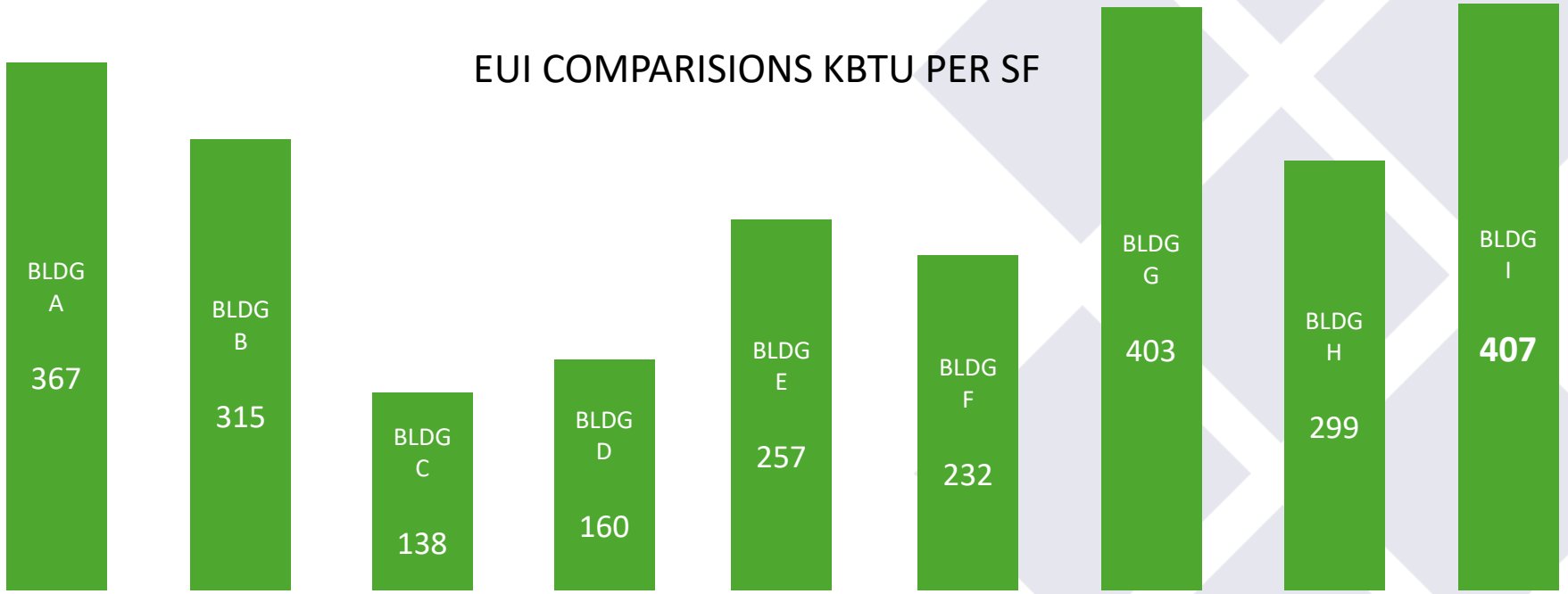
A Method for Carbon Reduction Planning

Tom Joyner
Managing Partner

Daniel Whittet
Senior Associate |
Energy & Sustainability

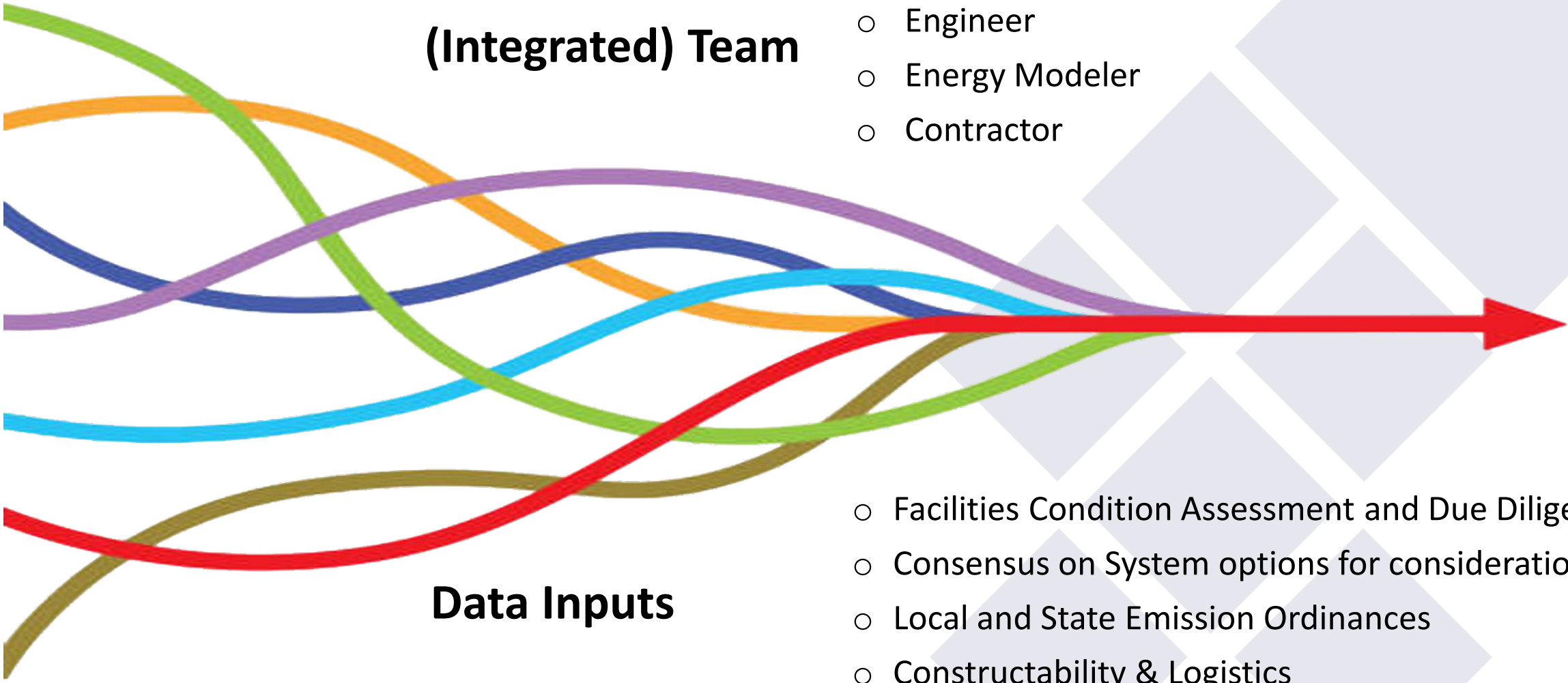
1. Understand the Challenges
    - Energy Intense Buildings
    - Large Infrastructure
    - Occupied Facilities
    - Maintaining Asset Value
2. Understand What's Needed for a Comprehensive Evaluation
    - Data
    - Team
3. Understand the Value of Energy Modeling

- Energy intensive buildings with large infrastructure with varying obsolescence
- Occupied Facilities (24/7), Rolling leases, logistics
- Maintain asset value (capacity, quality, reliability)
- Utility availability



(Integrated) Team

- Owner
- Engineer
- Energy Modeler
- Contractor



Data Inputs

- Facilities Condition Assessment and Due Diligence
- Consensus on System options for consideration
- Local and State Emission Ordinances
- Constructability & Logistics
- Budget, Incentives, Savings ($, EUI, CEI)

Data Input: Facilities Condition Assessment

EQUIPMENT TAG #	ITEM	NOTES/DESCRIPTION	APPROX. AGE	Model No.	Serial No.	RATING (1 - 10) 1 = Worst thru 10 = Best	RECOMMENDATION	Capacity BTU/H	Flow Rate	Delta T (°F)	CFM	Photo's
Air Distribution												
AHU-1	Air handling unit, 100% OA, Dual Ti						Per ASHRAE's equipment life expectancy chart, the air handling unit is past its useful life. Life Expectancy per ASHRAE is 15 years. The air handling unit is in good condition.	Heating: 8,748 MBH (Coil Qty. - 12) Cooling: 11,558 MBH (Total); 6,576 MBH (Sensible) (Coil Qty. - 12)			150,000 CFM Total, 75,000 CFM per Tunnel	
AHU-2	Air handling unit, 100% OA										75,000 CFM	
AHU-3	Air handling unit, 100% OA	pump due to 100% OA and no glycol use in HW piping.					replacement of pre & final filter racks with Dynamic V8 filters to reduce annual maintenance and filter cost. See Scope of Work Narrative for additional recommendations.				75,000 CFM	
AHU-4	Air handling unit, 100% OA	Ventrol air handling Unit (AHU) serves floors 1 - 12 for core spaces and tenant lab/office spaces. Unit has chilled water (CHW) cooling coils and pre-heat hot water (HW) coils, steam humidifiers, 30% pre-filters/85% filters and supply fan(s). Unit includes a freeze-protection pump due to 100% OA and no glycol use in HW piping.	15+	ITF-1-4	11280-4	7	Per ASHRAE's equipment life expectancy chart, the air handling unit is past its useful life. Life Expectancy per ASHRAE is 15 years. The air handling unit is in good condition. Recommend continue routine cleaning and maintenance on air handling unit components. Consider replace existing supply fan VFD with an ultra-low harmonic VFD. Unit replacement should be planned in 5 – 8 years. Consider a retro-fit of the existing supply fan with new supply fan array for redundancy. Also consider replacement of pre & final filter racks with Dynamic V8 filters to reduce annual maintenance and filter cost. See Scope of Work Narrative for additional recommendations.	Heating: 4,375 MBH (Coil Qty. - 6) Cooling: 5,779 MBH (Total); 3,286 MBH (Sensible) (Coil Qty. - 6) Humidification: 685 lbs./Hr. (Humidifer Qty. - 2)	Heating: 292 GPM Cooling: 825 GPM	Coil Entering Air Temp.: 91F DB/74°F WB (Summer); 6°F DB (Winter) Heating: 54°F ΔT; EWT: 200°F - LWT: 170°F Cooling: 40.5°F ΔT; EAT: 91°F - LAT: 50.5°F	75,000 CFM	
AHU-5	Air handling unit, 100% OA	Ventrol air handling Unit (AHU) serves floors 1 - 12 for core spaces and tenant lab/office spaces. Unit has chilled water (CHW) cooling coils and pre-heat hot water (HW) coils, steam humidifiers, 30% pre-filters/85% filters and supply fan(s). Unit includes a freeze-protection pump due to 100% OA and no glycol use in HW piping.	15+	ITF-1-4	11280-5	7	Per ASHRAE's equipment life expectancy chart, the air handling unit is past its useful life. Life Expectancy per ASHRAE is 15 years. The air handling unit is in good condition. Recommend continue routine cleaning and maintenance on air handling unit components. Consider replace existing supply fan VFD with an ultra-low harmonic VFD. Unit replacement should be planned in 5 – 8 years. Consider a retro-fit of the existing supply fan with new supply fan array for redundancy. Also consider replacement of pre & final filter racks with Dynamic V8 filters to reduce annual maintenance and filter cost. See Scope of Work Narrative for additional recommendations.	Heating: 4,375 MBH (Coil Qty. - 6) Cooling: 5,779 MBH (Total); 3,286 MBH (Sensible) (Coil Qty. - 6) Humidification: 685 lbs./Hr. (Humidifer Qty. - 2)	Heating: 292 GPM Cooling: 825 GPM	Coil Entering Air Temp.: 91F DB/74°F WB (Summer); 6°F DB (Winter) Heating: 54°F ΔT; EWT: 200°F - LWT: 170°F Cooling: 40.5°F ΔT; EAT: 91°F - LAT: 50.5°F	75,000 CFM	
AHU-6	Air handling unit, 100% OA	Ventrol air handling Unit (AHU) serves floors 1 - 18 for core spaces and tenant lab/office spaces. Unit has chilled water (CHW) cooling coils and pre-heat hot water (HW) coils, steam humidifiers, 30% pre-filters/85% filters and supply fan(s). Unit includes a freeze-protection pump due to 100% OA and no glycol use in HW piping.	15+	ITF-1-4	11280-6	7	Per ASHRAE's equipment life expectancy chart, the air handling unit is past its useful life. Life Expectancy per ASHRAE is 15 years. The air handling unit is in good condition. Recommend continue routine cleaning and maintenance on air handling unit components. Consider replace existing supply fan VFD with an ultra-low harmonic VFD. Unit replacement should be planned in 5 – 8 years. Consider a retro-fit of the existing supply fan with new supply fan array for redundancy. Also consider replacement of pre & final filter racks with Dynamic V8 filters to reduce annual maintenance and filter cost. See Scope of Work Narrative for additional	Heating: 3,888 MBH (Coil Qty. - 3) Cooling: 5,162 MBH (Total); 2,926 MBH (Sensible) (Coil Qty. - 3) Humidification: 600 lbs./Hr. (Humidifier Qty. - 2)	Heating: 259 GPM Cooling: 738 GPM	Coil Entering Air Temp.: 91F DB/74°F WB (Summer); 6°F DB (Winter) Heating: 54°F ΔT; EWT: 200°F - LWT: 170°F Cooling: 40.5°F ΔT; EAT: 91°F - LAT: 50.5°F	66,667 CFM	

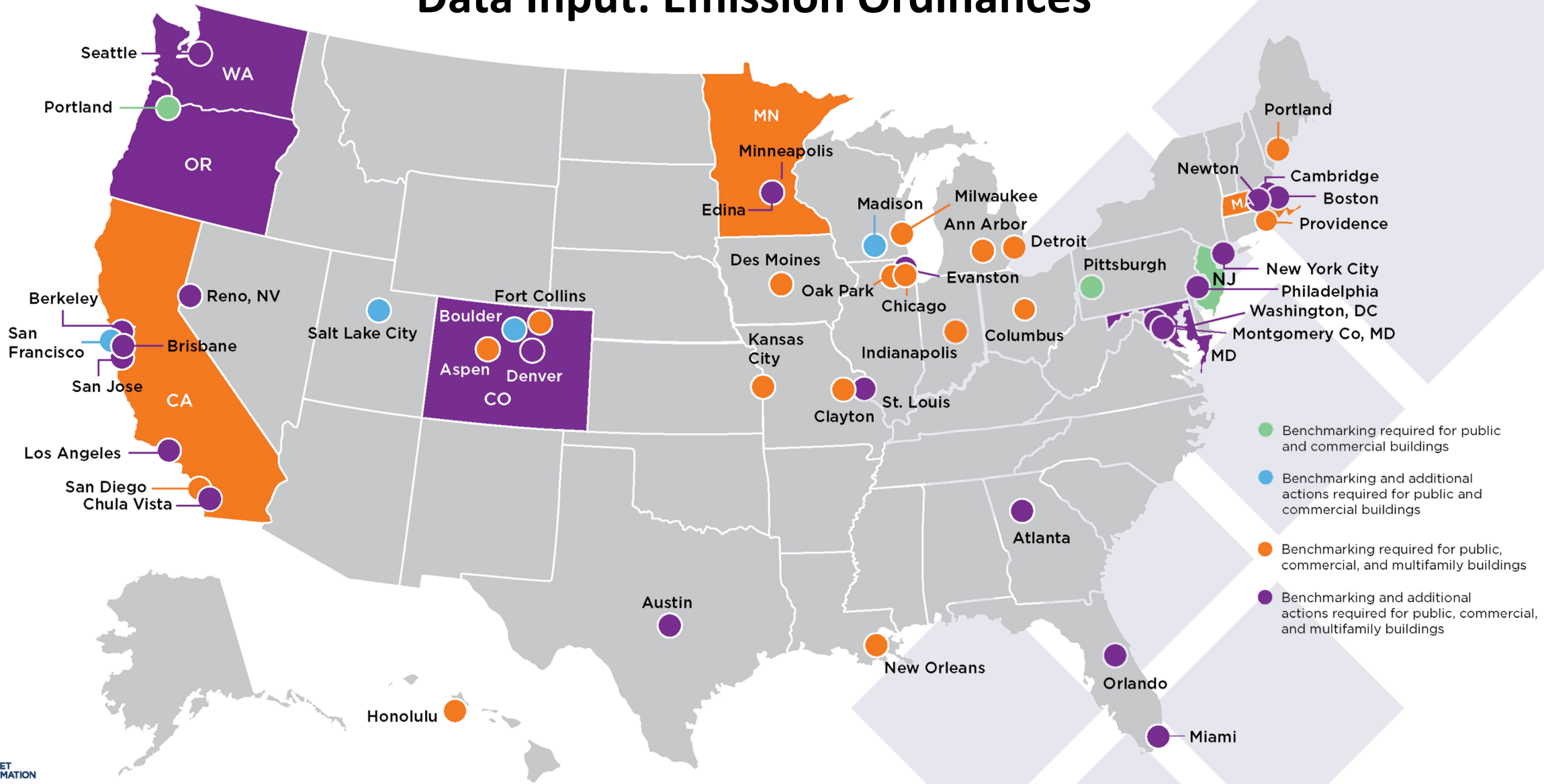
APPROX. AGE	Model No.	Serial No.	RATING (1 - 10) 1 = Worst thru 10 = Best	RECOMMENDATION	Capacity BTU/H	Flow Rate
15+	ITF-1-4	11280-1	7	Per ASHRAE's equipment life expectancy chart, the air handling unit is past its useful life. Life Expectancy per ASHRAE is 15 years. The air handling unit is in good condition. Recommend continuation of routine cleaning and maintenance on air handling unit components. Consider replace existing supply fan VFD with an ultra-low harmonic VFD. Unit replacement should be planned in 5 – 8 years. Consider a retro-fit of the existing supply fan with new supply fan array for redundancy. Also consider replacement of pre & final filter racks with Dynamic V8 filters to reduce annual maintenance and filter cost. See Scope of Work Narrative for additional recommendations.	Heating: 8,748 MBH (Coil Qty. - 12) Cooling: 11,558 MBH (Total); 6,576 MBH (Sensible) (Coil Qty. - 12) Humidification: 685 lbs./Hr. (Humidifer Qty. - 4)	Heating: 583 GPM Cooling: 1,650 GPM

Data Input: Consensus

Decarbonization Recommendations

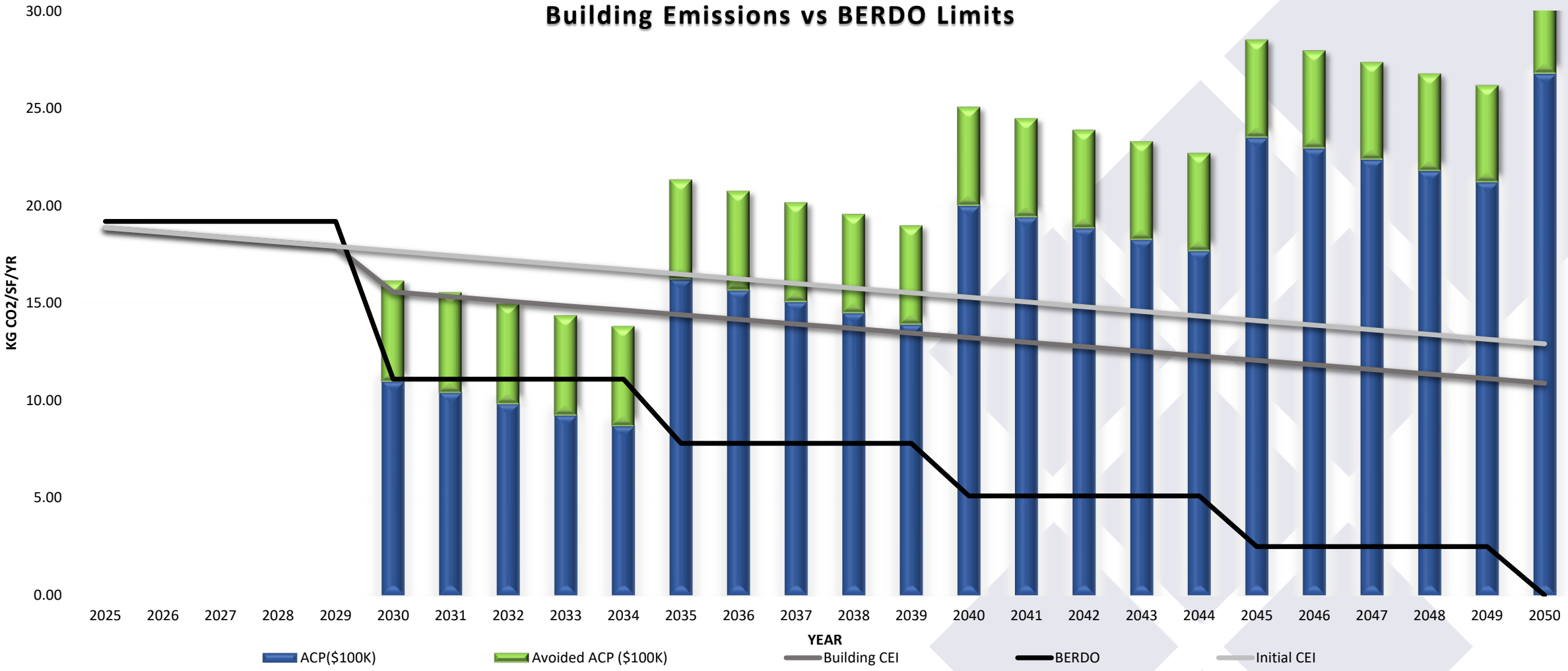
#	Trade	Type (CRM, Resiliency, etc)	Idea	Description	Engineering (Y/N)	Owner Approved (Y/N)	GC to Price (Y/N)	Notes
General								
G1	General	CRM	Renewable energy credits	Purchase renewable energy credits (RECs) for all electricy consumption	Yes			Will be required regardless of the quantity or size of CRMs implemented
Architectural								
A1	Architectural	CRM	Reduce infiltration	Pressure test the building floor-by-floor and fill cracks. May also be accomplished with exterior thermal scanning.	Yes			
A2	Architectural	CRM	Replace glazing with ultra low U-value	Replace existing punched window assemblies with triple pane window assemblies. (Does not include replacing curtainwall glass.)	Yes			
Plumbing								
P1	Plumbing	CRM	Replace gas water heaters with electric	Replace 8 gas fired water heaters in penthouse with total of 4 electric water heares (Two 15KW models for TW & Two 27KW models for NHW.)	Yes			
P2	Plumbing	CRM	Replace gas water heaters with ASHP	Did not pursue ASHP or WSHP's based on space required, total KW, and cost. Hot water usage in building does not justify the application.	No			Did not pursue ASHP or WSHP's based on space required, total KW, and cost. Hot water usage in building does not justify the application.
P3	Plumbing	CRM	Ultra low flow urinals and low flow fixtures	Reduce energy consumption from water booster pumps.	Yes			Reduce energy consumption from water booster pumps. Basement level fixtures observed to be 1.0 gpf urinals and 1.6 toilets. These would be replaced in kind, and provide water savings and slight reduction in booster pump usage.
P4	Plumbing	CRM	Centralize core toilet water heaters	Replace distributed electric water heaters with core toilets with centralized ASHP.	No			See above
Mechanical								
M1	Mechanical	CRM	ASHP - 84% (Option 1)	Provide 84% of the building's peak heating capacity with air source heat pumps. Heat pump modules to be placed on the high roof and connected into the existing heating hot water system.	Yes			Based on available space on high roof, 48 total modules may be located. These would account for approx. 84% of the building's new heating load (based on reduction in building airflow.)
M3	Mechanical	CRM	ASHP - 25% (Option 2)	Provide 25% of the building's peak heating capacity with air source heat pumps. Heat pump modules to be placed on the high roof and connected into the existing heating hot water system.	No			Provide 15 ASHP modules on the high roof. These would account for approx. 25% of the building's new heating load (based on reduction in building airflow.) In line with New stretch code requirement for new buildings.

Data Input: Emission Ordinances

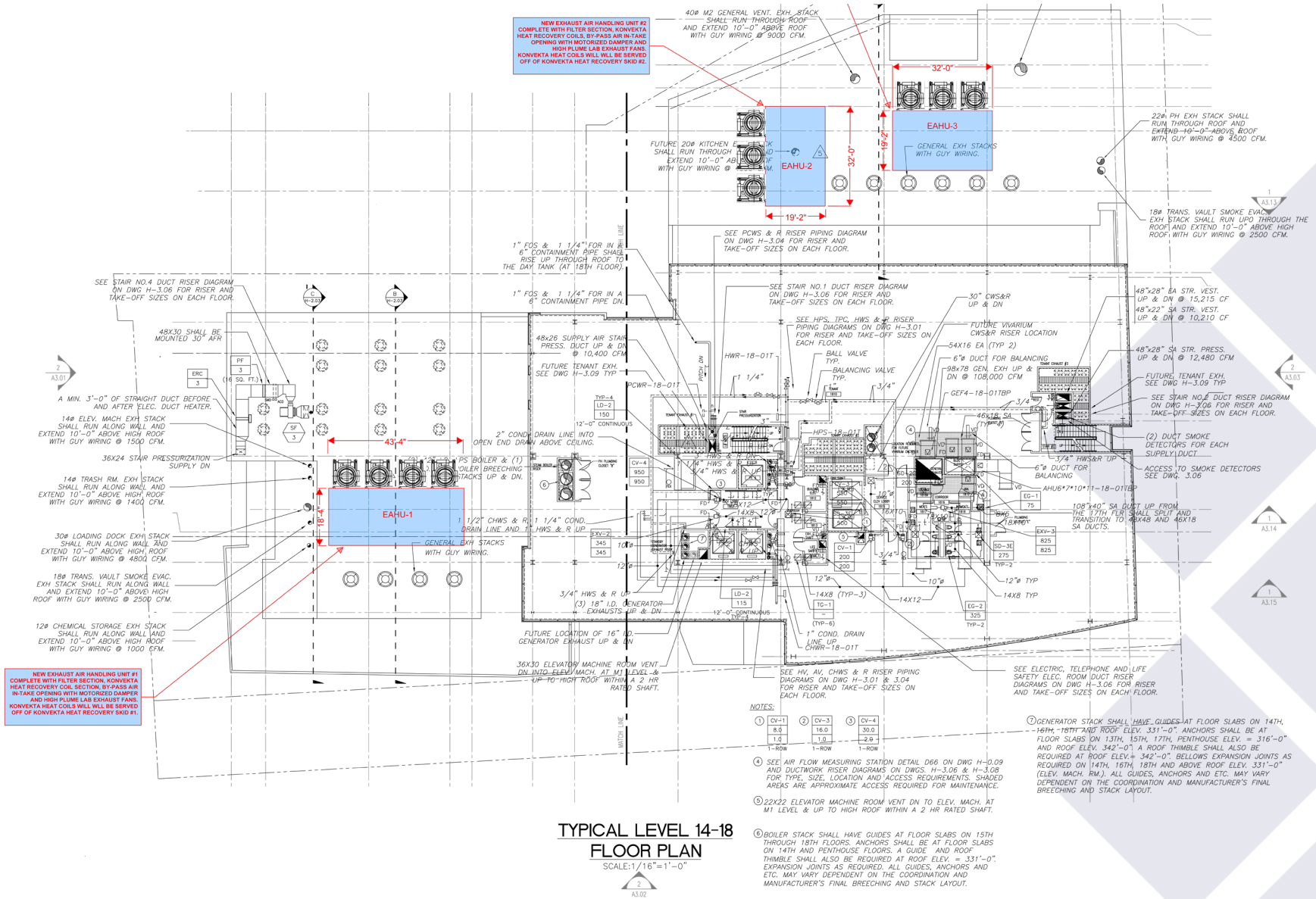


IMT
INSTITUTE FOR MARKET TRANSFORMATION

Data Input: Emission Ordinances



Data Input: Constructability & Logistics



Comprehensive Evaluation

A Method for Carbon Reduction Planning

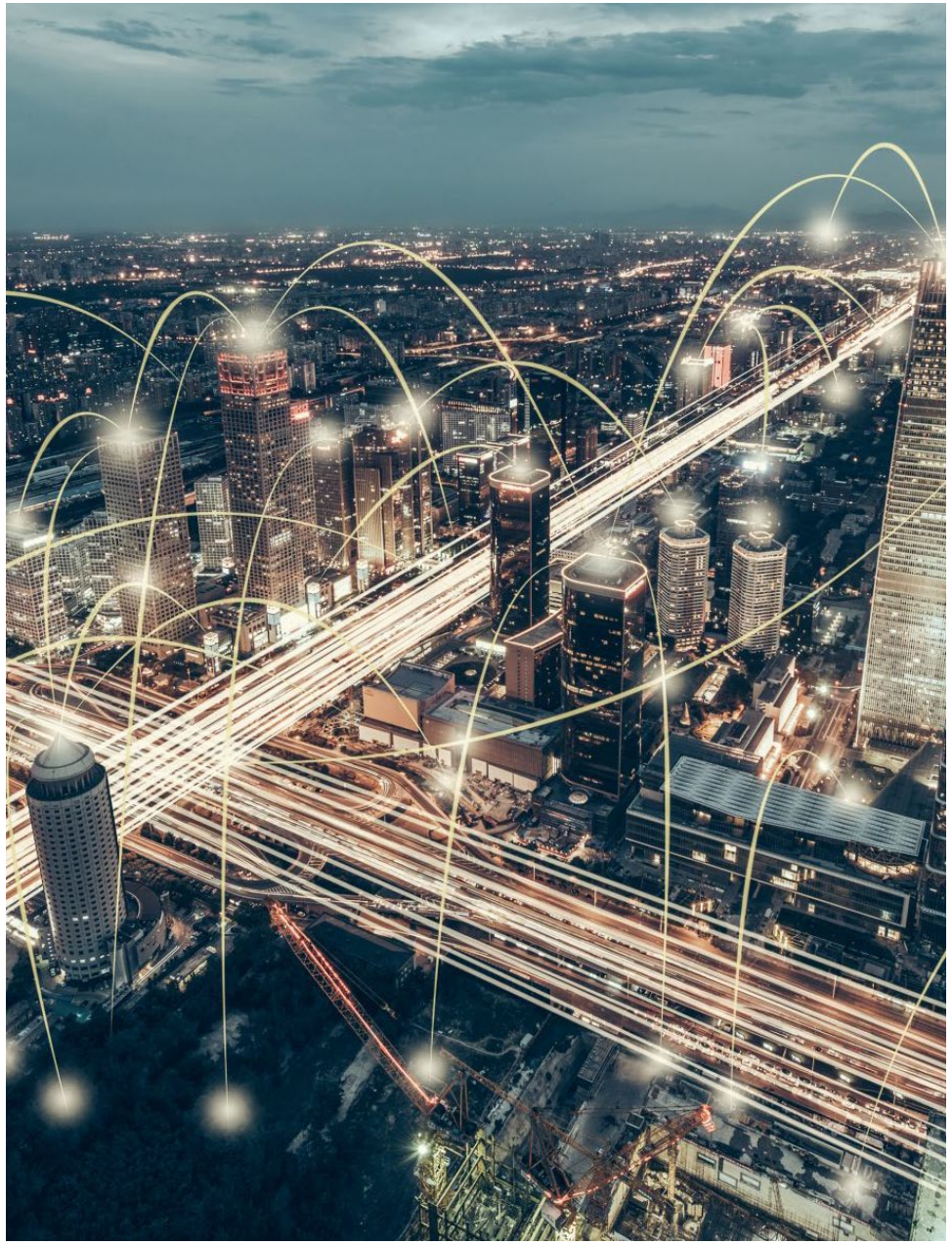
Data Input: Budget, Incentives, Savings ($, EUI, CEI

Carbon Reduction Measures (CRMs)

System Options	Option Description	Bldg. EUI (KBTU/Sq. ft.)	EUI Reduction (KBTU/Sq. ft.)	Bldg. CEI ($kgCO_2$/Sq. ft./Yr.)	New Bldg. CEI in 2050 ($kgCO_2$/Sq. ft./Yr.)	CEI Reduction in 2050 (KBTU/Sq. ft.)	Cumulative ACP through 2050	Cumulative Avoided ACP Through 2050	Cumulative Energy Cost Savings Through 2050	Total Cumulative Savings Through 2050	Budget Cost	(Budget + ACP) - Total Savings	Consruction Cost per EUI Point Reduction
Baseline	Existing Building	407											
1	Mis-match Base System RAERS - AHU Coils, HR Skids, EAHUs	35											
w/ 16 Boilers +Humidification		291											
2	Mis-match Base System RAERS Frosting - AHU Coils, HR Skids, EAHUs and EA Frosting Coils	35				N/A	$ 46,411,090	$ -	$ -	$ -			
w/ 16 Boilers +Humidification		291				7.98	$ 35,746,667	$ 10,664,423	$ 12,841,234	$ 23,505,657	$ 29,427,554	$ 41,668,564	$ 535,046
3	Mis-match Base System ZEERS - AHU Coils, HR Skids, EAHUs and EA Frosting Coils WSHP provides ~65% of heat at ~15 deg F OAT WHSP would not operate below ~15 deg F OAT	348				10.32	$ 23,845,525	$ 22,565,565	$ 22,881,287	$ 45,446,852	$ 45,196,148	$ 23,594,821	$ 392,328
w/ 10 Boilers +Humidification		288				7.98	$ 35,766,523	$ 10,644,567	$ 12,727,802	$ 23,372,369	$ 30,886,600	$ 43,280,754	$ 561,575
4	Full Flow System RAERS	328											
w/ 14 Boilers +Humidification		26				10.32	$ 23,865,382	22,545,708	22,767,855	$ 45,313,563	$ 46,655,194	$ 25,207,013	$ 405,345
5	Full Flow System RAERS Frosting	327											
w/ 14 Boilers +Humidification		267.8	139.2	13.57	7.65	11.22	$ 19,162,005	$ 27,249,085	$ 28,194,892	$ 55,443,977	$ 62,399,484	$ 26,117,512	$ 448,272
6	Full Flow System ZEERS	322.9	84.1	15.65	9.77	9.1	$ 30,016,727	$ 16,394,363	$ 17,987,019	$ 34,381,382	$ 58,340,667	$ 53,976,012	$ 693,706
w/ 6 Boilers +Humidification		262.8	144.2	13.4	7.43	11.44	$ 18,115,586	28,295,504	28,027,071	$ 56,322,575	$ 72,169,944	$ 33,962,955	$ 500,485
7A	Replace Steam Boilers w/ 19 Hi-Eff Condensing Boilers - Keeps Steam Humidification	381.8	25.2	17.92	11.94	6.93	$ 41,440,826	$ 4,970,264	$ 4,427,279	$ 9,397,543	$ 10,326,930	$ 42,370,213	$ 409,799
7B	Replace Steam Boilers w/ 19 Hi-Eff Condensing Boilers +hybrid adiabatic humidification	346.8	60.2	16.62	10.57	8.3	$ 34,509,948	$ 11,901,142	$ 10,040,053	$ 21,941,195	$ 15,768,594	$ 28,337,347	$ 261,937
~~7C~~	~~Replace Steam Boilers w/ 19 Hi-Eff Condensing Boilers + Electric Steam Boiler~~	~~344.2~~	~~62.8~~	~~17.01~~	~~9.67~~	~~9.2~~	~~$ 32,524,803~~	~~$ 13,876,287~~	~~$ (13,905,197)~~	~~$ 871,090~~		~~$ 31,653,713~~	$ -
8	Option 1 + Option 7B + Option 9	287.6	119.4	14.27	8.49	10.38	$ 23,200,234	$ 23,210,856	$ 26,567,624	$ 49,778,480	$ 51,559,137	$ 24,980,891	$ 431,819
9	Retrofit existing AHU's w/ Dynamic V8 air cleaners	402.7	4.3	14.27	12.85	6.02	$ 45,765,799	$ 645,291	$ 3,686,337	$ 4,331,628	$ 999,316	$ 42,433,487	$ 232,399
10	New 600T Heat Recovery Chiller	405.7	1.3	18.83	12.86	6.01	$ 46,163,239	$ 247,851	$ 119,20	$ 367,058	$ 6,362,569	$ 52,159,170	$ 4,894,607

Value of Energy Modeling

Doy you need a second on that?



The Importance of Planning

- Rising penalties & compliance costs
- Changing grid emissions factors
- Capital-intensive infrastructure
- Need for integrated strategy

ACHIEVE THE GOAL!!!

A Method for Carbon Reduction Planning

Tom Joyner
Managing Partner

Daniel Whittet
Senior Associate | Energy & Sustainability

Questions?