A Winning Approach to the Greening of Labs – A Case Study

Presented by B2Q Associates, Inc.

Chris Schmidt & Brad Newell

A Woman Business Enterprise (WBE)

UMass Amherst

- ISB
- ELAB II

Learning Objectives

1. Improve ability to identify, develop, implement, and maintain a successful lab energy efficiency and optimization project by taking a step-wise and multi-disciplinary approach.
2. Increase awareness of the importance of a collaborative team approach as a main driver of the success of lab safety and energy optimization projects – building the right team.
3. Provide a deeper understanding of the interaction between lab ventilation and fume hood controls in terms of safety, performance, and energy.
4. Highlight the importance of identifying changes in use, updated standards, and the ability to account for future changes in lab use or standards.

Project Introduction

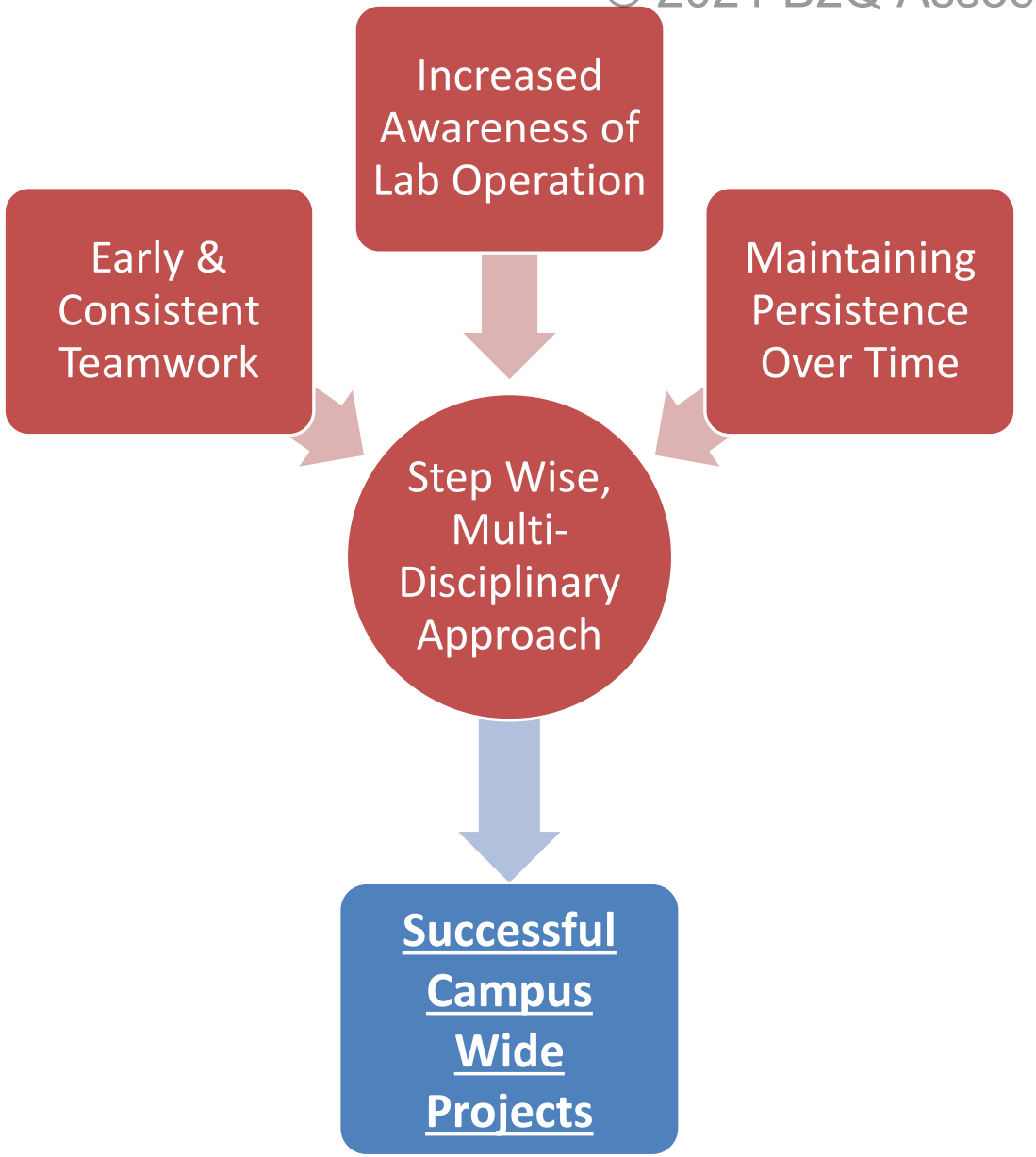
Recent projects at the University of Massachusetts Amherst, and co-sponsored by Eversource Energy and DCAMM, provided the opportunity for B2Q to develop a stepwise, multidisciplinary approach to optimizing lab buildings

5 Step Process

1. Multi-Building Scoping Audits
2. Focused Lab Optimization Studies on Selected Lab Buildings
3. Implementation, Commissioning & Owner Training
4. Measurement & Verification of Safety and Savings
5. Persistence via Communication & Continuous Commissioning

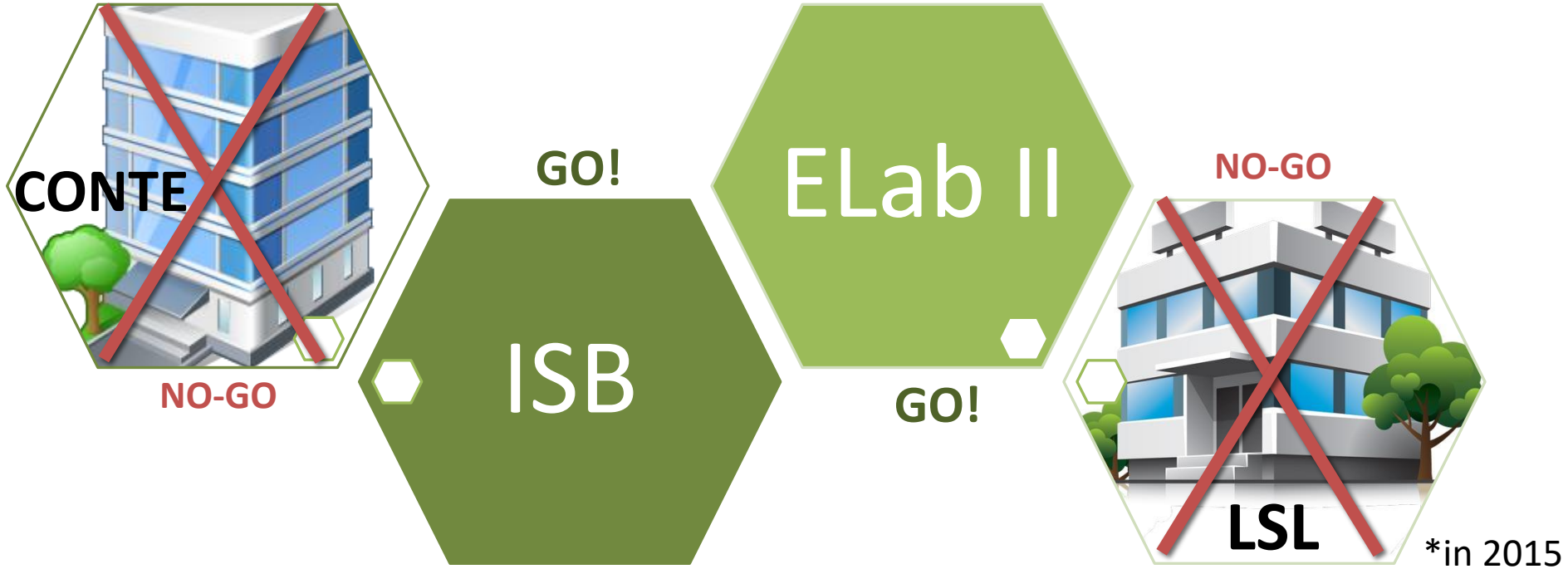
- **Integrated Sciences Building (ISB) – 8 years old**
  - 150,000 ft^2 (85,000 ft^2 of Lab Space)
  - 4,620,580 kWh - Baseline
  - 29,000 MLbs Steam - Baseline
  - **$1,042,058** in Energy Annually – Baseline
  - EUI: 275 kBtu/ft^2 – Baseline (2015)
- **Engineering Lab II (ELab II) – 13 years old**
  - 61,000 ft^2 (21,474 ft^2 of Lab Space)
  - 2,636,348 kWh - Baseline
  - 15,096 MLbs Steam - Baseline
  - **$565,554** in Energy Annually – Baseline
  - EUI: 359 kBtu/ft^2 – Baseline (2015)

One Approach with 3 Key Aspects to Cost Effective, Multi-Building Lab Optimization Projects

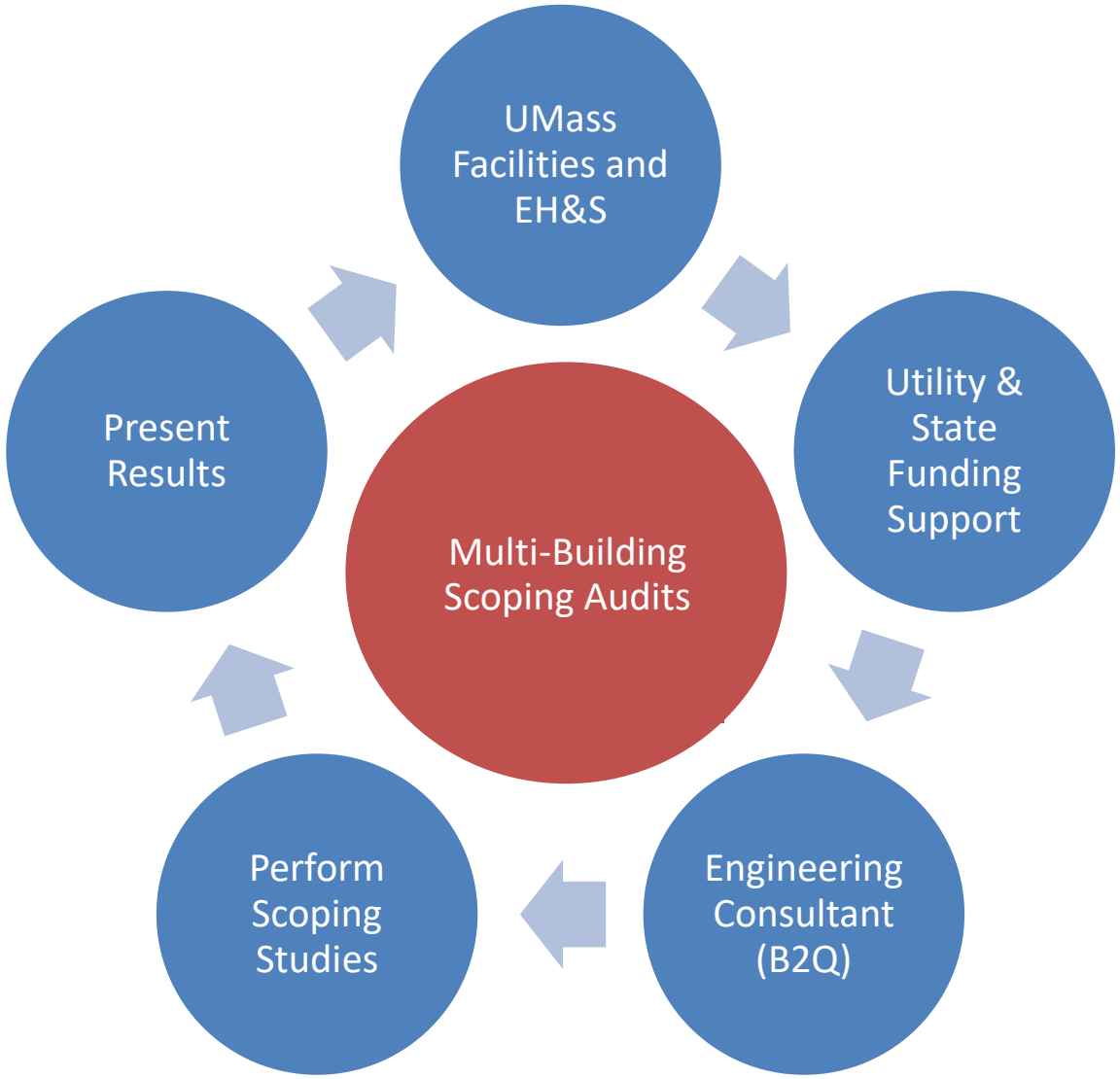


Step 1 – Scoping Audits

1. Multi-Building Scoping Audits
   - Provide a quick look at numerous buildings to provide high level insight to lab optimization and energy savings opportunities
   - Building level and sample lab ACH examined
   - Serve as a "go/no-go" screening for further evaluation



Step 1 – Scoping Audits



- Small, concentrated project team
  - Facilitates the communication of details and allows all major parties to track progress of scoping studies
  - Project results were discussed and laid out in a stakeholder meeting

Step 1 – Scoping Audit Results

Integrated Science Building - Energy Efficiency Measures (EEMs) Executive Summary									
EEM-#	Measure Description	Electric Savings	CHW Savings	Electric Cost Savings	Steam Savings	Steam Cost Savings	Total Cost Savings	Project Cost Estimate	Potential Utility Incentive
		kWh	kWh	$	Mlbs	$	$	$	$
1	Repair Cooling Leakby on AHU-1.4	195,908	195,908	$19,591	6,692	$133,831	$153,422	$7,700	$17,632
2	Optimize Enthalpy Wheel Control on Lab AHUs	109,796	109,796	$10,980	402	$8,039	$19,018	$30,000	$9,882
3	Optimize Admin AHU Control	76,450	76,450	$7,645	1,534	$30,676	$38,321	$102,300	$6,880
4	Implement Static Pressure Setback on Lab AHUs	46,513	0	$4,651	0	$0	$4,651	$16,000	$4,186
5	Reduce Ventilation Airflow to Lab Spaces	671,369	3,118	$67,137	786	$15,728	$82,865	$296,000	$60,423
Totals (Excluding EEM-8.B)		1,100,036	385,271	$110,004	9,414	$188,273	$298,277	$452,000	$99,003

Baseline Energy Consumption		Reduction
Annual Total Electric Use (kWh/yr)	3,773,534	19%
Annual HVAC Electric Use (kWh/yr)	2,242,689	32%
Annual Steam Use (MLbs/yr)	29,226	32%
Annual Chilled Water Use (kWh/yr)	847,046	45%

Simple Payback Before Potential Incentive:	1.5
Eversource RCx Measure Incentive Rate ($/kWh):	$0.09
Potential Electric Incentive from Eversource:	$99,003
Net Project Cost After Potential Incentive:	$352,997
Simple Payback After Potential Utility Incentive:	1.2

**The values in the "CHW Savings" column are shown for informational purposes only. These savings are included in the Total Steam Savings column.*

***The electric savings shown in the "CHW Savings" column are savings that would come from the ISB chiller plant and not directly the ISB electric meter.*

Step 2 – Focused Lab Optimization Study

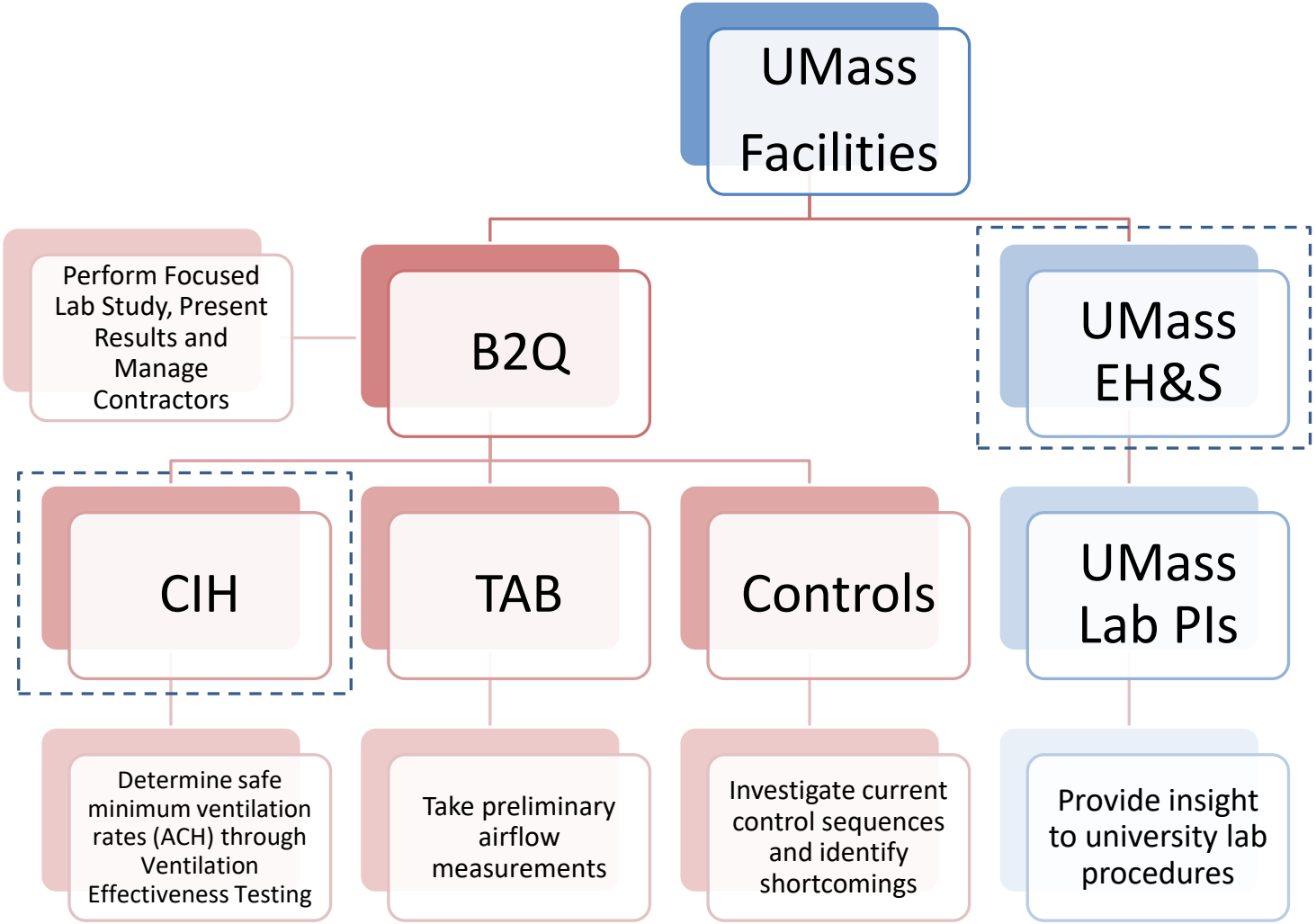
2. The most promising buildings with lab savings opportunities are investigated further in a Focused Lab Optimization Study

Lab Savings Opportunity

- Convert Variable Volume Fume Hoods to Variable Volume Operation
- Determine Safe Minimum Ventilation Rates & Control to these ACH
- Investigate existing sequence ability to control labs to appropriate cfm offsets
- Optimize Non-Lab Zones

- Proposed Operation
- Energy Savings
- Economics

Step 2 – Focused Lab Optimization Study



Lab Ventilation Effectiveness Performed by Ralph Stuart, CIH

2. Focused Lab Optimization Studies on Selected Lab Buildings
   - Project team starts to broaden and include specific sub contactors and parties which specialize in certain areas
   - Allows for accurate energy savings and cost estimates as well as building specific solutions built from the lab up

Step 2 – Focused Lab Optimization Study Results

Focused Lab Optimization Study Results

Integrated Science Building - Energy Efficiency Measures (EEMs) Executive Summary									
EEM	Measure Description	Total Electric Savings	CHW Savings	Electric Cost Savings	Steam Savings	Steam Cost Savings	Total Cost Savings	Project Cost Estimates	Potential Utility Incentives
		kWh/yr	kWh/yr	$/yr	Mlbs/yr	$/yr	$/yr	$/yr	$
Measures from Previous Study									
1	Repair Cooling Valves on AHU-1.4	195,908	195,908	$19,591	6,692	$133,840	$153,431	$12,250	$35,263
2	Optimize Enthalpy Wheel Control on Lab AHUs & Tie AHU-1.2 Wheel into Metasys	109,796	109,796	$10,980	402	$8,040	$19,020	$33,250	$19,763
3	Optimize Admin AHUs - OA, DCV, Admin Dampers, Return Air Ductwork Restriction	76,450	76,450	$7,645	1,227	$24,540	$32,185	$99,092	$13,761
4	Implement Static Pressure Setback on Lab AHUs & Install Building-Level dP Sensors	46,513	0	$4,651	0	$0	$4,651	$30,064	$8,372
Measures from Current Focused Lab Study									
5A	Optimize Laboratory Airflow Control & Set Occ/Unocc Min ACH Rates	460,054	48,858	$46,005	2,211	$44,216	$90,222	$98,240	$82,810
5B	Convert Fume Hoods to Variable Volume Control, Reduce Minimums, & Recertify	498,392	52,930	$49,839	2,395	$47,901	$97,740	$97,300	$89,711
Additional Measure Identified									
6	Reduce Non-Lab VAV Min Airflows	75,000	5,000	$7,500	750	$15,000	$22,500	$86,638	$13,500
	Totals	**1,462,113**	**488,942**	**$146,211**	**13,677**	**$273,537**	**$419,748**	**$456,834**	**$263,180**

Baseline Energy Consumption		*Reduction*		
Annual Total Building Electric Use (kWh/yr)	3,773,534	26%	Simple Payback Before Potential Incentive:	**1.1**
Annual Building HVAC Electric Use (kWh/yr)	2,242,689	43%	Eversource RCx Measure Incentive Rate ($/kWh):	**$0.18**
Annual BuildingSteam Use (Mlbs/yr)	29,226	47%	Potential Electric Incentive from Eversource:	**$263,180**
Annual Building Chilled Water Use (kWh/yr)	847,046	58%	Net Project Cost After Potential Incentive :	**$193,654**
			Simple Payback After Potential Incentive:	**0.5**

*The values in the "CHW Savings" column are shown for informational purposes only. These savings are included in the Total Electric Savings Column.

**The electric savings shown in the "CHW Savings" column are savings that would come from the ISB chiller plant and not directly the ISB electric meter.

Increased Lab Awareness

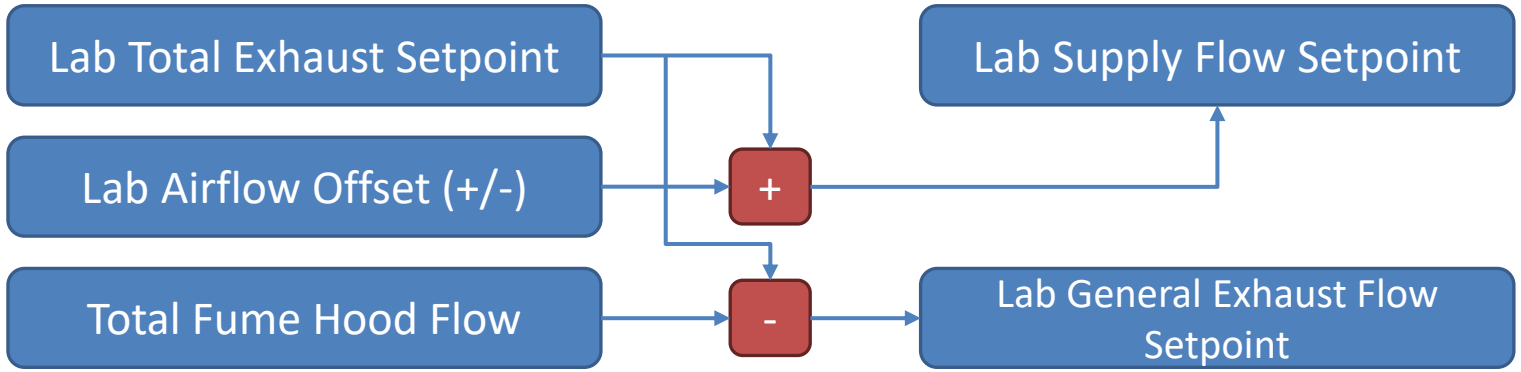
Sound lab practices already in place

- During the focused lab study and, specifically, the presentation of results, lab awareness of campus EH&S and lab occupants is greatly increased.
- Answers can be presented to questions such as:
  - How and why do our labs operate in this fashion?
  - How much does it cost to operate these labs?
  - What procedures should be carried out annually to maintain lab spaces?
- This is a great time to educate lab occupants and coordinators
  - This benefits not only their safety, but also helps maintain savings and makes them aware of costs
- This was accomplished through a project review meeting with attendees from the Dean of Engineering down to Lab PIs

Step 3 – Implementation, Cx & Training

3. Implementation
   - Engineer new lab control sequences, setpoints and lab airflow offsets to control to CIH recommended Air Change Rates. Setpoints and control sequences approved by EH&S.
   - Example Net Room Volume = 11,813 ft^3 with a recommended 6 occupied ACH. Furniture volume was subtracted from gross room volume.

$$6\ ACH = \frac{Flow\ Rate(\frac{cu.ft}{min}) * 60\ (\frac{min}{hr})}{11{,}813\ (cu.ft)} = \frac{6 * 11{,}813}{60} = 1{,}181\ CFM$$



Step 3 – Implementation, Cx & Training

3. Implementation
   - Engineer new fume hood controls and setpoints to be in line with ANSI Z9.5-2012 standards as well as UMass EH&S standards for face velocity.
   - Lower closed sash minimum airflow setpoints, control to 80 fpm face velocity above 4” sash position, use sash status as a backup to lab occupancy sensor

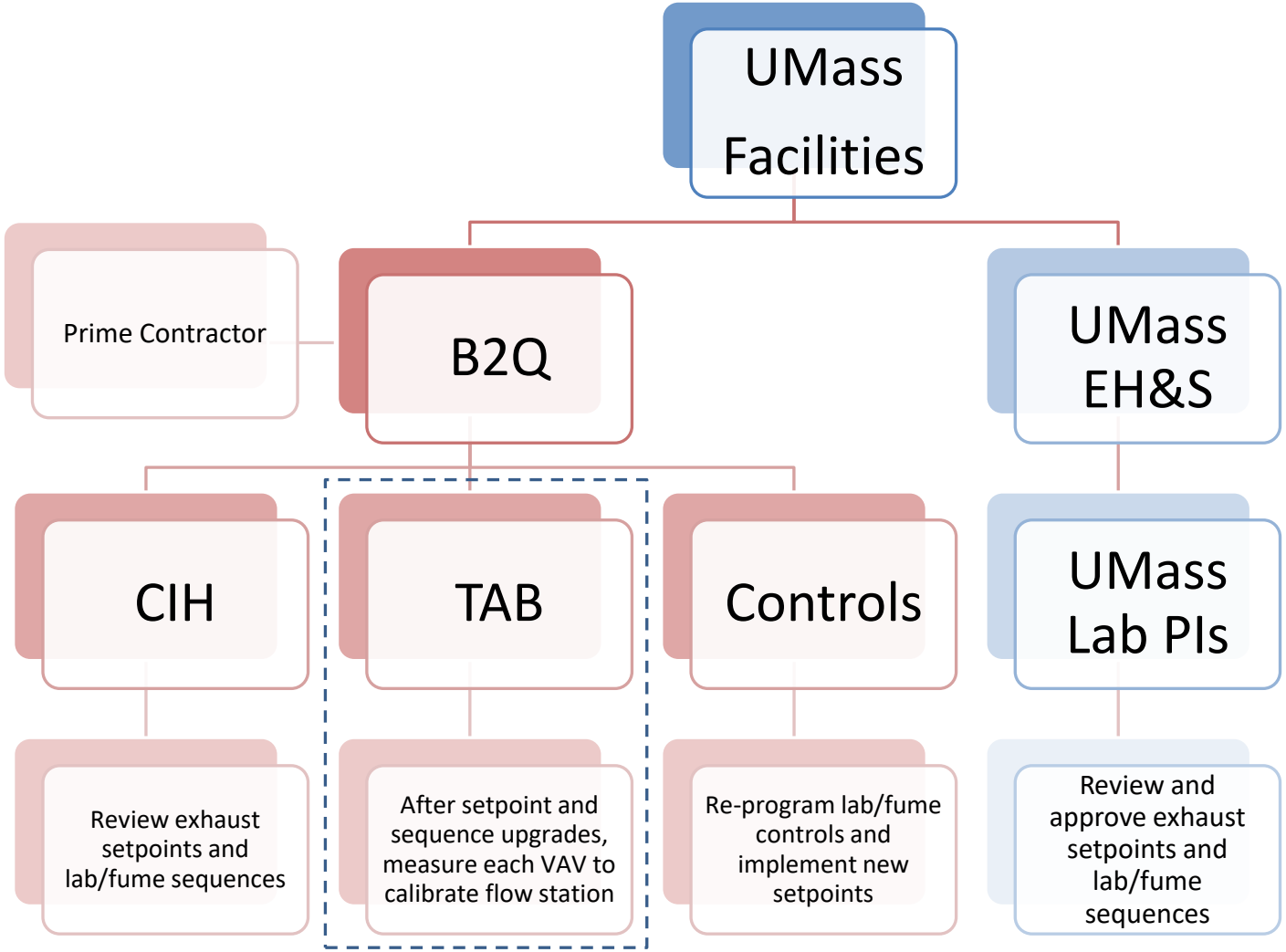
Fume Hood Min & Max Flows						
Fume Hood			Base		Proposed	
Hood Type	Hood Width	Hood Count	Occupied Flow	Unoccupied Flow	Max Flow	Min Flow
	(ft)	No.	(cfm)	(cfm)	(cfm)	(cfm)
Low Flow	4	4	530	190	450	120
	5	1	550	220	575	160
	6	62	600	300	700	200
	7	40	720	360	800	225
	8	2	835	415	950	250
By Pass	4	17	530	190	450	120
	6	7	860	300	700	200
	8	4	1,195	415	950	250
Pass Thru	6	10	920	450	700	200

Step 3 – Implementation, Cx & Training

3. Commissioning
   - Each lab underwent thorough testing and commissioning.
     - Each control sequence was tested for operation during occupied/unoccupied periods, fume hood use/non-use, heating and cooling, emergency purge modes to ensure that the optimized controls and new exhaust setpoints were being maintained
     - Each fume hood was tested and re-certified to verify proper operation
   - Through this process, 96 mechanical issues were discovered and were causing labs to not be able to control to their new setpoints leaving unsafe conditions

	VAVs With Broken Actuators	VAVs in Need of Repair	VAVs with Flow Fluctuation	Hunting VAVs & Programming Issues
Lab Wing	33	9	9	29
Admin Wing	10	6	0	0
Total	**43**	**15**	**9**	**29**

Step 3 – Project Team



- Hundreds of hours of day to day communication about issues encountered and progress made keep all parties informed and up to speed
- All parties participated in training where project details were reviewed and presented to Facilities Staff and Lab PIs

Lesson Learned - The Importance of TAB to Lab Safety

- After implementation the BAS was controlling to the correct lab offset as programmed by the controls contractor.

		Original K-Factor		New K-Factor	
		TAB Reading	Metasys Reading	TAB Reading	Metasys Reading
General Exhaust Flow	cfm	3,681	4,065	4,018	4,027
Total Fume Hood Flow	cfm	200	200	200	200
Total Supply Flow	cfm	4,091	3,786	3,696	3,751
Offset Setpoint	cfm	-500		-500	
Actual Measured Offset	**cfm**	**210**	**-479**	**-522**	**-476**

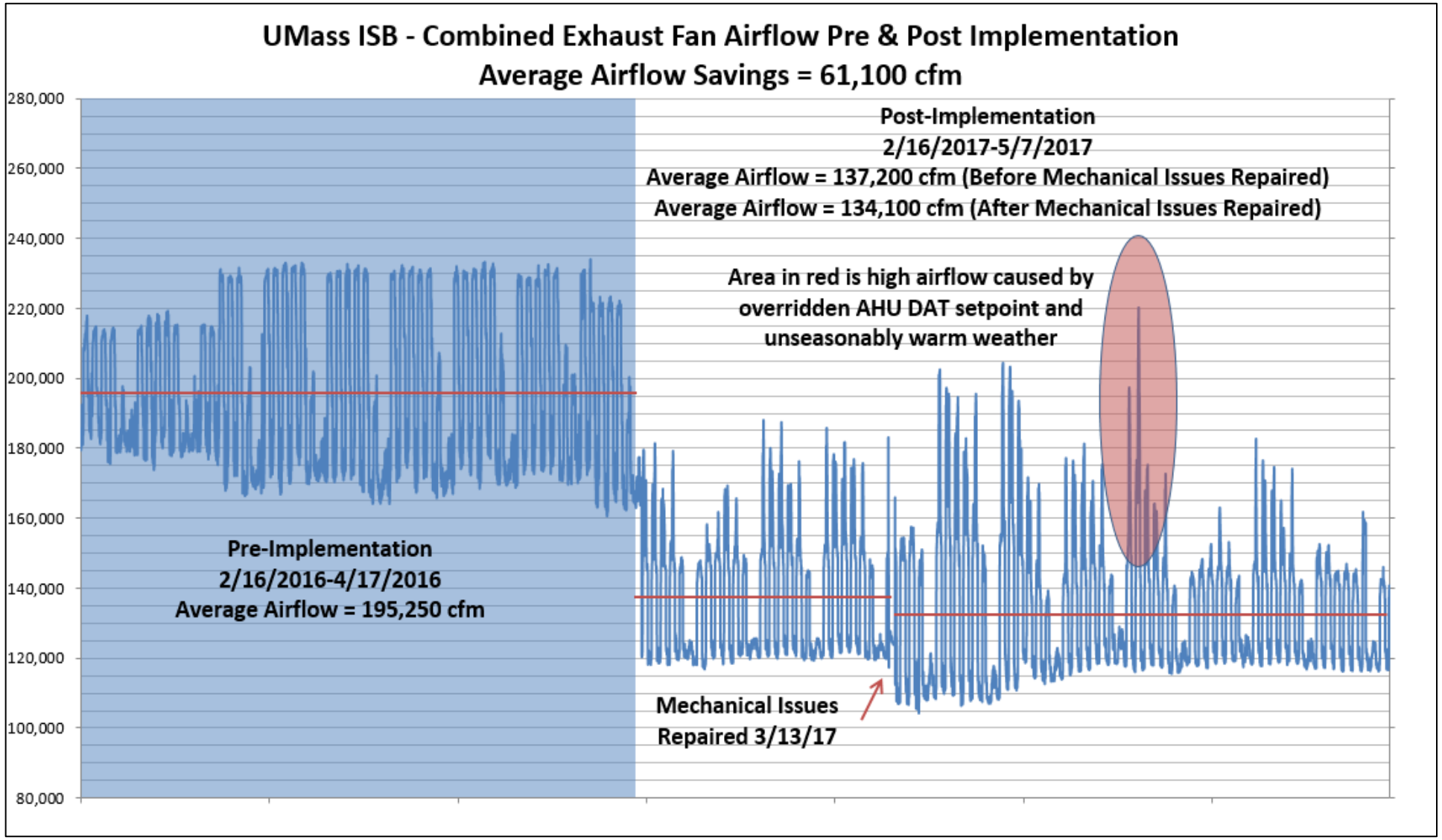
- A K-Factor (or pickup gain) relates pressure velocity and area to airflow in VAVs (and other flow applications)

Step 4 – Measurement and Verification

4. M&V
   - Separate from the commissioning effort which ensured the changes made were operating as intended, the M&V process observed the impact on building energy use as a result of the measures implemented

   - M&V was critical for the Utility to provide project funding to help pay for the lab optimization projects and provide UMass Management & EH&S with peace of mind that these energy savings are real and being maintained
     - Measured and verified energy savings were compared to predicted energy savings

Step 4 – Measurement and Verification - ISB



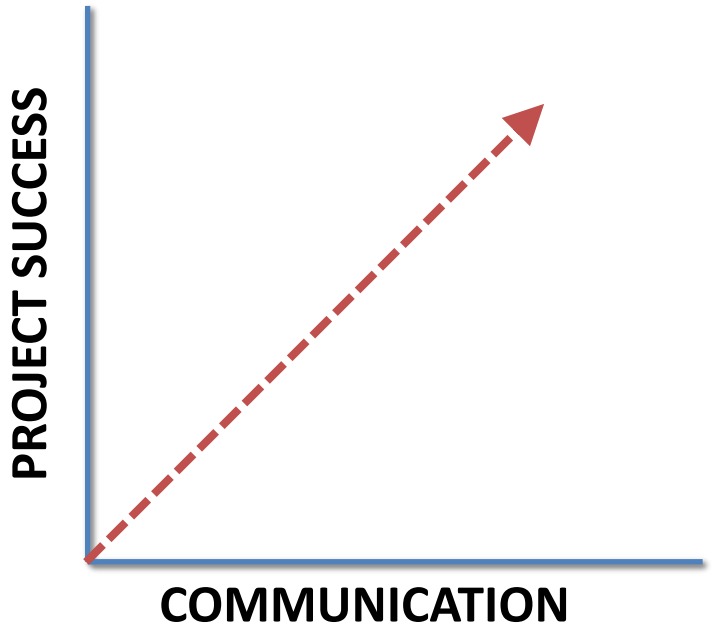
Step 4 – Measurement and Verification – Final Results

UMass ISB & Elab II Measured and Verified Savings					
Building	Total Electric Energy Savings	Steam Energy Savings	Energy Cost Savings	Implementation Cost	Simple Payback Before Incentive
--	kWh	Mlb	$	$	yrs.
ISB	1,851,862	10,738	$399,946	$590,968	1.5
Elab II	677,294	6,312	$193,968	$448,907	2.3
Total	**2,529,156**	**17,050**	**$593,914**	**$1,039,875**	**1.8**

- M&V savings amount to greater than 30% savings of baseline energy use
- M&V savings exceeded predicted savings by >20%

Early and Consistent Teamwork & Communication

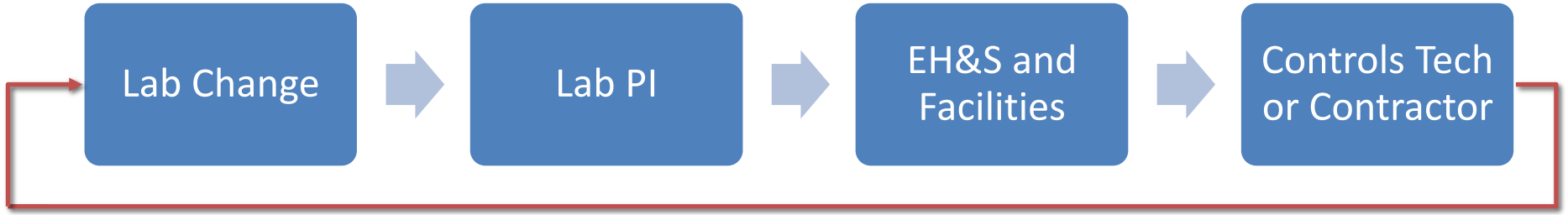
1. Key to project success during all project phases.
2. Allows an open stage to voice questions and concerns from different vantage points
3. No one gets left in the dark about changes in lab operation
4. Allows input from all parties where critical decisions are made before project implementation
5. Allows for the safest, most energy efficient and best functioning final product where **all parties are aware of the changes made and why.**



Step 5 - Maintaining Persistence Over Time

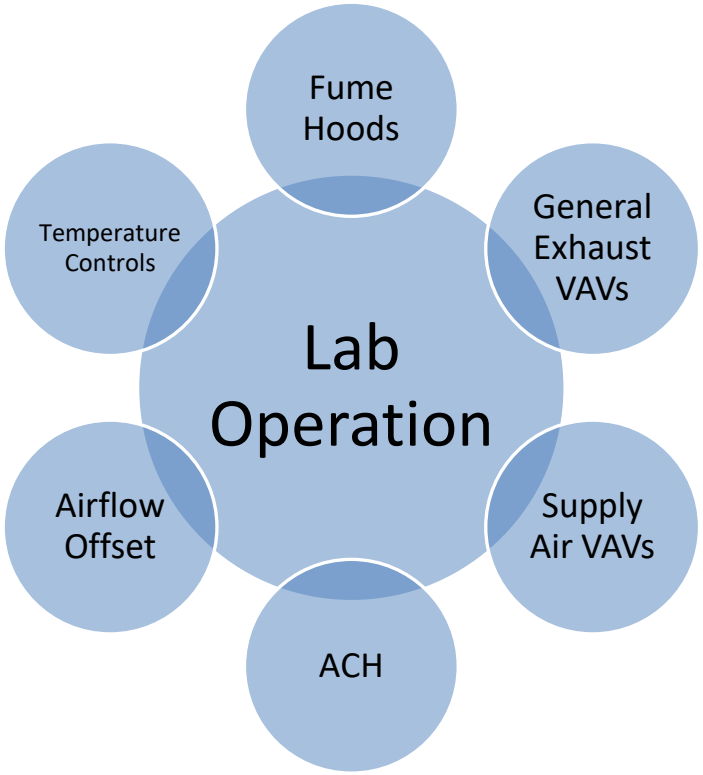
5. Maintaining Persistence Over Time

- Communication
  - While early and consistent teamwork is important to project success, it is equally important to maintain this level of communication after project completion
  - Labs are fluid environments and change constantly
    - With lab alteration, safe ventilation requirements may also change and the recently updated controls must be altered to meet them
    - For this to happen, the need for re-evaluation must be communicated from the Lab Coordinator, through EH&S and Facilities on up to the controls contractor or technician.



Step 5 - Maintaining Persistence Over Time

- Continuous Commissioning
  - B2Q installed FacilityConneX, a Monitoring Based Commissioning software in the integrated sciences building to continuously monitor critical lab operating points and raise flags if operation is not as intended



Environmental Impact – "Greening"

- If the annual energy savings realized at ISB & ELab II are maintained through persistence for **20** years…
- **50,583 MWh & 4.6 Million Therms of Natural Gas will be saved**

Year	CO_2 (tons)[1]	NO_x (tons)[1]	SO_2 (tons)[1]
1 Year	2,500	1.1	0.4
20 Years	**50,000**	**22**	**8**

or

The Equivalent[2] of:

- **403** passenger vehicles annually
- **211,797** gallons of gas consumed annually
- **2,059,345** pounds of coal burned annually
- **48,780** trees planted annually

[1]Emissions factors are an aggregate from https://www.eia.gov/electricity/state/massachusetts/ and Solar Gas Turbine Published Emissions Data
[2]Equivalent greenhouse gas factors from: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

Questions?

A Woman Business Enterprise (WBE)

100 Burtt Rd. Ste. 212
Andover, MA 01810

Chris Schmidt – Senior Project Manager
cschmidt@b2qassociates.com
(603) 247-1575 (Cell)

Brad Newell – Project Manager
bnewell@b2qassociates.com
(603) 703-3932 (Cell)
(978) 447-5604 (Office)

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