Commercial HVAC Retrofits

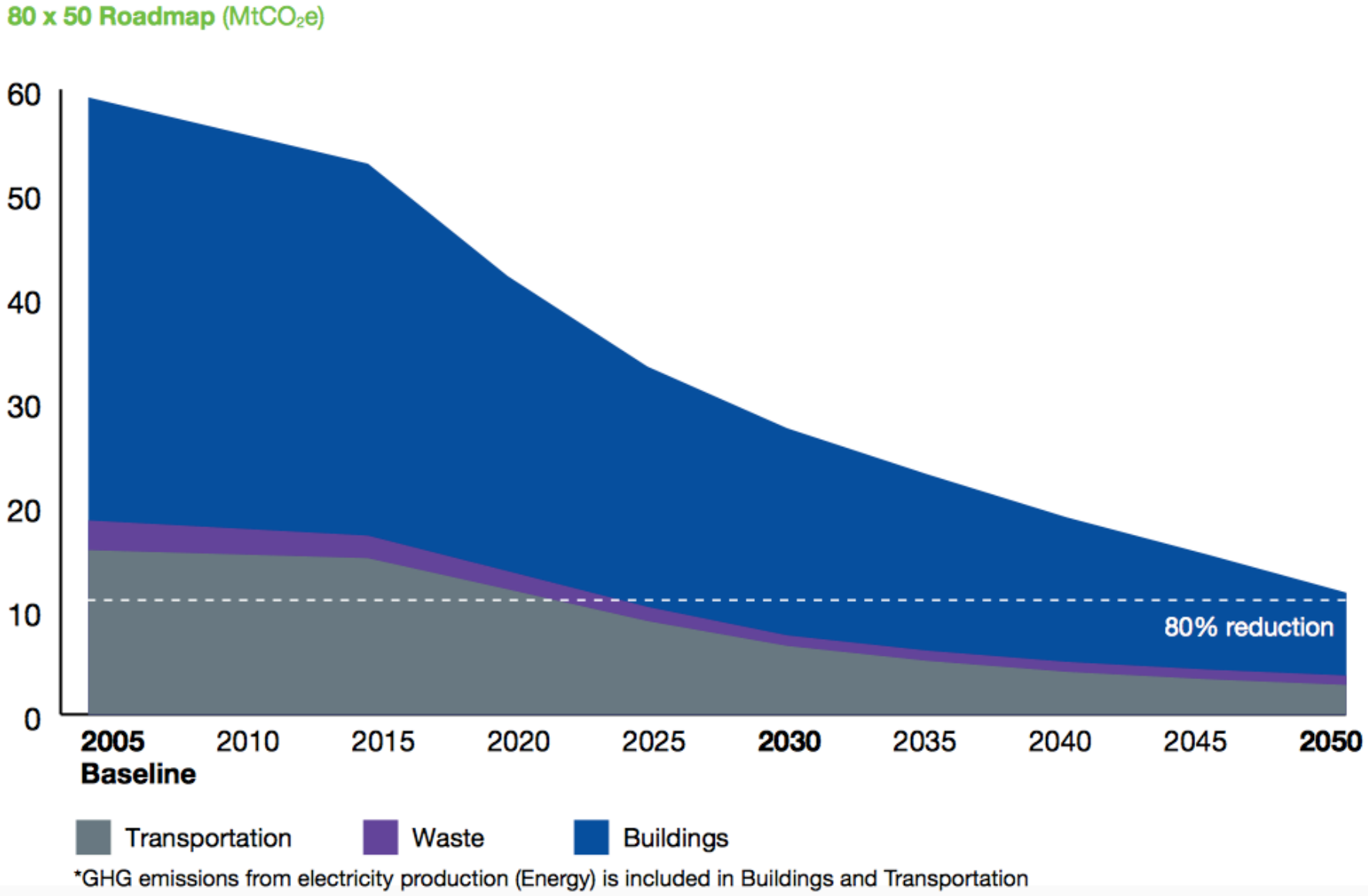
In The Age of Electrification

26 September 2019
BENYC 2019
Barry Stephens

THE PLAN

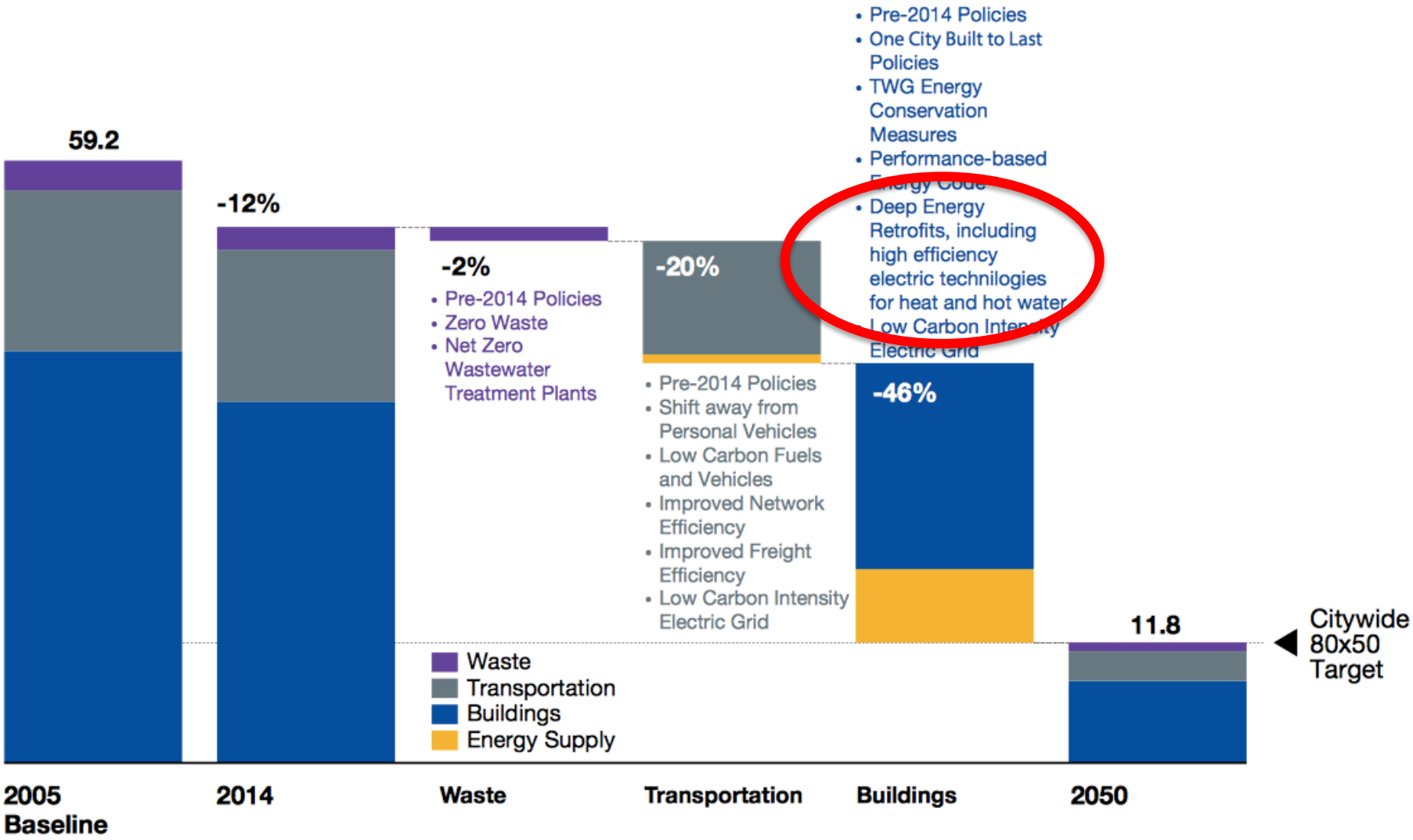
- Very aggressive program
- Buildings primary target for savings
- Retrofitting existing buildings key to significant savings
- City buildings targeting Passive House or NZE by 2030

AGGRESSIVE TARGETS FOR BUILDINGS



*GHG emissions from electricity production (Energy) is included in Buildings and Transportation

A Roadmap to 80 x 50, in Million Metric Tons of Carbon Dioxide Equivalent ($MtCO_2e$)



*All percent reductions are relative to the 2005 citywide baseline

Buildings	Implement cost-effective upgrades in existing buildings to improve energy efficiency in the near-term		●		
	Scale up deep energy retrofits that holistically address heating systems, cooling systems, and building envelopes and transition buildings away from fossil fuels	●	●		
	Expand distributed solar energy and install 1,000 MW of solar capacity by 2030	●	●		
	Ensure building decision-makers have access to building energy use information		●		
	Provide assistance to the private sector to accelerate adoption of energy efficiency and clean energy	●	●		
	Streamline regulatory processes for building energy efficiency and clean energy	●	●		
	Ensure building owners can finance energy efficiency projects	●	●		
	Achieve exceptional energy performance for new buildings and substantial renovations		●		
	Lead by example in City-owned buildings	●	●	●	●
	Prepare New York City's workforce to deliver high performance buildings		●		
	Position New York City as a global hub for energy efficiency and clean energy technology	●	●	●	●

Buildings Use About 40% of Total Energy in North America

OPPORTUNITY

- Up to 70% in NYC and other large cities
- OA is increasing in importance
- LEED points for extra OA
- The “Forgotten” component in EE

Outside Air (Ventilation) Accounts for 30-40% of Building Energy Use

(Fan Energy + Tempering Energy)

OPPORTUNITY

- Even more in high performance buildings
- Unrecognized by most energy modelers
- Will increase with more focus on IAQ and health in buildings

That Means That OA in Buildings Accounts for ***12-16%*** of All Energy Use In North America!

OPPORTUNITY

- **Unrecognized**
- **Huge Opportunity**
- **Misunderstood**
- **Crucially important to EE conversation**

WHY VENTILATE

BETTER VENTILATION MEANS BETTER HEALTH

California Study of 168 Classrooms[1]

Increasing classroom VRs from the California average (8.5 cfm per person) to the State standard of 15 cfm would decrease Illness Absences by 3.4%

Texas Study of 120 Classrooms[2]

Median CO2 levels were 28% higher than ASHRAE limit

Washington & Idaho Study of 434 Classrooms[3]

A 1000 PPM increase in CO2 was associated with a 10% - 20% increase in student absence

MORE IS BETTER?

(1) Mendell et al (2013) "Association of Classroom Ventilation With Reduced Illness Absence..."
(2) Corsi et al (2002) "Carbon Dioxide Levels and Dynamics in Elementary Schools..."

(3) Shendell et al (2004) "Associations between classroom CO2 concentrations and student attendance..."

For full references, see www.ventacity.com/

WHY VENTILATE

BETTER VENTILATION MEANS BETTER PERFORMANCE

Harvard Study[4]

On average, a 400 ppm increase in CO2 was associated with a 21% decrease in cognitive function scores

70-school Study in Southwestern US[5]

Students' mean mathematics scores were increased by 0.5% per 2 cfm/person increase in ventilation rate within the range of 2 – 15 cfm

54-school Study across USA[6]

Math and Reading scores were 14% higher when VRs were greater than 10 cfm/student compared to scores when VRs were less than 5 cfm/student

MORE *IS* BETTER

(4) Allen, et al., Associations of Cognitive Function Scores with Carbon Dioxide, Ventilation, and Volatile Organic Compound Exposures...

(5) Shaughnessy, et al., Effects of Classroom Ventilation Rate andTemperature on Students' Test Scores..."

(6) Shaughnessy, et al., "A preliminary study on the association between ventilation rates in classrooms and student performance …"

For full references, see www.ventacity.com/ahr

WHY VENTILATE?

HEALTHIER CONDITIONS

BETTER SCHOOLS

- Lawrence Berkeley National Laboratory study of California classrooms
- Increasing ventilation from 8 CFM/student to 15 CFM/student
- Reduced sickness related absenteeism by almost 4%

WHY VENTILATE?
BETTER PERFORMANCE

SURPRISING RESULTS

- Harvard/Syracuse study of cognitive function in office workers:
- Green days 61% better
- Green+ days 101% better
- Most effected categories were crisis response, information usage, and strategy

THE MODEL FOR TRANSMOGRIFICATION

THE MODEL

- Highly Insulated
- Superior verified air-sealing
- Thermal bridges eliminated
- Low u-value windows
- Efficient heating & AC systems
- VHE Heat Recovery Ventilation (HRV)

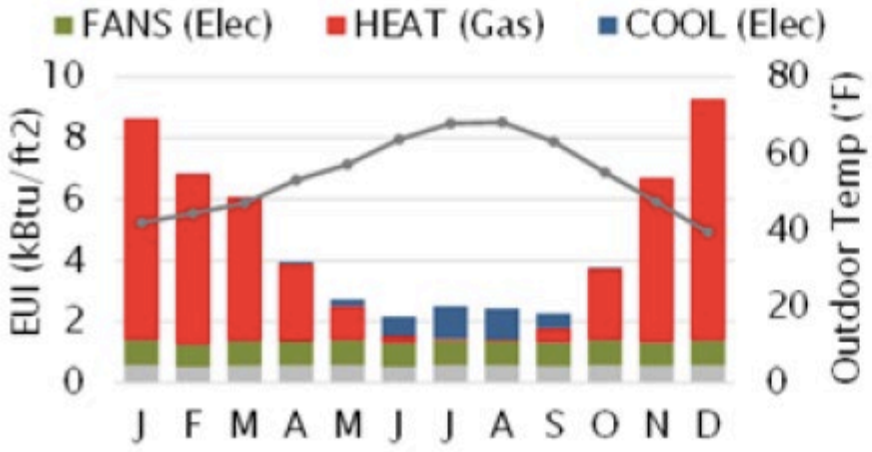
WHAT'S HAPPENING IN THE TRANSMOGRIFIER?

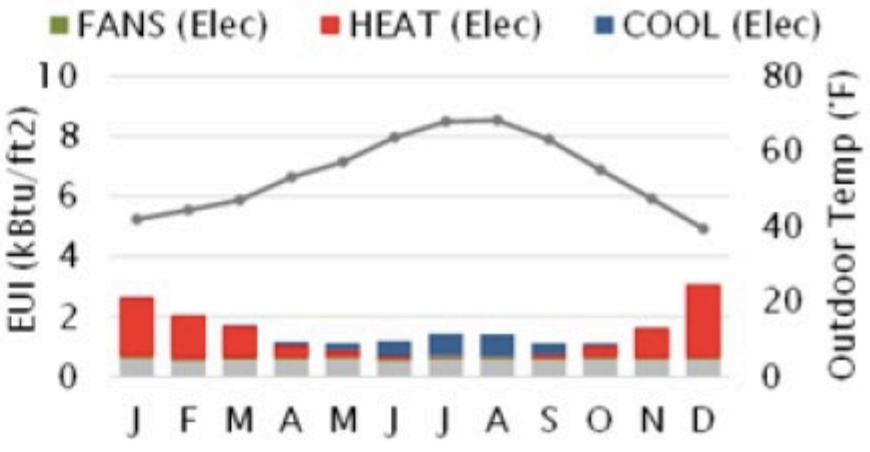
THE MODEL

- Remove Fossil Fuels (Electrification)
- Radically reduce fan energy
- Significantly reduce outside air penatly
- Introduce Advanced to proivide HVAC where needed, , when needed, at optimum efficiency

IMPRESSIVE RESULTS

REAL RESULTS





	ANNUAL EUI	---
Total:	57.4 kBtu/ft²	---
Fans:	9.5 kBtu/ft²	---
Heating:	37.6 kBtu/ft²	---
Cooling:	3.6 kBtu/ft²	---
HVAC:	50.7 kBtu/ft²	---
Electricity:	19.8 kBtu/ft²	---
Gas:	37.6 kBtu/ft²	---

	ANNUAL EUI	ANNUAL SAVINGS
Total:	19.7 kBtu/ft²	37.8 kBtu/ft²
Fans:	1.0 kBtu/ft²	8.5 kBtu/ft²
Heating:	9.2 kBtu/ft²	28.4 kBtu/ft²
Cooling:	2.8 kBtu/ft²	0.8 kBtu/ft²
HVAC:	13.0 kBtu/ft²	37.8 kBtu/ft²
Electricity:	19.7 kBtu/ft²	0.1 kBtu/ft²
Gas:	0.0 kBtu/ft²	37.6 kBtu/ft²

AIRSTAGE CASE STUDY

FUJITSU

FUJITSU PROVIDES SOLUTION FOR CON EDISON NATURAL GAS MORATORIUM

ELECTRIFICATION DONE RIGHT!

IMPROVED COMFORT

IMPROVED HEALTH

LARGEST PROJECT TO DATE

- 71,000 sq ft Office Building
- Four Floors
- Retrofit Done While Occupied
- 50% Complete on April 1, 2019

Savings 4 Months

1. $ 49,854
2. 126,200 kWh
3. 622.32 kW Demand Reduction
4. 38,800 Therms Gas Reduction (modeled)

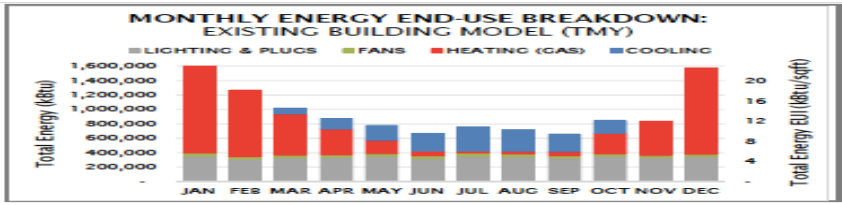


Figure 2.1
Monthly energy end-use breakdown for the Existing Building Model (TMY).

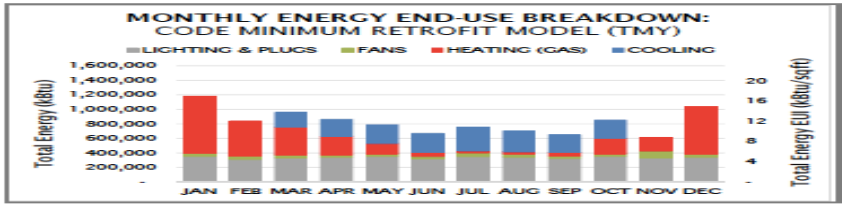


Figure 2.2
Monthly energy end-use breakdown for the Code Minimum Model (TMY).

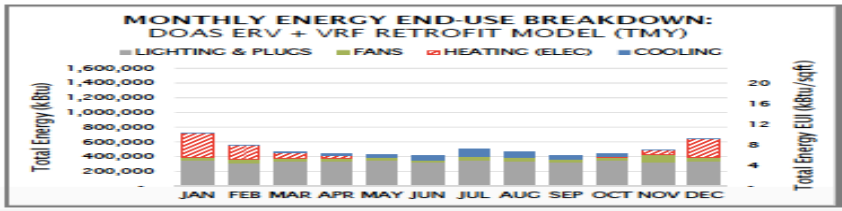


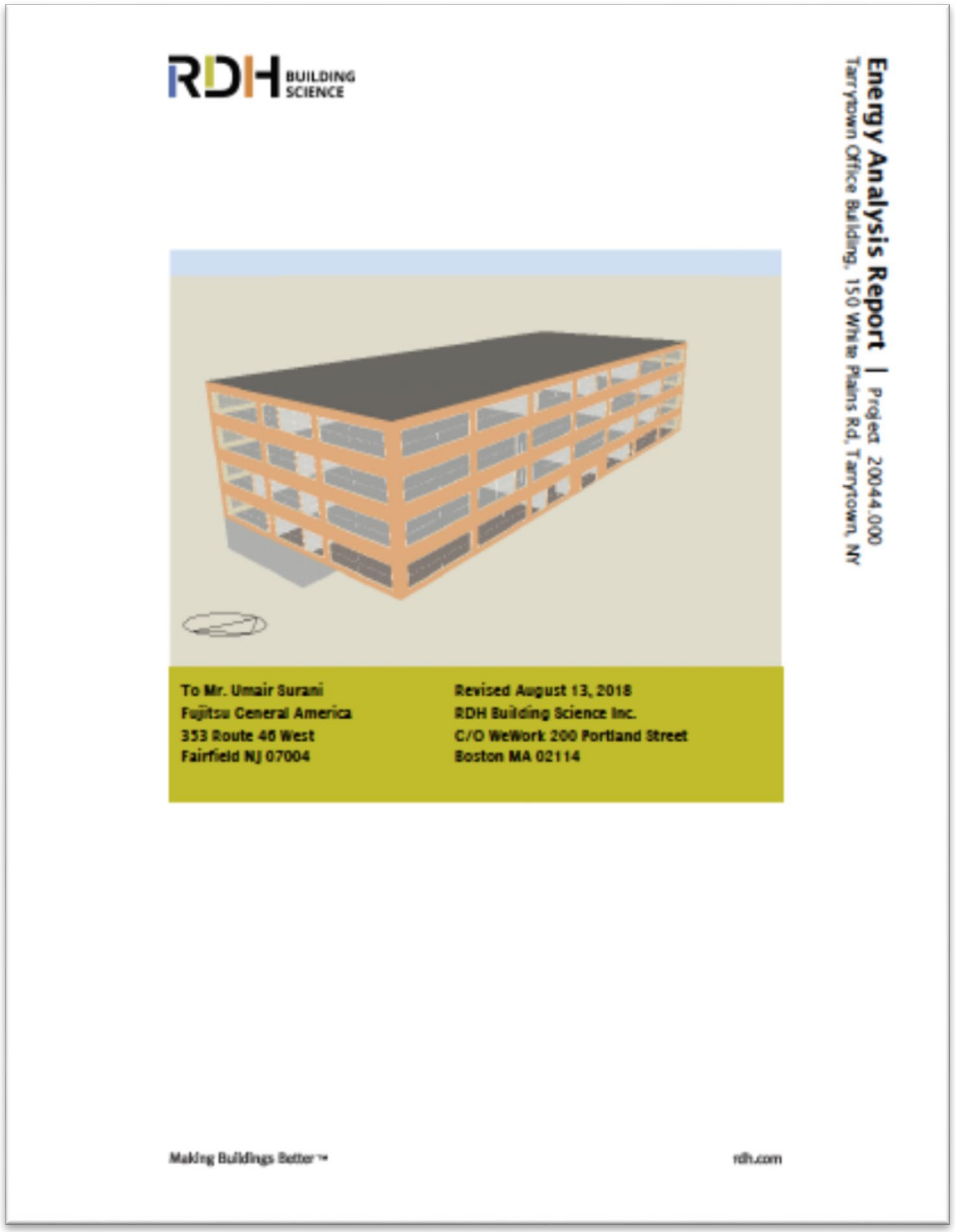
Figure 2.3
Monthly energy end-use breakdown for the DOAS ERV + VRF Model (TMY).

STEP BY STEP

WORKSHOP

- Introduce contractor to the model
- Provide insight and information to share with building owner
- Gain knowledge of HVAC systems involved in the retrofit

STEP BY STEP


RDH BUILDING SCIENCE

Energy Analysis Report | Project 20044.000
Tarrytown Office Building, 150 White Plains Rd, Tarrytown, NY

To Mr. Umair Surani
Fujitsu General America
353 Route 46 West
Fairfield NJ 07004

Revised August 13, 2018
RDH Building Science Inc.
C/O WeWork 200 Portland Street
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Making Buildings Better™

rdh.com

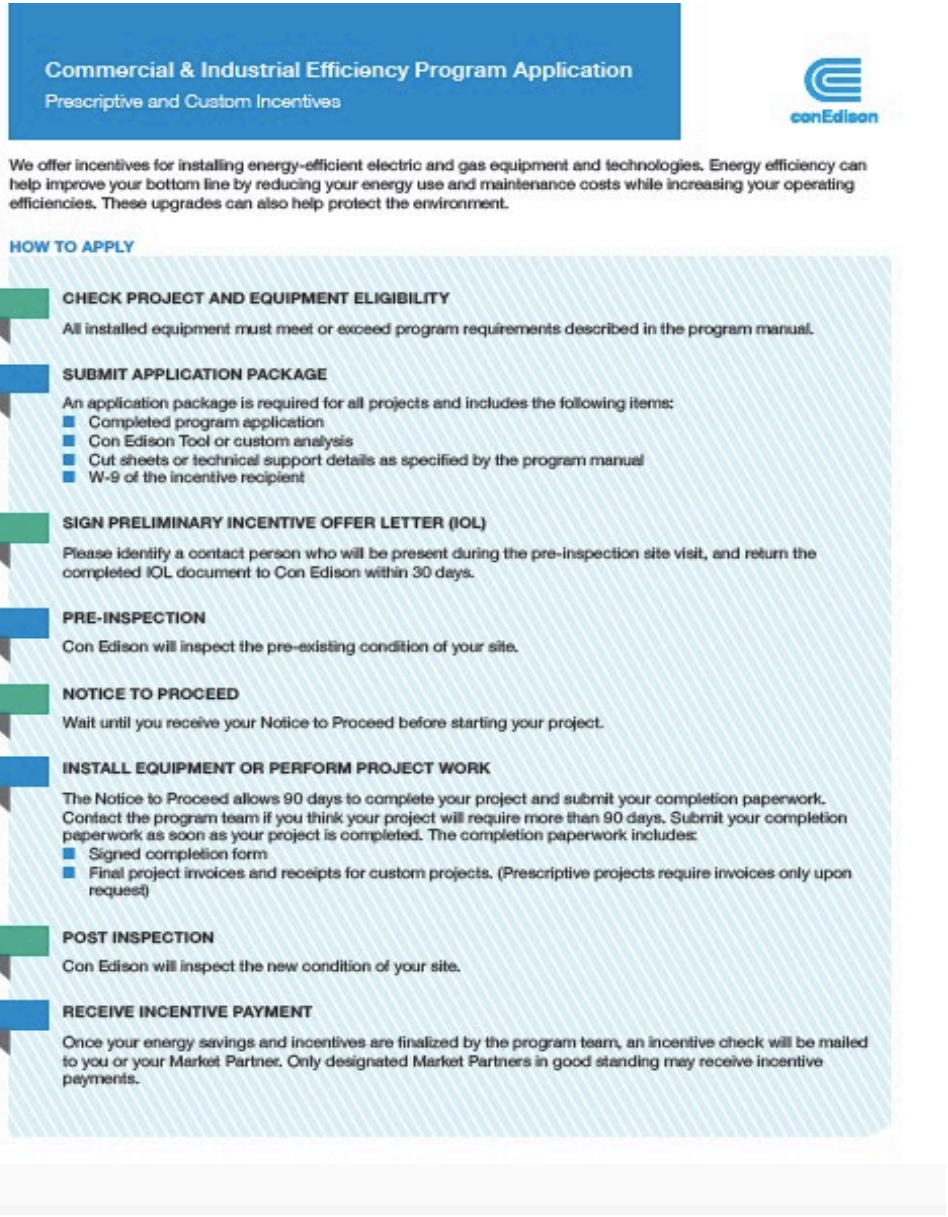
ENERGY ANALYSIS

- HVAC comparison
- Model savings
- Determine payback and scope of project

STEP BY STEP

Bill Period			Electricity Usage				Gas Usage	
Start Date	End Date	# of Days	Total kWh	Daily Avg kWh	Peak Demand (kW)	Reactive-Power Demand (kVAR)	Total therms	dekatherms/day
12/5/16	1/4/17	30	114400	3813.33	372.48	72.16	8592	28.64
1/4/17	2/3/17	30	116800	3893.33	383.76	65.52	8550	28.50
2/3/17	3/7/17	32	126800	3962.50	386.16	104.08	8174	25.54
3/7/17	4/5/17	29	112000	3862.07	360.48	64.40	7695	26.53
4/5/17	5/3/17	28	131200	4685.71	439.68	104.24	4317	15.42
5/3/17	6/2/17	30	152000	5066.67	482.40	128.88	3663	12.21
6/2/17	7/3/17	31	163200	5264.52	539.04	129.20	452	1.46
7/3/17	8/2/17	30	171200	5706.67	514.80	132.48	230	0.77
8/2/17	8/31/17	29	160800	5544.83	511.44	124.24	245	0.84
8/31/17	10/2/17	32	169200	5287.50	494.16	120.64	766	2.39
10/2/17	10/31/17	29	148000	5103.45	423.36	104.64	1675	5.78
	Totals	330	1565600	4744.24			44359	13.44

STEP BY STEP



Commercial & Industrial Efficiency Program Application

Prescriptive and Custom Incentives

conEdison

We offer incentives for installing energy-efficient electric and gas equipment and technologies. Energy efficiency can help improve your bottom line by reducing your energy use and maintenance costs while increasing your operating efficiencies. These upgrades can also help protect the environment.

HOW TO APPLY

CHECK PROJECT AND EQUIPMENT ELIGIBILITY

All installed equipment must meet or exceed program requirements described in the program manual.

SUBMIT APPLICATION PACKAGE

An application package is required for all projects and includes the following items:

- Completed program application
- Con Edison Tool or custom analysis
- Cut sheets or technical support details as specified by the program manual
- W-9 of the incentive recipient

SIGN PRELIMINARY INCENTIVE OFFER LETTER (IOL)

Please identify a contact person who will be present during the pre-inspection site visit, and return the completed IOL document to Con Edison within 30 days.

PRE-INSPECTION

Con Edison will inspect the pre-existing condition of your site.

NOTICE TO PROCEED

Wait until you receive your Notice to Proceed before starting your project.

INSTALL EQUIPMENT OR PERFORM PROJECT WORK

The Notice to Proceed allows 90 days to complete your project and submit your completion paperwork. Contact the program team if you think your project will require more than 90 days. Submit your completion paperwork as soon as your project is completed. The completion paperwork includes:

- Signed completion form
- Final project invoices and receipts for custom projects. (Prescriptive projects require invoices only upon request)

POST INSPECTION

Con Edison will inspect the new condition of your site.

RECEIVE INCENTIVE PAYMENT

Once your energy savings and incentives are finalized by the program team, an incentive check will be mailed to you or your Market Partner. Only designated Market Partners in good standing may receive incentive payments.

INCENTIVES

- Utilities
- EE Organizations
- Usually a custom program application

STEP BY STEP

THE TEAM!

INSTALLATION!

- Contractor
- Manufacturer's Engineer
- Manufacturers' Rep
- Distributor

STEP BY STEP

INSTALLATION!

- Heat pumps - Outside Units
- Transition from Existing RTUs to Heat Pumps
- While building is occupied
- Lots of planning!

STEP BY STEP

INSTALLATION!

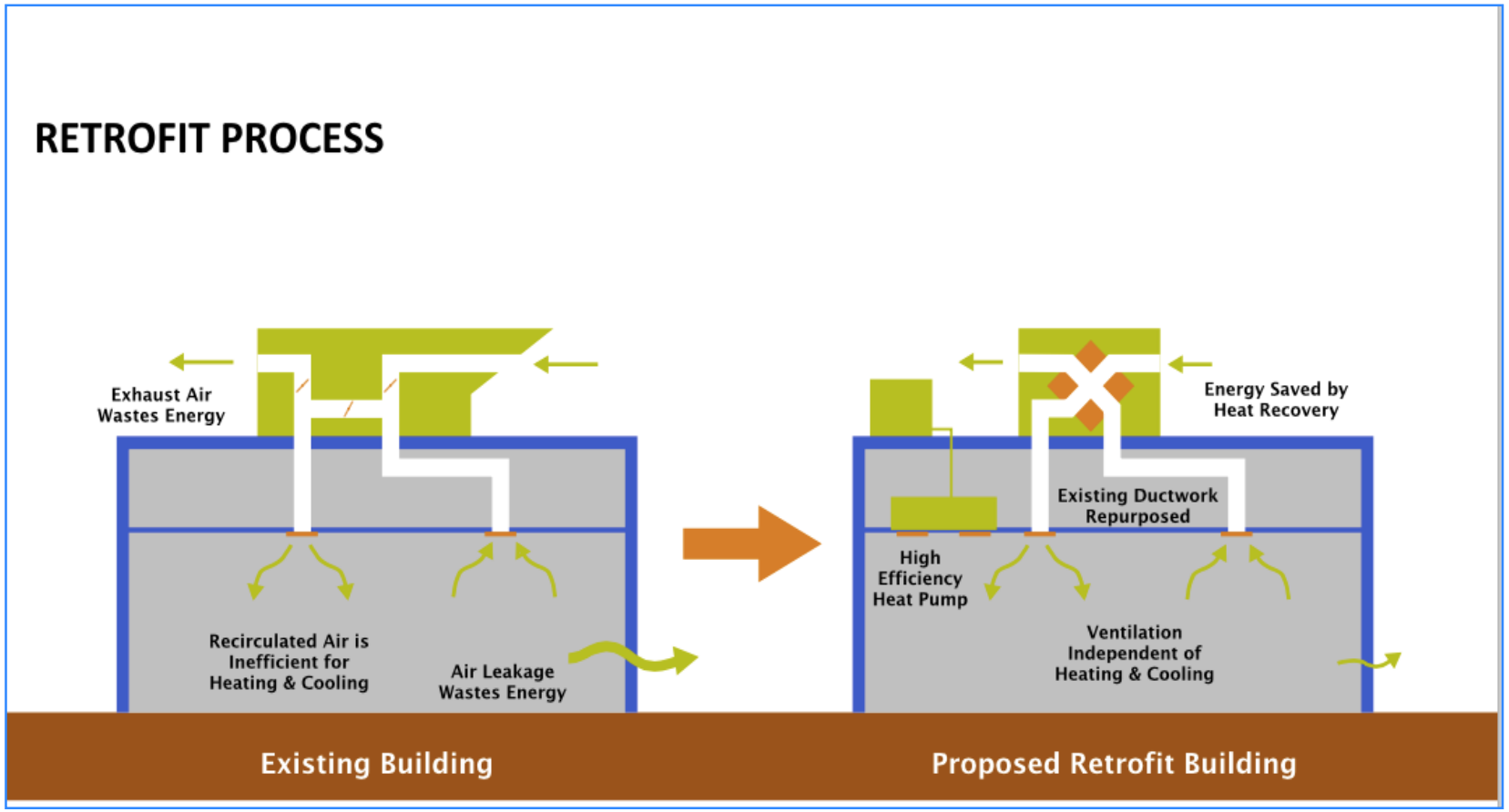
- Heat pumps - Inside Units
- Added control and diversity for better comfort
- While building is occupied
- Lots of planning!

Retrofitting Existing Commercial Buildings To Achieve Significant Energy Savings & Better IAQ

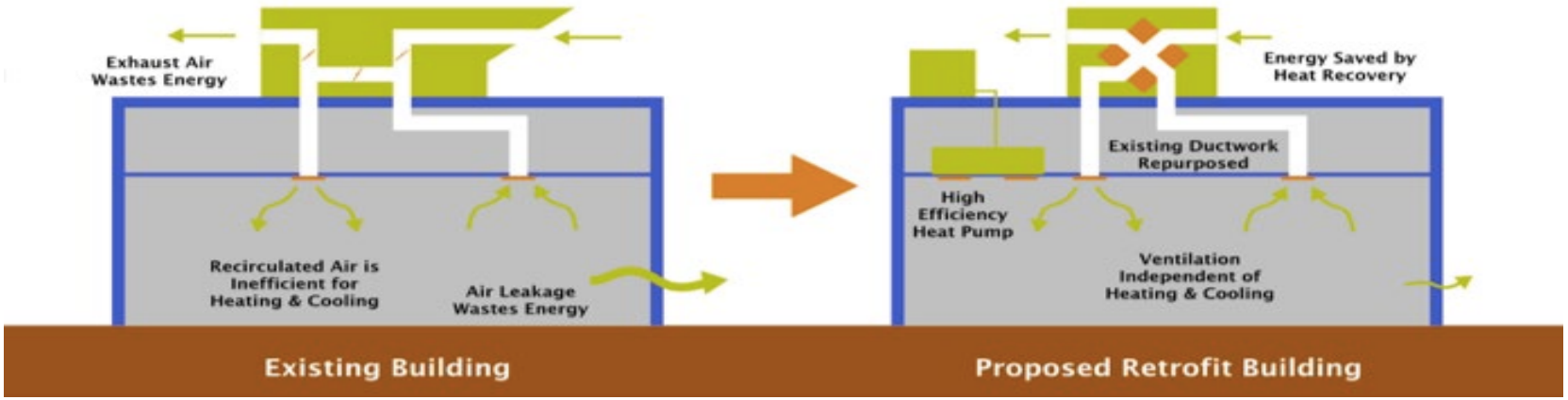
AGING INSTALLATIONS

- Many aging gas packs
- Possible curb reuse

Retrofitting Existing Commercial Buildings To Achieve Significant Energy Savings & Better IAQ



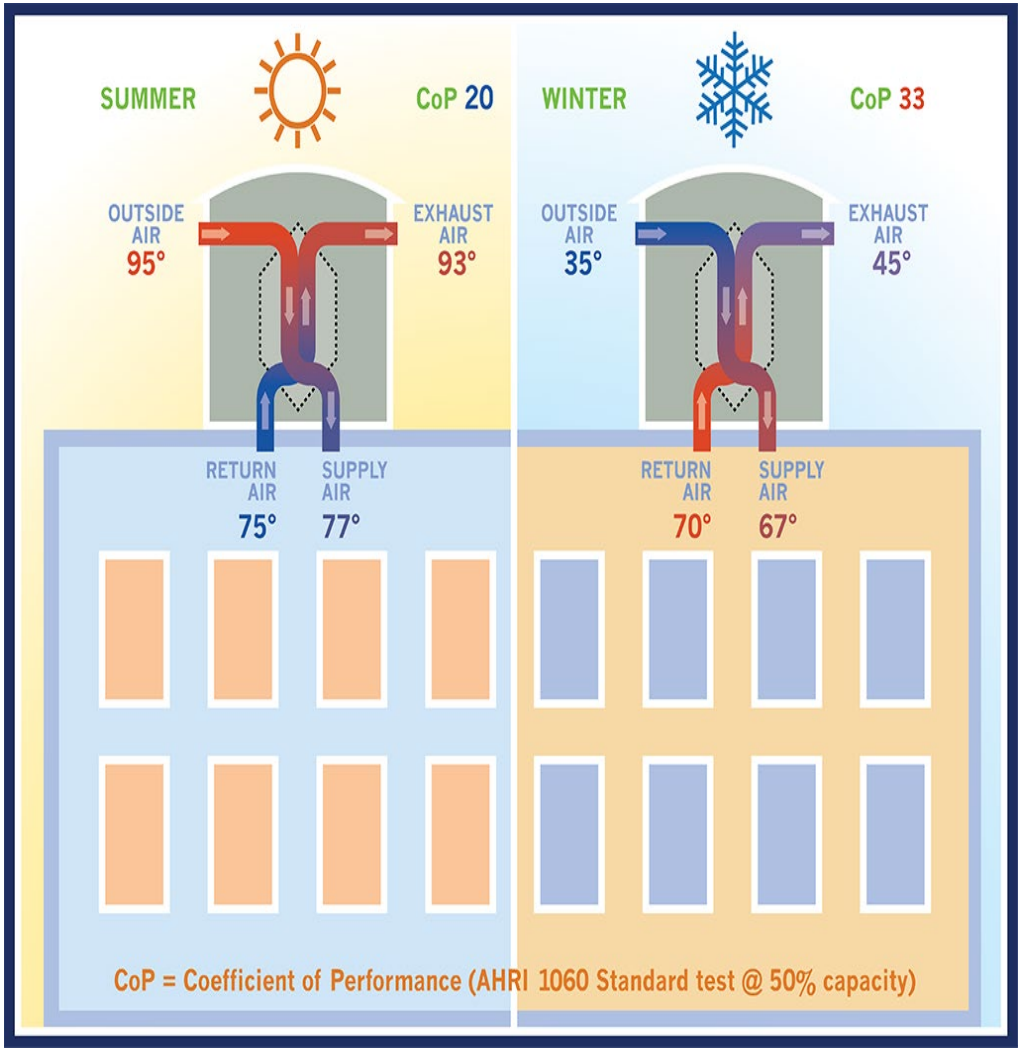
MANY BENEFITS



- Very Low Energy Savings (5% Typical)
- Same High Cost Maintenance
- 15 Year Life Span
- Same H/C Loads, Resulting in 1:1 Replacement
- Same Noise Level
- Same poor IAQ

- Significant Energy Savings (Proven 40-60+ %)
- 50% + Reduction In Maintenance Costs
- 25-30 Year Life Span
- Significant Reduction in H/C Loads, Reduced Equipment Sizing
- Improved Comfort & Quiet
- Great IAQ

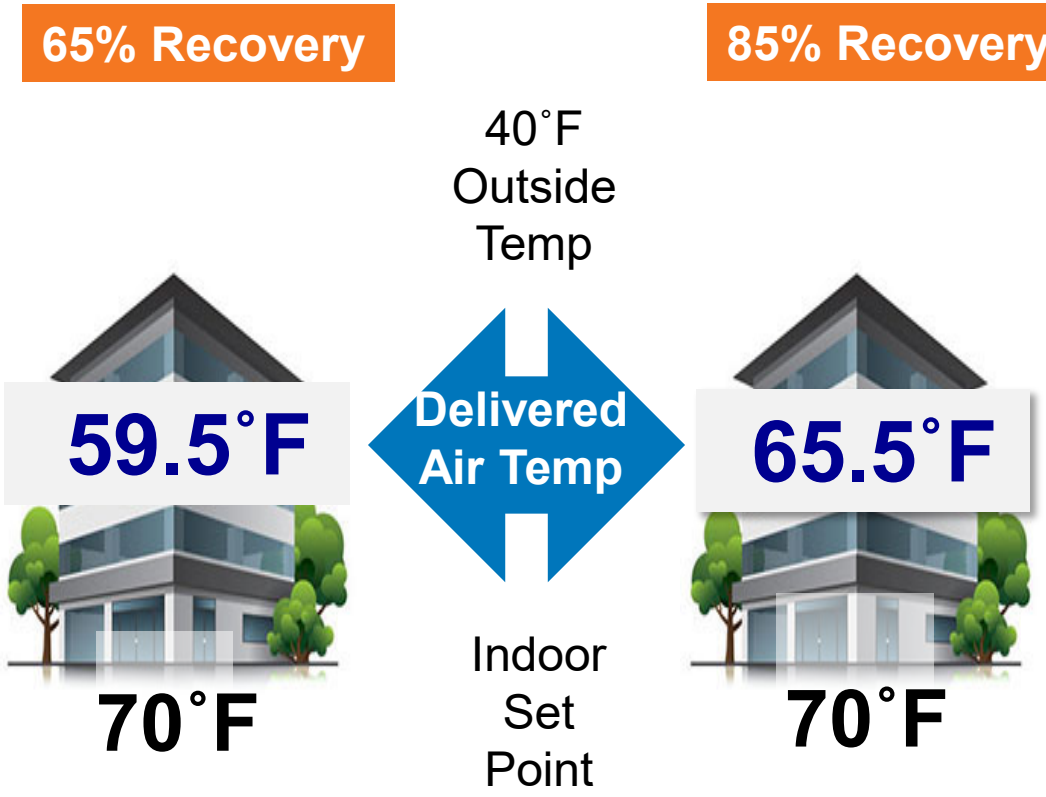
EFFICIENCY, EFFICIENCY, EFFICIENCY!



NET EFFICIENCY MATTERS!

- Building load reduction
- High comfort level
- No need to reheat
- Simple controls
- High return (COP)
- Economizer a bonus

EFFICIENCY = COMFORT



EFFICIENCY MATTERS

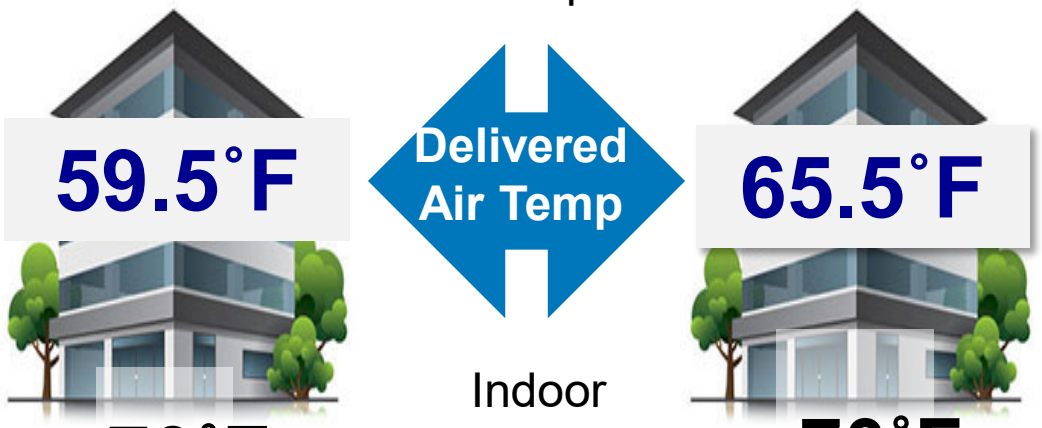
- Comfort is enhanced
- Energy efficiency is significantly improved

EFFICIENCY = COMFORT

65% Recovery

85% Recovery

40˚F Outside Temp



5,667 BTU/Hour

2,430 BTU/Hour

Fresh Air Contribution to Heating Load at 500 CFM

EFFICIENCY MATTERS

- **Comfort is enhanced**
- **Energy efficiency is significantly improved**

TOTAL SAVINGS SIGNIFICANT

	VHE	STD	STD
	 VS1000 RT		
Recovery Efficiency	**85%**	**70%**	**72%**
Tempering Energy			
Incoming Air Temp	65.5˚F	61˚F	61.6 ˚F
BTUs/Hour	2,430	4,860	4,536
kBTUs/Year	21,286	42,573	39,735
Fan Efficiency			
CFM/WATT	2.9	1.3	1.6
Power Used	172	384	312
kWH/Year	1,507	3,364	2,733
Operating Cost			
Total kWH/Year	**6,238**	**12,477**	**11,654**
Yearly Cost	$998	$1,996	$1,865

COMPETITIVE ANALYSIS

With Higher Efficiency The ROI Is In Months Not Years

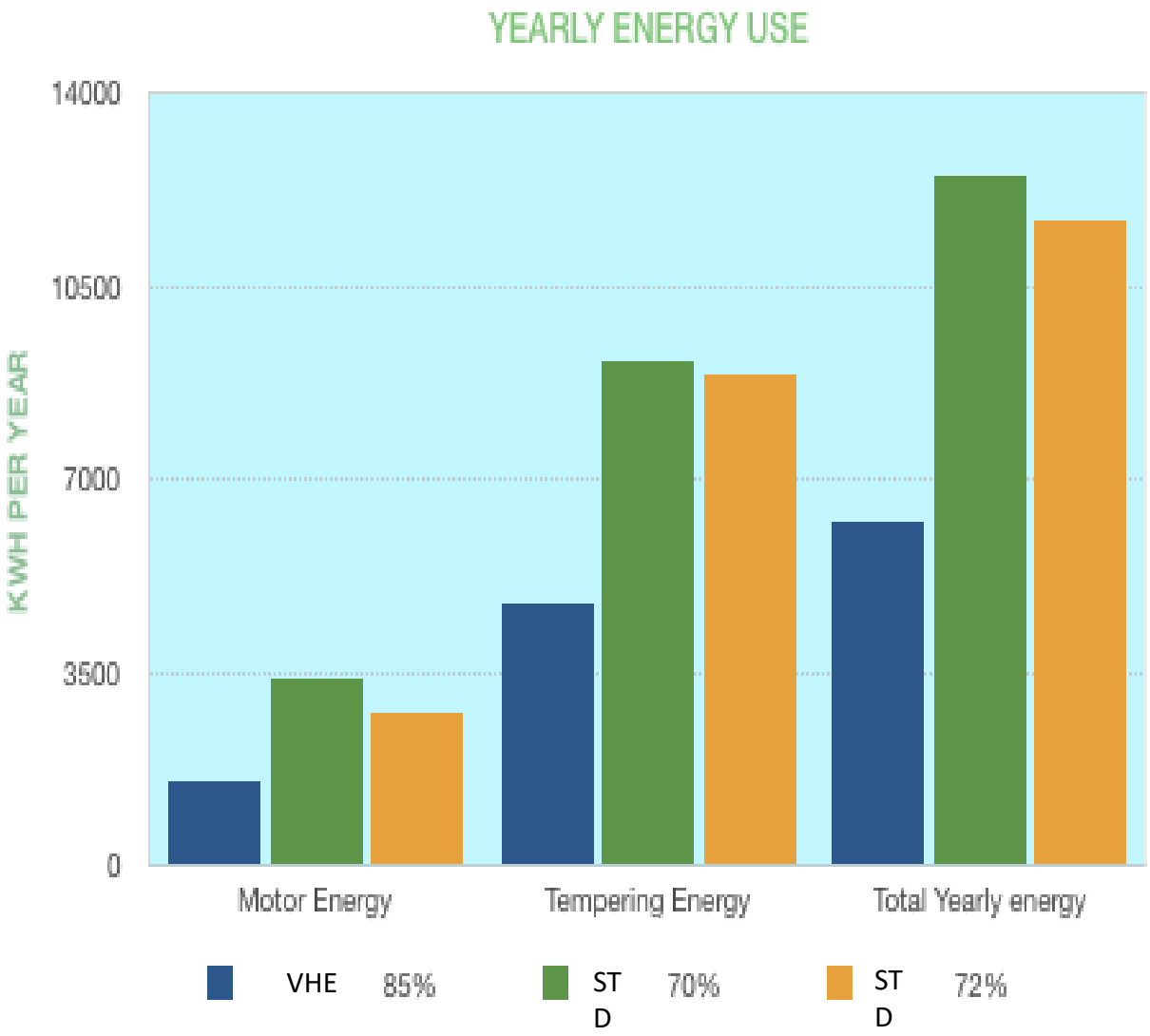
CALCULATED AT 500 CFM

30 DEGREE DELTA T

.25 INCHES STATIC PSI

$0.18 KW

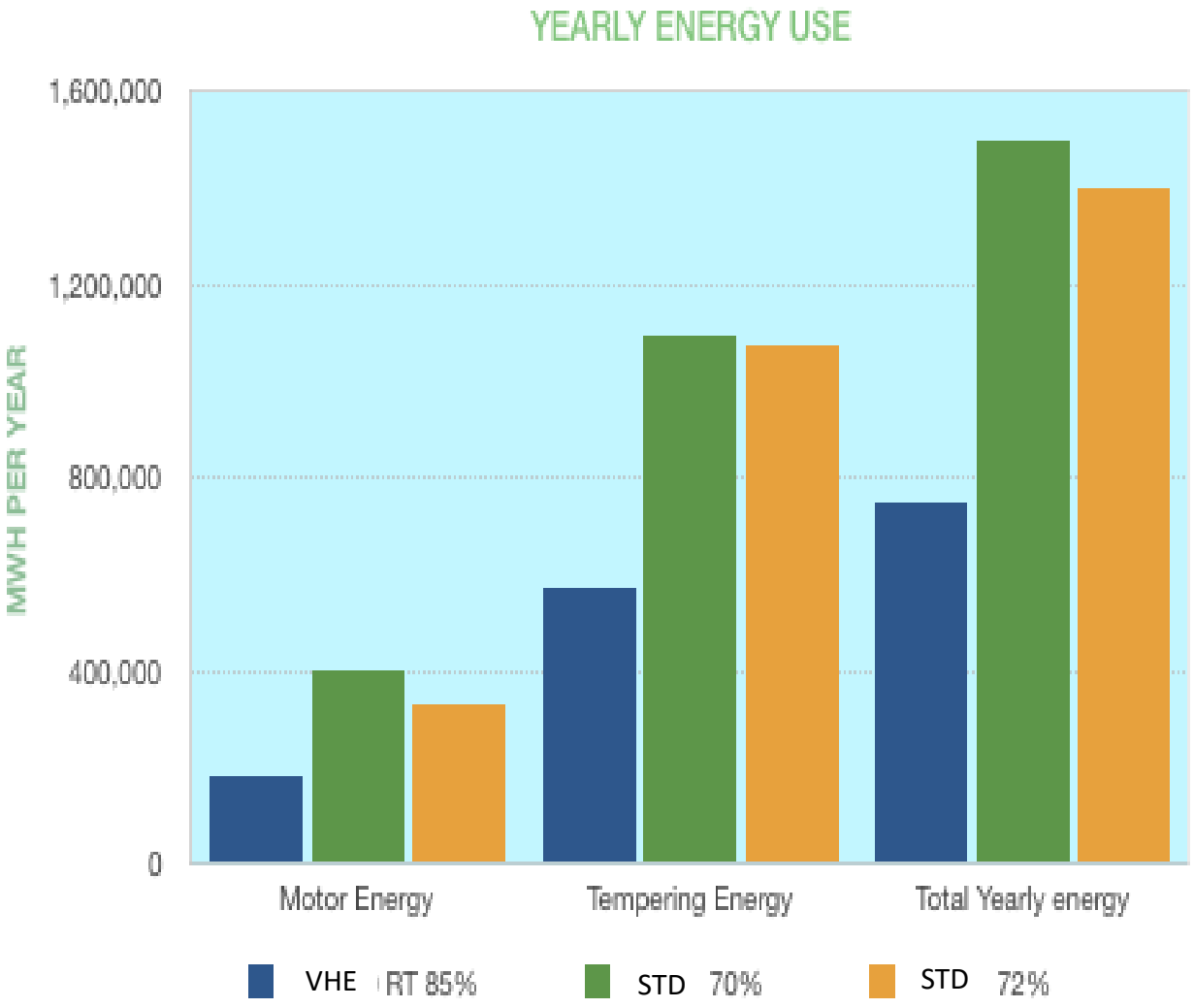
BIG ENERGY SAVINGS!



VENTILATION ENERGY REDUCTIONS ARE SIGNIFICANT

- Assuming 500 CFM
- Assuming ΔT of 30F
- 13-15% difference in results in nearly 100% reduction in energy use
- Translates in to savings of +/- $700 - $800/year at $0 .10/kWh

MWH OF POWER SAVED!



VERY SIGNIFICANT YEARLY SAVINGS

- Assuming +/- 115,00 Commercial H/ERVs sold every year
- Assuming ΔT of 30F
- 13-15% difference in results in nearly 100% reduction in energy use
- Adoption of Passive House level of efficiency would result in closing power plants

EFFICIENCY = SAVINGS

BRITISH COLUMBIA DAYCARE PROJECT

SPECIFICATON	PROPOSED
STD 1000 CFM ERVs (3)	VHE HRVs (3)
100 MBH GAS FIRED DUCT HEATER (3) TO MAINTAIN 55F SUPPLY AIR TEMPERATURE ADD-ONS: OUTDOOR INSULATION PACKAGE, DAMPERS, BY-PASS	NOT NEEDED, PROVIDES SUPPLY AIR TEMPERATURE AT DESIGN TEMEPRATURE INCLUDED AS STANDARD

- **Higher efficiency**
- **Lower overall cost**

Winter Design Temperature = 5F
Minimum Delivered Temperature = 55F

OFFICES

Indoor Air Quality Affects Productivity & Cognition

The connection between indoor air quality and its impact on crisis response, strategy and information usage in office workers is indisputable. Improving office ventilation with units from Ventacity Systems:

- *Reduces CO_2 levels and high concentrations of VOCs, thereby improving IAQ and resulting in higher worker cognition and productivity*
- *Improves comfort*
- *Decreases energy usage, lowering operating costs*
- *Provides sentient, intelligent and secure ventilation management with the Smart Building Gateway*

Building Retrofit

Separate Ventilation from Heating and Cooling

Install New VRF or DMS System

Remove Aging RTUs

Install New VS1000 RT HRV

Building is now Healthy and Efficient

VENTACITY SYSTEMS
ALWAYS HEALTHY • ALWAYS EFFICIENT™

2828 SW Corbett Ave, Portland, OR 97201
1-(888)-VENTIL8
ventacity.com

LAW FIRM REDUCES HVAC EUI BY 71%

Building Facts

Building Construction Year	Circa 1909
Occupancy Type	Office
Number of Stories	2
Conditioned Area	12,000 sq.ft.
Ownership	Private

Practicing Financial and Environmental Stewardship While Practicing Law

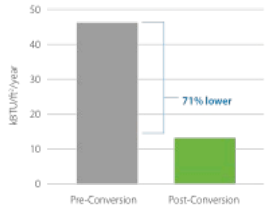
Ventacity regards an early adopter as a flagship customer: a law practice working above retail spaces in a 1909 historic warehouse. In completing a gut remodel, the owners eagerly removed nine aging RTU's and replaced them with just four Ventacity VS1000 RT's and one VRF system. By upgrading lights, windows, and air-tightness, the office's overall EUI is expected to drop from 61.4 to 28 kBtu/ft²/year. HVAC EUI, in particular, is expected to drop 71%, a large impact compared with incremental HVAC improvements. Taking the holistic energy conservation approach also enabled the law firm to receive some ratepayer-funded rebates on non-Ventacity items. Ventacity staff was present on record 100°F summer days, yet the incoming, pre-cooled air from the recovery core was an ideal 78°F.

HVAC Facts

	PRE CONVERSION	POST CONVERSION
Fuel Source	H: Natural Gas; AC: Electricity	H: VRF Heat Pump; AC: VRF Heat Pump
HVAC System	(9) RTU's	(4) VS1000 RT; Mitsubishi PURY-P192TSLMU-A, (8) SEZ-KD18NA4 AH;
CFM	est. 14,000	est. 4,000 (H & AC) max 4,000 V
Tons	36	16

"I was surprised by how much our energy bill dropped"—Building Owner

HVAC Energy Use Intensity



Post-Conversion Temperature and Performance Data: Modeled vs. Actual

VENTACITY SYSTEMS
ALWAYS HEALTHY • ALWAYS EFFICIENT™

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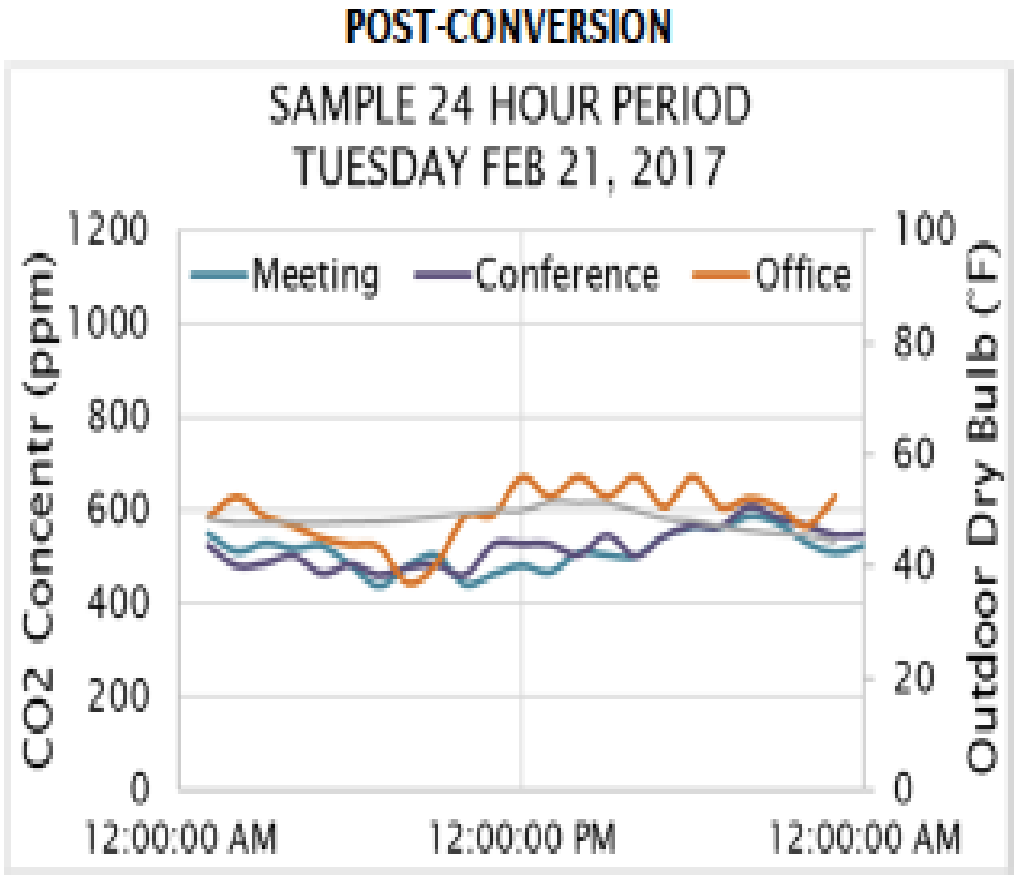
1-(888)-VENTIL8
ventacity.com

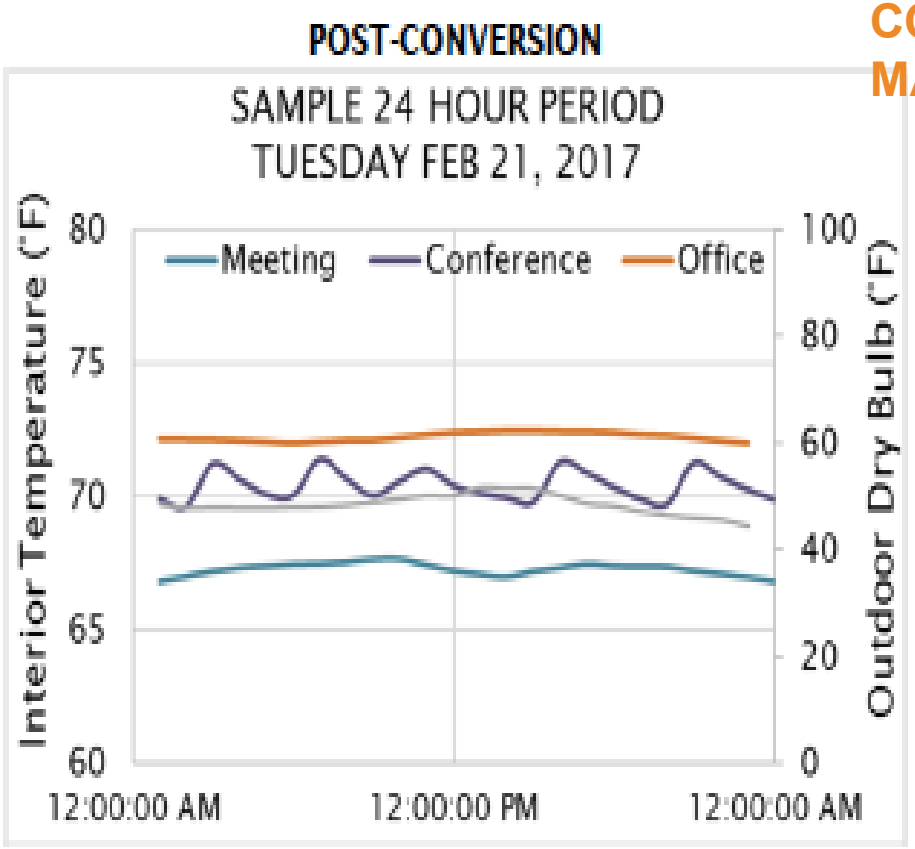
CONSISTENT, HEALTHY IAQ



OCCUPANTS WIN

- → Showing CO2 data from the conference room, a typical meeting room, and typical office.
- → In general, good control of interior CO2 levels in occupied spaces.

CONSISTENT, COMFORTABLE SPACES



CONSISTENCY MATTERS

- → Showing interior temperature data from the conference room, a typical meeting room, and typical office.
- → In general, temperatures vary significantly between spaces.
- → The owner changed setpoints on Dec 9, 2016.

STATE OFFICE BUILDING, OR

Offices **Case Study**

GOVERNMENT OFFICE CLEANS AIR AND LOWERS BILL

Building Facts

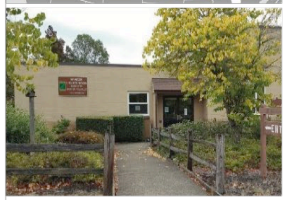
Building Construction Year	1940
Occupancy Type	Office
Number of Stories	1
Conditioned Area	13,200 sq.ft.
Ownership	Government Owned and Occupied

Partial Retrofit Still Reduces HVAC EUI By 22%

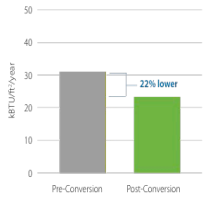
This Government Agency owns hundreds of buildings in the state of Oregon. With our help, they have modified 22% of one building as a test, working toward goals for a lessened energy footprint and carbon emissions. In short, 16 tons of heating/cooling capacity was replaced with 9 tons. This was done through a multi-zone ducted mini-split system, and the heat transferring powers of one VS1000 RT. Employees in the upgraded part of the offices report their workplace seems more comfortable and productive, while employees in the unaltered portion of the office report envy of their colleagues. Many visit the "fresh air" part of the building regularly. Three months of post-conversion summertime energy monitoring are following model projections closely, with the HVAC EUI at a 22% reduction

HVAC Facts

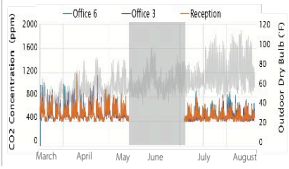
	PRE CONVERSION	POST CONVERSION
Fuel Source	H: Natural Gas; AC: Electricity	H: DMS, Ducted Fan Coils; AC: DMS, Ducted Fan Coils
HVAC System	(2) RTU's	(1) VS1000 RT; Mitsubishi MXZ-8C48NAHZ; (2) MVZ-A24AA4AH's
CFM	6,400	3,600
Tons	16	9



HVAC Energy Use Intensity



Interior CO2 Concentration, Temp Outdoor Pre and Post-Conversion



CS-OFFICE-GOVT-Jan2017

VENTACITY SYSTEMS
ALWAYS HEALTHY • ALWAYS EFFICIENT℠

2828 SW Corbett Ave, Portland, OR 97201
1-(888)-VENTIL8
ventacity.com

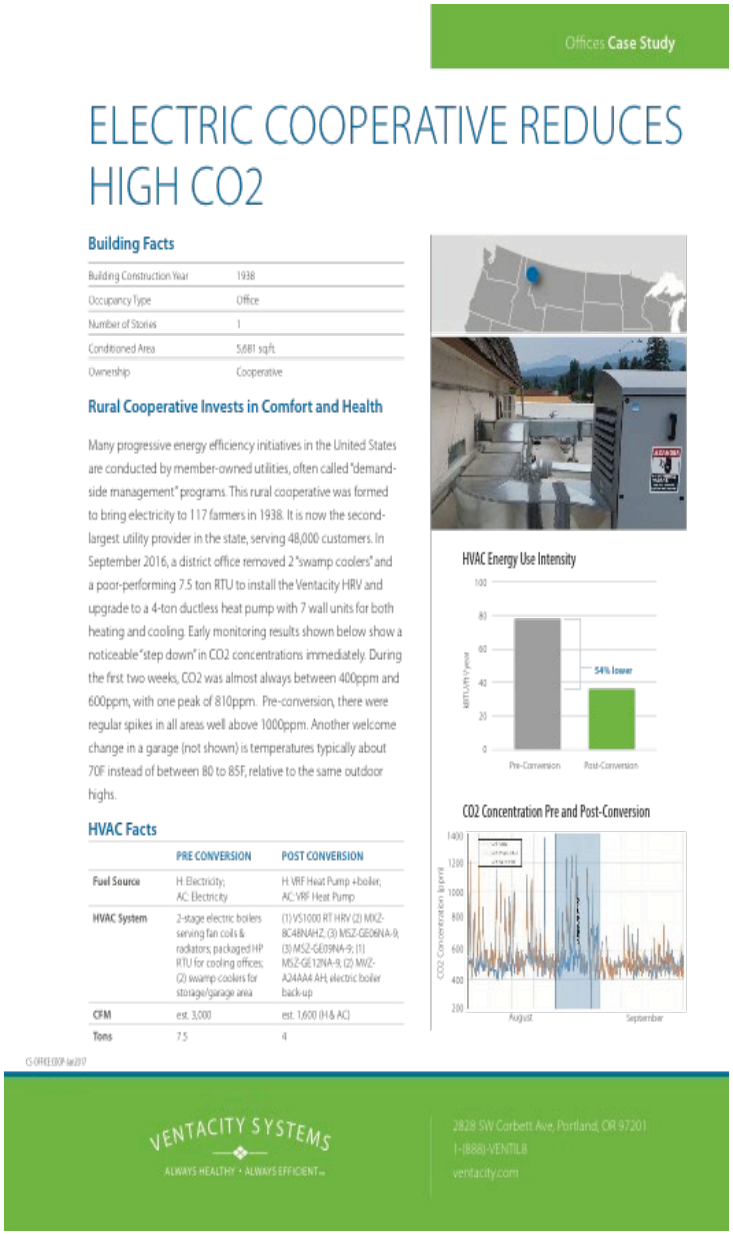
PARTIAL RTU REPLACEMENT

- **Replaced Single RTU**
- **22% of Space**
- **Reduced Building EUI by 22%**
- **"I want what they got!"**

MIXED USE OFFICE, MONTANA

OFFICES AND GARAGE

- Mixed Use
- Improved IAQ Significantly
- 54% EUI Reduction



Offices Case Study

ELECTRIC COOPERATIVE REDUCES HIGH CO2

Building Facts

Building Construction Year	1938
Occupancy Type	Office
Number of Stories	1
Conditioned Area	5,681 sqft
Ownership	Cooperative

Rural Cooperative Invests in Comfort and Health

Many progressive energy efficiency initiatives in the United States are conducted by member-owned utilities, often called "demand-side management" programs. This rural cooperative was formed to bring electricity to 117 farmers in 1938. It is now the second-largest utility provider in the state, serving 48,000 customers. In September 2016, a district office removed 2 "swamp coolers" and a poor-performing 7.5 ton RTU to install the Ventacity HRV and upgrade to a 4-ton ductless heat pump with 7 wall units for both heating and cooling. Early monitoring results shown below show a noticeable "step down" in CO2 concentrations immediately. During the first two weeks, CO2 was almost always between 400ppm and 600ppm, with one peak of 810ppm. Pre-conversion, there were regular spikes in all areas well above 1000ppm. Another welcome change in a garage (not shown) is temperatures typically about 70F instead of between 80 to 85F, relative to the same outdoor highs.

HVAC Facts

	PRE CONVERSION	POST CONVERSION
Fuel Source	H: Electricity; AC: Electricity	H: VRF Heat Pump +boiler; AC: VRF Heat Pump
HVAC System	2-stage electric boilers serving fan coils & radiators; packaged HP RTU for cooling offices; (2) swamp coolers for storage/garage area	(1) VS1000 RT HRV (2) MXZ-8C48NAHZ; (3) MSZ-GE06NA-9; (3) MSZ-GE09NA-9; (1) MSZ-GE12NA-9; (2) MVZ-A24AA4 AH; electric boiler back-up
CFM	est. 3,000	est. 1,600 (H & AC)
Tons	7.5	4

HVAC Energy Use Intensity

CO2 Concentration Pre and Post-Conversion

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KING COUNTY AIRPORT, SEATTLE, WA

Public Spaces **Case Study**

AIRPORT IMPROVES AIR QUALITY AND REDUCES ENERGY

Installation Facts

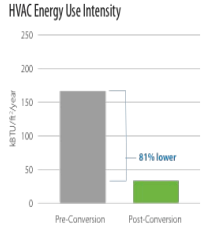
Building Construction Year	1930
Occupancy Type	Airport
Number of Stories	2
Conditioned Area	26,000 sq.ft.
Ownership	County Government

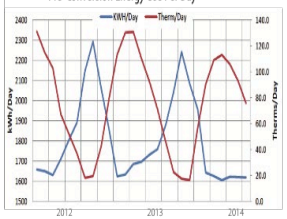
Airport Reduces HVAC EUI By 81%

This historic airport handles 200,000 flights per year for helicopters, small commercial airlines, private and chartered jets, flight tests, as well as celebrities and dignitaries needing immediate access to the city. With the help of a local energy consultant, the airport is acquiring three VS1000 RT units to reduce its EUI by 86% in the modified area to around 30 kBtu/ft²/year. One could say its current EUI is as large and unwieldy as early commercial aircraft, and is now being transformed by 21st century HRV technology. A number of the airport's 5,209 employees will soon benefit from improved ventilation, in addition to lowered utility bill costs for an urban county government.

HVAC Facts

	PRE CONVERSION	POST CONVERSION
Fuel Source	H: Natural Gas; AC: Electricity	H: VRF Heat Pump; AC: VRF Heat Pump
HVAC System	(3) Multi-Zone Air Handlers	(3) VS1000 RT; (3) Mitsubishi VRF Heat Pumps (model TBD)
CFM	est. 4,200	TBD
Tons	est. 10.5	TBD





CS-PUBLIC AIRPORT-Jun2017

VENTACITY SYSTEMS
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2828 SW Corbett Ave, Portland, OR 97201
1-(888)-VENTIL8
ventacity.com

HUGE IMPACT

- **HVAC EUI Reduced by 85%**
- **Improved IAQ**
- **Activated Charcoal Filters Reduce Fine Particulates**

KING COUNTY AIRPORT, SEATTLE

BEFORE

"NOW THAT'S A BIG BOX!

AFTER

"HONEY, I SHRUNK THE HVAC SYSTEM"

BIG CONTRAST

- 26,500 Sq Ft
- Airport Terminal and offices
- Circa 1930
- HVAC EUI Reduction

85%

MINIMUM 54% EUI REDUCTION

Location	Sq. Ft.	Use	HVAC Energy Reduction %
Corvallis, OR	2,600	Restaurant	54%
Portland, OR	12,000	Law Office	71%
Corvallis, OR	3,770	Government Office	72%
Seattle	26,000	Regional Airport	81%*
Seattle	5,911	3rd-Floor Offices	69%
Philadelphia	13,000	Multi-Family	64%*
Libby, MT	5,681	Office w/ Garage	54%*
Portland, ME	TBA	Multi-Family	TBA
Portland, OR	TBA	Church	TBA
8-Pilot Study (BetterBricks)		All of the above	53% Average
Location	Sq. Ft.	Use	HVAC Energy Reduction %

WORST CASE 54% REDUCTION!

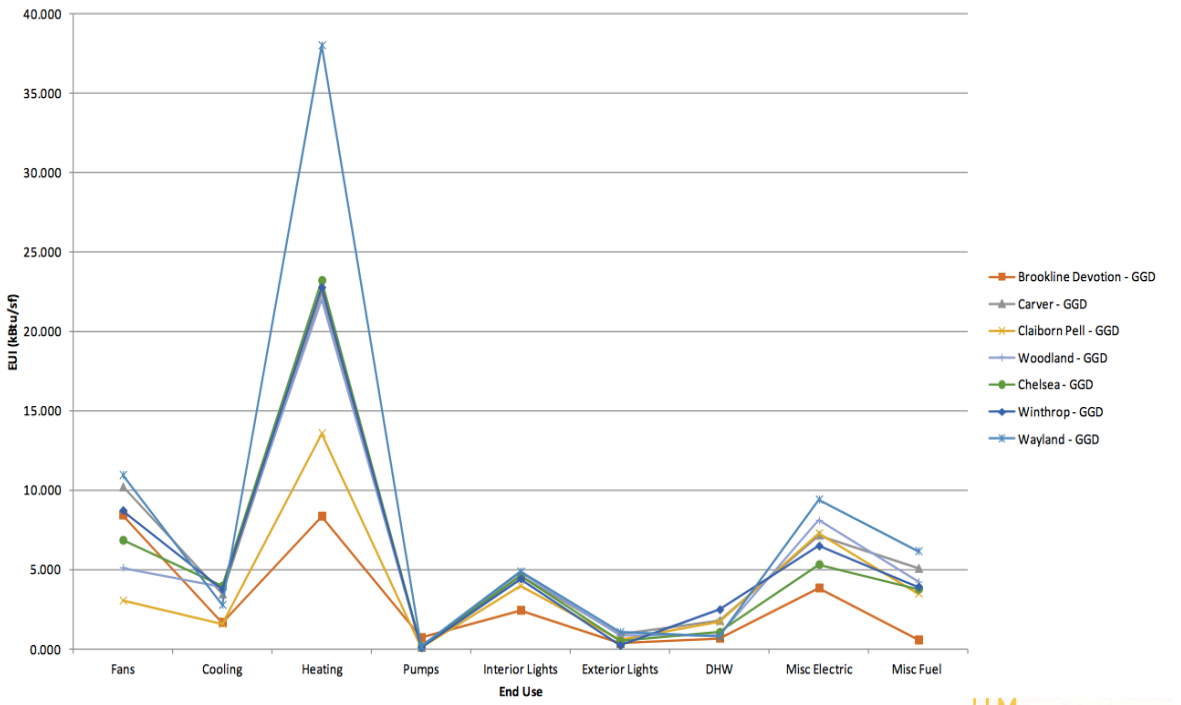
- **Predicted HVAC EUI reduction using whole-building energy modeling.**

Can we electrify our schools?

OPPORTUNITY

- Ventilation in need of improvement
- Existing solutions use fossil fuels
- A new approach is doable

THE PATH TO NET ZERO?

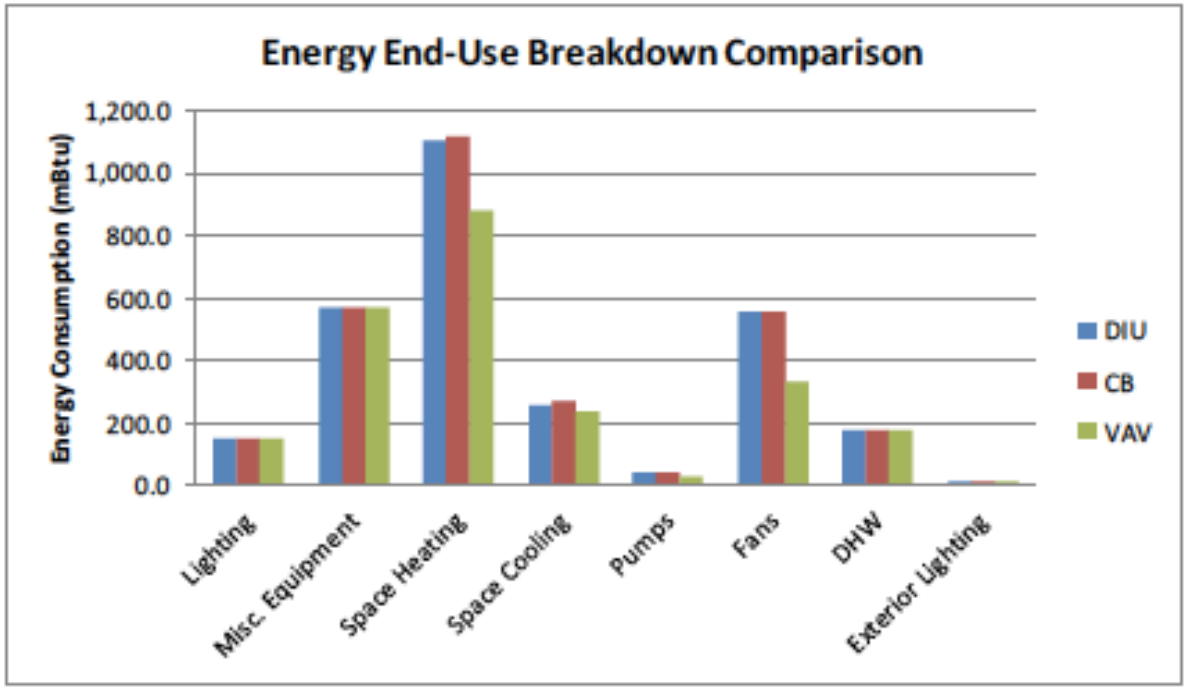


HMFH ARCHITECTS

NEW ENGLAND HIGH EFFICIENCY SCHOOLS

- Ventilation energy buried in HVAC numbers
- RTUs do not allow for Demand Control Ventilation
- Cut HVAC load in half, , how many solar panels saved to get to Net Zero?

TYPICAL NUMBERS FOR CONVENTIONAL APPROACHES TO HVAC



FANS STAND OUT

- Fans drive high energy use
- Systems do not allow for Demand Control Ventilation
- Large air volumes require very large ducts

THE SOLUTION

Item	DIU	CB	VAV	VRF/ERV
Equipment	$4,680,253	$5,007,280	$4,201,338	$2,084,083
Ductwork	$1,921,788	$1,755,648	$2,290,754	Included
Piping	$2,456,280	$1,948,199	$1,344,529	Included
Seismic	$ 25,777	$ 48,202	$ 22,350	$ 50,000
Other	$ 573,694	$ 550,201	$ 521,808	$ 600,000
Electrical			$ 200,000	$ 200,000
Gen Constr	$1,075,590		$ 70,300	Included
Total	$10,733,382	$9,309,530	$8,651,079	$2,934,083
Total Cost/SF	$ 178.89	$ 155.16	$ 144.18	$ 48.90

THE SOLUTION

	Energy Consumption			Energy Cost		
	Electricity	Natural Gas	Total	Electricity	Natural Gas	Total
	kWh	therms	mBtu	$/Year	$/Year	$/Year
DIU	475,338	12,303	2,852.7	$136,714	$ 13,678	$150,392
CB	479,746	12,506	2,888.0	$139,760	$ 13,903	153,663
VAV	400,746	10,124	2,380.1	$131,942	$ 11,255	143,197
VRF/ERV	351,685	0	1,500.0	$115,789	$ 0	$115,789

VRF/ERV YEARLY SAVINGS $ 16,153

THE SOLUTION

TOTAL COST REDUCTIONS FOR VRF/VHE HRV SYSTEM

VS

VAV (BEST OPTION FROM 2016 STUDY) HVAC SYSTEM

First Cost Reductions	**$ 5,716,996**
Structural Cost Reduction (BASED ON 4 FT REDUCED BUILDING HEIGHT)	**$ 2,000,000**
Annual Energy Savings	**$ 16,153**

WIN, WIN, WIN

- First Cost is lower
- Un-planned savings and benefits
- Improved IAQ and health an significant added benefit


PRO

BARRY STEPHENS
BARRY@VENTACITY.COM
603-498-9005

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