Lobby Question

What do you think needs to happen to the industry for residential homes to reach Zero Net Energy?

Mentors and information, not regulation and bureaucracy..

How about Architects and Engineers with on-site experience?

There has to be a fundamental change in performance expectations for a space conditioning system.

I think it is an unrealistic goal.

clarification of requirements for installers, homeowners, and inspectors

Decoding Comfort

Let's Talk HVAC Impacts On Residential Comfort

Host:
Gina Rodda
Gabel Associates, LLC

Guest Speaker:
Rick Chitwood
Chitwood Energy Management Inc.

This program is funded by California utility customers under the auspices of the California Public Utilities Commission and in support of the California Energy Commission.

Welcome

Welcome

- Who are we?
- Our goal today
- More about you

- What We Heard From you
- Let's Talk
- Next Steps
- Wrap Up

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This program is funded by California utility customers under the auspices of the California Public Utilities Commission and in support of the California Energy Commission.

Who Are We?

Host

Gina Rodda, Gabel Associates, LLC

gina@gabelenergy.com

Gina Rodda, our host for the Decoding Talk series, is a Certified Energy Analyst (CEA), Certified Energy Plans Examiner (CEPE) and LEED Accredited Professional (AP).

She is involved in providing residential and non-residential energy calculations for a variety of building types throughout California; an instructor of full day trainings; and host of various webinars specific to Title 24 (Part 6) Building Energy Efficiency Standards.

Gina has been in the energy modeling field since 1991, through the course of seven California building energy code cycles.

GABEL ASSOCIATES, LLC
BUILDING ENERGY ANALYSIS & ENERGY CODE COMPLIANCE

Who Are We?

- Guest Speaker:
  - Rick Chitwood, Chitwood Energy Management, Inc.
    - rick@chitwoodenergy.com

Rick Chitwood, BSME, founder and principal of Chitwood Energy Management Inc., is an expert in energy-efficient residential building construction, diagnostic testing, and performance evaluation. Pursuing building performance, and practicing home performance contracting, started in 1985 with the company's first blower door purchase – 20 years before the term "Home Performance Contracting" began to be used. Today Rick spends most of his time training contractors, developing curriculum, project consulting, doing field research, helping with the updates to the California Energy Code, and is the co-author of a new book *Measured Home Performance*.

CHITWOOD ENERGY MANAGEMENT INC

Our Goal Today

Review residential HVAC design and it's effects on comfort

- Where is California in terms of HVAC design?
- As we near Zero Net Energy (ZNE), what needs to change?
  - HVAC design and installation needs to improve

We Want To Hear From You

- Welcome
- **We Want To Hear from You**
  - Most common challenges
- Let's Talk
- Next Steps
- Wrap Up

Our Question To You

Do you feel that a home that meets the minimum energy efficiency standards is meant to be comfortable?

Proper system design (including of distribution) and subsequent quality of installation are more relevant to comfort than equipment efficiencies. A 'minimum efficiency' home can indeed be comfortable, just like a 'highly efficient' home can be uncomfortable

Yes, but not ideal.

The Standards are built around energy efficiency, not necessarily comfort.

Not sure

Yes, but at a higher cost.

4 steps

- 1st Step
  - Where are we?
- 2nd Step
  - How did we get here?
- 3rd Step
  - Why are we here?
- 4th Step
  - Where are we going?

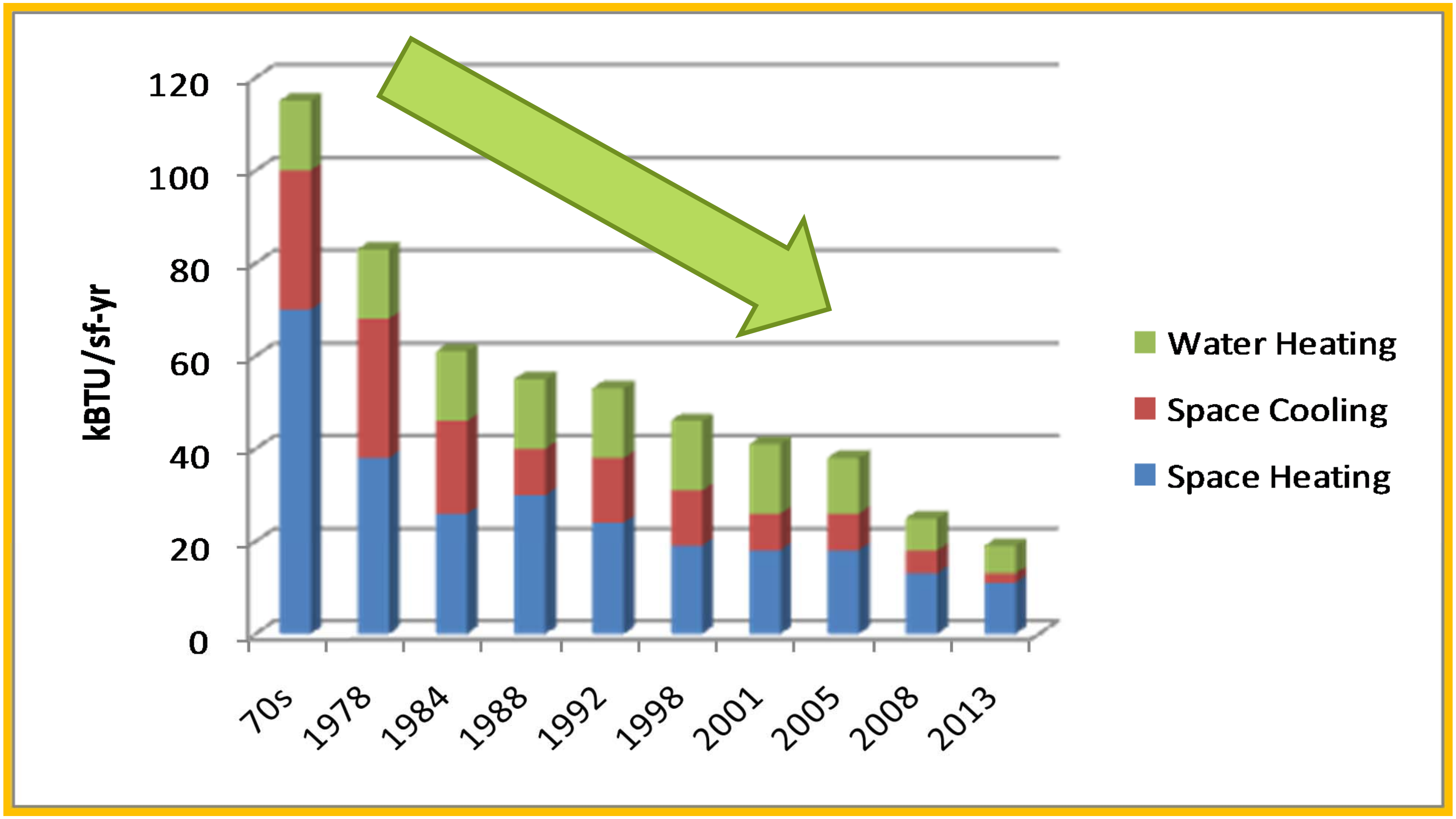
Where Are We?

- Code
- Modeled
- Reality

Code: CEC Documents

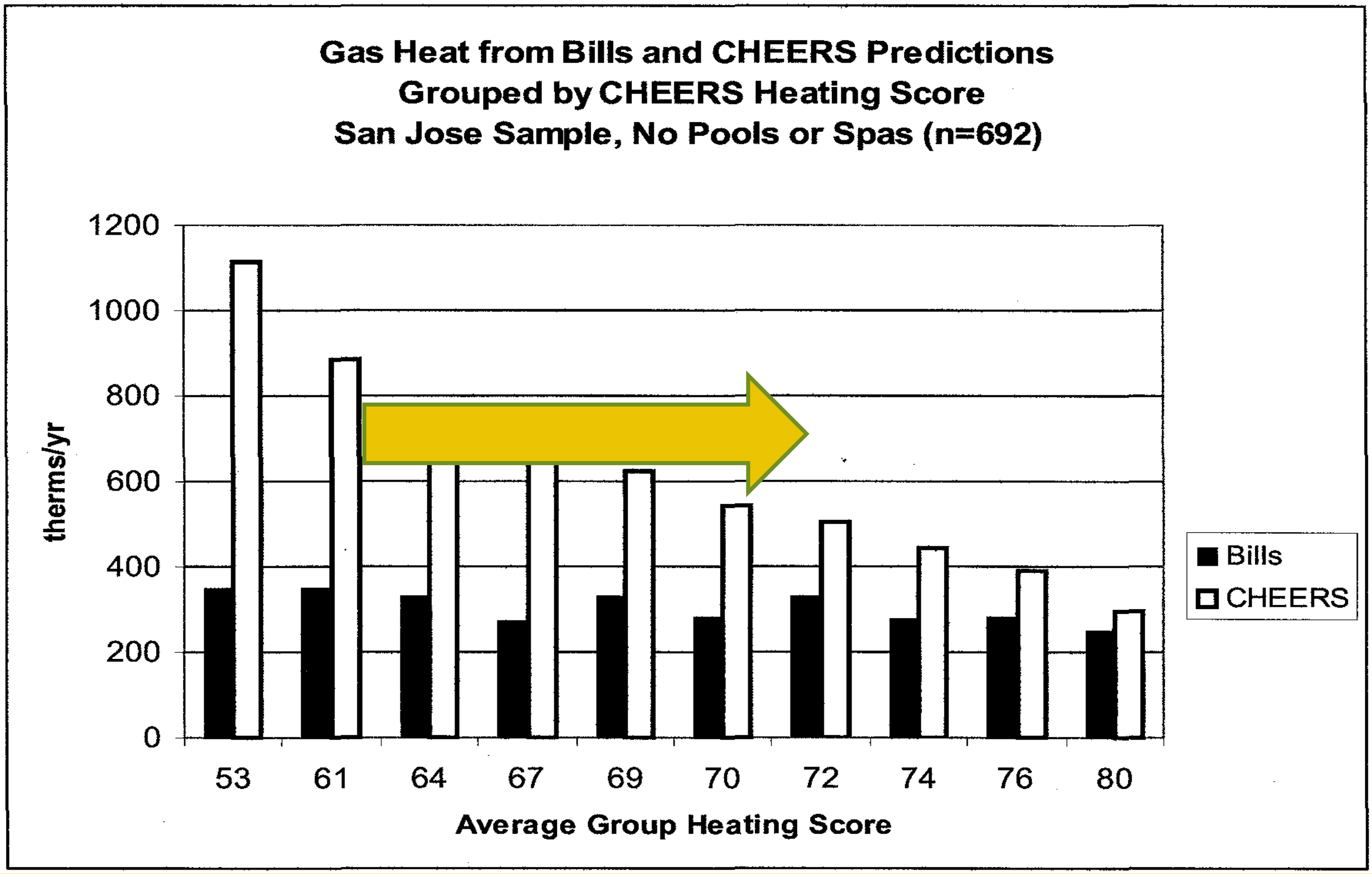
http://www.energy.ca.gov/title24/2013standards/index.html

Modeled

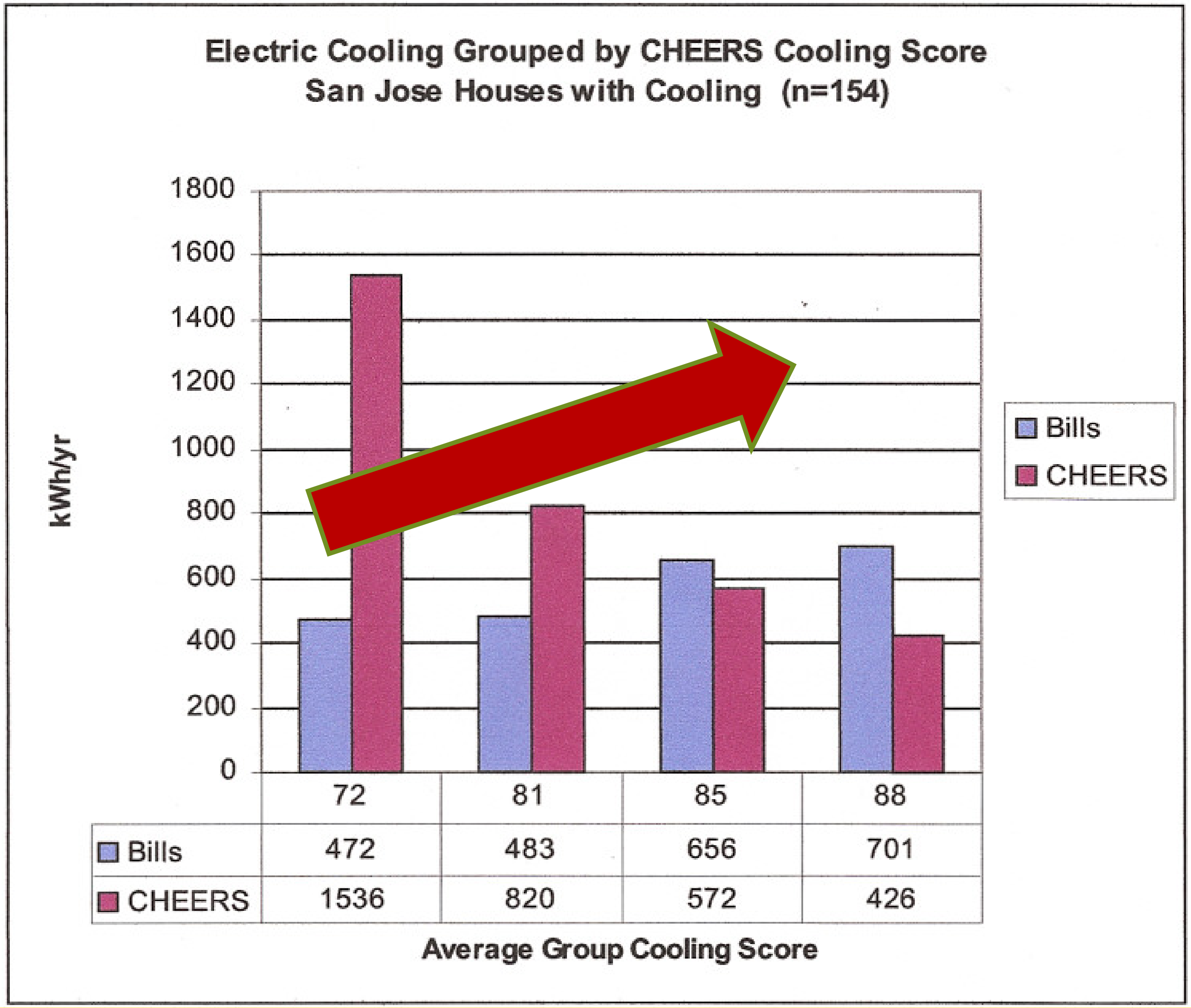


Source: California Energy Commission

Reality - Heating



Reality - Cooling

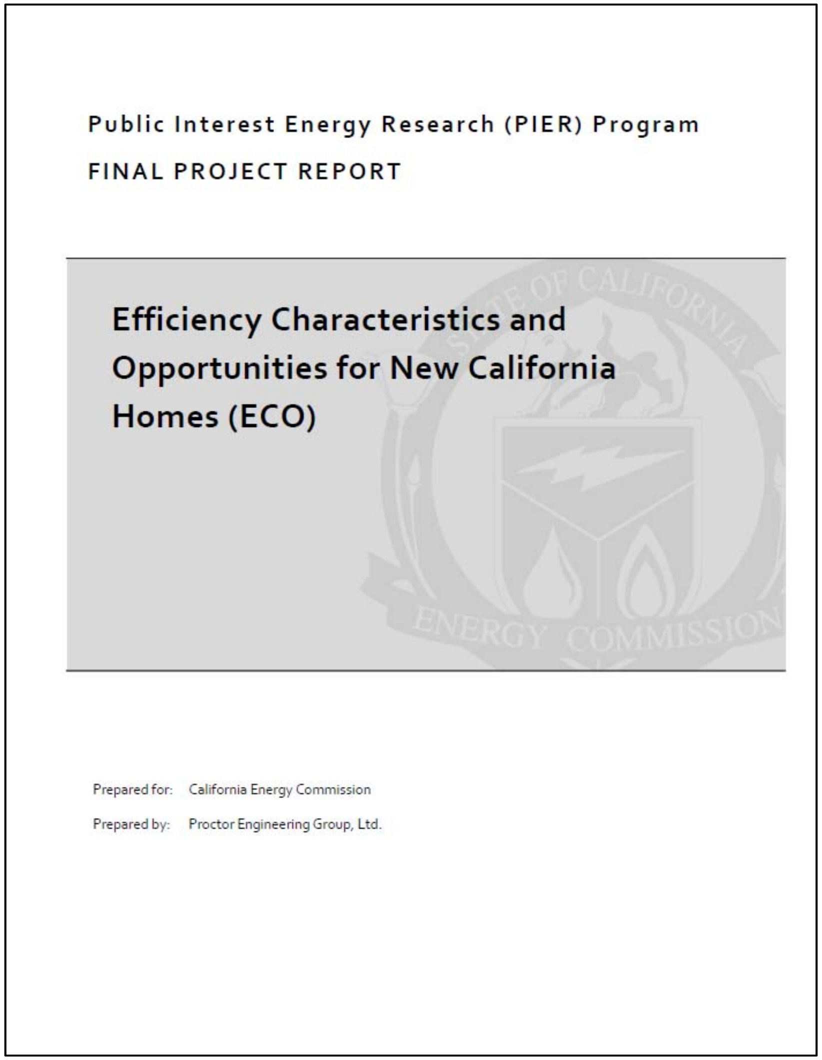


	72	81	85	88
Bills	472	483	656	701
CHEERS	1536	820	572	426

How Did We Get Here?

- Research where we are
- How are we using energy
- Performance Data

Research – WHY??



Public Interest Energy Research (PIER) Program

FINAL PROJECT REPORT

Efficiency Characteristics and Opportunities for New California Homes (ECO)

Prepared for: California Energy Commission

Prepared by: Proctor Engineering Group, Ltd.

PIER Program

- The California Energy Commission Public Interest Energy Research (PIER) Program
  - supports public interest energy research and development that will help improve the quality of life in California
  - by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

http://www.energy.ca.gov/2012publications/

Recommendations from PIER

1. Title 24–2013 should make mandatory a confirmed airflow greater than or equal to 400 CFM per ton and a fan watt draw less than or equal to 0.510 watts per CFM; with an acceptable alternative of the return system sizes specified in Table 25, as verified by the building inspector.
   - §150.0(m)13B. (350 CFM/0.58)
   - §150.0(m)13B. Table 150.0 C/D Return Duct Sizing
2. Title 24–2013 should mandate labeling HVAC return locations with the size, maximum clean filter pressure drop at 400 CFM per ton clean filter airflow.
   - §150.0(m)12 (Air Filtration)
3. Title 24–2013 should mandate that all HVAC filters sold in California be labeled with a standardized clean filter pressure drop and clean filter airflow table.
   - §150.0(m)12D (Air Filter Media Product Labeling)

Recommendations from PIER

4. Title 24–2013 should make mandatory a confirmed total duct leakage less than or equal to 24 CFM25 per ton for single family homes and town homes.
   - §150.0(m)11 (Duct System Sealing and Leakage Testing)
5. Title 24–2013 should make mandatory a confirmed total duct leakage of less than or equal to 48 CFM25 per ton for apartments regardless of the location of the duct systems.
   - §150.0(m)11C (Multi family – regardless of duct location)
6. Title 24–2013 ACM should calculate energy consumption based on 17% duct leakage imbalance.
   - New home = Supply duct leakage 6% x 1.17 / Return duct 6% x 0.83
7. Title 24 2013 ACM should calculate energy consumption based on 51% of the house air leakage area between the occupied space and the attic.
   - New home = 5 CFM50 (50% of that at ceiling if slab on grade / 40% if raised)

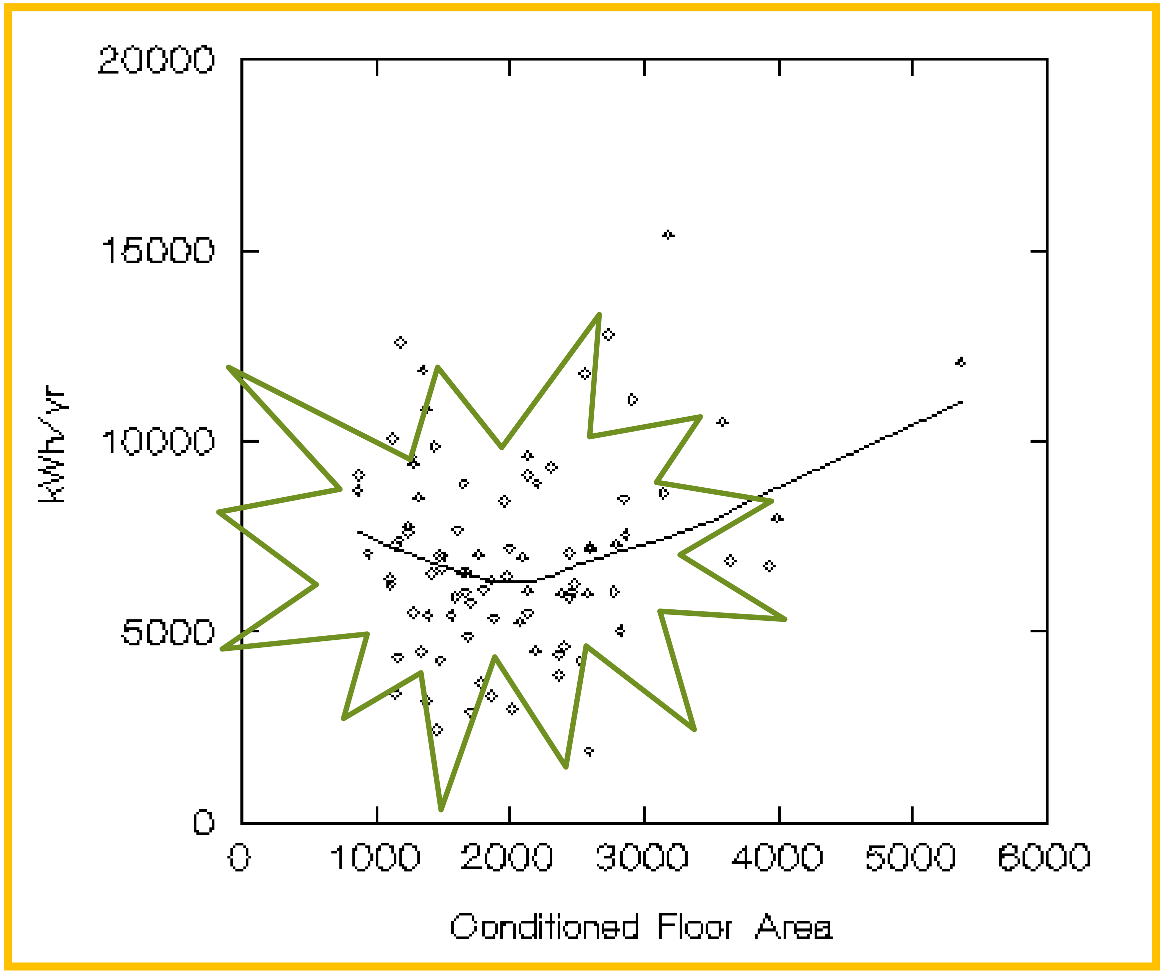
Recommendations from PIER

8. Title 24–2013 should make clear that the fan cabinet and return plenum on furnaces is part of the duct system and must be insulated to the levels specified for duct systems in the space in which they are located.
   - §150.0(m)1 (CMC Compliance)
9. Title 24 2013 should revise the acceptable limits for HERS inspections of TXV air conditioners. The limits should be >2° F and ≤ the manufacturer's target subcooling + 8°F.
   - RA3.2 (Reference Appedixes)
10. California Energy Commission should sponsor additional field research to determine the extent of non-condensables in the refrigerant of newly installed air conditioners.
11. Title 24–2013 should make mandatory that any zoned system must not have a bypass from the supply to the return and that the airflow in all potential operating modes meet recommendation number 1.
    - §150.0(m)15 (Zonally Controlled Central Forced Air Systems)

Recommendations from PIER

12. For single family buildings and town houses, Title 24–2013 should make mandatory a confirmed building shell air leakage of less than or equal to 4 ACH at 50 pascals using a single point test.
13. For multi-family buildings, Title 24–2013 should make mandatory a confirmed unit air leakage of less than or equal to 6 ACH at 50 pascals using a single point test.
14. Title 24–2013 should make mandatory that air conditioner condensing units may not be placed within 5 ft of a dryer vent.
    - 150.0(h)3 (Outdoor Condensing Units)
15. Title 24–2013 should make mandatory that there be no obstruction within 5 ft of the condenser coil inlet and condenser coil outlet.
16. Title 24–2013 should make mandatory that furnace heat rise must not exceed the manufacturer's specification.
    - §150.0(h)4 (Temperature Rise)

How Are We Using Electricity?

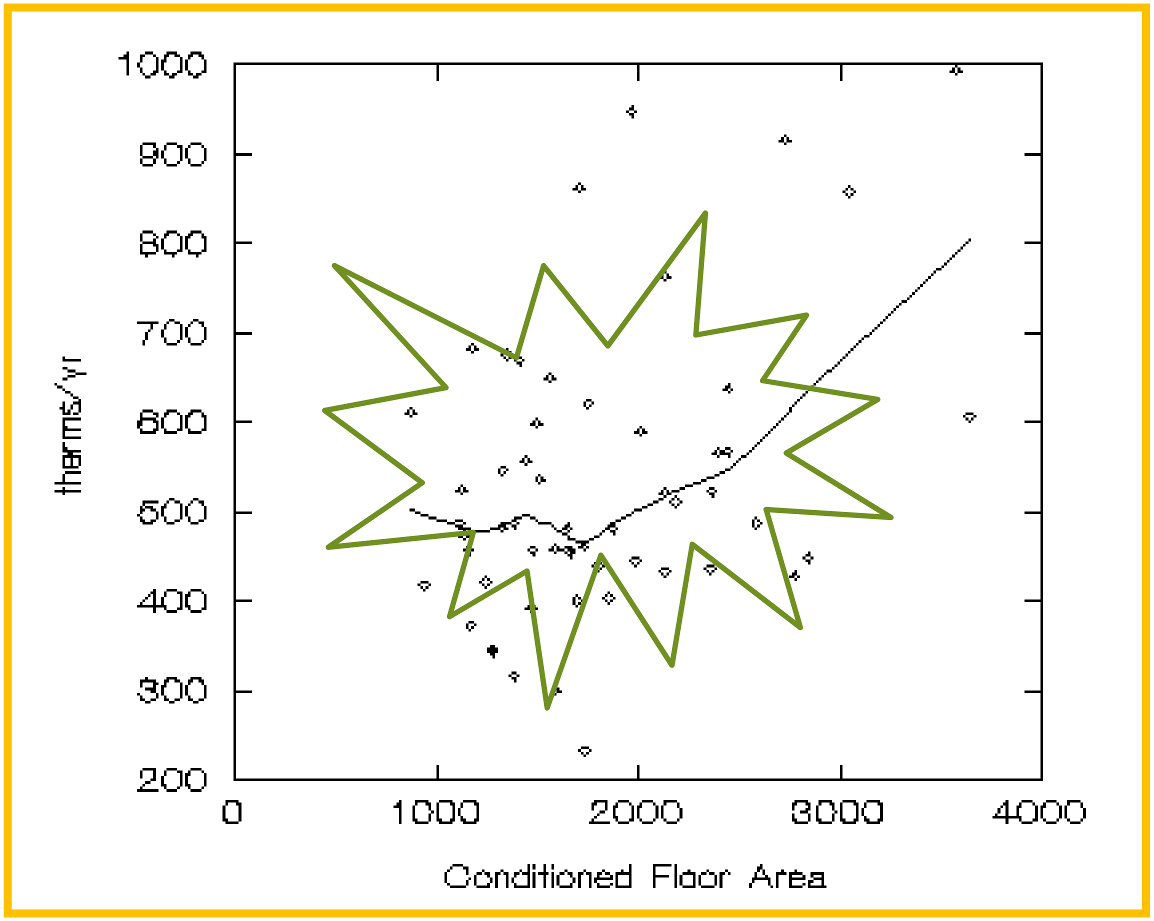


Source: California DSM Measurement Advisory Committee report

Huh?

- All over the place
  - What can this be attributed to?
    - Plug loads?
    - Pot growing?
    - Lot of kids?

How Are We Using Gas?



Source: California DSM Measurement Advisory Committee report

Huh?

- All over the place
  - What can this be attributed to?
    - Thermostat set at 100?
    - 10 hour showers?
    - 30 loads of laundry a day?

Performance Data

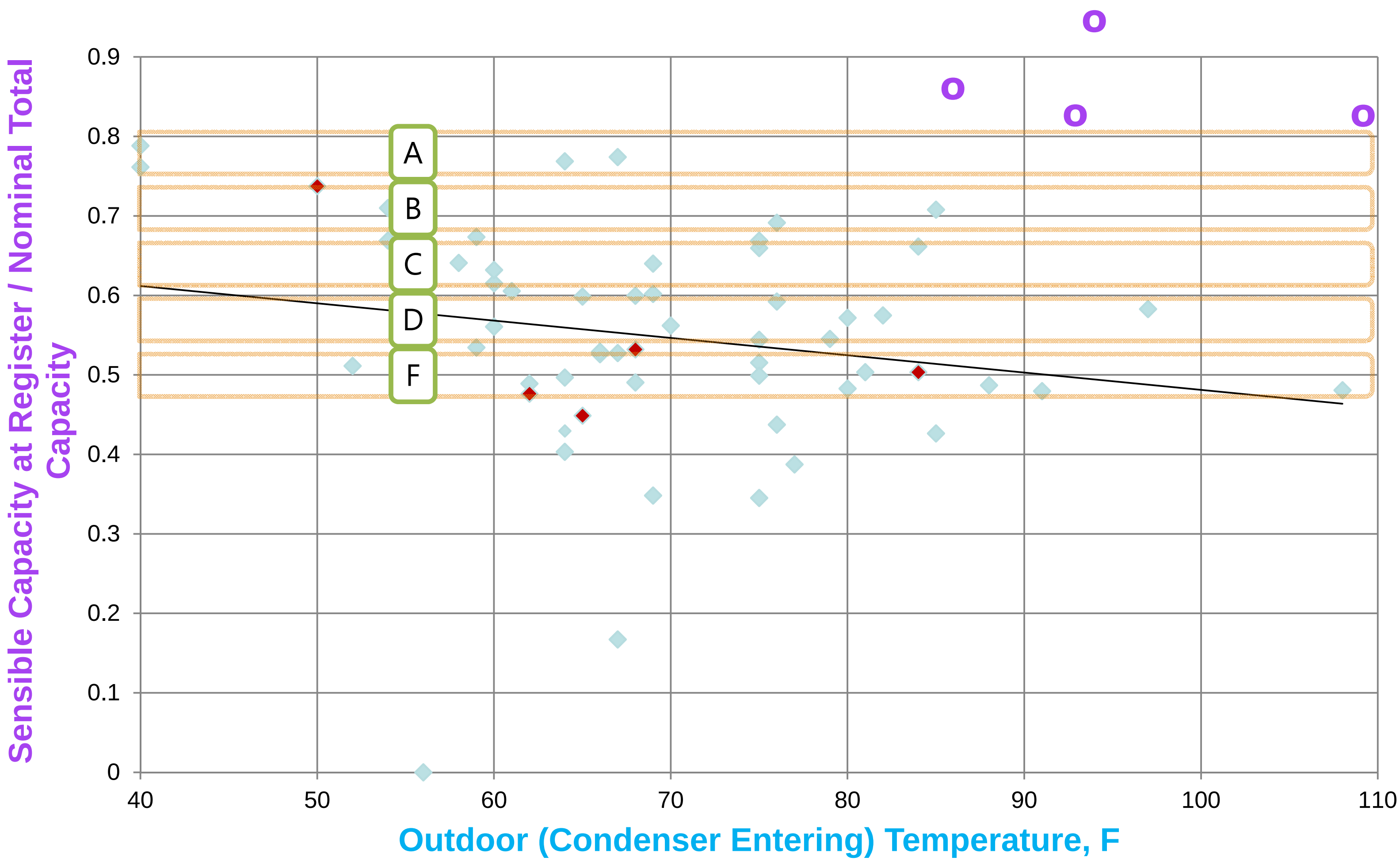
Current Residential HVAC Design and Installation

	Low	High	Difference %
Fan	0.13 w/sf	0.92 w/sf	708%
Heating	9 Btu/sf	110 Btu/sf	1222%
Cooling	1739 sf/ton	200 sf/ton	869%
Air Infiltration*	2.4 ACH_{50}	38.4 ACH_{50}	1600%

Source: California Energy Commission report 500-2012-062

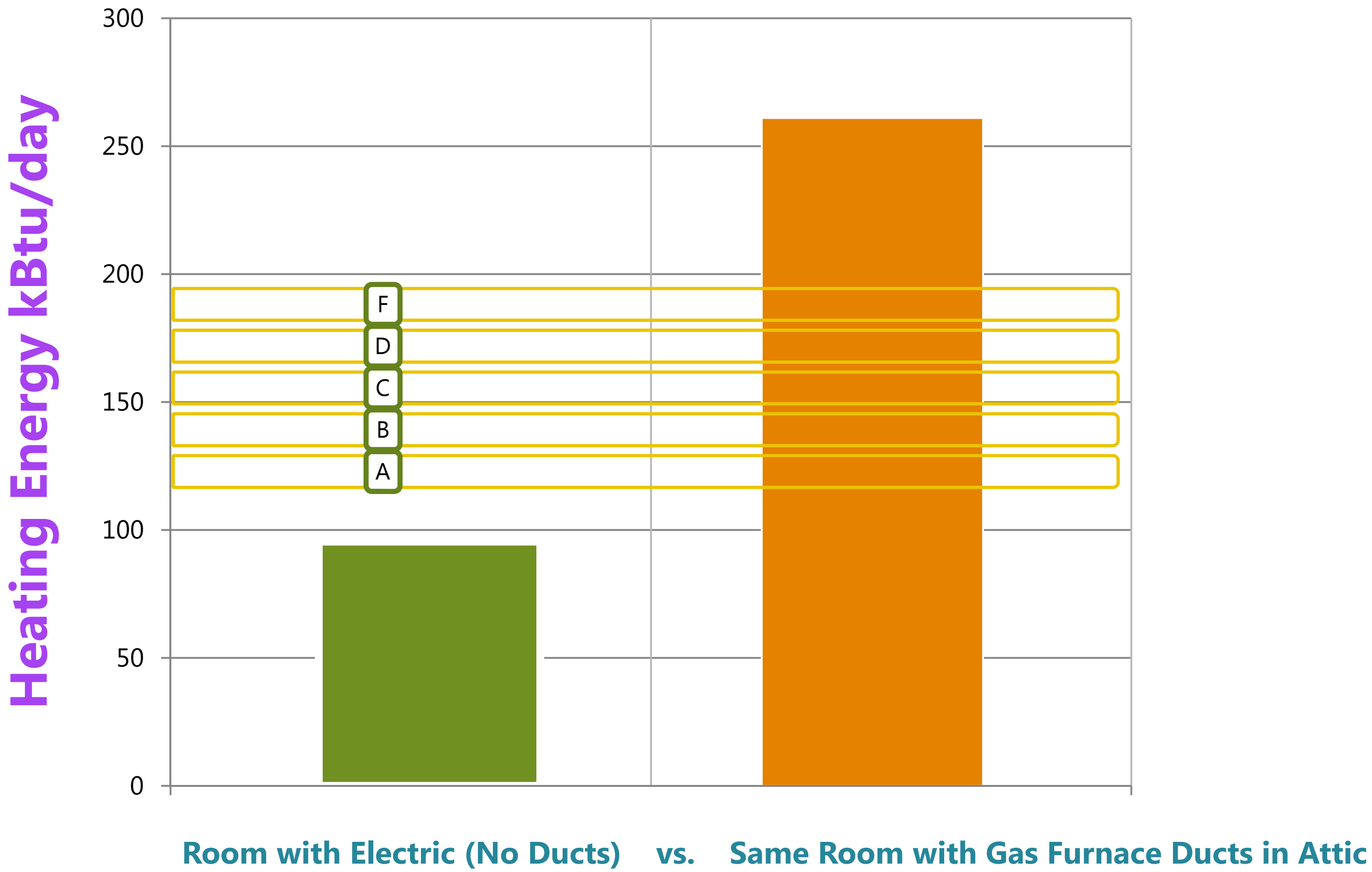
*Note: Average air infiltration is 0.25 ACH in new homes (2010 research, Wilcox, Proctor, Chitwood)

Performance Data - AC Sensible Capacity



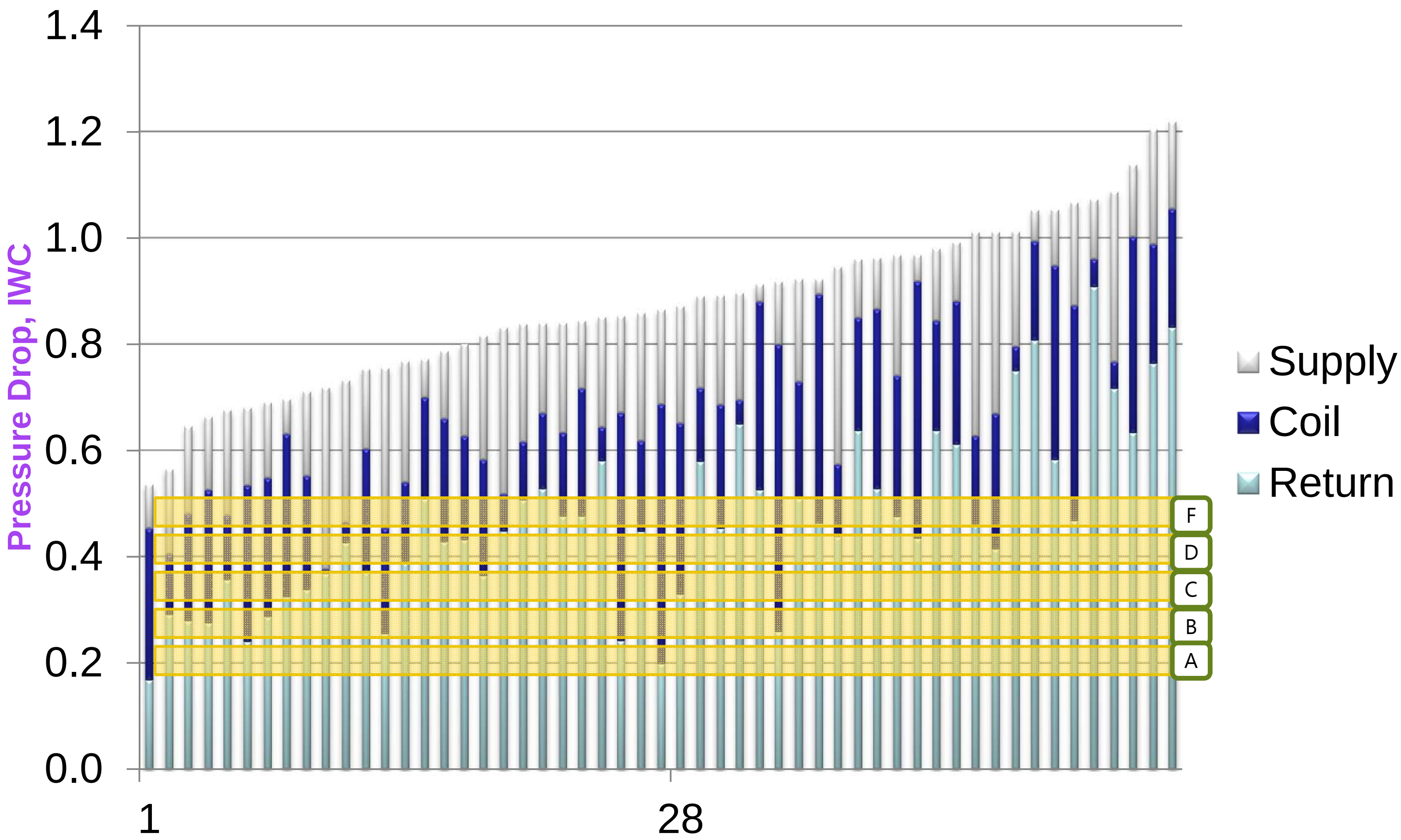
Source: California Energy Commission report 500-2012-062 and Rick Chitwood
and Energy Docs Home Performance

Performance Data – Heating Energy



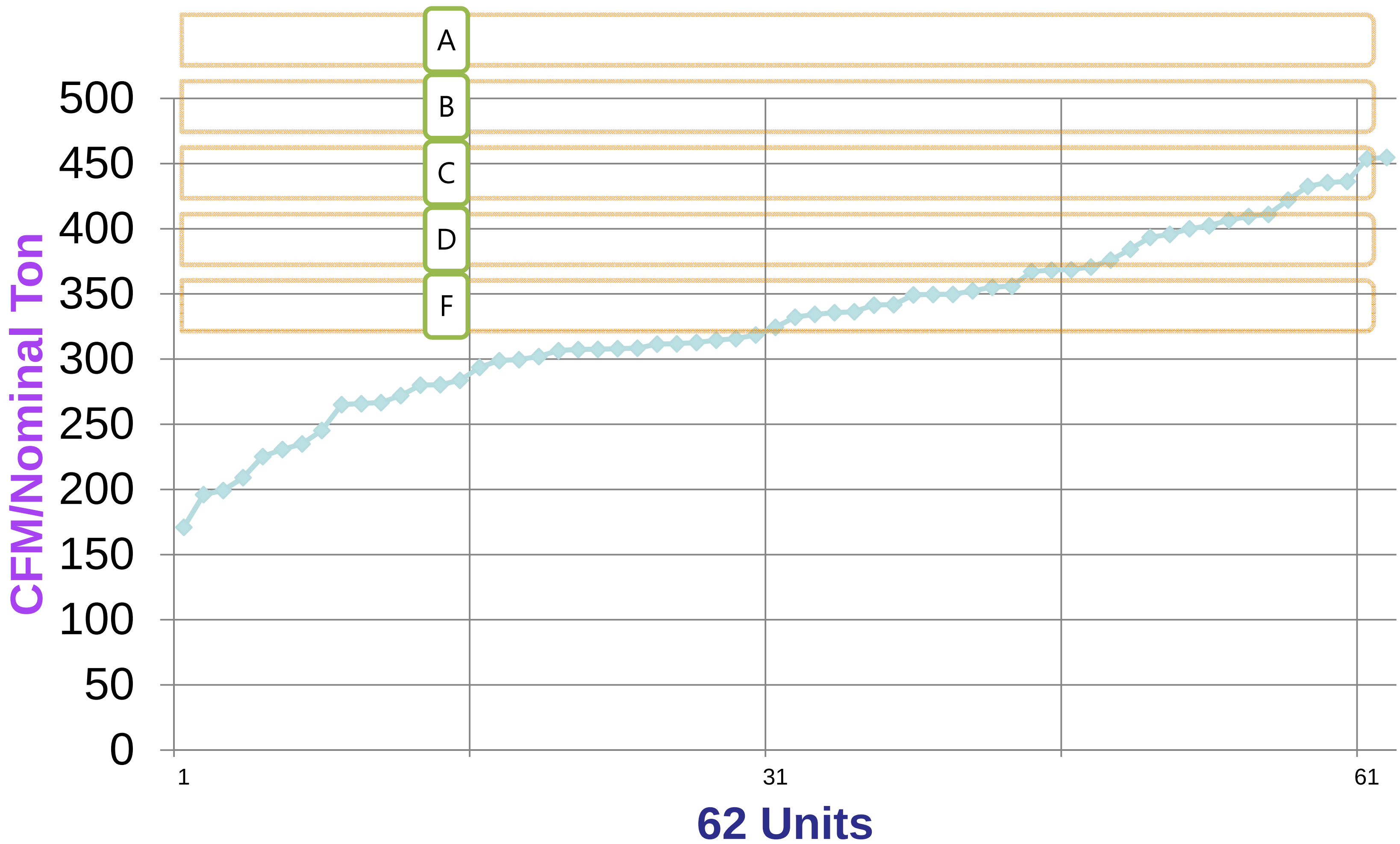
Source: California Energy Commission project Stockton Research Houses and Rick Chitwood

Performance Data - Measured External Static Pressure



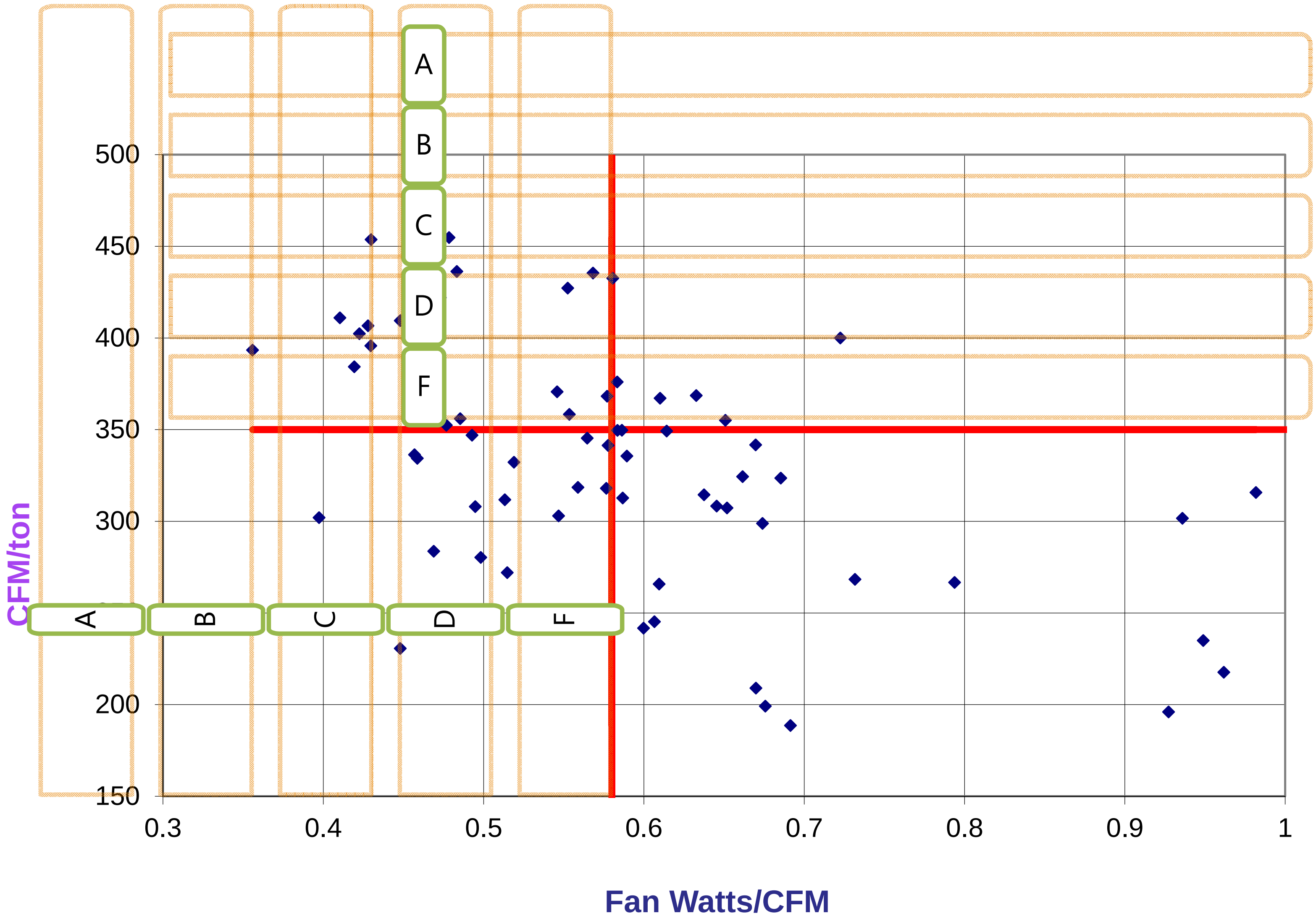
Source: California Energy Commission report 500-2012-062 and Rick Chitwood

Performance Data - Evaporator Coil Air Flow



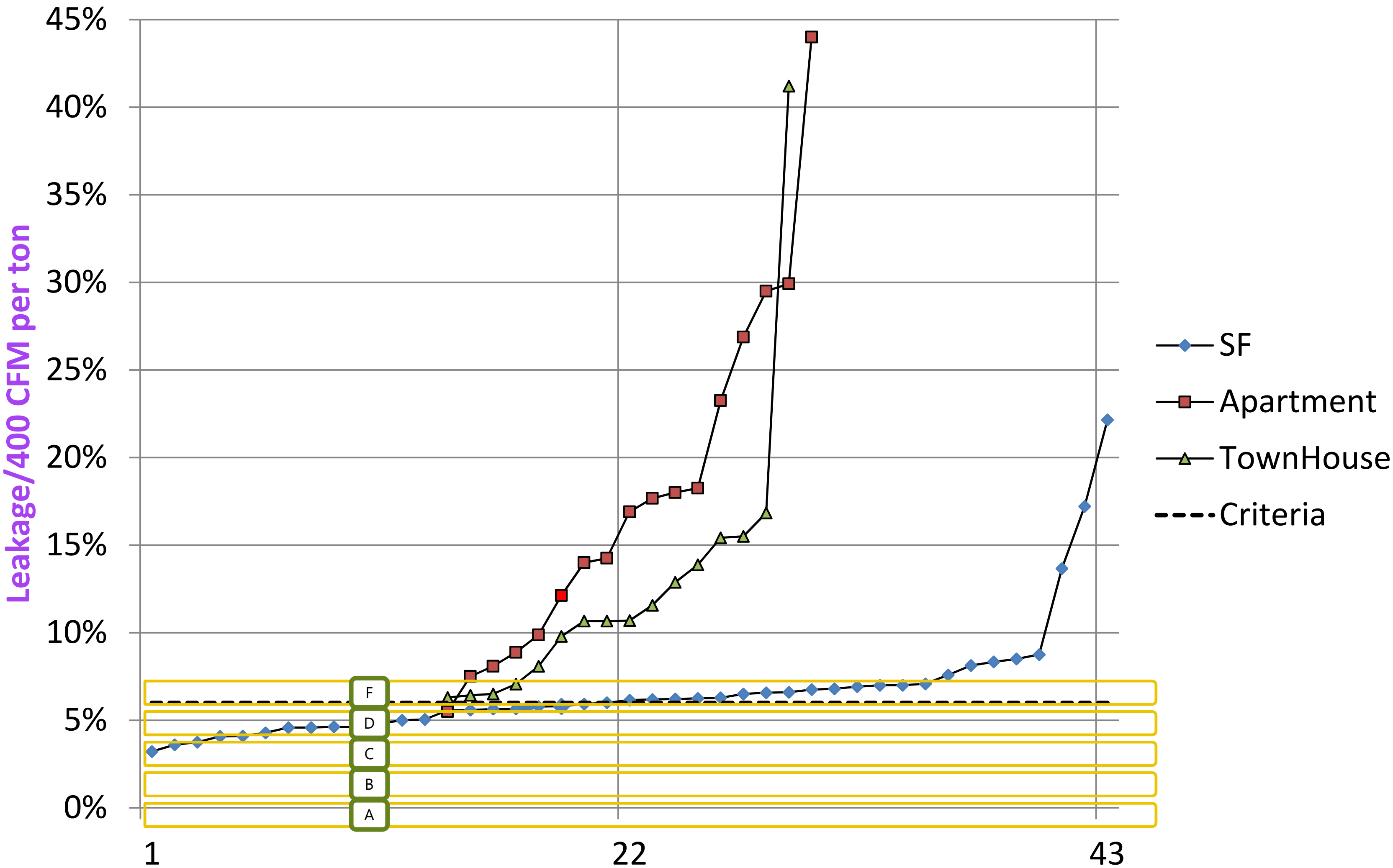
Source: California Energy Commission report 500-2012-062 and Rick Chitwood

Performance Data - Air Flow and Fan Watts



19 of 69 Meet 2008 Standard
Source: California Energy Commission report 500-2012-062 and Rick Chitwood

Performance Data - Total Duct Leakage @ 25 Pa



Source: California Energy Commission report 500-2012-062 and Rick Chitwood

Performance Data Score

	Average Grade
✓ *Building Enclosure Tightness*	*F*
✓ *Comfort Delivered*	*F*
✓ *Air Handler Static Pressure*	*F*
✓ *HVAC Air Flow*	*F*
✓ *HVAC Fan Watts*	*F*
✓ *HVAC Duct Leakage*	*F*
✓ *Delivered Cooling Performance*	*F*
✓ *Delivered Heating Performance*	*F*

Why Are We Here?

- Code Minimum
- Performance failures
- House is a system / Comfort (Goldilocks Effect)
- Value in HVAC as a Craft
  - Low bid
  - Manufacturer marketing

Residential Comfort (Goldilocks Affect)

Noise

- Too loud
- Too slow
- Just right

- Fans
- Ducts
- Supply Registers
- Return Registers
- Cycling of equipment

Residential Comfort (Goldilocks Affect)

Temperature

- Too hot
- Too cold
- Just right

- Fans
- Ducts
- Supply Registers
- Return Registers
- Cycling of equipment

Residential Comfort (Goldilocks Affect)

Indoor Air Quality

- Too smelly and nasty
- Too drafty and loud
- Just right

- Fans
- Ducts
- Supply Registers
- Return Registers
- Cycling of equipment

- Seventy-five of the 80 homes (94%) had formaldehyde concentrations higher than the Chronic Reference Exposure Level (REL) of 2.4 parts per billion (ppb). Twenty of the 80 homes (25%) exceeded the 8-hour REL of 27 ppb.

Residential Comfort (Goldilocks Affect)

Cost

- Too expensive
- You get what you pay for
- Just right

- Fans
- Ducts
- Supply Registers
- Return Registers
- Cycling of equipment

Where Are We Going?

ZNE Goals

1978: The state of California establishes the energy code. CA Energy Commission (CEC) re-visits and tightens the State's building energy efficiency standards (Title 24 Part 6) every three years.

2003: California adopted an Energy Action Plan which made energy efficiency the first choice in meeting the state's future energy needs. Part of the "Big Bold Strategies" of this plan includes a goal that all new residential achieve zero net energy by 2020.

2006: AB32 is adopted. California Global Warming Solutions Act of 2006 -- legislation that aims to reduce greenhouse gas emissions.

What Can We Do?

Contractors incorporate "Quality Control" performance testing

HVAC Contractors

- BTU's at the supply grilles compared performance tables
- Record run time to confirm sizing
- Duct leakage to outside less than 5 CFM_{25}
- Fan watt draw less than 0.2 watts/CFM
- Delivery velocities above 500 FPM

High Performance HVAC Specifications For ZNE Builder Pilot

Rick Chitwood / Revised: January 5, 2015

√	*Feature*	*Goal for ZNE*	*Specification*
1	**Cooling SEER/EER**	16/12	manufacturers' specifications
2	**Measured sensible EER**	>90% of manufacturer's performance data	measured at supply grille and compared to manufactures' data
3	**Heating AFUE/HSPF**	95%/10.0	manufacturers' specifications
4	**Measured heating efficiency**	>90% of manufacturer's performance data	measured at supply grille and compared to manufactures' data
5	**Maximum heating capacity**	<10 BTU/sq.ft	manufacturers' specified output at design temperature / CFA
6	**Furnace temperature rise**	<5°F above minimum allowed	measured furnace temperature rise compared to manufacturers' specifications
7	**Furnace sizing confirmation**	70% on at design temperature	monitored run time at constant 71°F indoor temperature at design temperature
8	**Duct location**	100% conditioned space	visual inspection and confirmed with duct leakage test (#9 below)
9	**Duct leakage**	<5 CFM_{25} duct leakage to the outside	measured leakage with Ring 4 on the duct blaster
10	**Duct insulation**	R-8.0	duct manufacturers' specification
11	**Cooling air flow**	>550 CFM/ton	measured at return with condensing unit off (68°F to 78°F indoor temperature)
12	**Verified refrigerant charge**	SH and SC within 1°F of minimum allowed	SH and SC measured with the liquid line temperature between 98°F and 102°F
13	**Fan watt draw**	<0.2 watts/CFM	measured RMS fan watts / cooling air flow (#11 above)
14	**Cooling capacity**	>1,200 sq.ft./ton	CFA / manufacturers' nominal tonnage
15	**AC sizing confirmation**	>70% on at design temperature	monitored run time at constant 74°F indoor temperature at design temperatures
16	**System standby watts**	>10 watts	measured total system RMS air handler and condensing unit watts when not operating
17	**Supply grille delivery velocity**	500 FPM to 700 FPM in both heat and cool	measured supply air flow (powered flow hood) and grille manufactures' data

Let's Talk

- Welcome
- What We Heard from You
- **Let's Talk**
  - Here, Now and Next
- Next Steps
- Wrap Up

Our Question To You

How often do you specify/verify HVAC systems that exceeds minimum code requirements?

1.Duct Testing
2.Themal measuring
3.Air Flow Testing
4.Fan Watt draw
5. manufactorers info plate…

Others use 400 sq. ft./ton or replace with the input BTUs of the old unit (waaaay overkill)

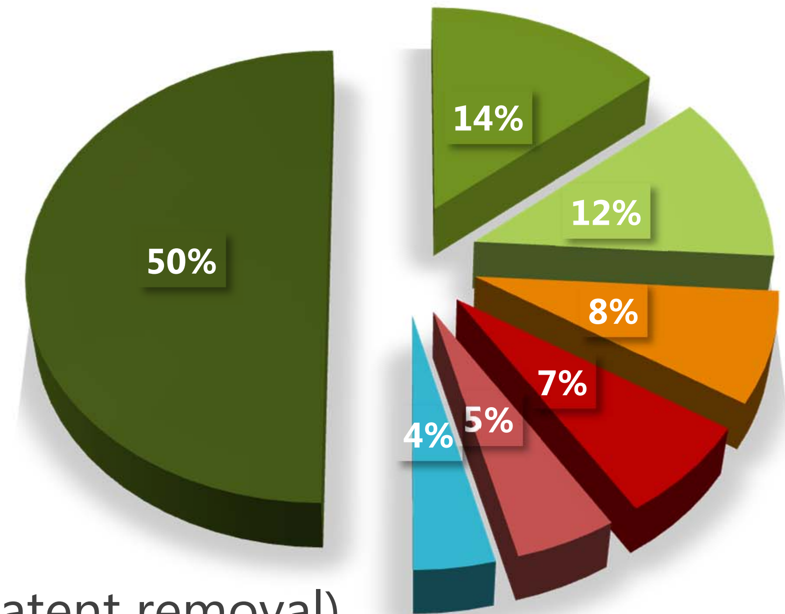
Verify all energy documentation and HERS forms.

Manufacturers' literature

Typically I identify efficiency's needed to comply with a system type. Now I seem to need to be a HVAC specialist! What guidelines should I use for sizing, input versus output, sensible heat, etc.?

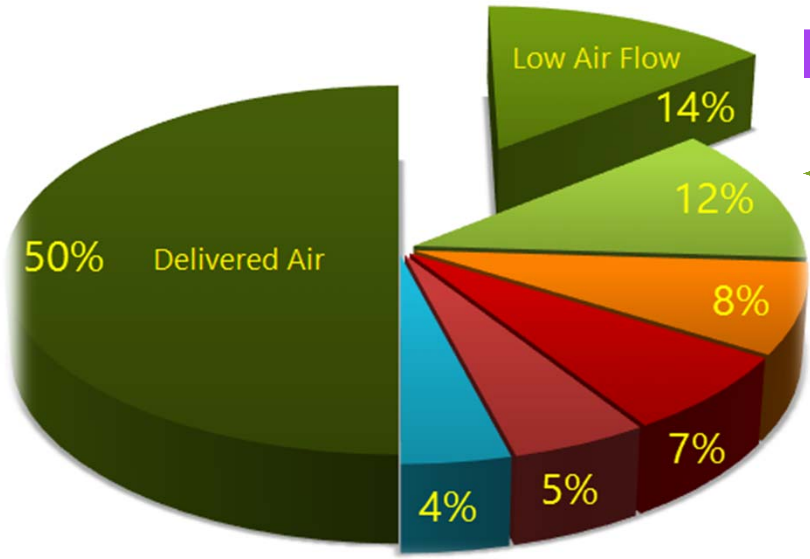
Where is the opportunity?

AC Efficiency Losses = 50%



- Low Air Flow (high latent removal)
- Duct Conductive Losses
- Refrigerant Charge and Contamination
- Duct Leakage
- Room Air Delivery and Mixing
- Equipment Oversizing

Low Air Flow Losses= 14%



Here, Now and Next

- Reality
  - Filters: Static Pressure not meeting manufacturer's specifications
  - Airflow/Fan Watt Draw: Exceeding 350 CFM per ton
- Code
  - Filters: §150.0(m)12 "Air Filtration"
  - Airflow/Fan Watt Draw: §150.0(m)13 "Duct System Sizing and Air Filter Grille Sizing"
- ZNE
  - Cooling air flow> 550 CFM/ton / Fan watt draw < 0.2 watts/CFM

Reality: Measured External Static Pressure

Figure 15: Unit 9—HVAC Label

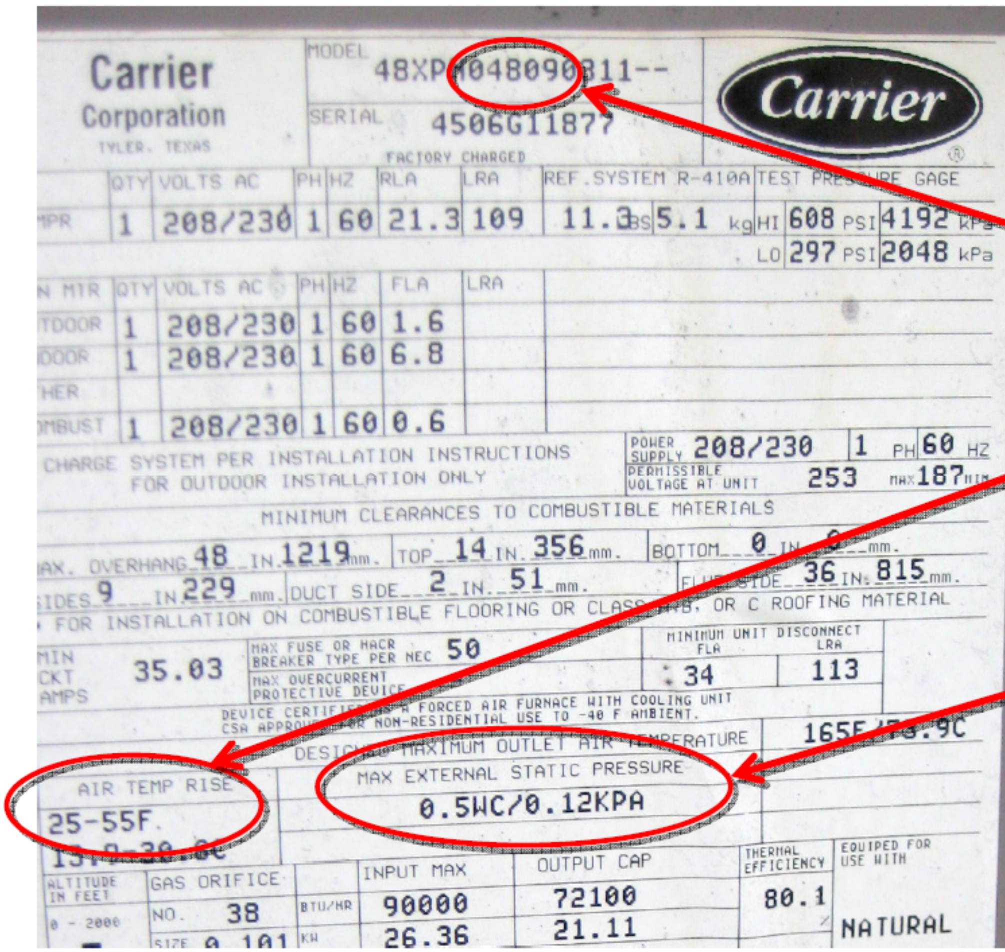


Photo credit: Rick Chitwood

A Four Ton Package Unit

with a heating heat rise range of 25 to 55°F

and a maximum external static pressure of 0.5 IWC

The high filter pressure drops are due to a combination of inadequate filter size and the widespread use of 1 in. pleated filters that have high pressure drops even when new.

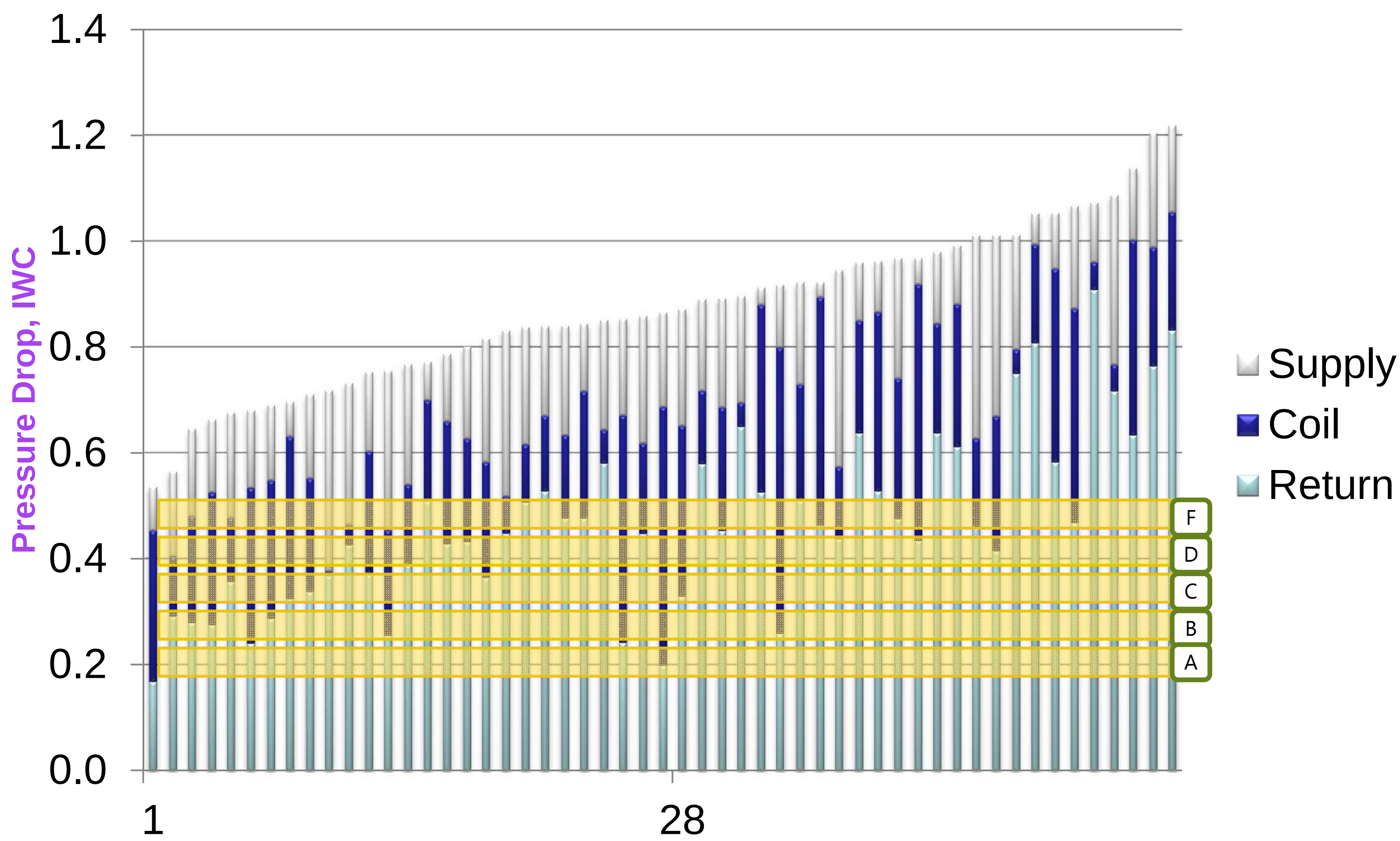
Source: California Energy Commission report 500-2012-062 / Rick Chitwood

Reality: Measured External Static Pressure

"Clean" minimum efficiency filter with 155 Pa (0.62 inches of water column)

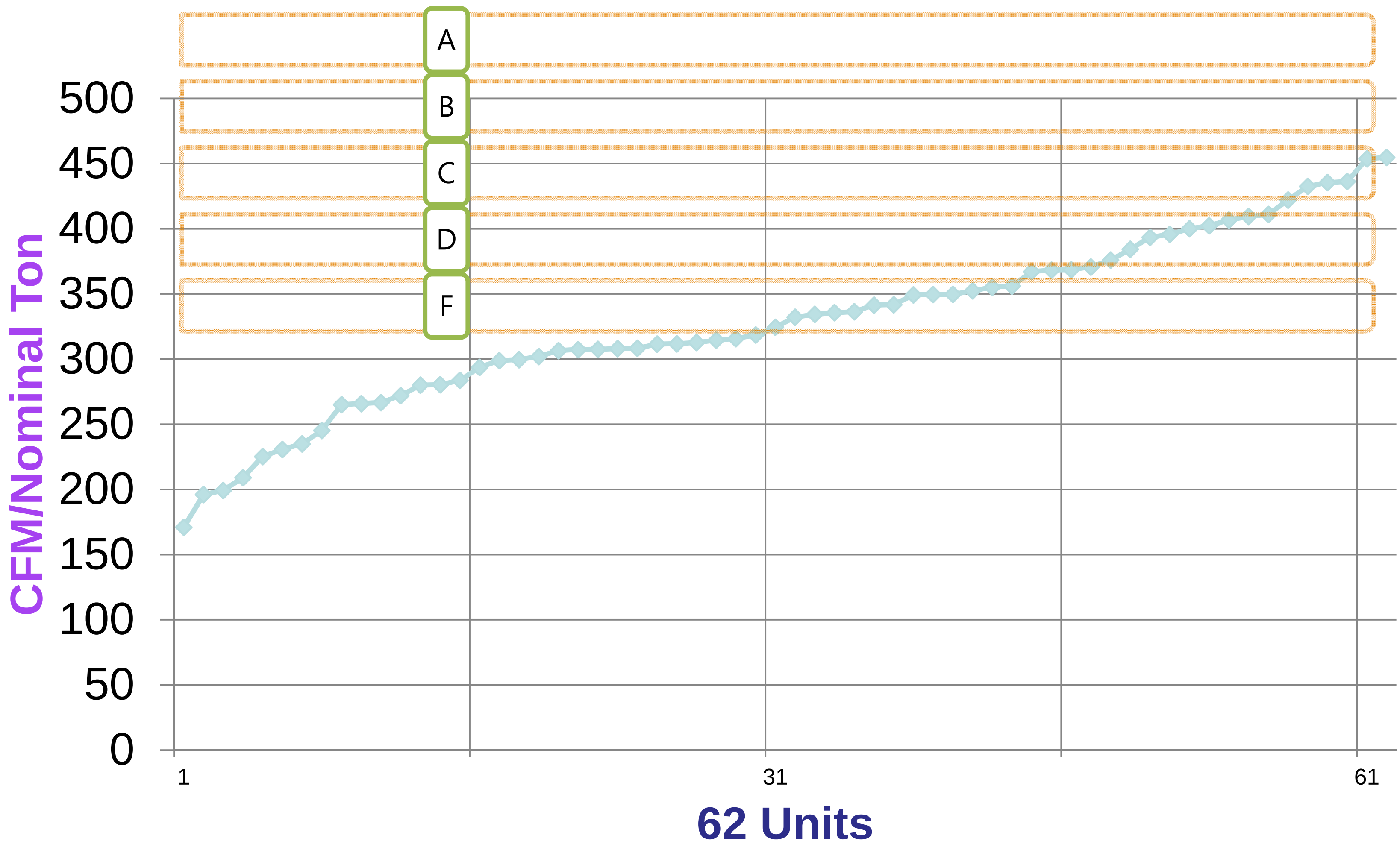
Source: California Energy Commission report 500-2012-062 / Rick Chitwood

Reality - Measured External Static Pressure



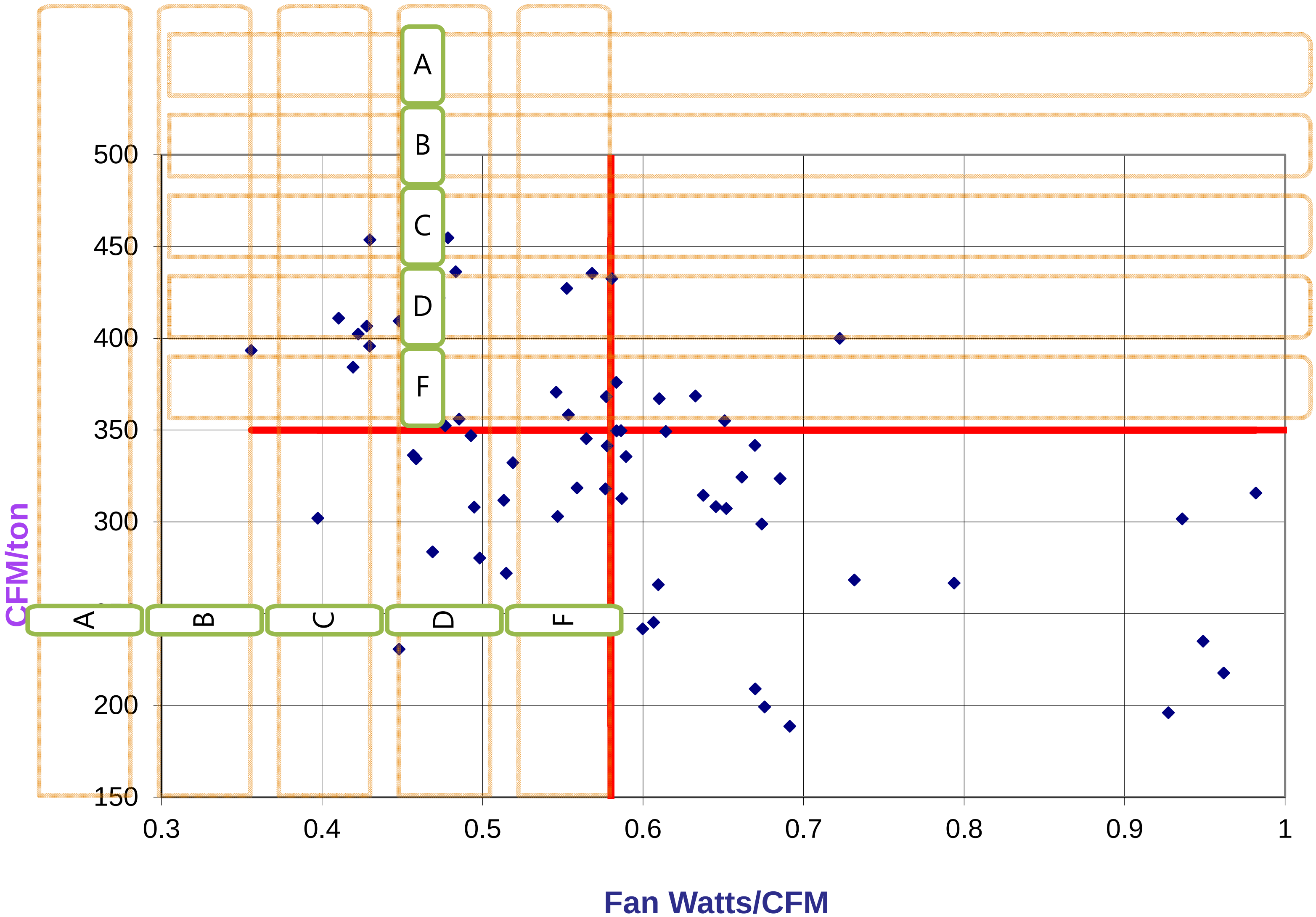
Source: California Energy Commission report 500-2012-062 and Rick Chitwood

Reality- Evaporator Coil Air Flow



Source: California Energy Commission report 500-2012-062 and Rick Chitwood

Performance Data - Air Flow and Fan Watts



19 of 69 Meet 2008 Standard

Source: California Energy Commission report 500-2012-062 and Rick Chitwood

Code – Filters §150.0(m)12

- Mechanical systems that supply air to an occupiable space through ductwork exceeding 10 ft (3 m) in length and through a thermal conditioning component, except evaporative coolers, shall be provided with air filter devices in accordance with the following:
  - A. System Design and Installation.
    - i. The system shall be designed to ensure that all recirculated air and all outdoor air supplied to the occupiable space is filtered before passing through the system's thermal conditioning components.
    - ii. ***The system shall be designed to accommodate the clean-filter pressure drop imposed by the system air filter device(s).*** The design airflow rate and maximum allowable clean-filter pressure drop at the design airflow rate applicable to each air filter device shall be determined.
    - iii. All system air filter devices shall be located and installed in such a manner as to allow access and regular service by the system owner.
    - iv. ***All system air filter device locations shall be labeled to disclose the applicable design airflow rate and the maximum allowable clean-filter pressure drop as determined according to subsection ii above. The labels shall be permanently affixed to the air filter device readily legible, and visible to a person replacing the air filter media.***
  - B. Air Filter Media Efficiency. The system shall be provided with air filter media having a designated efficiency equal to or greater than MERV 6 when tested in accordance with ASHRAE Standard 52.2, or a particle size efficiency rating equal to or greater than 50percent in the 3.0–10 µm range when tested in accordance with AHRI Standard 680.
  - C. Air Filter Media Pressure Drop. The system shall be provided with air filter media that conforms to the maximum allowable clean-filter pressure drop determined according to Section 150.0(m)12Aii, as rated using AHRI Standard 680, for the applicable design airflow rate(s) for the system air filter device(s). If the alternative to 150.0(m)13B is utilized for compliance, the design clean-filter pressure drop for the system air filter media shall conform to the requirements given in TABLE 150.0-C or 150.0-D.
  - D. Air Filter Media Product Labeling. The system shall be provided with air filter media that has been labeled by the manufacturer to disclose the efficiency and pressure drop ratings that demonstrate conformance with Sections 150.0(m)12B and 150.0(m)12C

Code – Airflow/Fan Watt Draw §150.0(m)13

- Space conditioning systems that utilize forced air ducts to supply cooling to an occupiable space shall:
  - A. Have a hole for the placement of a static pressure probe (HSPP), or a permanently installed static pressure probe (PSPP) in the supply plenum downstream of the air conditioning evaporator coil. The size, location, and labeling of the HSPP or PSPP shall conform to the requirements specified in Reference Residential Appendix RA3.3.1.1 as confirmed by field verification and diagnostic testing; and
    - EXCEPTION to 150.0(m)13A: Systems that cannot conform to the specifications for hole location in Reference Residential Appendix Figure RA3.3-1 shall not be required to provide holes as described in Figure RA3.3-1.
  - B. Demonstrate, in every control mode, ***airflow greater than or equal to 350 CFM per ton of nominal cooling capacity through the return grilles, and an air-handling unit fan efficacy less than or equal to 0.58 W/CFM*** as confirmed by field verification and diagnostic testing in accordance with the procedures given in Reference Residential Appendix RA3.3.
    - ***ALTERNATIVE to Section 150.0(m)13B: Standard ducted systems (systems without zoning dampers) may comply by meeting the applicable requirements in TABLE 150.0-C or 150.0-D*** as confirmed by field verification and diagnostic testing in accordance with the procedures in Reference Residential Appendix Sections RA3.1.4.4 and RA3.1.4.5. The design clean-filter pressure drop requirements of Section 150.0(m)12C for the system air filter device(s) shall conform to the requirements given in TABLES 150.0-C and 150.0-D.
    - EXCEPTION to Section 150.0(m)13B: Multispeed compressor systems or variable speed compressor systems shall verify air flow (cfm/ton) and fan efficacy (Watt/cfm) for system operation at the maximum compressor speed and the maximum air handler fan speed.

Code –Airflow/Fan Watt Draw Return Duct Sizing

TABLE 150.0-C: Return Duct Sizing for Single Return Duct Systems

Return duct length shall not exceed 30 feet and shall contain no more than 180 degrees of bend. If the total bending exceeds 90 degrees, one bend shall be a metal elbow.

Return grille devices shall be labeled in accordance with the requirements in Section 150.0(m)12A to disclose the grille's design airflow rate and a maximum allowable clean-filter pressure drop of 12.5 Pa (0.05 inches water) for the air filter media as rated in accordance with AHRI Standard 680 for the design airflow rate for the return grille.

System Nominal Cooling Capacity (Ton)*	Minimum Return Duct Diameter (inch)	Minimum Total Return Filter Grille Gross Area (inch^2)
1.5	16	500
2.0	18	600
2.5	20	800

*Not applicable to systems with nominal cooling capacity greater than 2.5 tons or less than 1.5 ton

TABLE 150.0-D: Return Duct Sizing for Multiple Return Duct Systems

Each return duct length shall not exceed 30 feet and shall contain no more than 180 degrees of bend. If the total bending exceeds 90 degrees, one bend shall be a metal elbow.

Return grille devices shall be labeled in accordance with the requirements in Section 150.0(m)12A to disclose the grille's design airflow rate and a maximum allowable clean-filter pressure drop of 12.5 Pa (0.05 inches water) for the air filter media as rated in accordance with AHRI Standard 680 for the design airflow rate for the return grille.

System Nominal Cooling Capacity (Ton)*	Return Duct 1 Minimum Diameter (inch)	Return Duct 2 Minimum Diameter (inch)	Minimum Total Return Filter Grille Gross Area (inch^2)
1.5	12	10	500
2.0	14	12	600
2.5	14	14	800
3.0	16	14	900
3.5	16	16	1000
4 .0	18	18	1200
5 .0	20	20	1500

*Not applicable to systems with nominal cooling capacity greater than 5.0 tons or less than 1.5 tons.

Code–Airflow/Fan Watt Draw HERS Verified

Airflow / Fan Watt Draw

- Section 150.0(m)13
  - New ducted systems with AC
  - *Entirely* new ducted systems with AC

Diagnostic	Description	Procedure
Forced Air System Airflow Rate, Fan Watt Draw, and Determination of Fan Efficacy.	(a) Verification of improved system airflow rate (cfm) in ducted split system and packaged space conditioning systems serving low-rise residential buildings. (b) Verification of reduced fan power (Watt) draw achieved through improved air distribution system design, including more efficient motors and ducts that have less resistance to airflow. (c) Determination of fan efficacy (Watt/cfm) utilizing simultaneous measurement of system Watt draw and airflow rate. *Exception: Size the return ducts per Table 150.0-C or 150.0-D*	RA3.3.3

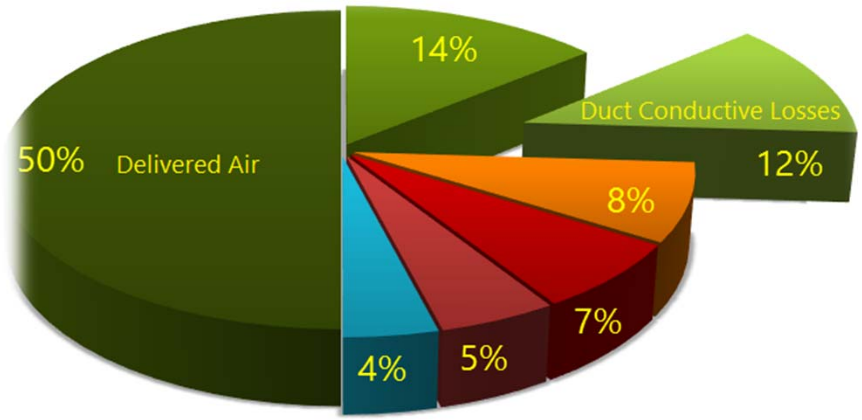
ZNE – HVAC Specifications

11	**Cooling air flow**	>550 CFM/ton	measured at return with condensing unit off (68ºF to 78ºF indoor temperature)
13	**Fan watt draw**	<0.2 watts/CFM	measured RMS fan watts / cooling air flow (#11 above)

High Performance HVAC Specifications For ZNE Builder Pilot
Rick Chitwood / Revised: January 5, 2015

√	*Feature*	*Goal for ZNE*	*Specification*
1	**Cooling SEER/EER**	16/12	manufacturers' specifications
2	**Measured sensible EER**	>90% of manufacturer's performance data	measured at supply grille and compared to manufactures' data
3	**Heating AFUE/HSPF**	95%/10.0	manufacturers' specifications
4	**Measured heating efficiency**	>90% of manufacturer's performance data	measured at supply grille and compared to manufactures' data
[illegible]	[illegible]	[illegible]	[illegible] specifications
7	**Furnace sizing confirmation**	70% on at design temperature	monitored run time at constant 71ºF indoor temperature at design temperature
8	**Duct location**	100% conditioned space	visual inspection and confirmed with duct leakage test (#9 below)
[illegible]	[illegible]	[illegible]	[illegible]
11	**Cooling air flow**	>550 CFM/ton	measured at return with condensing unit off (68ºF to 78ºF indoor temperature)
12	**Verified refrigerant charge**	SH and SC within 1ºF of minimum allowed	SH and SC measured with the liquid line temperature between 98ºF and 102ºF
13	**Fan watt draw**	<0.2 watts/CFM	measured RMS fan watts / cooling air flow (#11 above)
14	**Cooling capacity**	>1,200 sq.ft./ton	CFA / manufacturers' nominal tonnage
15	**AC sizing confirmation**	>70% on at design temperature	monitored run time at constant 74ºF indoor temperature at design temperatures
16	**System standby watts**	>10 watts	measured total system RMS air handler and condensing unit watts when not operating
17	**Supply grille delivery velocity**	500 FPM to 700 FPM in both heat and cool	measured supply air flow (powered flow hood) and grille manufactures' data

Duct Conductive Losses= 12%



Here, Now and Next

- Reality
  - Location: Uninsulated attic
  - Value: Not fully insulated
- Code
  - Location: Extra credit for not in uninsulated attic
  - Value: §150.0(m)1 "CMC Compliance" and §150.1(c)9 "Space Conditioning Ducts"
- ZNE
  - Location: 2016 Energy Code – High Performance Attics
  - Value: R-8

Reality - Duct Location

Photo Credit: Rick Chitwood

- Location, location, location
  - Air tight duct chasse to keep ducts "inside"
  - Large enclosure to keep furnace "inside"

Code – Value §150.0(m)1/150.1(c)9

150.0(m)1 - Mandatory

- All air-distribution system ducts and plenums, including, but not limited to, mechanical closets and air-handler boxes, shall be installed, sealed and insulated to meet the requirements of the CMC Sections 601.0, 602.0, 603.0, 604.0, 605.0 and ANSI/SMACNA-006-2006 HVAC Duct Construction Standards Metal and Flexible 3rd Edition, incorporated herein by reference. ***Portions of supply-air and return-air ducts and plenums of a space heating or cooling system shall either be insulated to a minimum installed level of R-6.0 (or any higher level required by CMC Section 605.0) or be enclosed entirely in directly conditioned space as confirmed through field verification and diagnostic testing in accordance with the requirements of Reference Residential Appendix RA3.1.4.3.8.*** Connections of metal ducts and the inner core of flexible ducts shall be mechanically fastened. Openings shall be sealed with mastic, tape, or other duct-closure system that meets the applicable requirements of UL 181, UL 181A or UL 181B or aerosol sealant that meets the requirements of UL 723. If mastic or tape is used to seal openings greater than 1/4 inch, the combination of mastic and either mesh or tape shall be used.
- Building cavities, support platforms for air handlers, and plenums defined or constructed with materials other than sealed sheet metal, duct board or flexible duct shall not be used for conveying conditioned air. Building cavities and support platforms may contain ducts. Ducts installed in cavities and support platforms shall not be compressed to cause reductions in the cross-sectional area of the ducts.
  - EXCEPTION to Section 150.0(m)1: Ducts and fans integral to a wood heater or fireplace.

150.1(c)9 - Prescriptive

- All ducts shall either be in directly conditioned space as confirmed by field verification and diagnostic testing in accordance with Reference Residential Appendix RA3.1.4.3.8 or be ***insulated to a minimum installed level as specified by TABLE 150.1-A COMPONENT PACKAGE-A*** Standard Building Design. All ducts shall meet all applicable mandatory requirements of Section 150.0(m).
  - NOTE: Requirements for duct insulation in TABLE 150.1-A do not apply to buildings with space conditioning systems that do not have ducts.

ZNE – HVAC Specifications

High Performance HVAC Specifications For ZNE Builder Pilot
Rick Chitwood / Revised: January 5, 2015

√	*Feature*	*Goal for ZNE*	*Specification*
1	**Cooling SEER/EER**	16/12	manufacturers' specifications
2	**Measured sensible EER**	>90% of manufacturer's performance data	measured at supply grille and compared to manufactures' data
3	**Heating AFUE/HSPF**	95%/10.0	manufacturers' specifications
7	**Furnace sizing confirmation**	70% on at design temperature	monitored run time at constant 71°F indoor temperature at design temperature
8	**Duct location**	100% conditioned space	visual inspection and confirmed with duct leakage test (#9 below)
9	**Duct leakage**	<5 CFM_{25} duct leakage to the outside	measured leakage with Ring 4 on the duct blaster
10	**Duct insulation**	R-8.0	duct manufacturers' specification
11	**Cooling air flow**	>550 CFM/ton	measured at return with condensing unit off (68°F to 78°F indoor temperature)
12	**Verified refrigerant charge**	SH and SC within 1°F of minimum allowed	SH and SC measured with the liquid line temperature between 98°F and 102°F
13	**Fan watt draw**	<0.2 watts/CFM	measured RMS fan watts / cooling air flow (#11 above)
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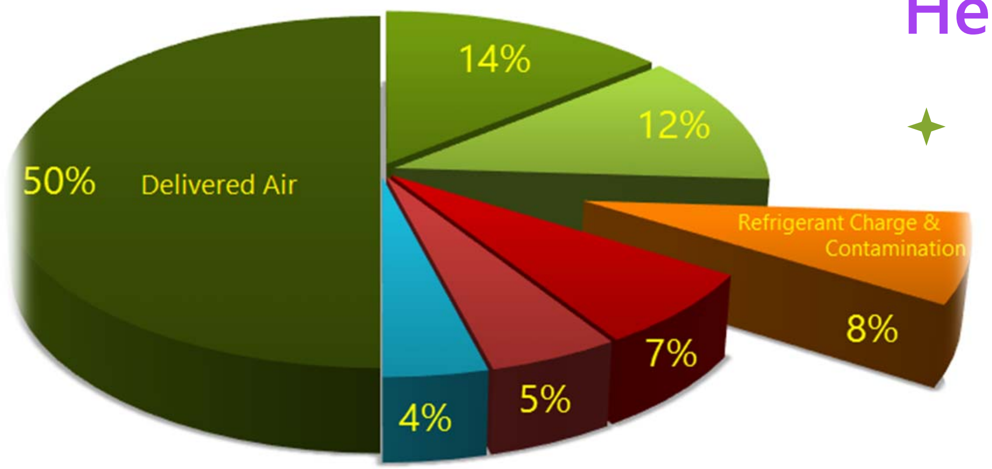
17	**Supply grille delivery velocity**	500 FPM to 700 FPM in both heat and cool	measured supply air flow (powered flow hood) and grille manufactures' data

8	**Duct location**	100% conditioned space	visual inspection and confirmed with duct leakage test (#9 below)
9	**Duct leakage**	<5 CFM_{25} duct leakage to the outside	measured leakage with Ring 4 on the duct blaster
10	**Duct insulation**	R-8.0	duct manufacturers' specification

Refrigerant Charge Losses = 8%



Here, Now and Next

- Reality
  - Measurement: The amount of refrigerant in an air conditioner affects the efficiency of the unit.
    - Both too little refrigerant (Undercharge) and too much refrigerant (Overcharge) result in lower efficiencies.
- Code
  - Measurement: §150.1(c)7a "Refrigerant Charge"
- ZNE
  - Verified refrigerant charge SH and SC within 1°F of minimum allowed

Code – Measurement

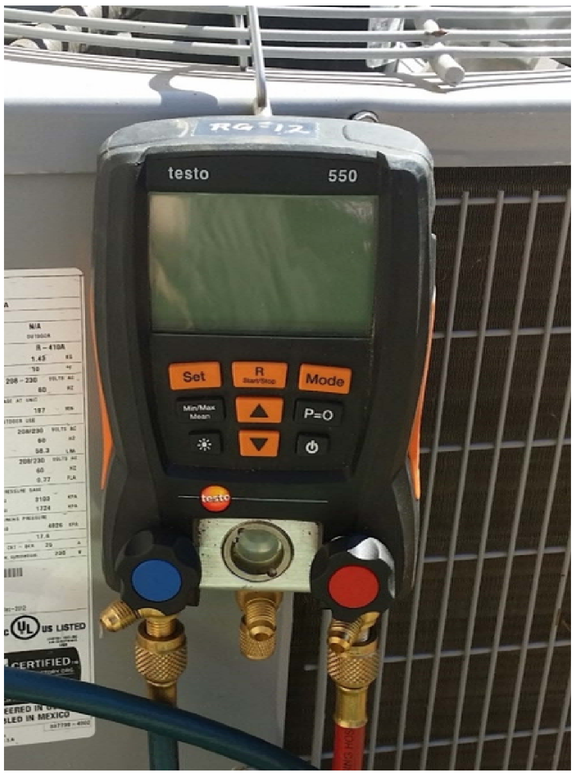
150.1(c)7 - Prescriptive

- When refrigerant charge verification or charge indicator display is shown as required by TABLE 150.1-A,
  - i ***air-cooled air conditioners and air-source heat pumps (including but not limited to ducted split systems, ducted packaged systems, and mini-split systems)shall*** shall comply with the following requirements if the procedures are applicable to the system:
    - a. Have measurement access holes (MAH) installed according to the specifications in the Reference Residential Appendix RA3.2.2.3 as verified by field verification and diagnostic testing; and correct refrigerant charge shall be confirmed through field verification and diagnostic testing in accordance with applicable procedures specified in Reference Residential Appendix Section RA3.2.2, or RA1; or
    - b. Be equipped with a charge indicator display (CID) device that provides a clearly visible indication to the occupant when the air conditioner fails to meet the required system operating parameters specified in the applicable section of Reference Joint Appendix JA6 for the installed CID technology. The CID indication shall be constantly visible and within one foot of the air conditioner's thermostat. CID installations shall be confirmed by field verification and diagnostic testing utilizing the procedures specified in Reference Residential Appendix RA3.4.2.
      - EXCEPTION to Section 150.1(c)7Aia: Systems that cannot conform to the specifications for hole location in Reference Residential Appendix Figure RA3.2-1, shall not be required to provide holes as described in Figure RA3.2-1.
    - EXCEPTION to Section 150.1(c)7Ai : When the outdoor temperature is less than 55 degrees F and the installer utilizes the weigh-in charging procedure in Reference Residential Appendix Section RA3.2.3.1 to verify the refrigerant charge, the installer may elect to utilize the HERS Rater verification procedure in Reference Residential Appendix Section RA3.2.3.2. If the HERS Rater verification procedure in Section RA3.2.3.2 is used for compliance, the system's thermostat shall conform to the specifications in Reference Joint Appendix JA5 and shall be capable of receiving and responding to Demand Response Signals prior to final approval of the building permit by the enforcing agency.
  - ii. Air-cooled air conditioners or air-source heat pumps (including but not limited to packaged systems and mini split systems) that cannot comply with the requirements of Section 150.1(c)7Aia or 150.1(c)7Aib shall conform to the following requirement:
    - a. Correct refrigerant charge shall be confirmed by the system installer utilizing the weigh-in charging procedure specified in Reference Residential Appendix RA3.2.3.1, as confirmed through field verification by a HERS Rater according to the procedure specified in Reference Residential Appendix RA3.2.3.2.
  - EXCEPTION to Section 150.1(c)7A: Packaged systems for which the manufacturer has verified correct system refrigerant charge prior to shipment from the factory are not required to confirm refrigerant charge through field verification and diagnostic testing. The installer of these packaged systems shall submit Certificate of Installation documentation that certifies the system is a packaged system for which the correct refrigerant charge has been verified by the system manufacturer prior to shipment from the factory.

Code – Measurement

Refrigerant Charge

- Section 150.1(c)7A
  - New systems with AC in CZ 2, 8-15
  - Altered AC in CZ 2, 8-15



Diagnostic	Description	Procedure(s)
Refrigerant charge verification (RCV) and the installation of a measurement access hole (MAH)	1. For use for residential air-cooled air conditioners and air source heat pumps to verify the systems have the required refrigerant charge. 2. For dwelling units with multiple air conditioners or heat pumps, the procedures shall be applied to each system separately.	RA3.2.2 *Standard Charge*
		RA3.2.3 *Weigh-in Charging*

ZNE – HVAC Specifications

High Performance HVAC Specifications For ZNE Builder Pilot

Rick Chitwood / Revised: January 5, 2015

√	*Feature*	*Goal for ZNE*	*Specification*
1	**Cooling SEER/EER**	16/12	manufacturers' specifications
2	**Measured sensible EER**	>90% of manufacturer's performance data	measured at supply grille and compared to manufactures' data
3	**Heating AFUE/HSPF**	95%/10.0	manufacturers' specifications
4	**Measured heating efficiency**	>90% of manufacturer's performance data	measured at supply grille and compared to manufactures' data
5	**Maximum heating capacity**	<10 BTU/sq.ft	manufacturers' specified output at design temperature / CFA
6	**Furnace temperature rise**	<5°F above minimum allowed	measured furnace temperature rise compared to manufacturers' specifications
7	**Furnace sizing confirmation**	70% on at design temperature	monitored run time at constant 71°F indoor temperature at design
9	**Duct leakage**	<5 CFM_{25} duct leakage to the outside	measured leakage with Ring 4 on the duct blaster
10	**Duct insulation**	R-8.0	duct manufacturers' specification
11	**Cooling air flow**	>550 CFM/ton	measured at return with condensing unit off (68°F to 78°F indoor temperature)
12	**Verified refrigerant charge**	SH and SC within 1°F of minimum allowed	SH and SC measured with the liquid line temperature between 98°F and 102°F
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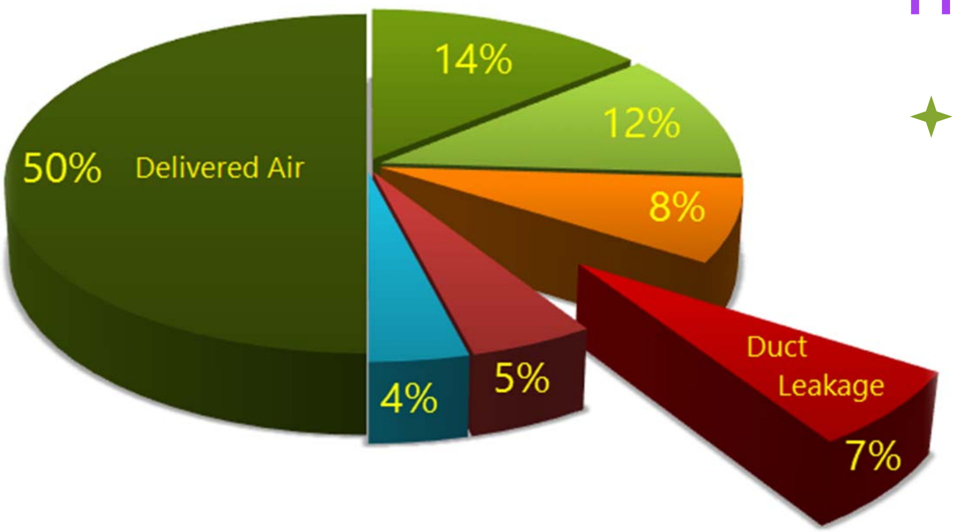
16	**System standby watts**	>10 watts	measured total system RMS air handler and condensing unit watts when not operating
17	**Supply grille delivery velocity**	500 FPM to 700 FPM in both heat and cool	measured supply air flow (powered flow hood) and grille manufactures' data

12 **Verified refrigerant charge** SH and SC within 1°F of minimum allowed SH and SC measured with the liquid line temperature between 98°F and 102°F

Duct Leakage Losses= 7%



Here, Now and Next

- Reality
  - Leakage: Getting better
- Code
  - Leakage: 6% or less §150.0(m)11 "Duct System Sealing and Leakage Testing"
- ZNE
  - Leakage: <5 CFM_{25} duct leakage to the outside

Reality - Duct Leakage

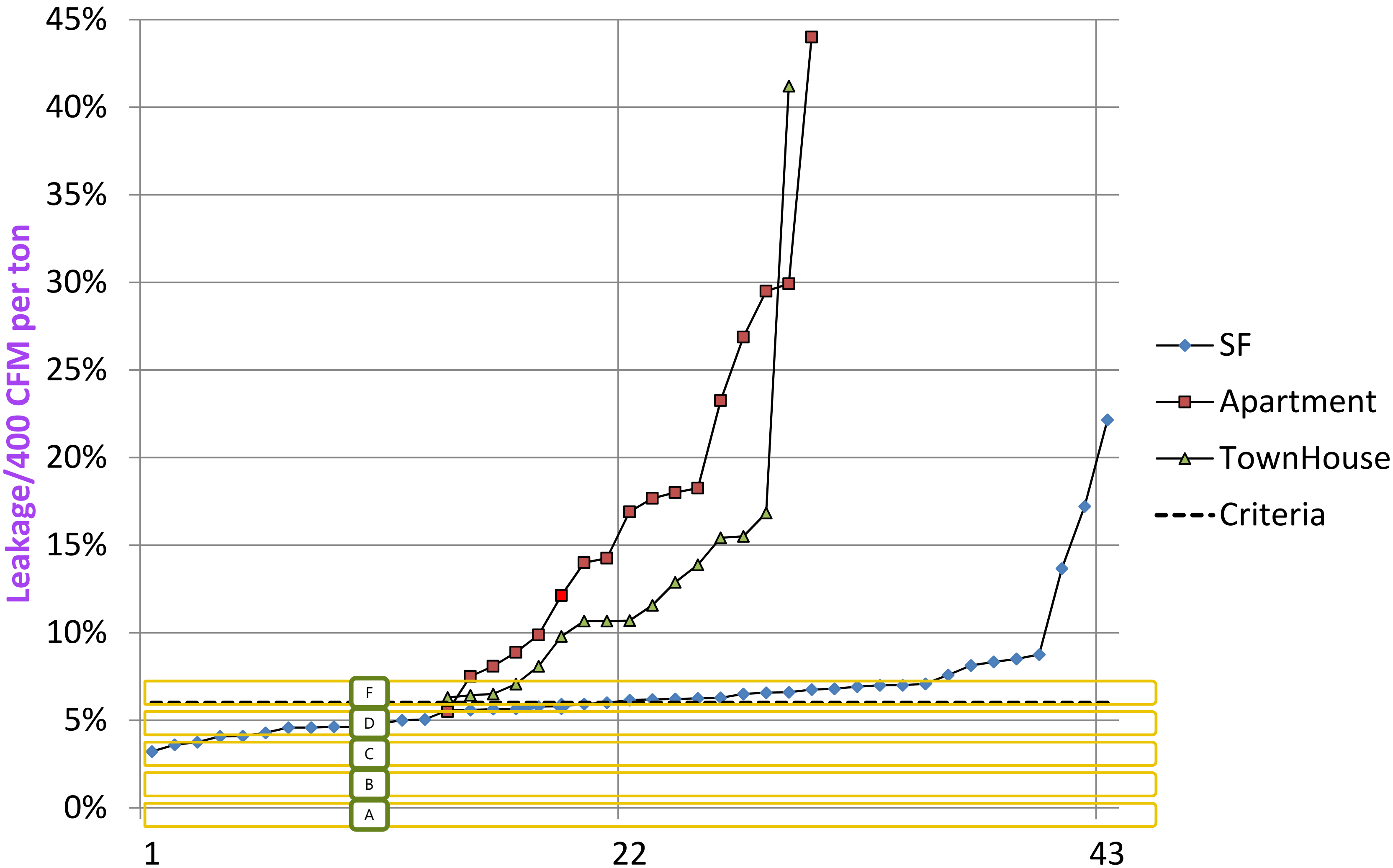
Photo Credit: Rick Chitwood

Yikes

- In summer, the effects of duct leakage include capacity loss from supply leaks, infusion of superheated attic air from return leaks, and house infiltration due to the imbalance between supply and return leakage.

Source: California Energy Commission report 500-2012-062 / Rick Chitwood

Reality - Total Duct Leakage @ 25 Pa



Source: California Energy Commission report 500-2012-062 and Rick Chitwood

Code - Duct Testing

Mandatory Duct Testing all CZ's

- Section 150.0(m)11
  - New systems >10 ft. ducting
  - Altered systems with >25 ft. ducting

Diagnostic	Description	Procedure
Duct Leakage	Verify that duct leakage is less than or equal to the compliance criteria given in Table RA3.1-2.	RA3.1.4.3

ZNE – HVAC Specifications

9	**Duct leakage**	<5 CFM_{25} duct leakage to the outside	measured leakage with Ring 4 on the duct blaster

High Performance HVAC Specifications For ZNE Builder Pilot

Rick Chitwood / Revised: January 5, 2015

√	*Feature*	*Goal for ZNE*	*Specification*
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17	**Supply grille delivery velocity**	500 FPM to 700 FPM in both heat and cool	measured supply air flow (powered flow hood) and grille manufactures' data

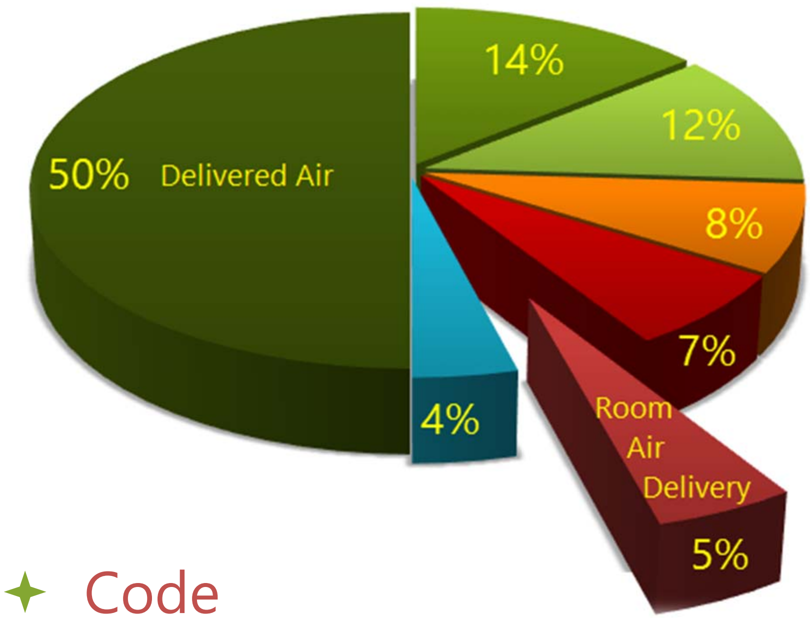
ZNE – Too Small To Measure

Zero leakage means “too small to measure” or below about 9 CFM_{25}

Ring 4 Club: www.ring4club.com

Photo Credit: Rick Chitwood

Room Air Delivery= 5%



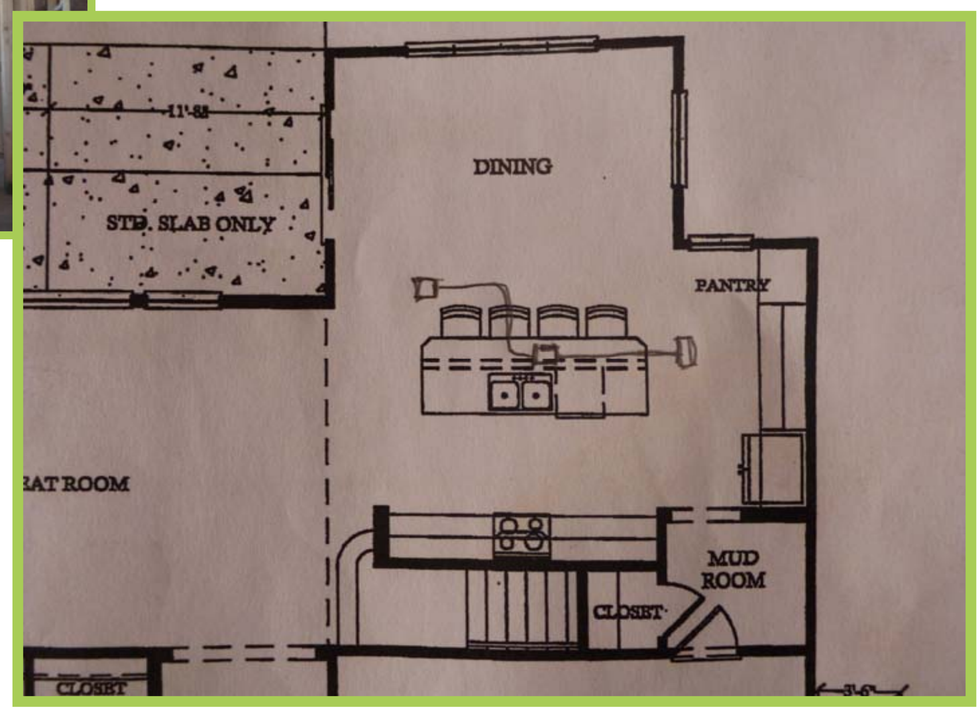
Here, Now and Next

- Reality
  - We don't pay attention to this
  - Effects Comfort!!
  - Impacts efficiency
- Code
  - Not much there
- ZNE
  - Supply grille delivery velocity 500 FPM to 700 FPM in both heat and cool

Reality – Room Air Delivery

Photo Credit: Rick Chitwood

- Enough is Enough
  - 3 supply grilles where 1 is enough
  - ACCA Manual J & D



Code – Space-Conditioning Equipment
§150.0(h)

150.0(h) - Mandatory

- 1. Building Cooling and Heating Loads. Building heating and cooling loads shall be determined using a method based on any one of the following:
  - A. The ASHRAE Handbook, Equipment Volume, Applications Volume, and Fundamentals Volume; or
  - B. The SMACNA Residential Comfort System Installation Standards Manual; or
  - C. The ACCA Manual J.
    - The cooling and heating loads are two of the criteria that shall be used for equipment sizing and selection.
  - NOTE: Heating systems are required to have a minimum heating capacity adequate to meet the minimum requirements of the CBC. The furnace output capacity and other specifications are published in the Commission's directory of certified equipment or other directories approved by the Commission.
- 2. Design conditions.
  - For the purpose of sizing the space-conditioning (HVAC) system, the indoor design temperatures shall be 68°F for heating and 75°F for cooling. Outdoor design conditions shall be selected from Reference Joint Appendix JA2, which is based on data from the ASHRAE Climatic Data for Region X. The outdoor design temperatures for heating shall be no lower than the Heating Winter Median of Extremes values. The outdoor design temperatures for cooling shall be no greater than the 1.0 percent Cooling Dry Bulb and Mean Coincident Wet Bulb values.
- 3. Outdoor Condensing Units.
  - A. Clearances. Installed air conditioner and heat pump outdoor condensing units shall have a clearance of at least five (5) feet (1.5 meters) from the outlet of any dryer vent.
- 4. Central Forced-Air Heating Furnaces.
  - A. Temperature Rise. Central forced-air heating furnace installations shall be configured to operate in conformance with the furnace manufacturer's maximum inlet-to-outlet temperature rise specifications.

ZNE – HVAC Specifications

17 **Supply grille delivery velocity** | 500 FPM to 700 FPM in both heat and cool | measured supply air flow (powered flow hood) and grille manufactures' data

High Performance HVAC Specifications For ZNE Builder Pilot Rick Chitwood / Revised: January 5, 2015			
√	*Feature*	*Goal for ZNE*	*Specification*
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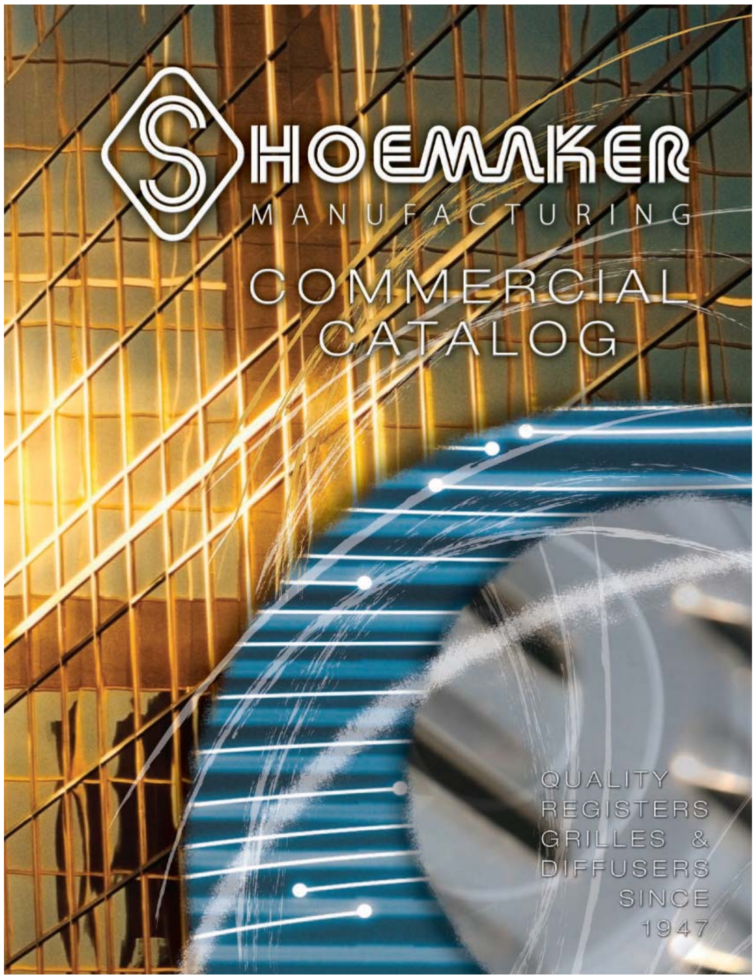


REFERENCE

ENGINEERING KEY

DIFFUSER TYPE SELECTION: The diffuser, since it is an inexpensive part of an air conditioning or heating system may get a minimum of consideration. This is the device which brings the conditioned air into the presence of the occupants of the room. Their judgement of the whole system may depend on how they consider the supply device works. The return grille has little effect on the conditions within a room as it is a device primarily for covering an opening. The design is important only from an appearance standpoint. The supply diffuser can also be considered a device for covering an opening, in which case it would have thin vanes set to give a minimum resistance to air flow; this gives the maximum effective area for a given diffuser's size. If the vanes of a diffuser are set to fan the air it causes the supply air to mix quickly with the room air and the portion of the room where high air motion exists is considerably cut down. Setting the vanes to fan the air reduces the effective area. Considering only the effective area of a diffuser can give a distorted view of its effect on the whole system an 18% increase in the effective area by changing the diffuser from a fan type to a straighter flow type only increased the flow to the diffuser by 3.3%. That is, the diffuser loss is such a small percentage of the total branch line loss it is not a controlling factor in the flow to that branch.

REGISTER LOCATION: The measure of how well a given register location or design is performing can be determined by how much stratification (temperature difference between floor and ceiling) exists and how uniform the temperature is on any given level in the room.

THROW AND SPREAD: These terms can be misleading for someone who has not witnessed a smoke test on an air supply device. We tend to liken these terms to what happens when water or ink is spilled on a table. The distance it goes out and the amount it spreads to either side can be definitely measured. Air is a gas and cannot normally be seen, but when smoke is added, its motion can be observed. Within limits when smoke is blown into a room from a supply, in a matter of seconds the room will be so filled with smoke one cannot find a spot to get a breath of clean smokeless air. THROW is the distance from the supply to where the air speed has dropped sufficiently so that the air motion becomes unobjectionable. Air near the end of the throw moves in pulses, the velocity varying from 50, 75, to 100 FPM. At 100 FPM the air motion is beginning to be objectionable to most people. The throw is the distance to the point where the pulses do not go over 75 FPM. It should not, however, be assumed that if the length of the room happens to be more than the noted throw the air will reach the end of the room.

Air from a supply grille, diffuser, or any opening maintains the same velocity for a reasonable distance (several inches) from the opening. The same situation does not hold for the return grille. A return is basically what the aerodynamicist would call a SINK, or a point where air is being sucked in from all directions. Consequently the location of the velocity measuring instrument with respect to the distance away from the grille face can affect the velocity reading more than the actual air flow itself. From a point of an inch or so in front of the grille to a point between the vanes, the reading can vary over 100%. The effect of moving the instrument a given distance away from the grille face will also vary with the size and shape of the opening. The effective area will then vary with how far the velocity measuring device is located from the grille face. To eliminate this problem, the effective area values for the returns in these tables have been selected so that the velocity measuring device was located between the grille vanes. This gives the true velocity reading and will depend only on the suction pressure behind the grille. The effective area values then appear low because of the high velocity reading. The effective area of a return depends primarily on the grille face area and the deflection angle on the vanes. With the vanes at right angle to the face the greatest flow area is obtained, but the grille is less effective in concealing the duct work.

SELECTION OF SIZES:

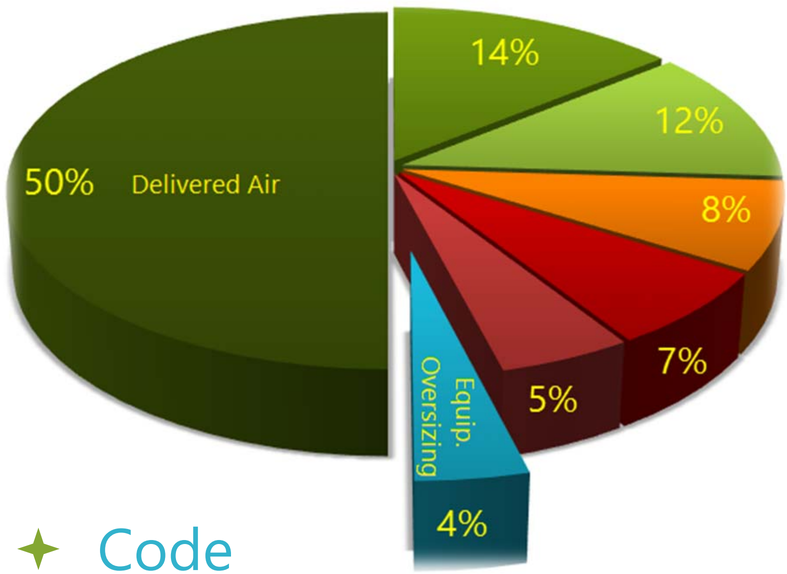
1. Throw should reach approximately 3/4 of distance from outlet to opposite wall.
2. Velocities of air in the air conditioned space are a major factor in the comfort of the occupants in that space. In general these velocities should not exceed 75 FPM in the occupied level in the room.
3. Due to difference of temperature between the entry air and the room air, the entry air stream will drop below the level of introduction in the room. Extreme caution and good judgement are required in the selection and location of the supply of air conditioned air so that the air stream will not enter the occupied zone at the critical velocity and cause discomfort due to excessive drafts. If the entry air stream is overthrown and strikes the wall opposite of the grille location downdrafts will occur which will be objectionable to the occupants.

OUTLET SELECTION BY NOISE CRITERIA:
The following outlet selection takes into account the room absorption, ceiling height, number of outlets, etc., to match the tabulated outlet NC level with the space NC criteria. A direct comparison of the tabulated outlet NC level (assuming a 10 db room absorption and about a 5 ft. direct field from the single source) to the space NC criteria is used most frequently as a simple selection procedure. The actual outlet NC level obtained in a space depends on the sound power level from the outlet, the number of outlets, the distance from the outlet and the attenuation characteristics of the room. A complete treatment of this is found in the ASHRAE Handbook. However an approximate method follows.

RECOMMENDED DELIVERY VELOCITIES FOR VARIOUS APPLICATIONS:
The sound caused by an air outlet in operation varies in direct proportion to the velocity of the air passing through it. The air velocity can be controlled by selecting outlets of proper sizes. The following recommended outlet velocities are within safe sound limits for most applications:

APPLICATION RECOMMENDED		
Face Velocities	FPM	**NC-Criteria**
Broadcasting studios	500	25
Residences	500 to 750	25-30
Apartments	500 to 750	25-30
Churches	500 to 750	25-30
Hotel bedrooms	500 to 750	25-30
Theatres	500 to 1000	20-35
Private offices	500 to 1000	20-35
Motion picture theatres	1000 to 1250	35-40
Private offices, not treated	1000 to 1250	35-40
General offices	1250 to 1500	40-45
Stores, upper floors	1500	45
Stores, main floors	1500	45
Industrial buildings	1500 to 2000	>45

Equipment Oversizing= 4%



Here, Now and Next

- Reality
  - Not much impact on efficiency
  - Impacts comfort, noise, and the getting the system in the conditioned space
- Code
  - §150.0(h)1, 2 "Building Cooling and Heating Loads" "Design Conditions"
- ZNE
  - Maximum heating capacity < 10 BTU/sf
  - Cooling capacity > 1,200 sq.ft./ton
  - Furnace and AC sizing confirmation 70% on at design temperature

Code – Loads §150.0(h)1 and 2

150.0(h)1 - Mandatory

- ***Building Cooling and Heating Loads. Building heating and cooling loads shall be determined using a method based on any one of the following:***
  - ***A. The ASHRAE Handbook, Equipment Volume, Applications Volume, and Fundamentals Volume; or***
  - ***B. The SMACNA Residential Comfort System Installation Standards Manual; or***
  - ***C. The ACCA Manual J.***
- The cooling and heating loads are two of the criteria that shall be used for equipment sizing and selection.
  - NOTE: Heating systems are required to have a minimum heating capacity adequate to meet the minimum requirements of the CBC. The furnace output capacity and other specifications are published in the Commission's directory of certified equipment or other directories approved by the Commission.

150.0(h)2 - Mandatory

- ***For the purpose of sizing the space-conditioning (HVAC) system, the indoor design temperatures shall be 68°F for heating and 75°F for cooling.*** Outdoor design conditions shall be selected from Reference Joint Appendix JA2, which is based on data from the ASHRAE Climatic Data for Region X. The outdoor design temperatures for heating shall be no lower than the Heating Winter Median of Extremes values. The outdoor design temperatures for cooling shall be no greater than the 1.0 percent Cooling Dry Bulb and Mean Coincident Wet Bulb values.

ZNE – HVAC Specifications

High Performance HVAC Specifications For ZNE Builder Pilot

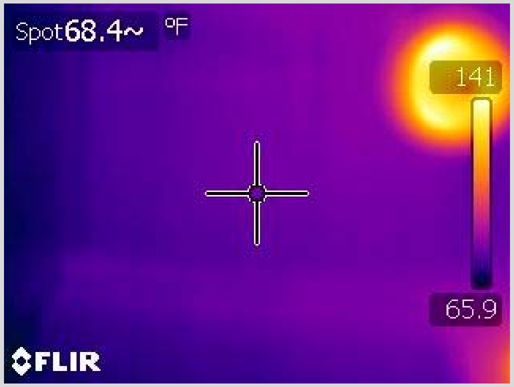
Rick Chitwood / Revised: January 5, 2015

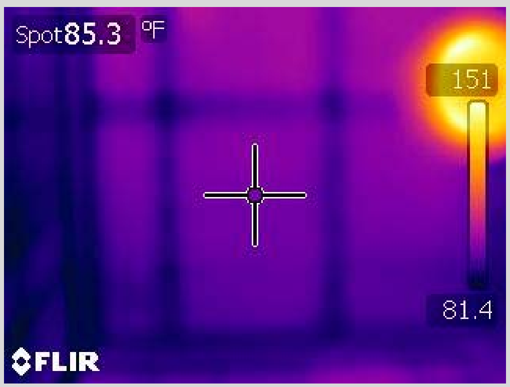
√	*Feature*	*Goal for ZNE*	*Specification*
1	**Cooling SEER/EER**	16/12	manufacturers' specifications
2	**Measured sensible EER**	>90% of manufacturer's performance data	measured at supply grille and compared to manufactures' data
3	**Heating AFUE/HSPF**	95%/10.0	manufacturers' specifications
4	**Measured heating efficiency**	>90% of manufacturer's performance data	measured at supply grille and compared to manufactures' data
5	**Maximum heating capacity**	<10 BTU/sq.ft	manufacturers' specified output at design temperature / CFA
7	**Furnace sizing confirmation**	70% on at design temperature	monitored run time at constant 71ºF indoor temperature at design temperature
8	**Duct location**	100% conditioned space	visual inspection and confirmed with duct leakage test (#9 below)
10	**Duct insulation**	R-8.0	duct manufacturers' specification
11	**Cooling air flow**	>550 CFM/ton	measured at return with condensing unit off (68ºF to 78ºF indoor temperature)
12	**Verified refrigerant charge**	SH and SC within 1ºF of minimum allowed	SH and SC measured with the liquid line temperature between 98ºF and 102ºF
13	**Fan watt draw**	<0.2 watts/CFM	measured RMS fan watts / cooling air flow (#11 above)
14	**Cooling capacity**	>1,200 sq.ft./ton	CFA / manufacturers' nominal tonnage
15	**AC sizing confirmation**	>70% on at design temperature	monitored run time at constant 74ºF indoor temperature at design temperatures
16	**System standby watts**	>10 watts	measured total system RMS air handler and condensing unit watts when not operating
17	**Supply grille delivery velocity**	500 FPM to 700 FPM in both heat and cool	measured supply air flow (powered flow hood) and grille manufactures' data

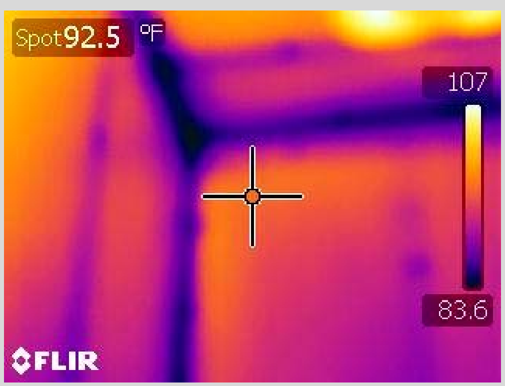
5 **Maximum heating capacity** <10 BTU/sq.ft manufacturers' specified output at design temperature / CFA

14 **Cooling capacity** >1,200 sq.ft./ton CFA / manufacturers' nominal tonnage

How to fix this?







How to fix this?

Start Test: (Lower Floor Only Calling)

Lower Floor Thermostat	68°F
Upper Floor Thermostat	69°F
Upper Floor Ceiling	68.4°F

At 15 Minutes: (Lower Floor Only Calling)

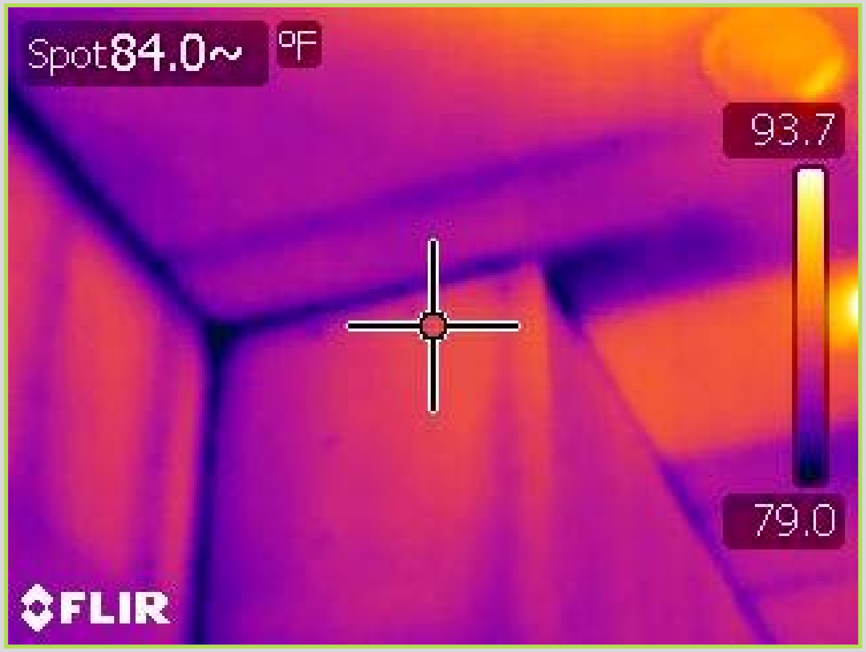
Lower Floor Thermostat	68°F
Upper Floor Thermostat	69°F
Upper Floor Ceiling	*85.3°F*

Test Ended at 53 Minutes:

Lower Floor Thermostat	*72°F*
Upper Floor Closet	*92.5°F*

Source: PG&E ET Project field observation

How to fix this?

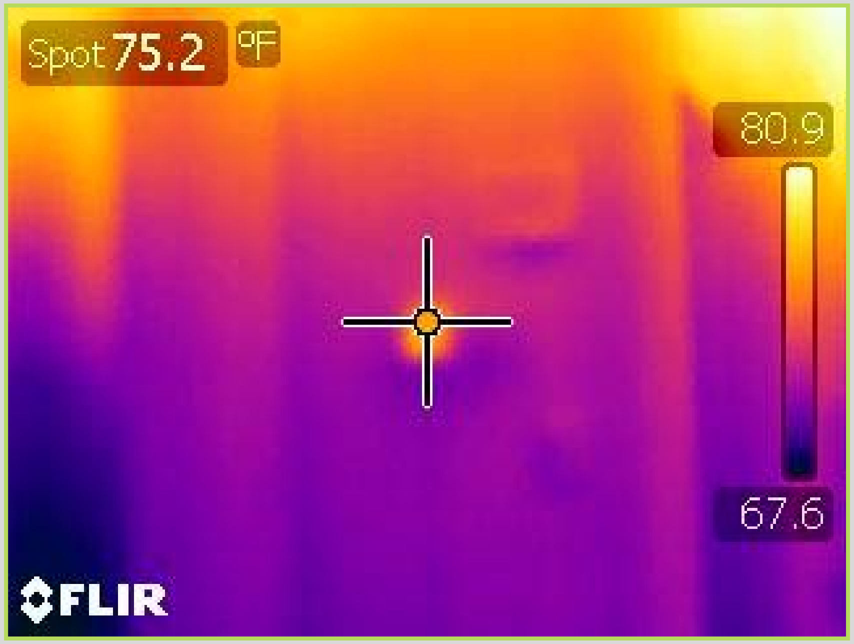


Air That is Too Hot

- The hotter the furnace supply air is the more tendency there is for temperature stratification (and discomfort) since the hotter the air is, the more buoyant it is – the more it wants to rise to the ceiling and stay there.
  - A high temperature rise can be addressed by increasing the furnace air flow or by reducing the Btu output of the furnace, or a combination of the two.

Source: PG&E ET Project field observation

How to fix this?



Source: PG&E ET Project field observation

Short Furnace Run Times

- When a heating system is oversized it doesn't need to run very long to meet the heating load.
  - A properly sized heating system will have very long run times at design temperatures.
  - We need very long run times at design conditions so during more mild weather we still have significant run times for room air mixing.

How to fix this?

Low Delivery Velocity

- The higher the supply grille velocity the better the room air is mixed.
  - But there can be problems if the velocity is too high; velocity noise at the grille, and uncomfortable drafts on the occupants.
  - So we need to get velocity just right; high enough for good mixing but not too high or it will be noisy.

Source: PG&E ET Project field observation

Next Steps

- Welcome
- What We Heard from You
- Let's Talk
- **Next Steps**
  - Best Practices
  - Improvements
- Wrap Up

Our Question To You

What are your top 3 questions or concerns regarding typical residential HVAC equipment being designed for homes?

zoning: when and when not to, and equipment/controls to facilitate a comfortable and efficient zoned system

Understanding of the equipment efficiencies and installation.

Proper heating and cooling capacity.
Proper duct and sizing and register location
Proper condenser location and line set installation

Right sizing

Where is the best location for the HVAC unit within the home?

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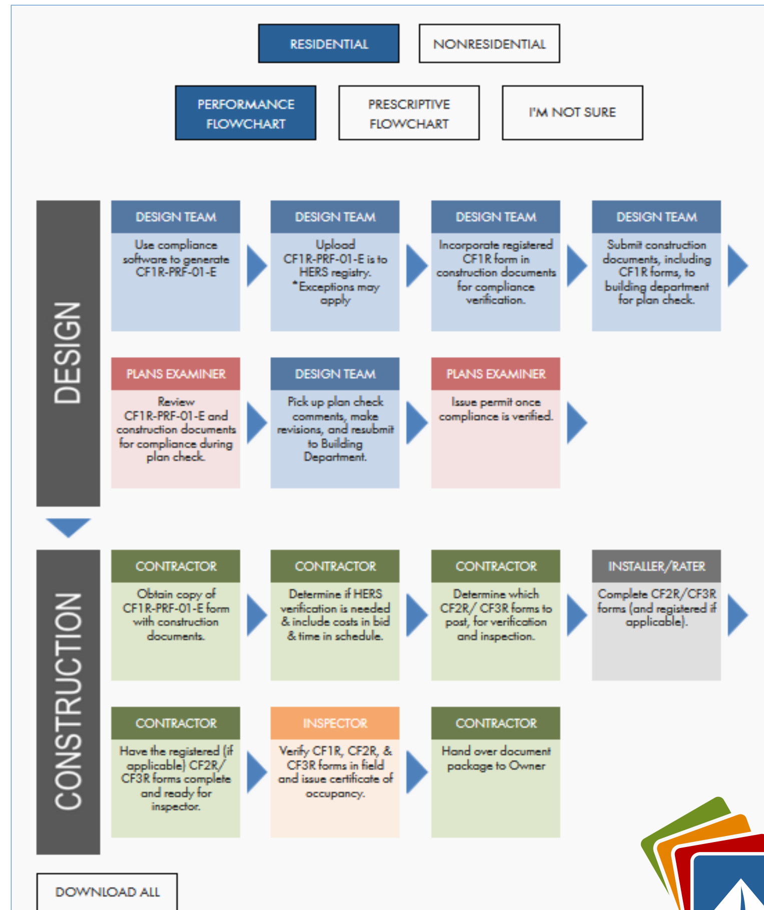
- Each step described in detail for the responsible party including:
  - Links to resources
  - Code language and
  - Tools to assist with compliance
- Download and print single subjects or the entire set



EnergyCodeAce.com/tools

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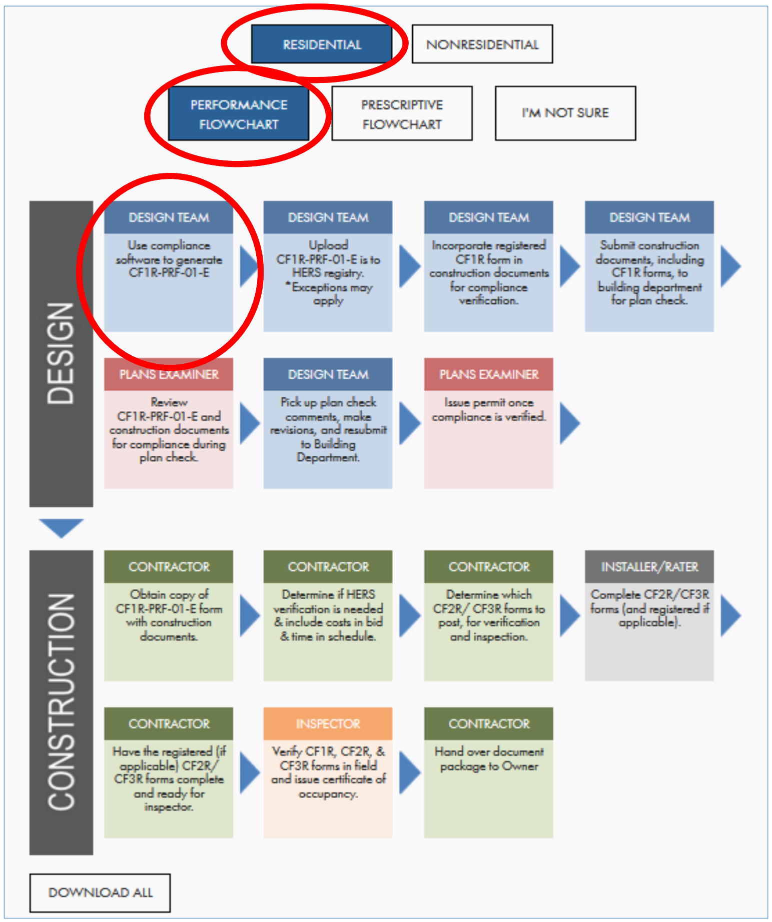

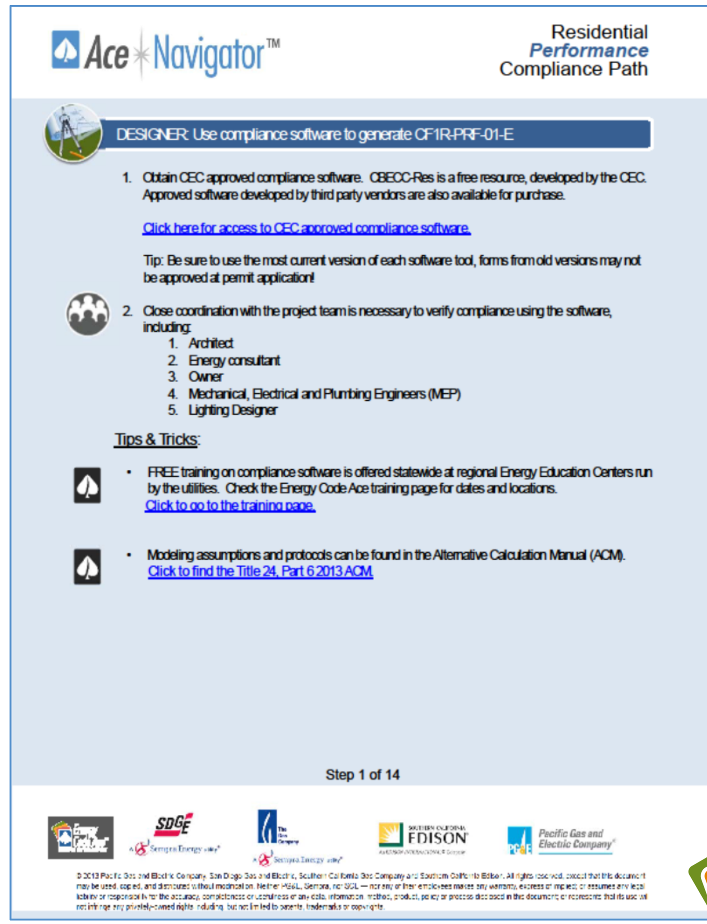

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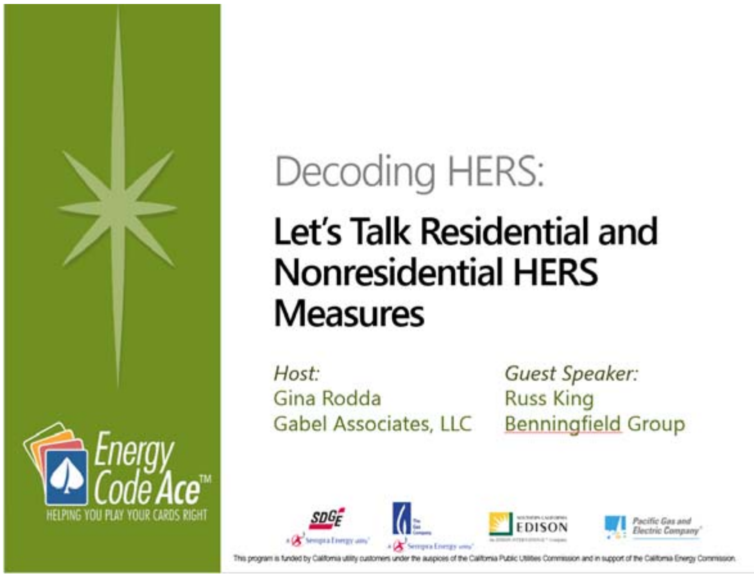
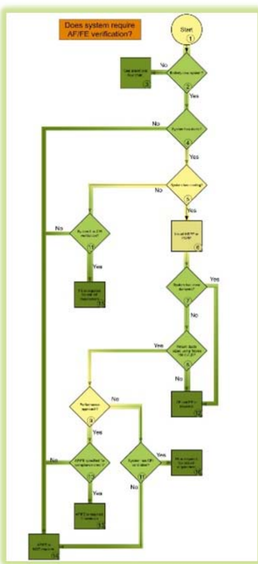
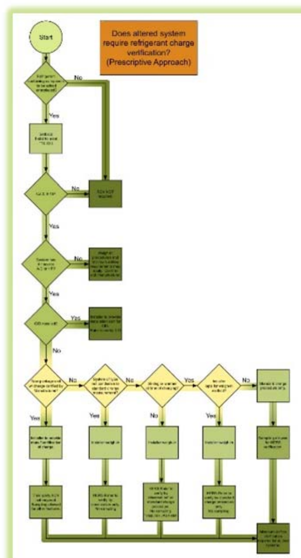
Decoding HERS - Handout







2013 Residential HERS Measures

Measure	Mandatory	Prescriptive	Performance	Reference Appendices #
Mechanical				
Duct sealing (maximum leakage)	§150.0(m)11			3.1
Indoor air quality ventilation (consistent with ASHRAE Standard 62.2)	§150.0(o)			3.7
Refrigerant charge or Installation of a charge indicator display (CID)		CZ 2, 8-15 §150.1(c)7A	CZ 1, 3-7, 16	1.2, 3.2
Duct design (reduced surface area, high insulation, and duct location)			X	3.1
Ducts entirely in conditioned space		§150.1(c)9	X	3.1
Low leakage ducts entirely in conditioned space			X	3.1
Ducts < 12 feet outside conditioned space			X	3.1
Low leakage air handlers			X	3.1
Cooling coil air flow and air handler fan watt draw **OR** Verified return duct design and air filter device	§150.0(m)13			3.1, 3.3
High SEER and/or High EER			§150.1(b)4B	3.4
Photovoltaic (PV) system capacity to qualify for PV rebate via New Solar Home Partnership			X	4.6
Central fan integrated ventilation cooling systems		§150.1(C)10		3.3
Zonal control for compliance credit			X	3.3
Evaporatively cooled condensers			X	3.1, 3.2, 3.4
Ice storage air conditioners			X	4.3
Envelope				
Quality insulation installation (QII)			X	3.5
Building envelope sealing			X	3.8
Plumbing				
Pipe insulation			X	3.6
Verified design (parallel piping, compact design, point of use)			X	3.6
Multi Family recirculation loops			X	3.6

2013 Nonresidential HERS Measures

Measure	Mandatory	Prescriptive	Performance	Reference Appendices #
Mechanical				
Duct sealing (maximum leakage)		§140.4(l)		3.1
Low leakage air handlers			§110.2(f)	3.1
Plumbing				
Multi Family/Hotel & Motel recirculation systems (piping and controls)			X	4.4
Multi Family/Hotel & Motel pipe insulation			X	4.4

Ace Resources

2013 Residential - T

Climate Z

Quick Ref

Insulation (1)[A]	Roofs / Ceilings		
	Walls	Above Grade	2x4 Framed
			Mass W Interior
			Mass W Exterior
		Below Grade	Below G Interior
			Below G Exterior
	Floors	Slab Perimeter	
		Raised	
		Concrete Raised	
Radiant Barrier			
Roofing Products	Low-sloped	Aged Solar Reflecta	
		Thermal Emittance	
	Steep-sloped	Aged Solar Reflecta	
		Thermal Emittance	
Fenestration	Maximum U factor (4)		
	Maximum SHGC (5)		
	Maximum Total Area		
	Maximum West Facing Area		
Space Heating (8) (9)	Electric-Resistance Allowed		
	If gas, AFUE		
	If Heat Pump, HSPF (6)		
Space Cooling	SEER		
	Refrigerant Charge Verificati Charge Indicator Display		
	Whole House Fan (7)		
Central System Air Handlers	Central Fan Integrated Ventil System Fan Efficacy		
Ducts (10)	Duct Insulation		
Water Heating	All Buildings		

A For numbered notes (#), see the reverse side of this shee

B See the tables at the end of the quick reference for inform refer to Chapter 4 of the *2013 Residential Compliance Ma*

C V= rated storage volume of water heater

Ace Resources

2013 Residential - T

Climate Z

Quick Ref

Minimum Heating Efficiencies

Gas- and Oil-Fired Central Furnaces — Mi

Table 4-1 of 2013 Residential Compliance Manual

Applian
Weatherized gas central furnaces with single phas
Non-weatherized gas and oil central furnaces with
Weatherized oil central furnaces with single phase
Non-weatherized oil central furnaces with single p
Gas central furnaces
Oil central furnaces

Heat Pump — Minimum Heating Efficiency

Adapted from Table 4-3 of 2013 Residential Compli

Single phase air source heat pumps (NAECA)
Configuration
Packaged
Split
Space-constrained Packaged
Space-constrained Split
Small duct high velocity

Continued on reverse.

Minimum Cooling Efficiencies

(Smaller) Central Air Conditioners and Heat Pumps — Minimum Cooling Efficiencies

Adapted from Table 4-6 from 2013 Residential Compliance Manual

Appliance	Type	Size	SEER Before 1/1/2015	SEER Effective 1/1/2015	EER Effective 1/1/2015
Central Air Conditioners	Split System	<45,000	13.0	14.0	12.2
		≥45,000 and <65,000	13.0	14.0	11.7
	Single Package	<65,000	13.0	14.0	11.0
Central Air Source Heat Pumps	Split System	<65,000	13.0	14.0	NR
	Single Package	<65,000	13.0	14.0	
Space Constrained Air Conditioner	Split System	<65,000	12.0	12.0	NR
	Single Package	<65,000	12.0	12.0	NR
Space Constrained Heat Pump	Split System	<65,000	12.0	12.0	NR
	Single Package	<65,000	12.0	12.0	NR
Through-the-wall Air Conditioner	Split System	<65,000	10.9	10.9	NR
	Single Package	<65,000	10.6	10.6	NR
Through-the-wall Heat Pump	Single Package	<65,000	10.9	10.9	NR
	Split System	<65,000	10.6	10.6	NR
Small Duct, High Velocity Air Conditioner	All	<65,000	13.0	13.0	NR
Small Duct, High Velocity Heat Pump	All	<65,000	13.0	13.0	NR

Source: California Appliance Efficiency Regulations Table C-2

NR = No Requirement

Minimum DHW Efficiencies

Small Federally Regulated Water Heaters — Minimum Efficiencies

From Table 5-1 of the 2013 Residential Compliance Manual

Single phase air source heat pumps (NAECA)			
Type	**Size**	**Energy Factor (EF) January 1, 2014**	**Energy Factor (EF) Effective April 16, 2015**
Gas Storage (≤55 gallons)	≤75 Btuh:	0.67-(0.0019*V)	0.675-(0.0015*V)
Gas Storage (>55 gallons)	≤75 kBtuh:	0.67-(0.0019*V)	0.8012 – (0.00078*V)
Gas Instantaneous	≤200 kBtuh:	0.62	0.82
Oil Storage	≤105 kBtuh:	0.59-(0.0019*V)	0.68-(0.0019*V)
Oil Instantaneous	≤210 kBtuh:	0.59-(0.0019*V)	--
Electric Storage (≤55 gallons, exc. table top)	≤12 kW	0.97-(0.00132*V)	0.96-(0.0003*V)
Electric Storage (>55 gallons, exc. table top)	≤12 kW	0.97-(0.00132*V)	2.057 – (0.0013 *V)
Electric Table Top	≤12 kW	0.93-(0.00132*V)	No change
Electric Instantaneous (exc. table top)	≤12 kW	0.93-(0.00132*V)	No change
Heat pump Water Heater	≤24 Amps	0.97-(0.00132*V)	See Electric Storage >55 gallons

This program is funded by California utility customers under the auspices of the California Public Utilities Commission and in support of the California Energy Commission.

Wrap Up

- Welcome
- What We Heard from You
- Let's Talk
- Next Steps

▶ **Wrap Up**

- Thank you!
- Questions?
- CEUs

Thank you !

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