder floors (-) Greater heat loss (+) Less expensive (+) Reduced material use	R0	
Foundation	Existing and new concrete walls Option 1 - Recommended Interior insulation 1-1/2" XPS (R7.5) insulation against concrete wall, stop at underside of floor joists Alternate – Option 2: If interior smart air/vapor barrier approach is followed, insulation at floor joists can be added to reduce thermal bridging and add 3-1/2" mineral fiber blanket insulation(R15) in stud cavity.	(+) Increased Occupant Comfort (+) Reduces heating loads (-) Option 1 Does not reduce thermal bridging at first floor structure and does not reduce heating loads as significantly as Option 2	Option 1 – R7.5 Option 2 - R22.5	
Walls	Existing Wall Section – Option 1 - Recommended Existing Brick and Terracotta Block Walls: 1-1/2" of XPS insulation (R7.5) (Wall section will still require furring, as in other sections, to accommodate wiring/utilities)	(+) Lower Cost than Option 2 (+) Sustainable option in terms of keeping existing materials in building and not increasing construction waste (+) Sustainable option in terms of not needing to use as many new materials (insulation, concrete etc) in	R7.5 Preliminary modeling shows it may still be possible to achieve a site EUI of 30, as long as other components (Roof, New Walls, Air Tightness, MEP	

SUSTAINABLE STRATEGIES: MEP (MECHANICAL, ELECTRICAL, PLUMBING)			
SYSTEM	DESCRIPTION	PROS/CONS	MEASURED BENEFITS
HEATING	Option #1: Campus Steam	(+) no site fossil fuel (-) higher EUI	Utilizes existing heating source
	Option #2: Air Source VRF Heat Pump with supplemental steam heating	(+) no site fossil fuel – could be offset by PV/GEC (+) lower EUI (-) requires supplemental heat for extreme cold	Reduced EUI and reduce Carbon footprint when coupled with PV/GECs
COOLING	Option #1: Air Cooled Chiller	(+) High Efficiency (-) High First Cost	Less equipment to support AC.
	Option #2: Air Source VRF Heat Pump	(+) High Efficiency (-) Distributed refrigerant	Reduced EUI and reduce Carbon footprint when coupled with PV/GECs
VENTILATION	Energy Recovery Units (ERUs)	(+) Provide Code required ventilation (-) Space in existing building for ductwork (-) High First Cost	Comfort Air Quality Reduce Energy
	Occupancy Based Control	(+) High Efficiency	
	Single room recovery ventilation unit	(+) Low energy (+) Eliminate the need for ductwork	
	Operable windows (see passive section)		
FILTRATION	MERV 13 Filters in ERUs Comply with LEED	(+) Air Quality (-) Fan Power (-) Filter Cost	Air Quality

Designed by Centerline Architects

System		First Cost	Operating Cost	Source EUI*	Architectural Requirements	Thermostats	notes
Heating Only	Hot-Water Radiant Panels	$$$	Low	Medium	Basement Mechanical Room; Recessed Ceiling Panels	Individual Control	**Horn Hall** is designed with this off campus steam plant – primary campus standard
	Air-Source Heat Pumps	$$	Medium	Low	Mechanical Closets with Ducting	Shared Control	
	Electric Baseboard	$	High	Medium	Recessed Wall or Ceiling Panels	Individual Control	
Heating & Cooling	VRF Heat Pumps	$$	Medium	Medium	Mechanical Closets with Ducting	Shared Control	Installed at Kellogg Center
	Ground Source Heat Pumps (Water-to-Air)	$$$	Low	Low	Mechanical Closets with Ducting	Shared Control	
	Ground Source Heat Pumps (Water-to-Water)	$$$($)	Low	Low	Mechanical Room; Recessed Terminal Units	Individual Control	Current design for the CDE
Domestic Hot Water	Natural Gas	$$	Medium	Medium	Mechanical Room	N/A	
	Air-Source Heat Pump	$$	Medium	Medium	Mechanical Room	N/A	

***Source EUI:**

In comparing the projected energy performance of the Garfield House to other new construction at Williams College, it is important to make an apples to apple comparison of heating energy sources. Buildings such as Horn Hall rely on district steam, so the efficiency of the district heating plant must be taken into consideration when comparing it to the efficiency of Garfield's proposed heating systems (local boilers, etc.).

Designed by SGA, Vanderweil and Thorton Tomasetti

B6-Water	System Description	Pros / Cons	Measured Benefits	Owner Review & Comments
Hot Water	Preheating Domestic Hot Water using Solar Thermal Panels combined with VRF heat pump heater(s) and finally electric resistance for final temperature trimming	(+) Very good thermal efficiency (-) Slow recovery requires storage to provide capacity during peak periods	EUI < 30	
Cold Water	Municipal Water	(+) Very reliable		
Water Savings	Fixture flow rates recommended are: - Toilets: 1.28 GPF - Lavatories: .35 GPM - Showers: 1 GPM Kitchen Faucet: 1.5 GPM	(+) Based on use patterns, these fixtures will provide a 43.95% potable water use reduction following LEED calculations.	(+) Reduced operation cost	
Water Re-Use	None planned			
Site Water	Based on EPA Water Budget Tool, landscape irrigation allowance is 60,919 gal/month.	(+) No irrigation on site	(+) Reduced operation cost	

T-Biophilic moment

DELIVERABLE 3

VALUE ASSESSMENT

WHEN Occurs at 25% of Design Development

WHAT Identify primary building strategies to reduce energy and carbon use, and quantify how much these strategies cost & how much energy they save.

Together with the Owner, identify discrete design elements from the above strategies to be compared in terms of cost by the Design Team's cost estimator.

(See attached example & template)

WHY Provide clear summary of how much each option saves versus how much it costs, so that the Owner can decide where to spend their money to get the greatest energy return on their investment.

GREEN GAUGES

2015 Customer and Partner
Energy Efficiency Summit

nationalgrid
HERE WITH YOU. HERE FOR YOU.

Williams College Science Center

Project Description: 68,000sf. Extension

Total Incremental Cost	$450,435
Total Dollar Savings Per Year	$163,530
Incentive(electric)	$92,980
Incentive(estimated gas)	$163,407
Simple Payback	**1.75**
Total kWh savings per yr.	**265,659**
Therms	**96,122**
Total savings over 20yr life	**$3,270,600**
Total savings over IECC2012	**46%**

Value Assessment- typical modeling summary results

	SCIENCE CENTER SOUTH		Incremental costs from Nat. Grid study	KWH savings	Equ. Carbon avoided in metric tons	THERMS savings	Equ. Carbon avoided in metric tons	Total metric tons avoided eCO2	cost per avoided metric ton	System Life	cost per metric ton of eCO2 avoided over system life
C2	Envelope Enhancements		$ 33,204	17,726	5.9	6,297	33.3	39.3	$ 846	40	$ 21
C3	High Efficiency Lighting		$ 38,785	137,486	45.9	- 3,561	-18.9	27.0	$ 1,435	20	$ 72
C3	Enhanced Lighting controls		$ 122,707	22,755	7.6	- 223	-1.2	6.4	$ 19,136	10	$ 1,914
C3	Chilled beams at offices		$ 29,700	- 15,590	-5.2	2,857	15.1	9.9	$ 2,993	25	$ 120
C3	Lab exhaust enhancements		$ 226,039	103,282	34.5	96,122	508.9	543.4	$ 416	25	$ 17
C8	Photovoltaics (147.9 kv	123.6	$ 494,500	148,350	49.5	-	0.0	49.5	$ 9,990	20	$ 499
							TOTAL	675.5			

Operation Carbon- SITE

Value Assessment- Example

Data Key Green by Payette- analysis to cost/aCO2e/year by c&h
Carbon equivalent values from Clean Air Cool planet

Williams College	Enter data in highlighted cells only	180214
Building Emissions Calculator		

Building Name	
Building Area [2]	
Name of person entering data	
Company of person entering data	
Date data entered	
Design phase [3]	

Energy Consumption

Fuel Source	unit	Btu/unit	Site Energy -- Units per year at the building	Source Energy/Site Energy - ratio	Source Energy -- Units per year (calculated)	total lbs CO2e/unit	Total lbs CO2e /year (calculated)	Metric tons CO2e /year (calculated)
WC Steam	MMBtu	1,000,000		-	-	344	-	-
WC Chilled Water	kBtu	1,000		-	-	83	-	-
Natural Gas	therm	100,000		1.09	-	23	-	-
Propane	gallon	91,330		1.15	-	18	-	-
Oil #2	gallon	139,600		1.16	-	29	-	-
Electricity [1]	kWh	3,413		1.7	-	1.16	-	-
PV generated electricity	kWh	3,413		1.0	-	0.064	-	-

Building Metrics

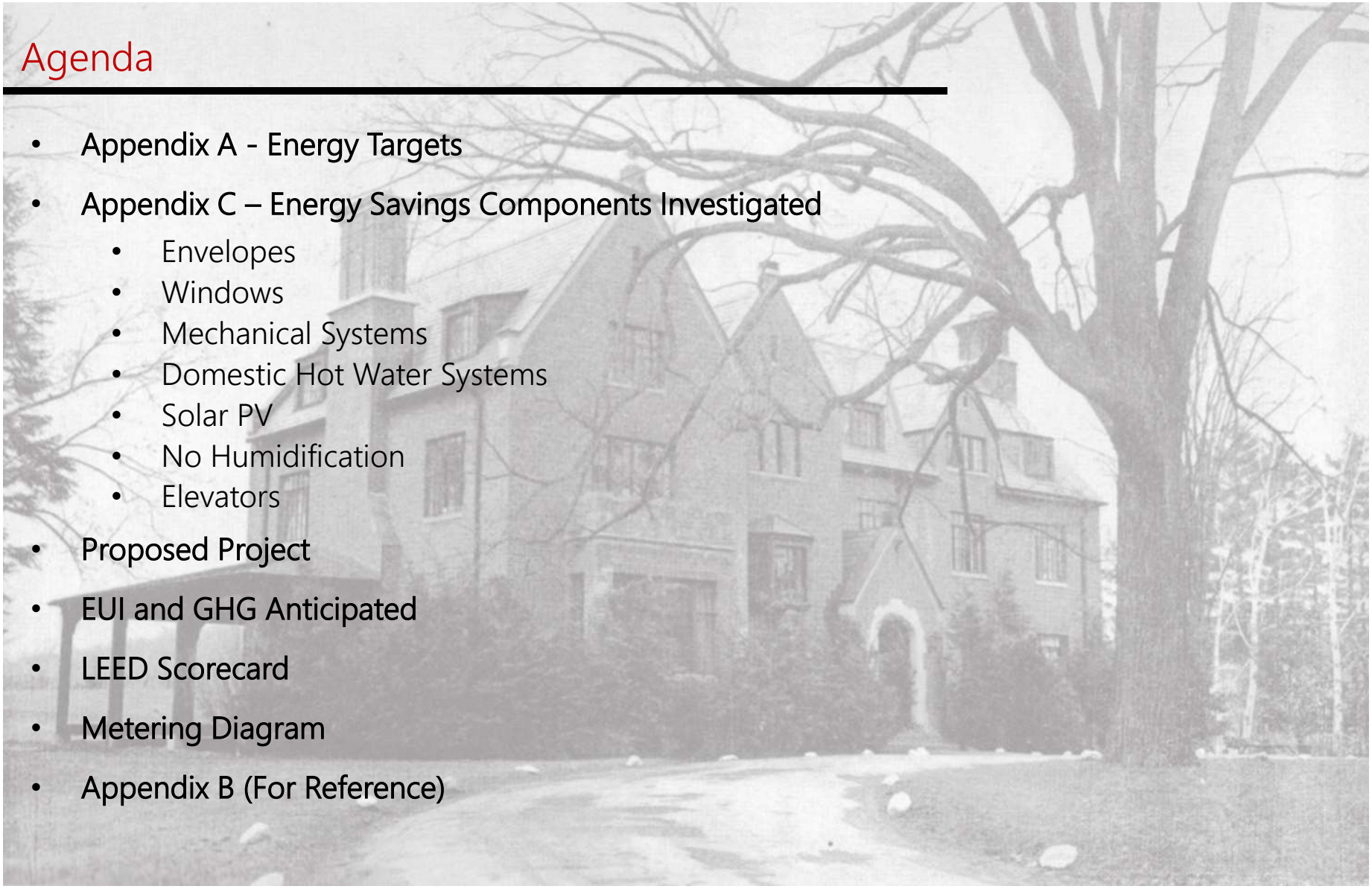
Peak Heating Load [4]	kBtu/hr.	
Peak Cooling Load [4]	kBtu/hr.	
Annual Heating Load [5]	MMBtu/yr	
Annual Cooling Load [5]	MMBtu/yr	
Lighting Power Density [6]	watts/sq.ft.	
Building air tightness [7]	cfm75/sq.ft. shell	
Building air tightness units used in energy model [8]		
Building air tightness value used in energy model [9]		

Operation Carbon- SOURCE

Updated Calculator with $/CO2e/year – **SOURCE CARBON**

Fort Bradshaw - Green Gauges Appendix C

December 14, 2018



Agenda

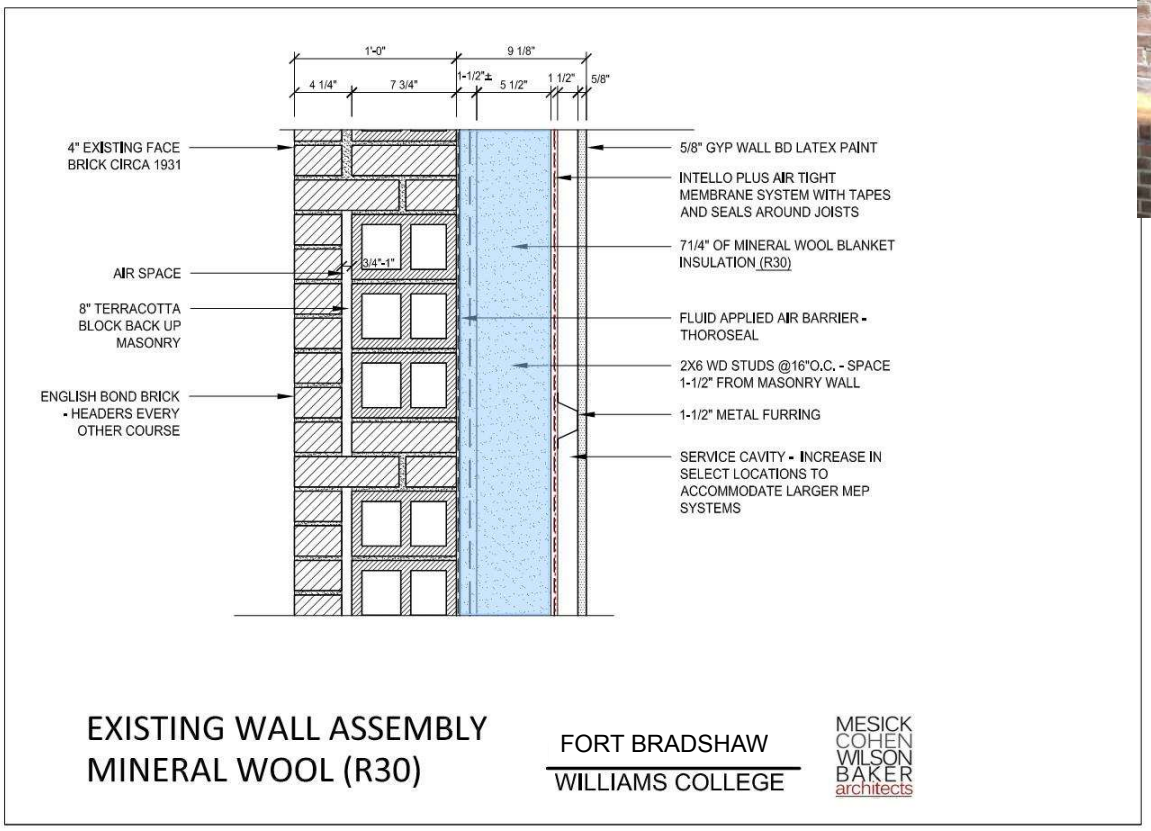
- Appendix A - Energy Targets
- Appendix C – Energy Savings Components Investigated
  - Envelopes
  - Windows
  - Mechanical Systems
  - Domestic Hot Water Systems
  - Solar PV
  - No Humidification
  - Elevators
- Proposed Project
- EUI and GHG Anticipated
- LEED Scorecard
- Metering Diagram
- Appendix B (For Reference)

Envelope Targets

	Site Energy Savings
1. Air Tightness	11%-26%
2. Insulation	7%-12%
3. Windows	3%-5%

	Basement Slabs		Foundation Walls		Exterior Walls		Roof		Air-Tightness	
	Existing	New	Existing	New	Existing	New	Existing	New	Exist'g	New
Code Minimum Prescriptive Requirements	Not Req'd	Not Req'd	Not Req'd	R7.5ci	Not Req'd Fill exposed cavities	R13.3ci	R30ci or R49	R30ci or R49	Not Req'd	0.4 cfm/ft2 @75pa
Envelope 1 (Recommended)	None	None	None	R7.5ci	R7.5ci	R15ci + R10 (R25)	R17ci+R30 (R47)	R17ci+R30 (R47)	0.4 cfm/ft2 @75pa	
Envelope 2 (Upgrade)	None	None	(R5ci+R23) R28	(R5ci+R23) R28	R30	R15ci + R10 (R25)	R17ci+R30 (R47)	R17ci+R30 (R47)	0.4 cfm/ft2 @75pa	
Envelope 3	None	None	None	R7.5ci	None	R15ci + R10 (R25)	R17ci+R30 (R47)	R17ci+R30 (R47)	0.4 cfm/ft2 @75pa	

Envelope 2



Pros and Cons:

+ **No thermal breaks in envelope**
+ **Required if Passive House were to be pursued**
+ **Increase occupant comfort**
+ **Decreased energy costs**

- **Cost**

Envelope 2

$1,412 per tonne per year

Upgrade

Green Gauges Appendix C
Williams College - Fort Bradshaw
12/13/2018

Williams College
Green Gauges: Value Assessment

Enter data in highlighted cells only

Building Name	Fort Bradshaw
Name of person entering data	Bob Patton
Company of person entering data	Quantum Engineering Co., P.C.
Date data entered	11/20/2018
Design phase [1]	Design Development
Conservation Measure Name	Envelope 2
Design Case Description	Add R28 to existing foundation and R30 to existing masonry walls
Design Case Cost	$1,905,608
Base Case Description	Code min prescriptive requirements
Base Case Cost	$1,071,723
Incremental Cost	$833,885
System Life [2]	50

No insulation in existing walls

Energy Consumption

Fuel Source	unit	Btu/unit	Energy Saved -- Units per year at the building [3]	Source Energy/Site Energy - ratio	Source Energy -- Units per year (calculated)	total lbs CO2e/unit (Source)	Total lbs CO2e saved /year (calculated)	Metric tons CO2e saved /year (calculated)
WC Steam	MMBtu	1,000,000	-	-	-	344	-	-
WC Chilled Water	kBtu	1,000	-	-	-	83	-	-
Natural Gas	therm	100,000	-	1.09	-	23	-	-
Propane	gallon	91,330	-	1.15	-	18	-	-
Oil #2	gallon	139,600	-	1.16	-	29	-	-
Electricity [4]	kWh	3,413	22,420	1.7	38,267	1.16	26,039	11.8
PV generated electricity	kWh	3,413	-	1.0	-	0.064	-	-

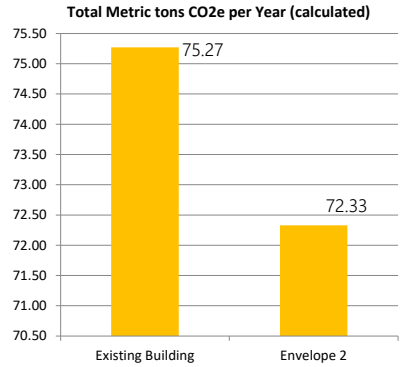
Total		12
$/tonne CO2e Saved	$	70,614.2
Per Year	$	1,412.3

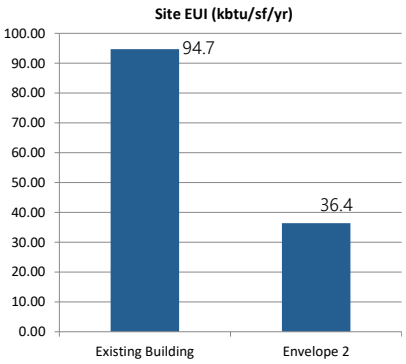
Source

[1] Schematic, Design Development, Final Design or actual data
[2] Use the following: Envelope- 50 years, Windows, Mech, Controls & PVs- 20 years, Lighting Systems- 10 years
[3] Show your work and how this was calculated in an attachment
[4] All electricity saved at the building, regardless of source

Submitted by: A/Z Corporation, MCWB Architects, Quantum Engineering, Sustainable Design Consulting

Page 4 of 23





Williams College – Renovation to Fort Bradshaw

EUI and GHG Calculations

Williams College – Renovation to Fort Bradshaw

Energy saving components to be selected for project

		Cost per tonne saved per year	EUI	Recommended by design team	Decision by Williams College		
					Yes	No	Comments
1	Envelope 1 – R7.5	$363	37.8	X	✓		
2	Envelope 2 – R30	$1412	36.4			✓	
3	Envelope 3 – R0	$0	42.2			✓	
4	Fiberglass Windows	$2456	41.1	X	✓		
5	Steel Windows (75 yr)	$5122	42.0			✓	
6	Mech Sys Opt 1 – VRF GSHP	$1814	37.2	X			Analysis] likely opt 1
7	Mech Sys Opt 2 – VRF ASHP	$2270	41.6				
8	Mech Sys Opt 3 – Ground Coupled WSHP	$3586	40.7			✓	not likely
9	DHW Opt 1 – Solar Thermal	$420	37.7		✓		
10	DHW Opt 2 – Heat Pump Preheat	$42	36.9		✓		if gshp
11	DHW Opt 1 & 2 Combined	$351		X			
12	Shower Drain Recovery	$77	41.7	X	✗		
13	Solar PV	$485	41.2			✗	
14	No Humidification	($444)	41.5				discuss
15	Hydraulic Elevator	$15,562	42.4			✓	
16	Regenerative Drive Elevator	$54,244	42.3			✓	
17	Project As Proposed	$1254	25.6	X			
18	Project – Alt 1 (Stl. Wind.)	$1520	26.1				
19	Project - Alt 2 (Stl. Wind. No Hum)	$1428	25.3				
20	Project - Alt 3 (VRF ASHP)	$1088	30.1				

DELIVERABLE 4

METERING DIAGRAM

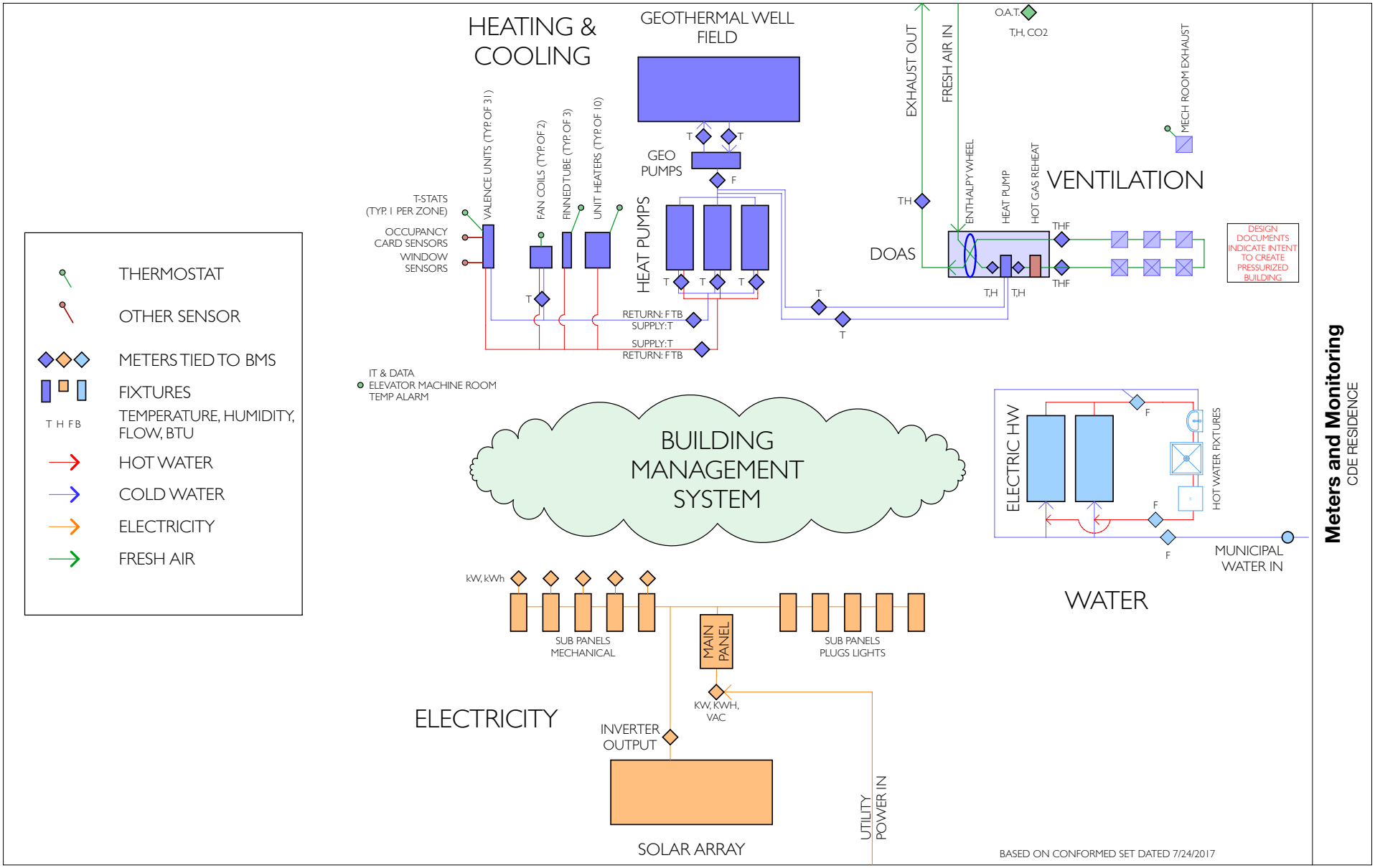
WHEN Occurs at 50% of Design Development

WHAT Provide a comprehensive diagram showing how each system will be metered and monitored for consumption data.

This diagram will form the basis of a submittal from the contractor during construction.

(See attached example)

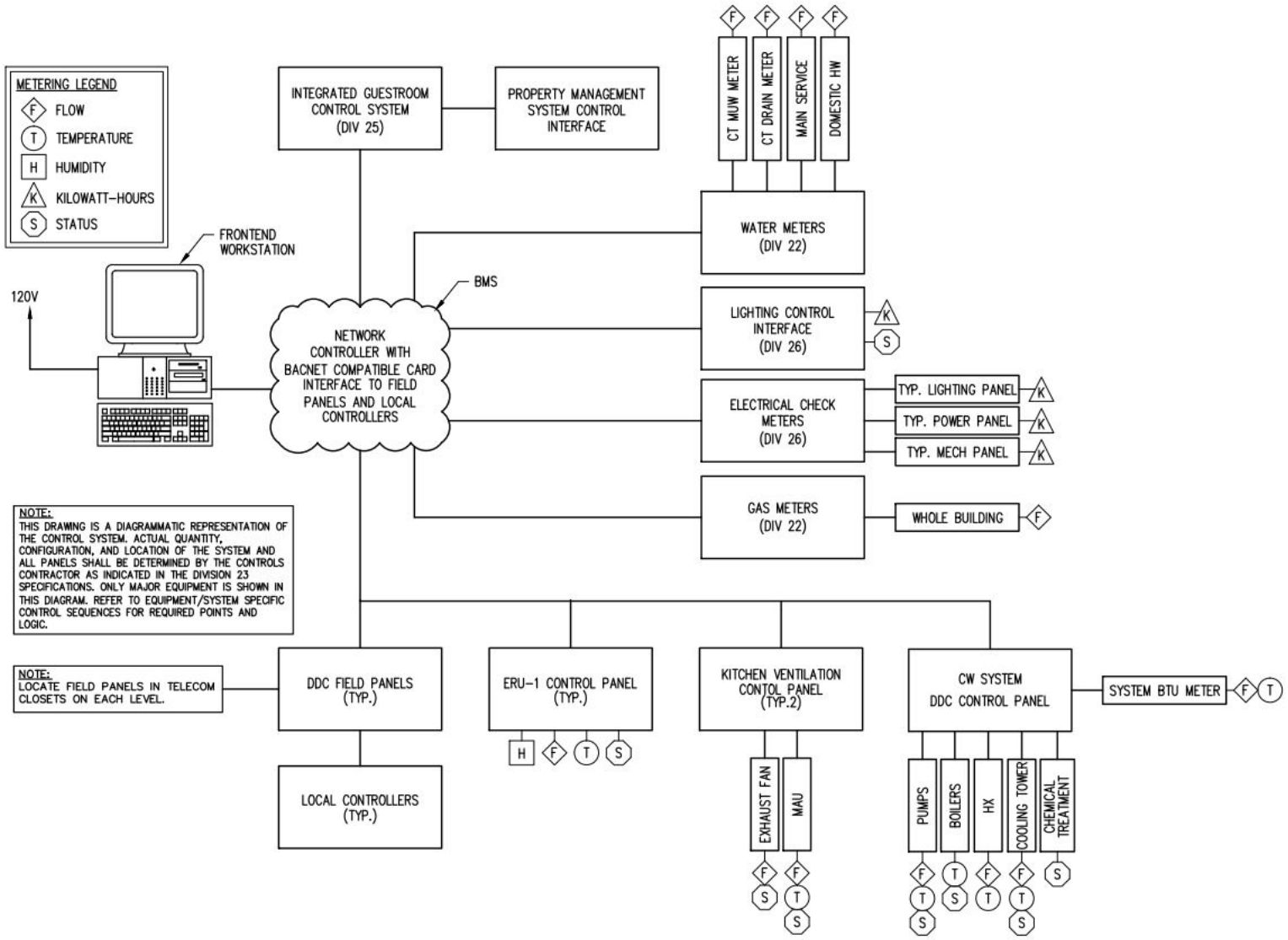
WHY Rather than provide isolated diagrams showing electric meters in one location, water meters in another, and controls only described in the specifications, this single document allows the Design Team to show all metering in one place and for the Owner to review and modify as needed.



Designed by PBDW, diagrammed by c&h

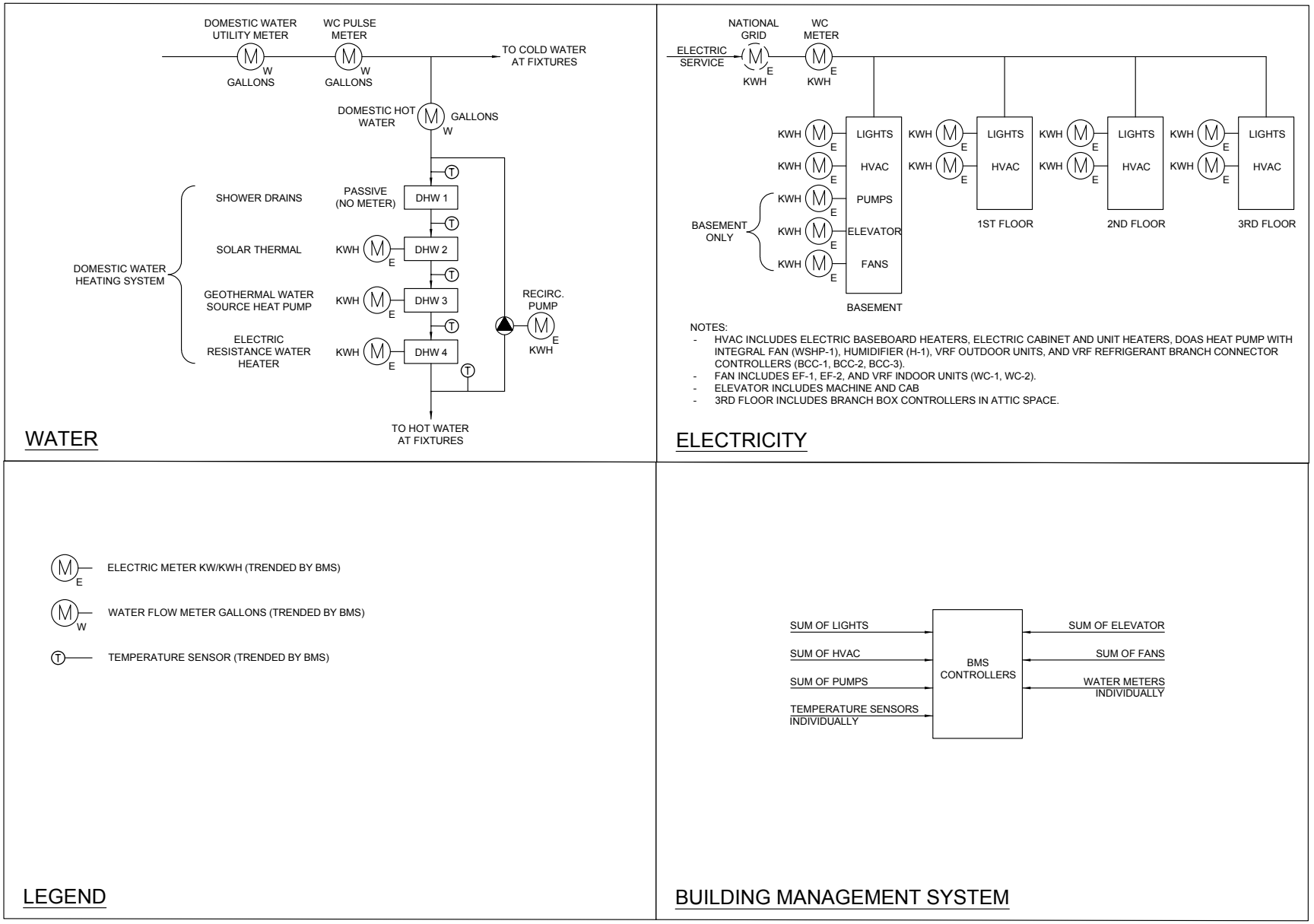
Metering Diagram- Example

METERING DIAGRAM



Designed by C7A and WSP. Diagram by WSP.

Metering Diagram- Example



METERING DIAGRAM - APPENDIX D
FORT BRADSHAW, WILLIAMS COLLEGE
February 4, 2019

T-Biophilic moment

DELIVERABLE 5

OCCUPANCY MONITORING NARRATIVE

WHEN At completion of construction/start of building occupancy

WHAT Provide a concise document describing what is important to monitor in the building to ensure the projected savings are realized.

Projected energy consumption and production should be updated based upon changes made to the project during design or construction. Itemize each type of fuel, and then calculate the final predicted EUI for the building.

WHY To extract key information from the wisdom that the team has gained during design and construction, and pass it on to the operations and maintenance staff—so that they know how to best take care of the building, and what particular issues to be aware of to make sure it functions well.

DELIVERABLE 6

VERIFICATION

WHEN 11 & 18 months after building occupancy

WHAT Design Team reviews Owner-provided energy consumption for the building, then prepares an evaluation of this actual energy consumption (by fuel type) and production compared to the predictions made at the completion of construction.

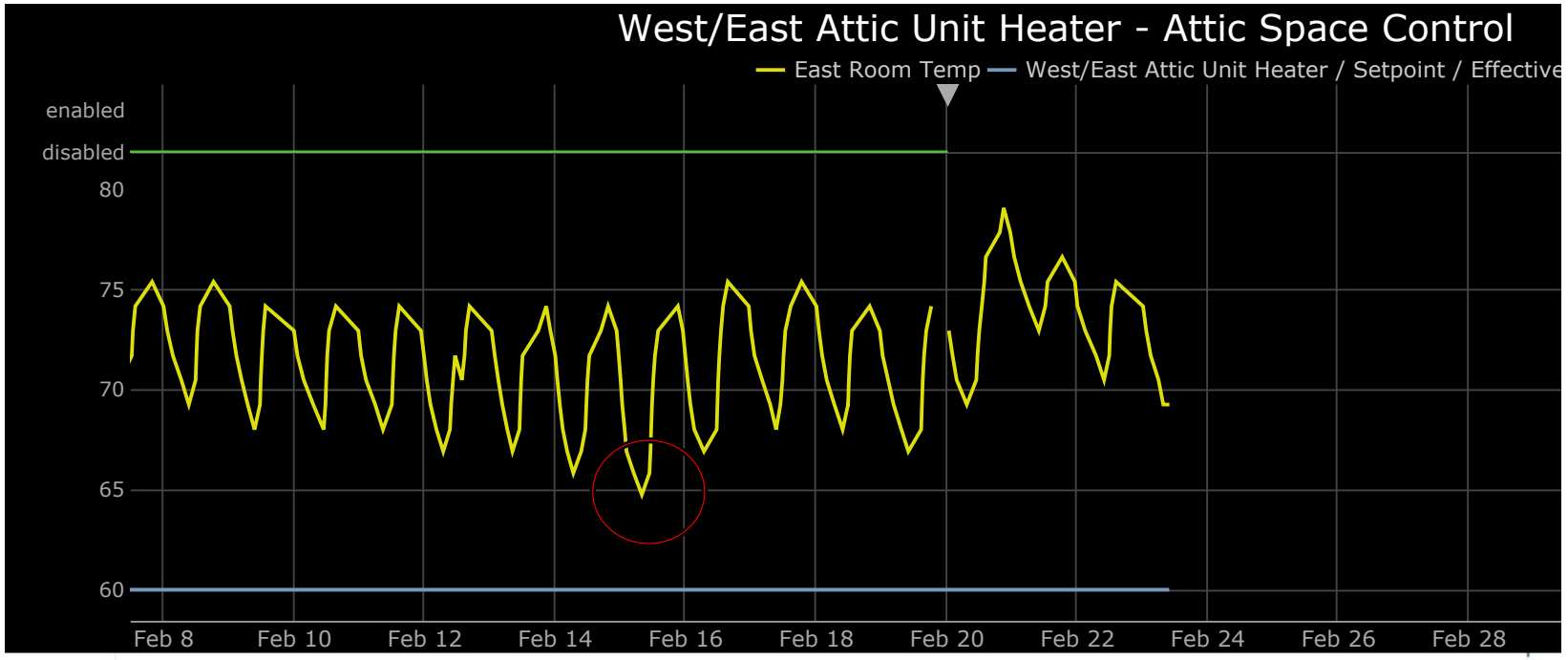
WHY To identify issues of under performance and/or dysfunction in building systems and then resolve them.

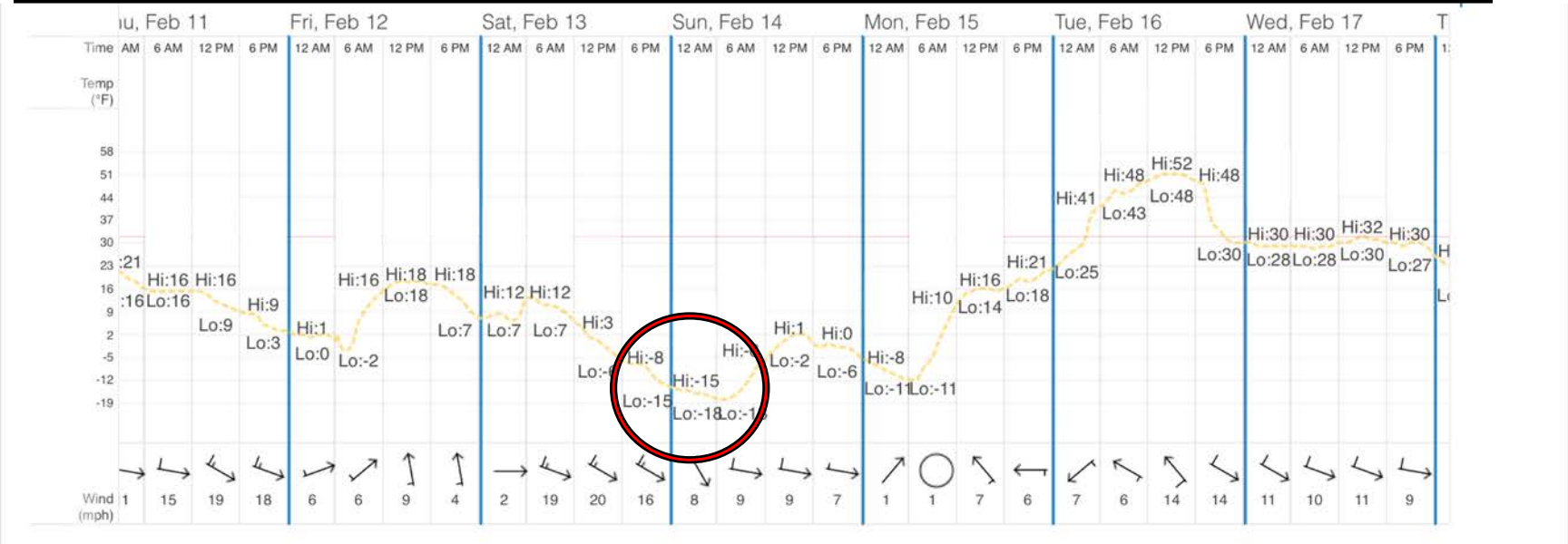
APPENDIX D

Project Name: The Log
Date: 5/16/16
Appendix D: **Monitoring**

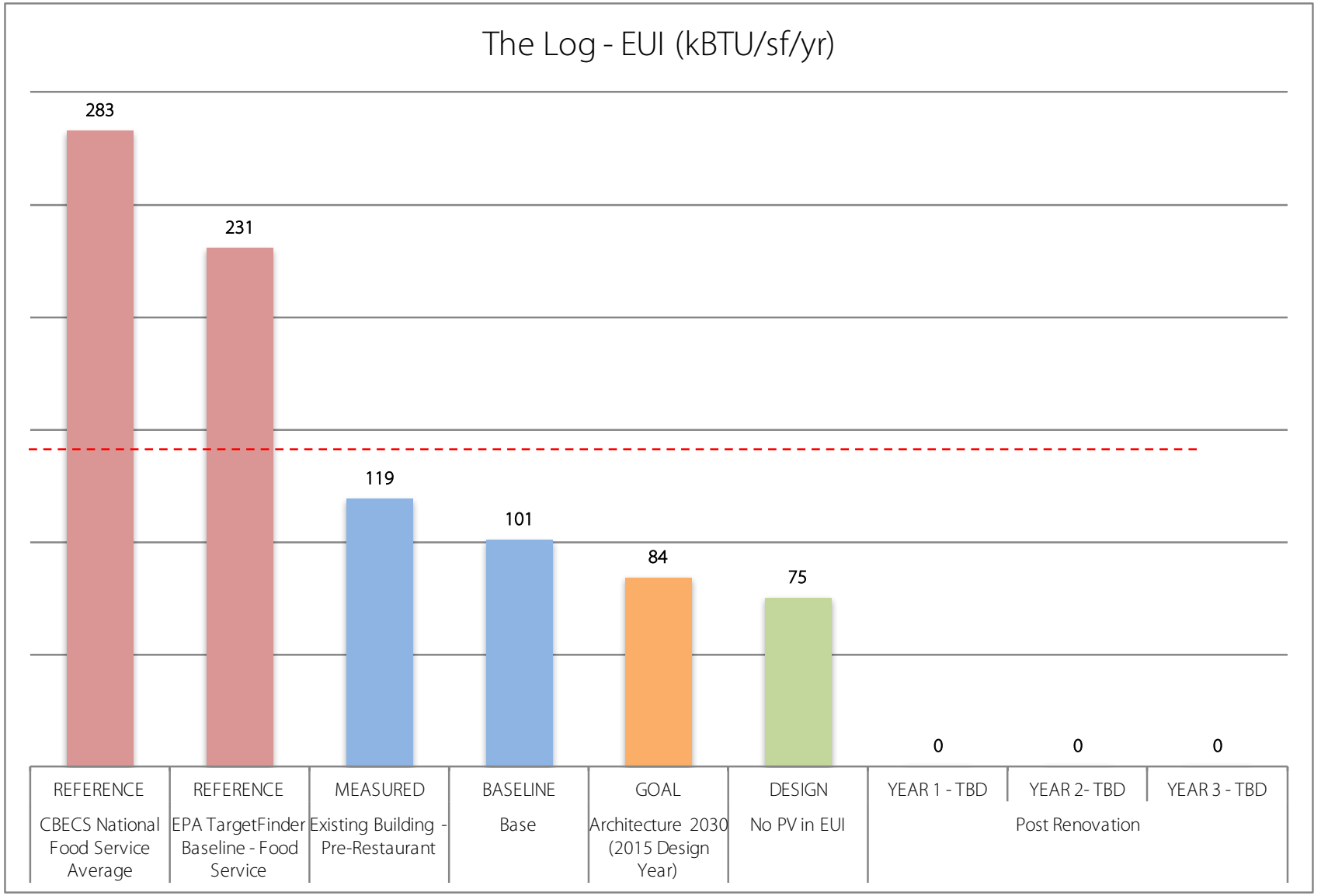
Component	EXPECTED RANGE	ACTUAL:	NOTES:
Kitchen Hood			Review data with actual occupancy trends. Ensure staff is not turning on hood before cooking starts as a habit.
Hot Water			Review summer gas loads with flow meters.
Attic	60-80 degrees	Checked when -10 degrees and 20 mph winds- ok	Attic contains freeze sensitive equipment – sprinklers. Attic is within envelope, but has no dedicated full time heat source. Attic is provided with emergency electric fan coil connected to T-Stat to prevent freezing.
Fireplace Gas			Fireplace consumption trends should be logged in concert with occupancy and cooling equipment to confirm they are not driving unnecessary space conditioning. Ensure staff is not turning on the fireplaces in the summer when unoccupied.

Occupancy Monitoring Narrative and Verification





Occupancy Monitoring Narrative and Verification


The Log - EUI (kBTU/sf/yr)
283
231
119
101
84
75
0
0
0
REFERENCE
CBECS National Food Service Average
REFERENCE
EPA TargetFinder Baseline - Food Service
MEASURED
Existing Building - Pre-Restaurant
BASELINE
Base
GOAL
Architecture 2030 (2015 Design Year)
DESIGN
No PV in EUI
YEAR 1 - TBD
YEAR 2- TBD
YEAR 3 - TBD
Post Renovation

The following is based upon information from Automated Logic Dashboard and School Dude from July 1, 2016 to June 30th, 2017.

EUI (kbtu/sf/year)	Proposed at Schematic	Actual	Notes
Total	75	142	EPA Target finder for Food Service is 231 This total does not include the pv production.
Cooking (Nat Gas)	12 (16%)	69 (51%)	Was induction electric cooking at SD with far fewer meals and no catering.
Building (Steam & Elec)	63	57	
PV offset	nic	(8)	Estimated pv production

Energy Mix	Electric- 43%	125,168 Kwh (we think this is net of pv production)
	Steam- 4%	11,195 Kwh
	Natural Gas- 53%	5,136 CCF
	PV Production	Meter not reading on Automated Logic at the moment 15.6kw should produce ±17,000 kwh annually (or 58,021 kbtu)

Comment & Suggestions:

1. If the vendor is not paying the gas bill, consider it, especially if they are servicing their catering business from this kitchen. The initial projection for cooking was 100-120 meals a day for 260 days per year. Based on a call to the Log, they estimate 300-400 meals per day all year, not including the catering function.

2. We have observed the two gas fireplaces are on frequently. They each are rated 31,500 btu/hr Max, 17,100 btu/hr Min. This load is within the Natural Gas allocation and included within Actual cooking above. Their use could be one reason the steam load in so low.

Biophilic moment

Williams College	Enter data in highlighted cells only	180214
Building Emissions Calculator		

Building Name	
Building Area [2]	
Name of person entering data	
Company of person entering data	
Date data entered	
Design phase [3]	

Energy Consumption

Fuel Source	unit	Btu/unit	Site Energy -- Units per year at the building	Source Energy/Site Energy - ratio	Source Energy -- Units per year (calculated)	total lbs CO2e/unit	Total lbs CO2e /year (calculated)	Metric tons CO2e /year (calculated)
WC Steam	MMBtu	1,000,000		-	-	344	-	-
WC Chilled Water	kBtu	1,000		-	-	83	-	-
Natural Gas	therm	100,000		1.09	-	23	-	-
Propane	gallon	91,330		1.15	-	18	-	-
Oil #2	gallon	139,600		1.16	-	29	-	-
Electricity [1]	kWh	3,413		1.7	-	1.16	-	-
PV generated electricity	kWh	3,413		1.0	-	0.064	-	-

Building Metrics

Peak Heating Load [4]	kBtu/hr.	
Peak Cooling Load [4]	kBtu/hr.	
Annual Heating Load [5]	MMBtu/yr	
Annual Cooling Load [5]	MMBtu/yr	
Lighting Power Density [6]	watts/sq.ft.	
Building air tightness [7]	cfm75/sq.ft. shell	
Building air tightness units used in energy model [8]		
Building air tightness value used in energy model [9]		

Updated Calculator with $/CO2e/year – **SOURCE CARBON**

Exemplar Buildings CO2e Emissions	
Project	Project Site EUI kBtu/ sq.ft.-yr
CoA dorms	27
Putney Gray Dorm	20
Waterfront Apts	39
South village offices	33
Oakes Hall	35
Putney Field House	14
Proctor Dinning Hall	88

Site EUI doesn't tell the whole story

Exemplar Buildings
CO2e Emissions

Project	Project Site EUI kBtu/ sq.ft.-yr		Oil	electricity	natural gas	propane	wood pellets	CO2-e emitted
			gallons/yr	kWh/yr	ccf/yr	gallons/yr	tons/yr	Metric tonnes CO2e/yr
		lbs Co2-e/unit>>>>	29	1.23	23	18	3,740	
			Annual usage					
		Sq.ft. conditioned						
CoA dorms	27	20,552		62,625			21	71
Putney Gray Dorm	20	10,457		61,277				34
Waterfront Apts	39	45,000		202,000	10,545			225
South village offices	33	17,000	1,508	101,960				77
Oakes Hall	35	23,000	3,450	96,039				99
Putney Field House	14	14,000		57,000				32
Proctor Dinning Hall	88	16,642		400,000		948		231

Operation Carbon- SITE

Site EUI doesn't tell the whole story

By Andy Shapiro, Energy Balance Inc.

Exemplar Buildings
CO2e Emissions

Project	Project Site EUI kBtu/ sq.ft.-yr		Total pounds CO2e/sq.ft.-yr	
		lbs Co2-e/unit>>>>	With no PV	With PV on Project
		Sq.ft. conditioned		
CoA dorms	27	20,552	**7.6**	7.6
Putney Gray Dorm	20	10,457	7.2	**0.38**
Waterfront Apts	39	45,000	**11**	11
South village offices	33	17,000	**10**	10
Oakes Hall	35	23,000	**9.5**	9.5
Putney Field House	14	14,000	5.0	**0.26**
Proctor Dinning Hall	88	16,642	31	***1.5***

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Questions?

Thank you.

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Tom@CandHArchitects.com

Contact information