Impacts of the OPA HVAC Installation Optimization Training Program on Realized Energy Efficiency of Retrofit AC Systems

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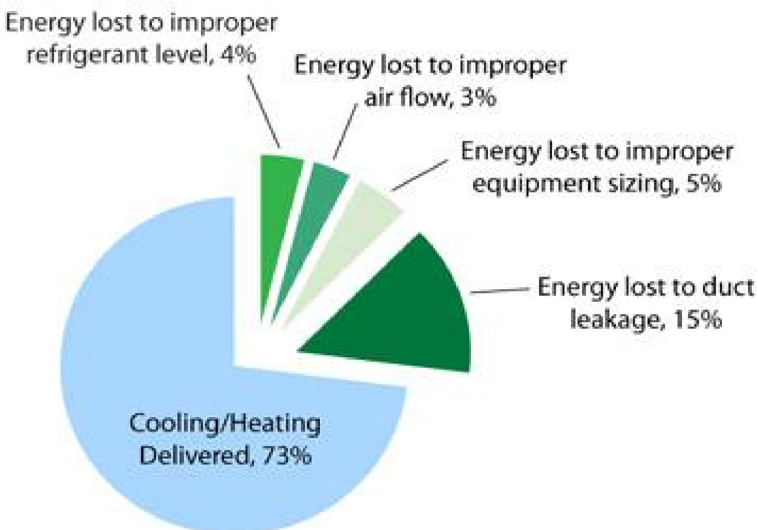
Introduction

Problem

- more than 25% of retrofit energy savings lost to installation practices



Solution

- Training for sales and installation contractors
  - Fundamentals of duct design and sealing
  - Calculation of correct size of system (in AC Tons)
  - Correct evaporator coil matched with condensing unit
  - Correct air flow over the evaporator coil
  - Correct refrigerant charge
  - Complete commissioning

HVAC Installation Optimization

- Training course required of all contractors claiming incentives under OPA
- 16,000 contractors trained in the spring of 2013 and 2014
- 40 hours of classroom training
- Most were refrigeration mechanics so the course was a refresher – i.e., nothing new but a serious reminder of best practices

Evaluation Methodology

- RCT impossible to implement
  - Program was underway when evaluation was started
  - Sales and installation technicians voluntarily selected dates and times of training
- Key question was:
  - Not whether training improved awareness of best practices (they were trained technicians)
  - But whether training in best practices improved energy efficiency of installations

Approach

Compare field energy efficiency ratios (EER) for units installed before and after training.

1. All locations receiving HAC Incentives (2011 through 2013) identified
2. 100 installers who had installed at least 10 air conditioning systems before and after exposure to the 2013 training were selected at random
3. Owners of buildings with AC units installed by each trainee were recruited in random order – one system before the installer was trained and one after
4. Engineers visited the cooperating sites collecting static field measurements and installing data loggers measuring current and temperature data needed to calculate the EER of the installed units
5. Loggers recovered after 3-5 weeks during the summer season.
6. Data were cleaned

Field Measuring EER

- Simple in principal difficult in practice

$$\frac{\textit{cooling energy}}{\textit{power consumption}}$$

- Requires solid measurements of numerous inputs varying over time

- Cooling Energy

$$Cooling\ Energy\left[\frac{Btu}{hr}\right] = 4.5 \times CFM \times \Delta h$$

$$\Delta h = h_{return} - h_{supply}$$

$$h = Enthalpy = SH_{air} \times DBT_{°F} + (SH_{vapor} \times DBT_{°F} + h_{WV}) \times \frac{Ratio \times AVP \times \frac{RH}{100}}{BP - AVP \times \frac{RH}{100}}$$

- Power Consumption

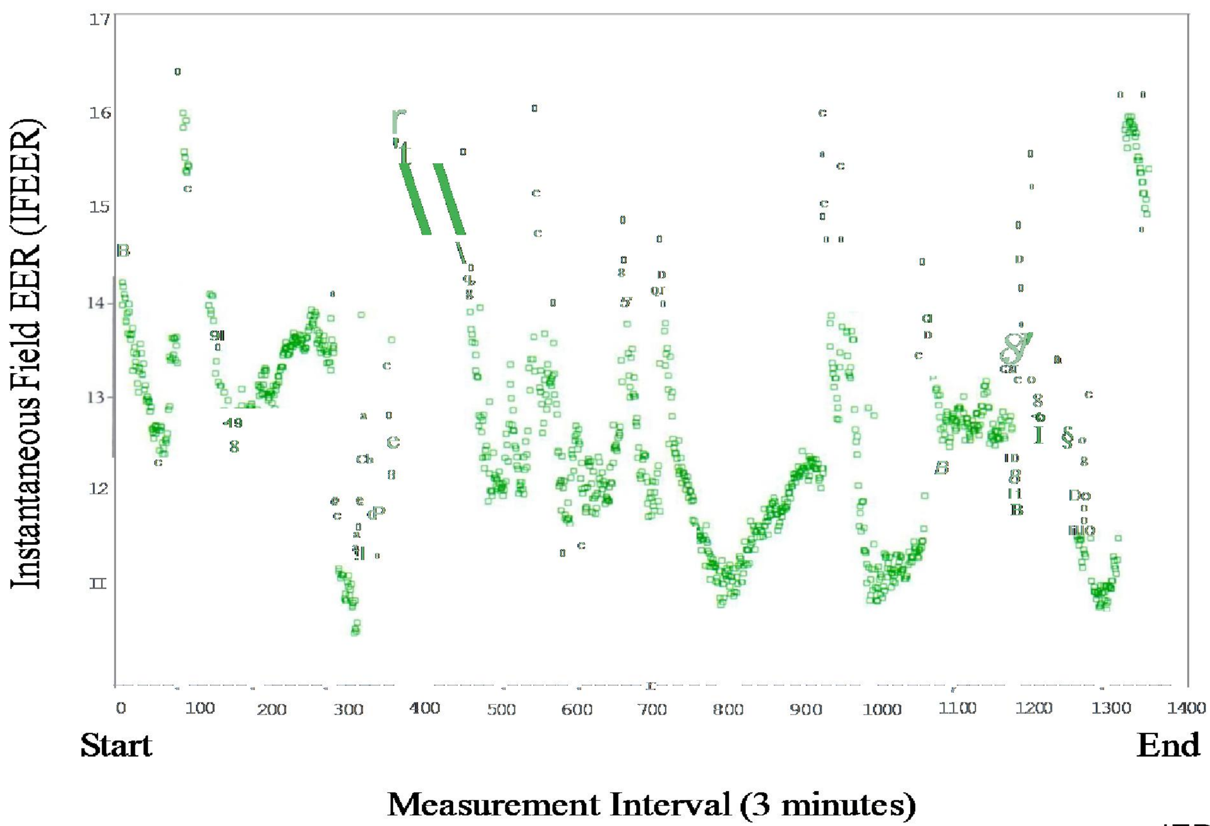
$$Power\ Consumption = [V_{AHU} \times I_{AHU} \times Power\ Factor_{AHU}] + [V_{AC} \times I_{AC} \times Power\ Factor_{AC}]$$

Resulting measurements

Filter	**Number of Participants Removed**	**Remaining Participants**
Initial target	-	200
Unable to install equipment	19	181
Logger failure in field	13	168
Loggerprovided questionable data	3	165
Data filters	55	110 (55 pre-training and 55 post-training)

Results

IEER varies over time within subjects



Results

- Average EER of installed units is somewhat higher than expected

Group	Number of Homes	Average Ratio	Standard Deviation
Before Training	55	0.8131	0.2619
After Training	55	0.7814	0.2566
Difference (After – Before)		-0.0317	0.2593

- Training doesn't improve EER

Method	Mean	T-statistic	P-value	95% CL Mean	
Pooled	-0.0317	-0.64	0.5224	-0.1297	0.0663

Results

LFER model doesn't detect a change in EER either

Parameter	Estimate	Standard Error	95% Confidence Limits		Z-statistic	p-value
Intercept	-10.2749	3.3497	-16.8401	-3.7096	-3.07	0.0022
AC Tonnage	-2.5687	0.3732	-3.3002	-1.8372	-6.88	<.0001
AHU Fan Wattage	-0.0068	0.0010	-0.0087	-0.0049	-6.91	<.0001
Supply RH	-0.1632	0.0276	-0.2173	-0.1091	-5.91	<.0001
Return RH	0.2866	0.0263	0.2350	0.3382	10.89	<.0001
Outdoor Temp (F)	-0.0736	0.0099	-0.0930	-0.0541	-7.43	<.0001
CFM	0.0102	0.0010	0.0081	0.0122	9.77	<.0001
Rated EER	0.7463	0.2719	0.2134	1.2793	2.74	0.0061
Treatment	0.0228	0.2610	-0.4889	0.5344	0.09	0.9305
Delta T (F)	0.9208	0.0727	0.7782	1.0633	12.66	<.0001

Conclusions and Recommendations

Conclusions

1. Realized EER somewhat higher than expected based on priors – closer to 80% than 70-75% reported in literature
2. No improvement in realized EER resulted from installation optimization training

Recommendations

1. Further investigation of installations to refine our understanding of the problem – suspect ducts
2. If appropriate, provide additional incentives to support duct maintenance and repair
3. Require proof of compliance with best installation practices as a condition of performance payments