U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Looking to the Future - What's in Store for ASHRAE Standard 90.1

National Energy Codes Conference Seminar Series

Building Technologies Office

Fall 2020

Timely Tales of Energy Codes: Looking to the Future - What's in Store for ASHRAE Standard 90.1

Len Sciarra, AIA – Chair ASHRAE Std. 90.1 Envelope Subcommittee

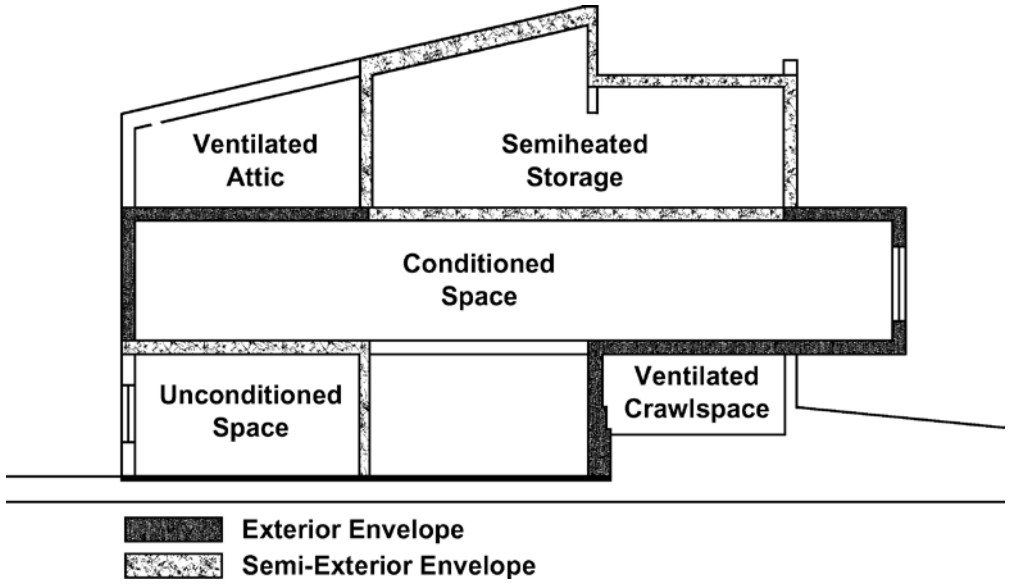
Topics: Envelope Backstop, Thermal Bridging, Air-Leakage

Dr. Thomas Culp– Co-Vice Chair ASHRAE Std. 90.1 Project Committee

Topic: On-Site renewable Energy

Richard Lord, Fellow ASHRAE – Co-Vice Chair ASHRAE Std. 90.1 Project Committee

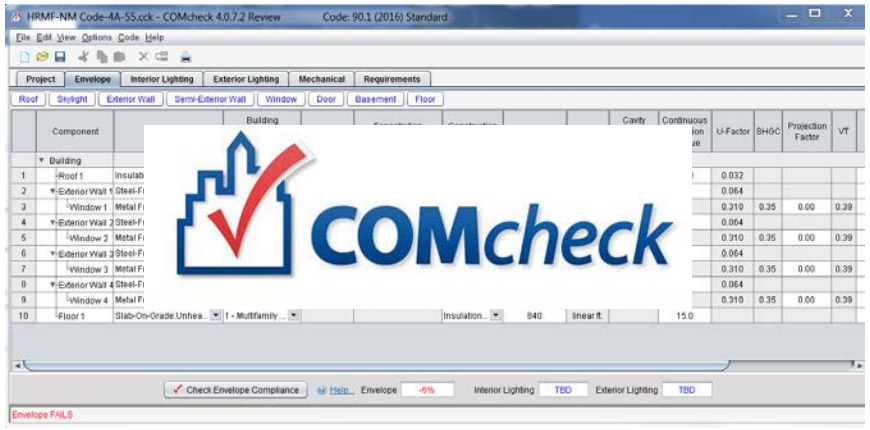
Topic: Advanced HVAC Metrics



90.1 – Current/Future Activities

~Envelope

Leonard Sciarra, AIA, LEED ap+, ASHRAE



- **Envelope Backstop**
- **Thermal Bridging**
- **Air Leakage**

Envelope Backstop

- **Known as addendum cr in the 2016 cycle**
- **Approved by SSPC 90.1 in fall 2020**
- **Concept currently in place in NYC and Washington State**
- **Only applies to Section 11 or Appendix G**
- **Only applies to New Buildings**

Envelope Backstop

"...weaker building envelopes can permanently limit building energy performance even as lighting and HVAC components are upgraded over time, because retrofitting the envelope is less likely and more expensive."

One could design a uninsulated building in Buffalo, NY with a super efficient mechanical system, but long term does that make sense?

Envelope Backstop

How does it work?

Section 11 / Appendix G currently allows full (unlimited) trade offs between different mechanical systems*, lighting, envelope components, etc…

Addendum cr puts a limit on that unlimited trade off for Envelope Components (items under Section 5).

**note there is a difference in the baseline methodology between Section 11 and Appendix G and the way Energy Conservation Measures are baselined.*

Envelope Backstop

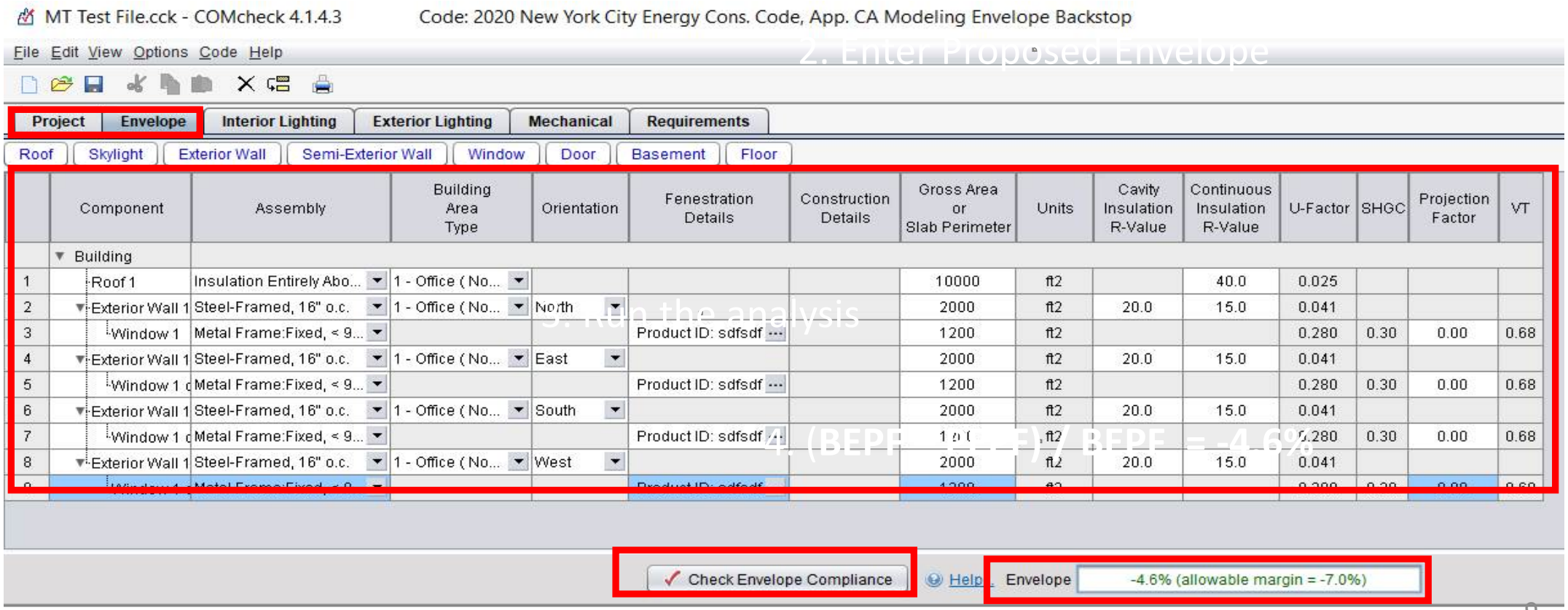
How does it work

- Meet Prescriptive requirements from Section 5, or
- Utilizing the methodology in Section 5.6 (Envelope Trade Off / ComCheck) Create an envelope only model that is no more than:
  - 15% worse than the baseline - residential
  - 7% worse than the baseline – non-residential

Note ComCheck is more sophisticated Envelope Trade off that takes into account thermal mass, daylight etc...

Envelope Backstop

How does it work?



Thermal Bridging

- **Known as addendum av in the 2016 cycle**
- **Currently in public review process**
- **Concept currently in place in Washington State**
  - international jurisdictions (Australia,Canada,Denmark,France,New Zealand,United Kingdom)
- **Will be a prescriptive requirement (tradeable)**

Thermal Bridging

"…unaccounted heat flow through the cumulative impact of thermal bridges can increase the annual energy consumption associated with the building envelope when compared to a building without thermal bridges."

ASHRAE Research Project 1365 "Thermal Performance of Building Envelope Details for Mid- and High-Rise Buildings".

Thermal Bridging

How does it work?

- Part of Section 5
- Prescriptive path (solutions) for some assemblies
- Trade off for other solutions via Section 5.6 / Section 11 / Appendix G

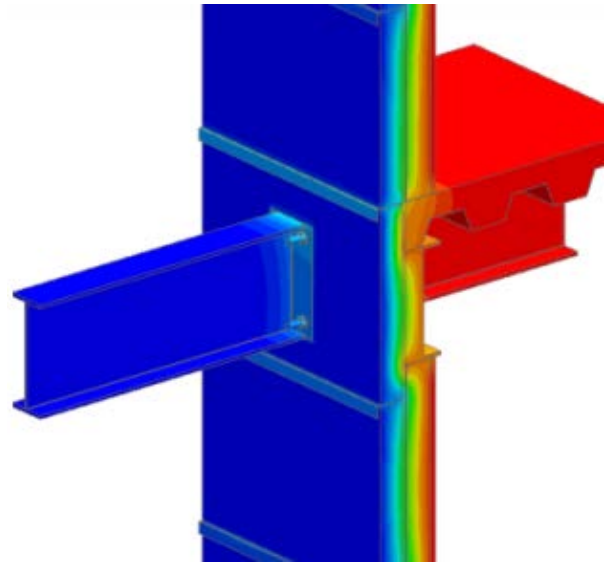
**note there is a difference in the baseline methodology between Section 11 and Appendix G and the way Energy Conservation Measures are baselined*

Thermal Bridging

How does it work?

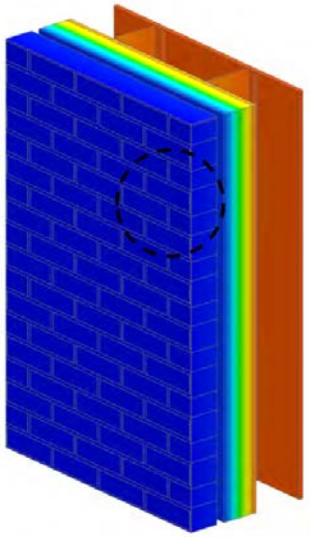
Definitions

- Clear Field Thermal Bridges
- Linear Thermal Bridges
- Point Thermal Bridges

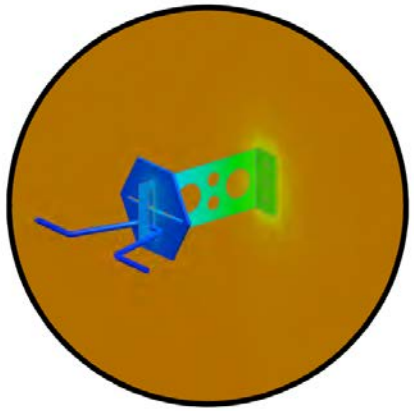


Thermal Bridging

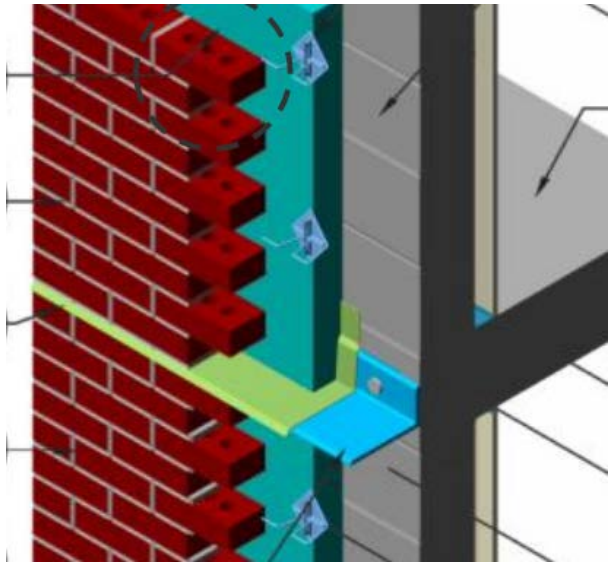
CLEAR LINEAR POINT



View of Exterior



View of Anchoring Tie



Thermal Bridging

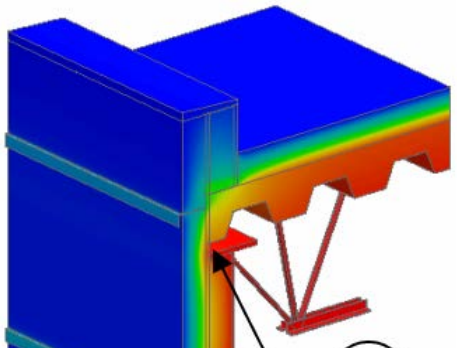
Roof-Wall intersections

Walls and Intermediate Floor Intersections

Opaque Wall and Vertical Fenestration Intersection

Cladding Support

Other Elements



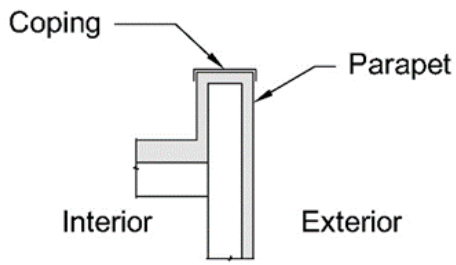
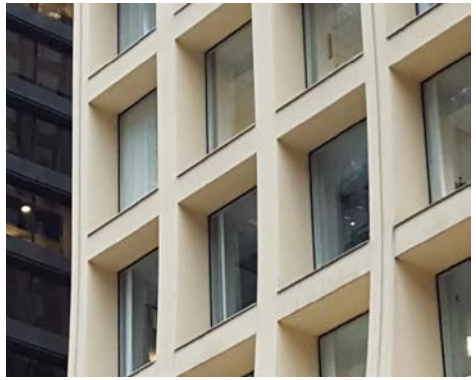


Figure 5.4.4.1 Exception 2a
Wall with Exterior Continuous Insulation



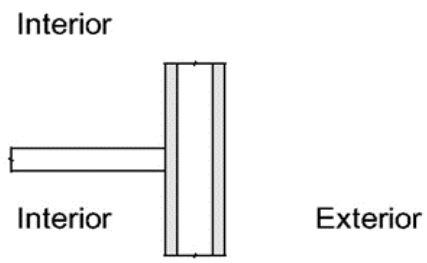
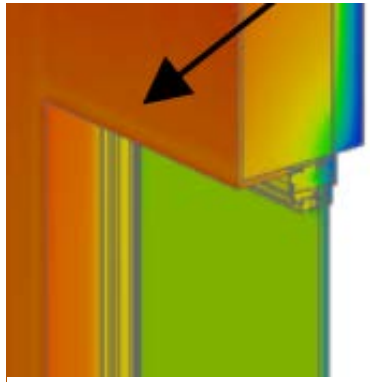


Figure 5.4.4.2a



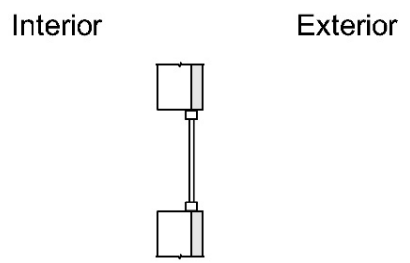
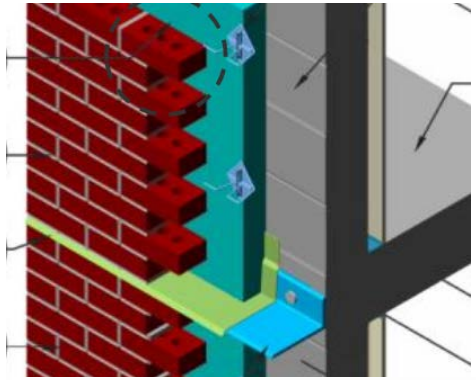


Figure 5.4.4.3a
Fenestration and Continuous Insulation



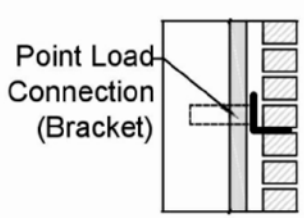
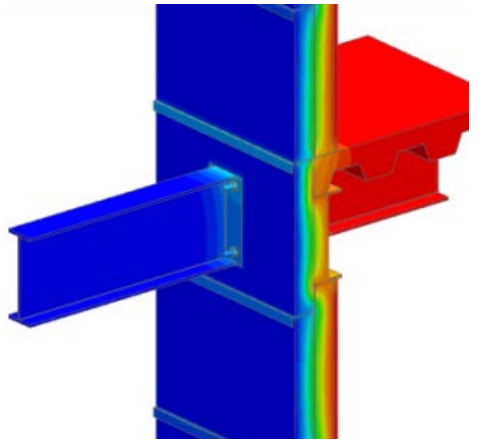


Figure 5.5.5.2 Exception 3
Shelf Angles Supporting Exterior Cladding



Thermal Bridging

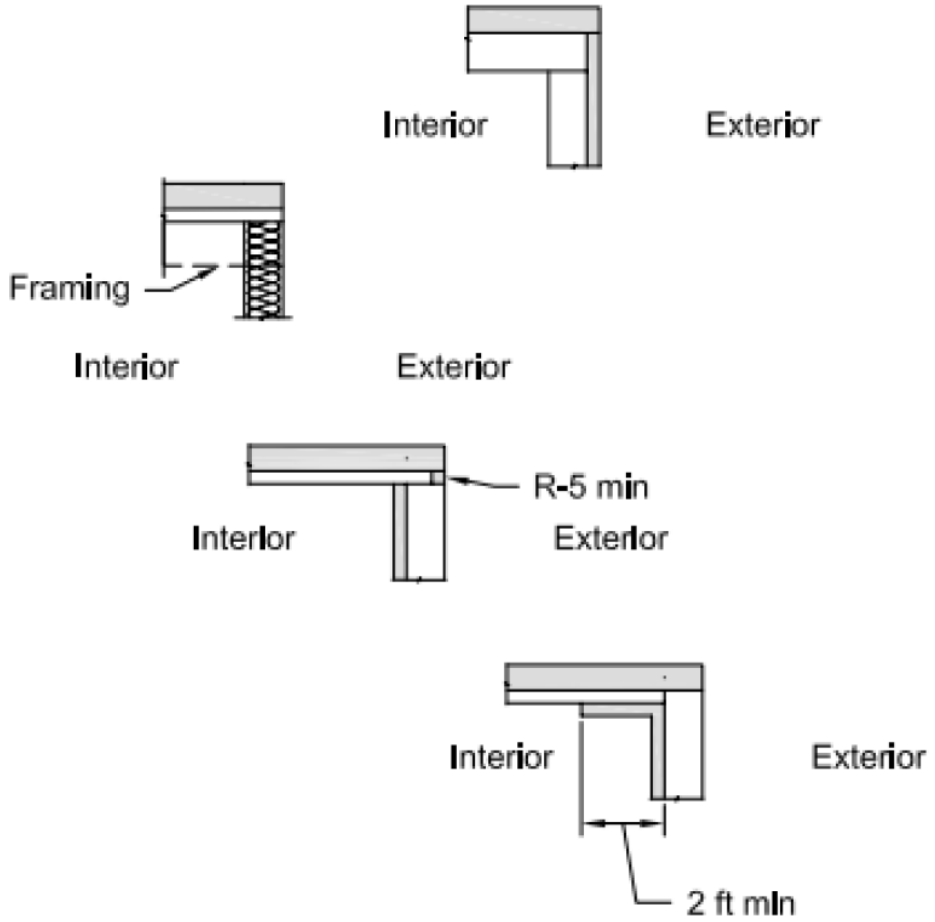
Example of prescriptive solution

5.5.5.1.1 Roof edges. At *roof* edges without parapets or overhangs, the *roof* insulation and the *wall* insulation shall comply with the following, as applicable to the location of the insulation:

a. Where a *wall* has exterior *continuous insulation*, the *roof* insulation shall extend to the exterior of the *wall* insulation and the *wall* insulation shall extend to the *roof* insulation;

b. Where a *wall* has cavity, or integral insulation, that represents more than 50 percent of the total wall insulation…..

c. Where a *mass wall* has interior insulation that represents more than 50 percent of the total wall insulation…..



Thermal Bridging

Trade off –

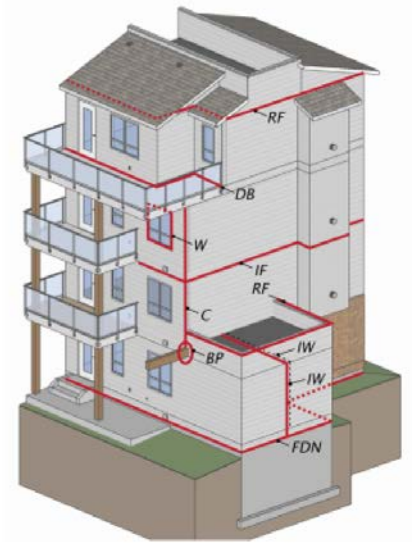
Section 5.6 (ComCheck)

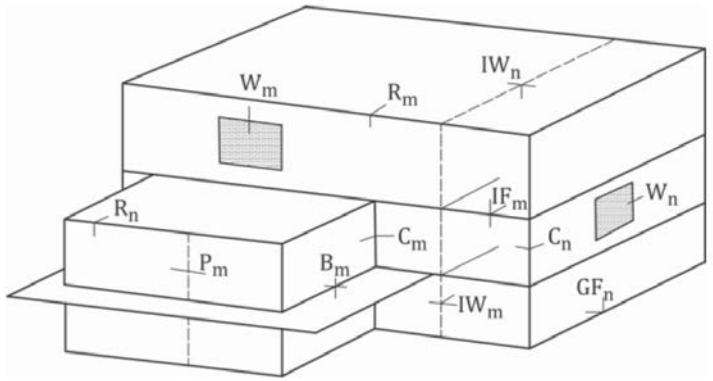
Section 11

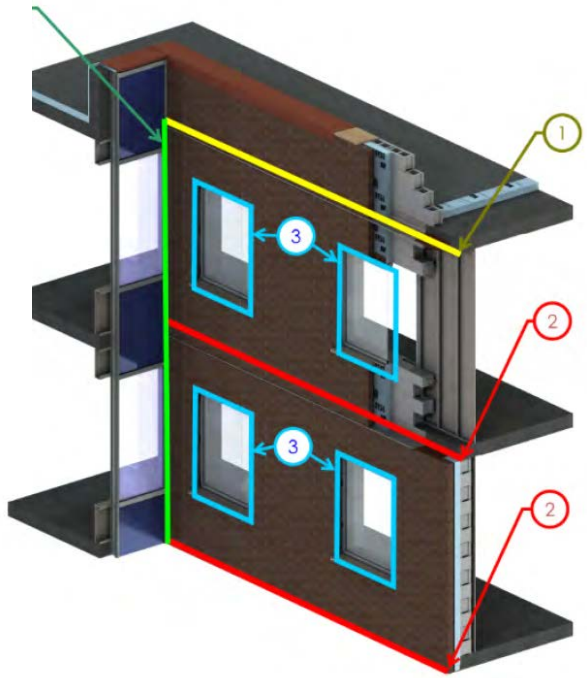
Appendix G

REQUIRES AREA TAKE OFFS

(ComCheck already requires building envelope take offs)







1. Parapet Length
2. Slab Lengths
3. Wall to Window Transition Lengths

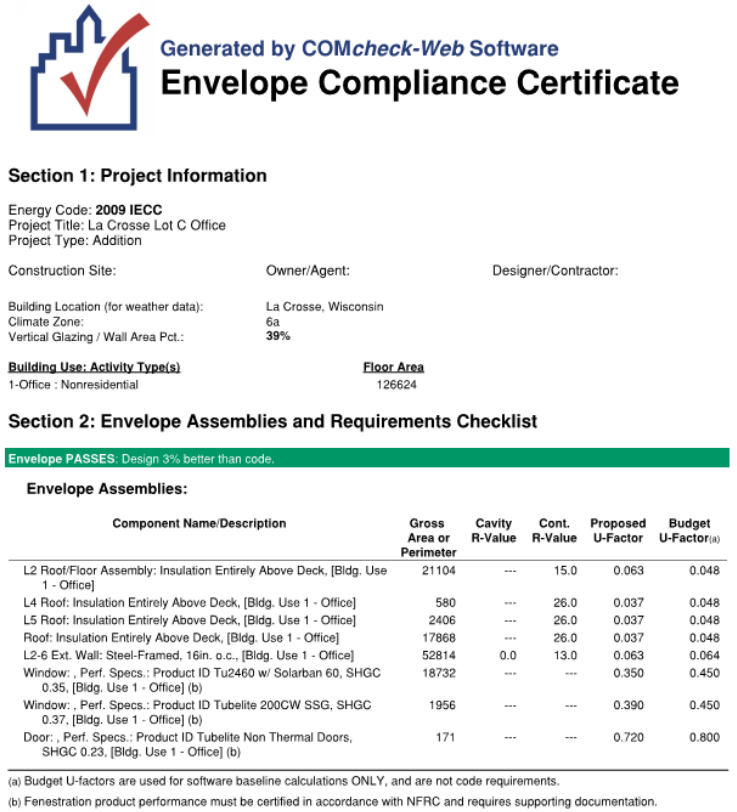
Thermal Bridging

Appendix c (5.6)

meet prescriptive requirements-no change

or

utilize simple trade off – baseline ComCheck model will automatically utilize modified U-factors for the baseline This is all done in the background, AHJ / designer will only need to work with one set of values – what is in the project design and what is entered into the ComCheck form



Generated by COM*check-Web* Software

Envelope Compliance Certificate

Section 1: Project Information

Energy Code: **2009 IECC**
Project Title: La Crosse Lot C Office
Project Type: Addition

Construction Site: | Owner/Agent: | Designer/Contractor:

Building Location (for weather data): La Crosse, Wisconsin
Climate Zone: 6a
Vertical Glazing / Wall Area Pct.: **39%**

Building Use: Activity Type(s)	Floor Area
1-Office : Nonresidential	126624

Section 2: Envelope Assemblies and Requirements Checklist

Envelope PASSES: Design 3% better than code.

Envelope Assemblies:

Component Name/Description	Gross Area or Perimeter	Cavity R-Value	Cont. R-Value	Proposed U-Factor	Budget U-Factor(a)
L2 Roof/Floor Assembly: Insulation Entirely Above Deck, [Bldg. Use 1 - Office]	21104	---	15.0	0.063	0.048
L4 Roof: Insulation Entirely Above Deck, [Bldg. Use 1 - Office]	580	---	26.0	0.037	0.048
L5 Roof: Insulation Entirely Above Deck, [Bldg. Use 1 - Office]	2406	---	26.0	0.037	0.048
Roof: Insulation Entirely Above Deck, [Bldg. Use 1 - Office]	17868	---	26.0	0.037	0.048
L2-6 Ext. Wall: Steel-Framed, 16in. o.c., [Bldg. Use 1 - Office]	52814	0.0	13.0	0.063	0.064
Window: , Perf. Specs.: Product ID Tu2460 w/ Solarban 60, SHGC 0.35, [Bldg. Use 1 - Office] (b)	18732	---	---	0.350	0.450
Window: , Perf. Specs.: Product ID Tubelite 200CW SSG, SHGC 0.37, [Bldg. Use 1 - Office] (b)	1956	---	---	0.390	0.450
Door: , Perf. Specs.: Product ID Tubelite Non Thermal Doors, SHGC 0.23, [Bldg. Use 1 - Office] (b)	171	---	---	0.720	0.800

(a) Budget U-factors are used for software baseline calculations ONLY, and are not code requirements.

(b) Fenestration product performance must be certified in accordance with NFRC and requires supporting documentation.

Thermal Bridging

Section 11 / Appendix G

Baseline models need to model *Linear and Point Thermal bridges* using default values in accordance with A10

Proposed models need to model *Linear and Point Thermal bridges* in accordance with A10

New Appendix A10 section with default and mitigated Psi & Chi Factors

$$U_{tot} = ([(\sum \psi_i \cdot L_i) + (\sum \chi_j \cdot n_j)] / A_{total}) + U_o$$

FYI, Appendix G already required this.

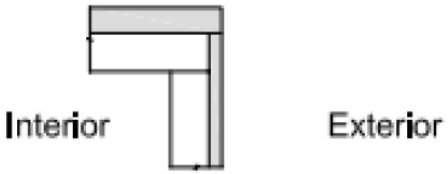
Table A10.1 Thermal Bridging Default Psi-Factors and Chi-factors for Thermal Bridges

			Un-mitigated		Default	
Class of Construction -Wall, above Grade	**Thermal Bridge Type**	**Section**	***Psi-Factor*** Btu/(h·ft·°F)	***Chi-Factor*** Btu/(h·°F)	***Psi-Factor*** Btu/(h·ft·°F)	***Chi-Factor*** Btu/(h·°F)
Steel Framed	Parapet	5.5.5.1	0.289	n/a	0.151	n/a
	Floor to *Wall* intersection	5.5.5.2	0.487		0.177	
	Relieving Angle	5.5.5.2	0.314		0.217	
	Wall to *Vertical Fenestration* intersection	5.5.5.3	0.292		0.112	
	Shading Device	5.5.5.4	0.402		0.117	
	Other Element	5.5.5.5	n/a	1.73	n/a	0.91
Mass	Parapet	5.5.5.1	0.238	n/a	0.126	n/a
	Floor to *Wall* intersection	5.5.5.2	0.476		0.118	
	Relieving Angle	5.5.5.2	0.270		0.186	
	Wall to *Vertical Fenestration* intersection	5.5.5.3	0.188		0.131	
	Shading Device	5.5.5.4	0.352		0.140	
	Other Element	5.5.5.5	n/a	0.91	n/a	0.19
Wood-framed and Other	Parapet	5.5.5.1	0.032	n/a	0.032	n/a
	Floor to *Wall* intersection	5.5.5.2	0.322		0.049	
	Relieving Angle	5.5.5.2	0.186		0.108	
	Wall to *Vertical Fenestration* intersection	5.5.5.3	0.099		0.026	
	Shading Device	5.5.5.4	0.083		0.072	
	Other Element	5.5.5.5	n/a	0.19	n/a	0.07

n/a = not applicable

Thermal Bridging

Example of CHI & PSI factors for trade off solution



Where do I get them?

Appendix A

Table A10.1 Thermal Bridging Psi-Factors and Chi-factors for Thermal Bridges

			Un-mitigated		Default	
Class of Construction -Wall, above Grade	**Thermal Bridge Type**	**Section**	***Psi-Factor*** W /m K	***Chi-Factor*** W /m K	***Psi-Factor*** W /m K	***Chi-Factor*** W /m K
Steel Framed and *Metal Buildings*	Roof Edge	5.5.5.1.1	0.650		0.020	
	Parapet	5.5.5.1	0.500		0.260	
	Intermediate floor to *wall* intersection	5.5.5.2	0.842		0.307	

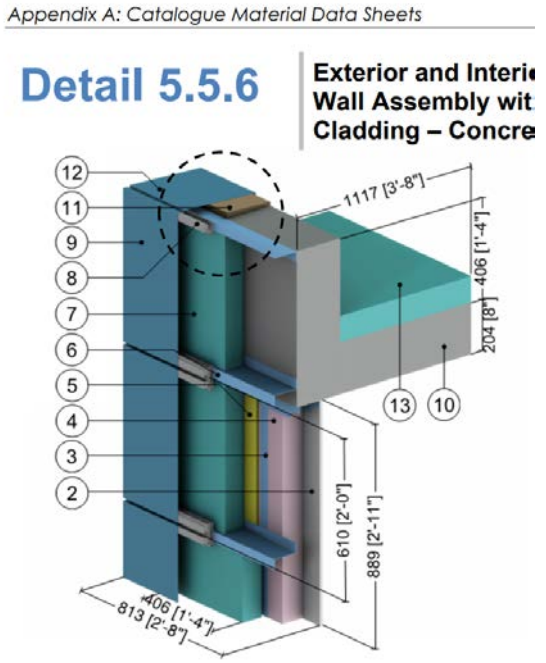
Thermal Bridging

Example of CHI & PSI factors for trade off solution

Where do I get them?

Thermal Bridging Guide / BC Hydro (now online)

https://betb.ca/catalogue/



Parapet Linear Transmittance

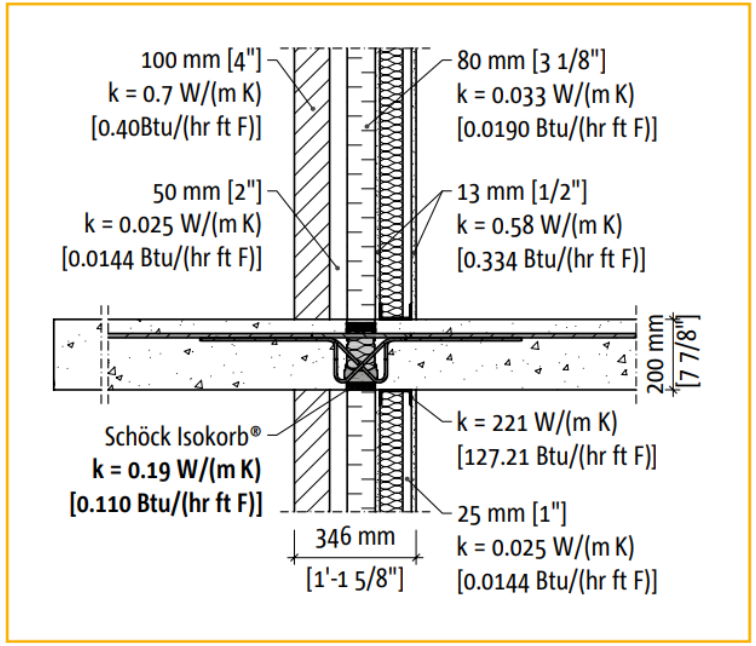
Exterior Insulation 1D R-Value (RSI)	R $ft^2 \cdot hr \cdot {}^oF$ / Btu (m^2 K / W)	U Btu/ft^2 ·hr ·^oF (W/m^2 K)	ψ Btu/ft ·hr·^oF (W/m K)
R-10 (1.76)	R-7.9 (1.39)	0.127 (0.72)	0.448 (0.776)
R-15 (2.64)	R-8.2 (1.44)	0.122 (0.70)	0.444 (0.768)

Thermal Bridging

Example of CHI & PSI factors for trade off solution

Where do I get them?

Manufacturer's

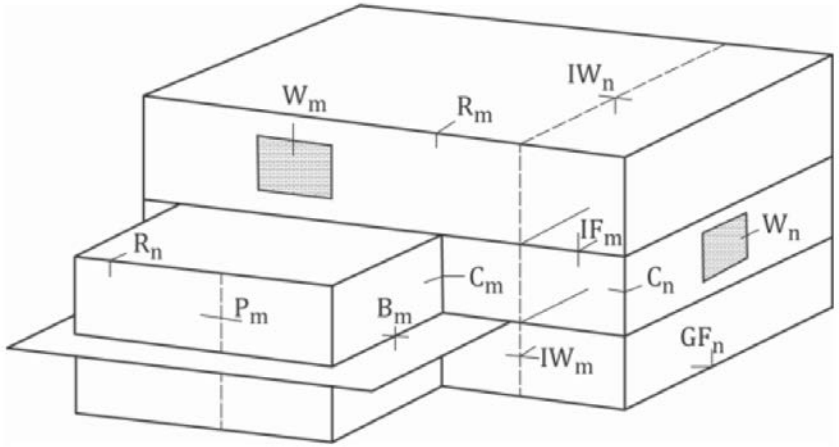


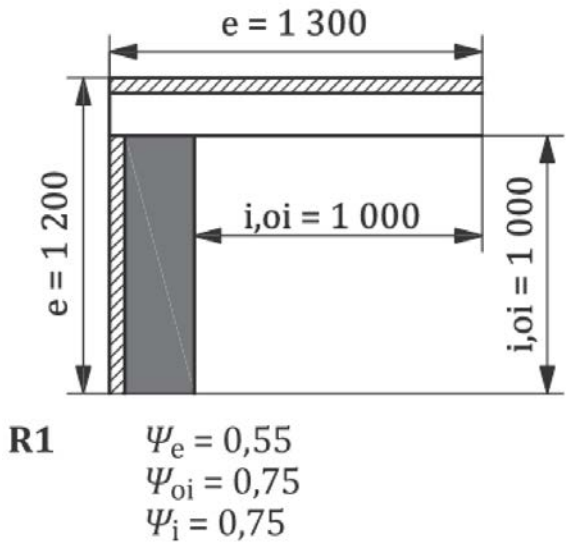
Thermal Bridging

Example of CHI & PSI factors for trade off solution

Where do I get them?

ISO 14683






INTERNATIONAL STANDARD **ISO 14683**

Third edition 2017-06

Thermal bridges in building construction — Linear thermal transmittance — Simplified methods and default values

Ponts thermiques dans les bâtiments — Coefficient linéique de transmission thermique — Méthodes simplifiées et valeurs par défaut

Air Leakage

- **Known as addendum t in the 2019 cycle**
- **Currently in public review process**
- **Concept currently in place in numerous codes both commercial and residential**
- **Will be / Continues to be a mandatory requirement (with options)**
- **Will be in the IECC 2021**

Air Leakage

Uncontrolled Air Leakage is a known Energy Savings strategy.

Air Leakage

How does it work?

- Same as before

Air Leakage

What Changed?

- Air Leakage Target changed to 0.30 cfm/ft^2 @ 75 pa for all buildings [0.45 cfm/ft^2 @ 75 pa]

  current Target is 0.40 cfm/ft^2 @ 75 pa → .060 cfm/ft^2 @ 75 pa

- New Buildings less than 25,000 SF must test. (larger buildings can still inspect or test)

- ASTM E 3158 - *"Standard Test Method for Measuring the Air Leakage Rate of a Large or Multizone Building" was added*

- "Air Infiltration" changed to "Air Leakage"

WHAT'S IN STORE FOR ASHRAE 90.1 MECHANICAL EFFICIENCY TRENDS

November April 22, 2020
Richard Lord
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Carrier Corporation
Sr. Carrier Fellow
ASHRAE Fellow
ASHRAE 90.1Co-vice chair

Learn Objectives

- The learning objective for this presentation is;
  1. Review some of the recent changes to chapter 6 as it relates to equipment efficiency metrics that were include in the 2019 standard, some of which do not go into effect immediately and are controlled by date effectivity
  2. Review possible changes to HVAC&R equipment efficiency that are being considered by ASHRAE 90.1 Mechanical Subcommittee and other organization and industry activity

Keep in mind that for item 2 the information is based on concepts that have not been thru the ASHRAE 90.1 approval process including public review and may not be approved or could change as part of the final approval process

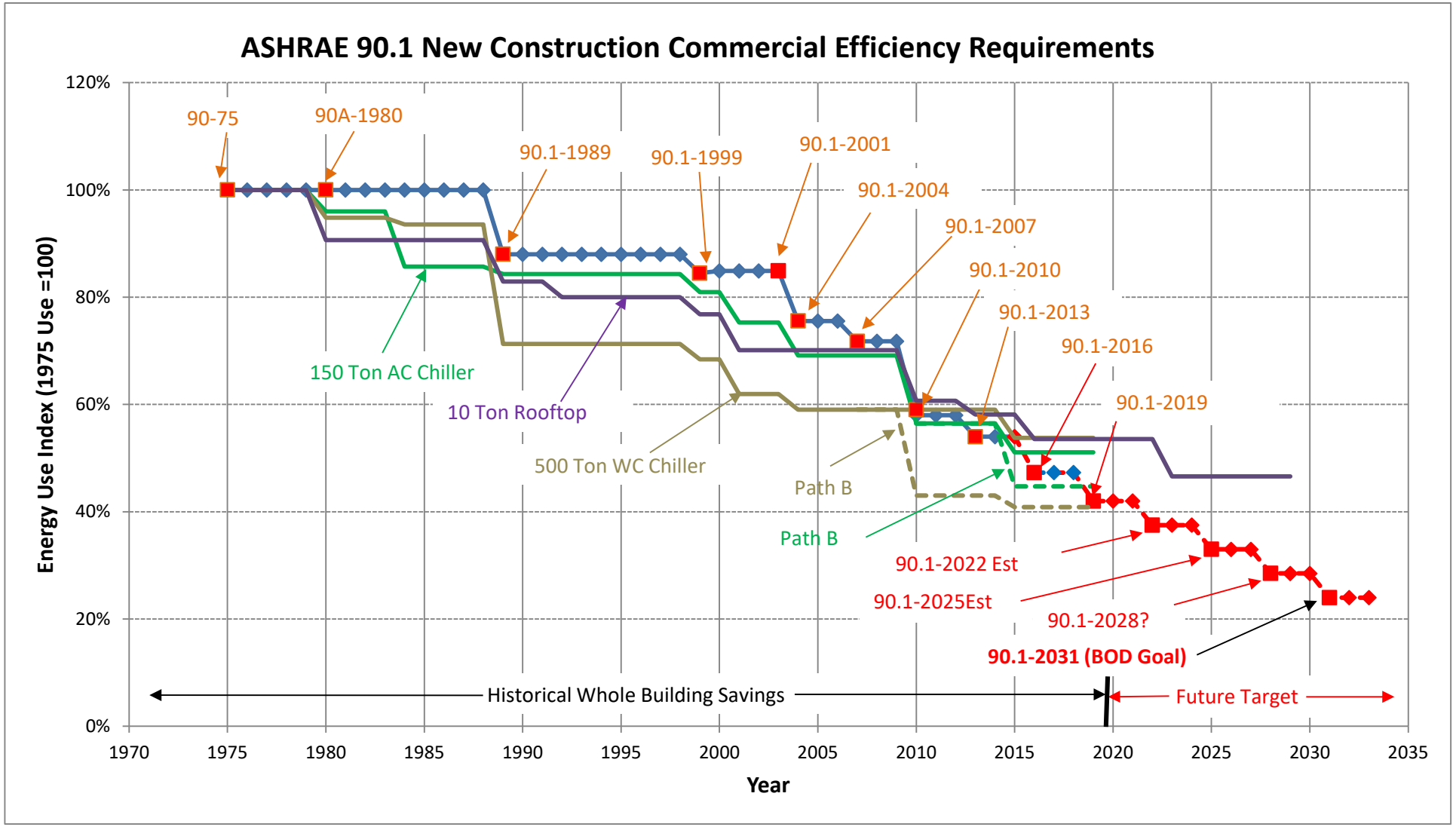
Background

- Since the 1970's, when efficiency standard and regulations were first implemented, the approach for HVAC Equipment has been to use **standardized efficiency metrics** combined with **prescriptive application and system requirements** to regulate and improve HVAC efficiencies in buildings.
- The **metrics** have the following attributes;
  - Based on industry rating and **test standards** (AHRI, DOE -10 CFR, AMCA, ANSI, AHAM, CTI, ISO)
  - Based on **standard rating conditions** typically at full load and at US average design temperature (i.e.. 95 OAT, 80/67 return air)
  - Separate metrics for cooling and heating operation
  - Typical for a basic products without options (i.e. no economizer, no energy recovery, no reheat)
  - **Product specific** and not capable of being used to compare different product types
  - Historical done at **full load design** conditions
  - Intended to compare like products but **not intended to predict energy use for a building or application**
- Definition and updates to metrics vary;
  - Some products are directly defined by DOE as defined NECA (i.e. residential and single-phase unitary products)
  - Some products are defined by ASHRAE and then approved by DOE as defined in ESIA
  - Typically these are aligned especially for **preempted requirements** but not always for others due to implementation timing in building codes
- Prescriptive application requirements are typically defined by Standards like ASHRAE 90.1, IECC, ASHRAE 189.1/IGCC and Title 24

Equipment Efficiency Improvements

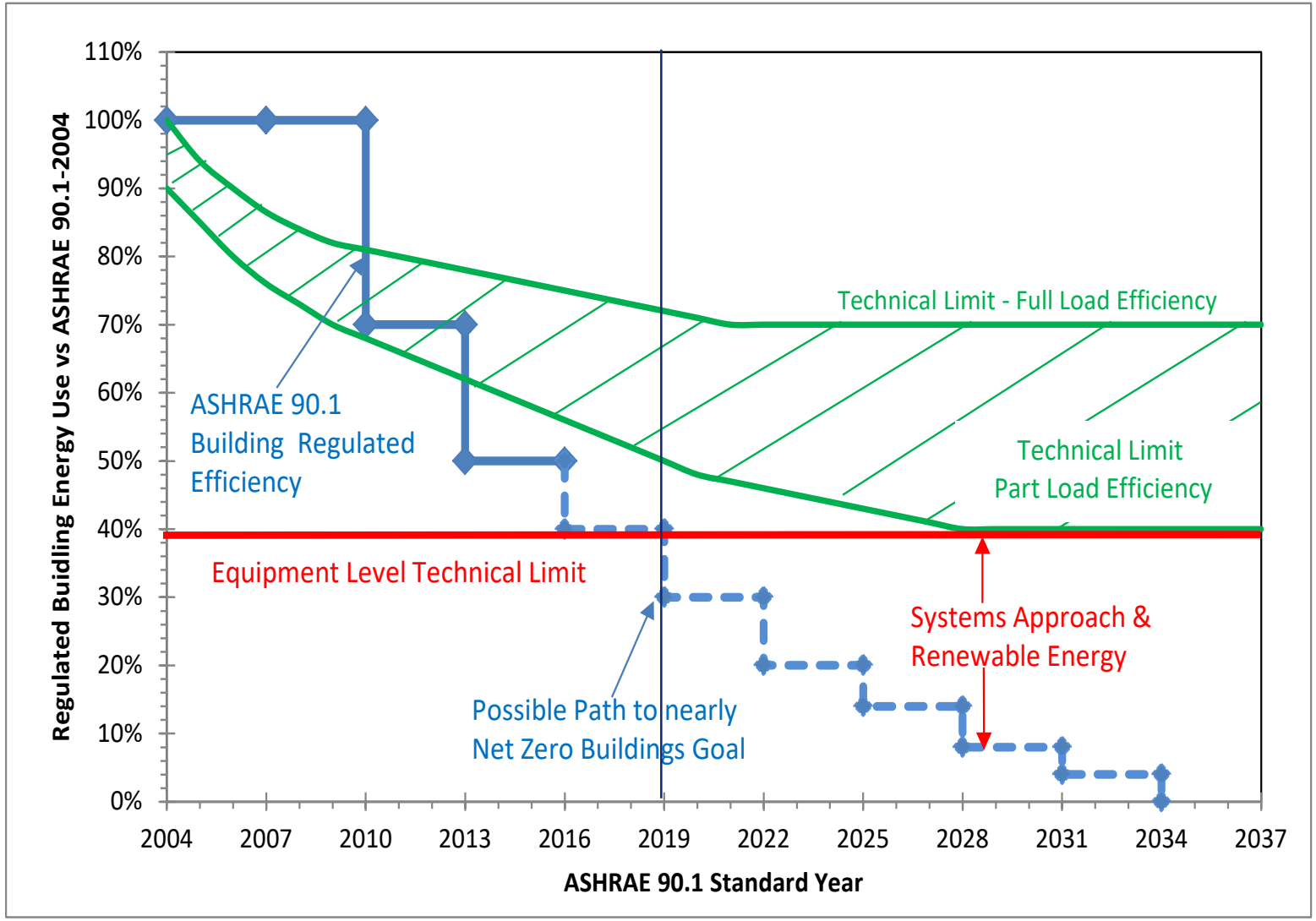
Overall the ASHRAE 90.1 standard efficiency improvements have been significant

Similar Results have been seen for HVAC&R equipment metrics



Equipment Efficiencies “Max Tech”

- We are starting to run out of technological approaches to continue the improvement in efficiency of equipment using the old metric approach (i.e. “second law of thermodynamics”)
- The industry often refers to this as “Max Tech”
- At full load, the limits are started to be reached for some products or are not cost effective
- There is opportunity at part load and the industry is moving in that direction but for some products limits are also be reached.
- This is shown in the figure.



Issues with Current Efficiency Metrics

- The current efficiency metrics have been effective at guiding the improvements in HVAC product efficiencies, but there are issues with comparing different products and for use in full building analysis;
- Some of the issues are;
  - Most have been **full load based**, and equipment seldom if ever runs at full load. There are new metrics being used and developed to look at **part load and or annualized performance** (i.e. IPLV, IEER, SEER, SEER2, HSPF, HSPF2, ISMRE)
  - Metrics are based on a **common national rating conditions** and in most cases are not regional
  - Based on conditions that are **not always seen in real buildings** (i.e. return air temperatures, airflow, static pressure, barometric pressure)
  - Metrics are for **basic units** and do not include optional features(i.e. economizers, energy recover, enhanced filters)
  - Metrics are **component based** and do not consider the full system (cooling towers, pumps, terminals, ductwork and ductwork leakage)
  - Most are based on very detailed and **prescriptive testing** procedures that are run at steady state conditions
  - Metric included some cyclic degradation allowances but not all interactions of system components (i.e. thermostats)
  - Metrics do not support **building modeling** and approaches defined in ASHRAE 90.1 chapter 11, and Appendix G
  - Do not allow **comparison of systems** (i.e.. Rooftop vs VRF vs WSHP vs Chiller)
  - Some **new products** do not yet have metrics

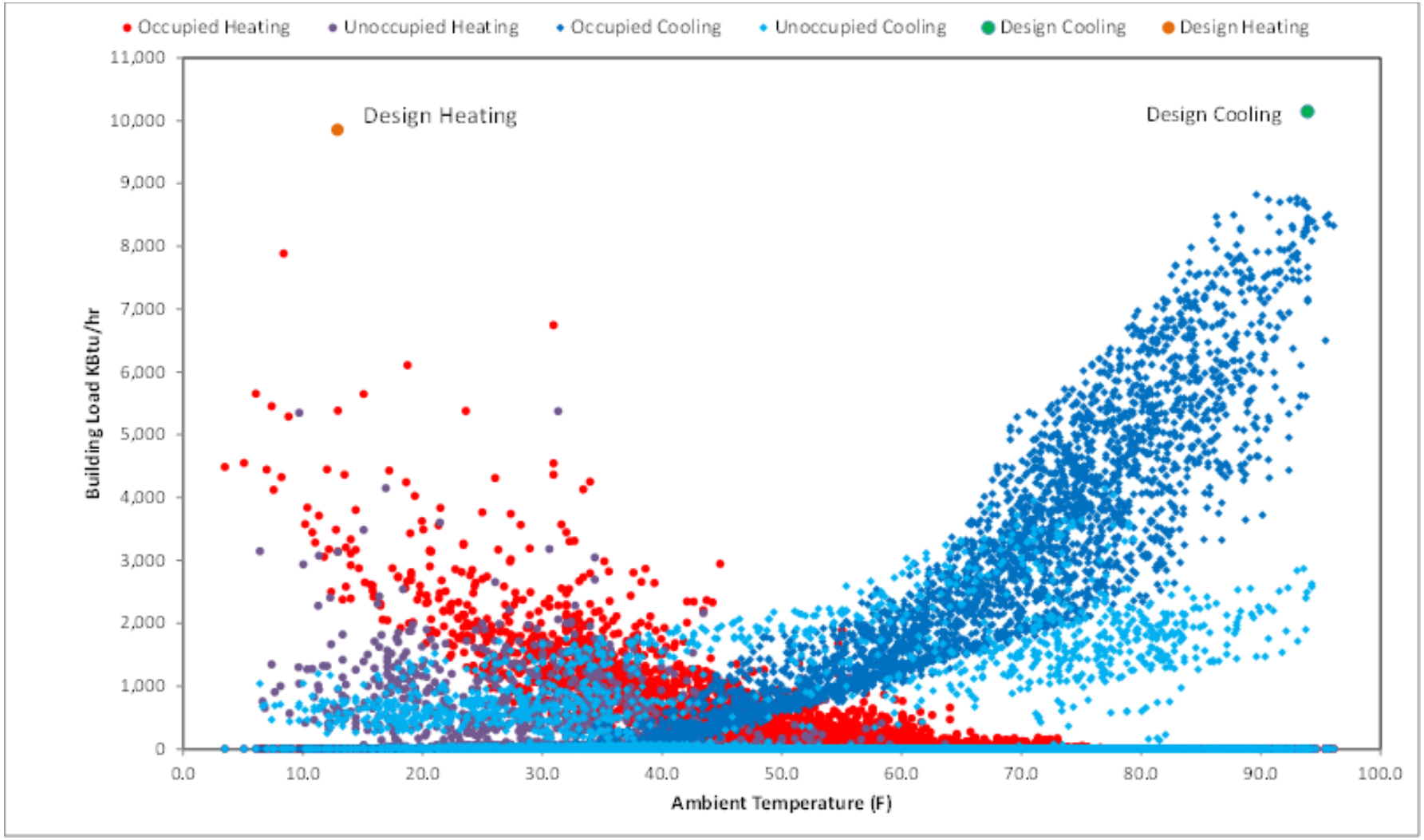
Understand Building Energy Use

The figure shows the hourly loads of a typical large commercial building off in climate zone 4a

Typically HVAC systems are oversized by 15% for cooling and 25% for heating but all metrics assume no oversizing

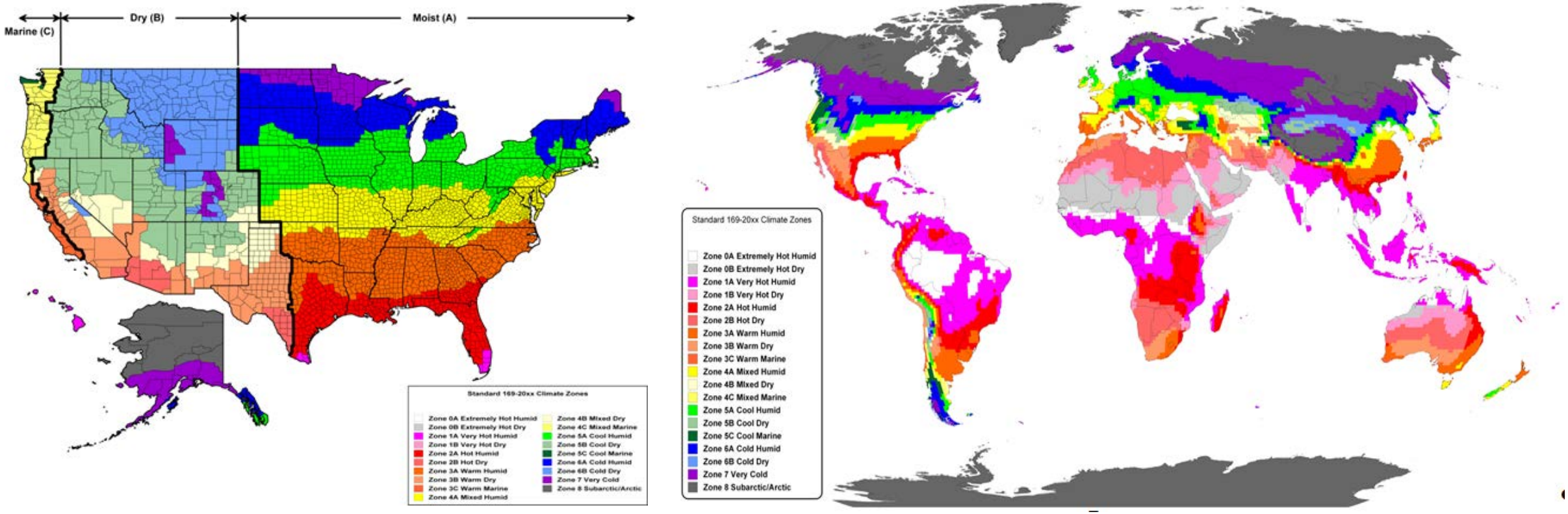
Historically energy efficiency regulations have been focused on full load efficiency which is seldom if every seen

In recent years new metrics have been developed to look at average annualized performance and this is now a focus of AHRI system initiative



Regional Climate Impact on Efficiency

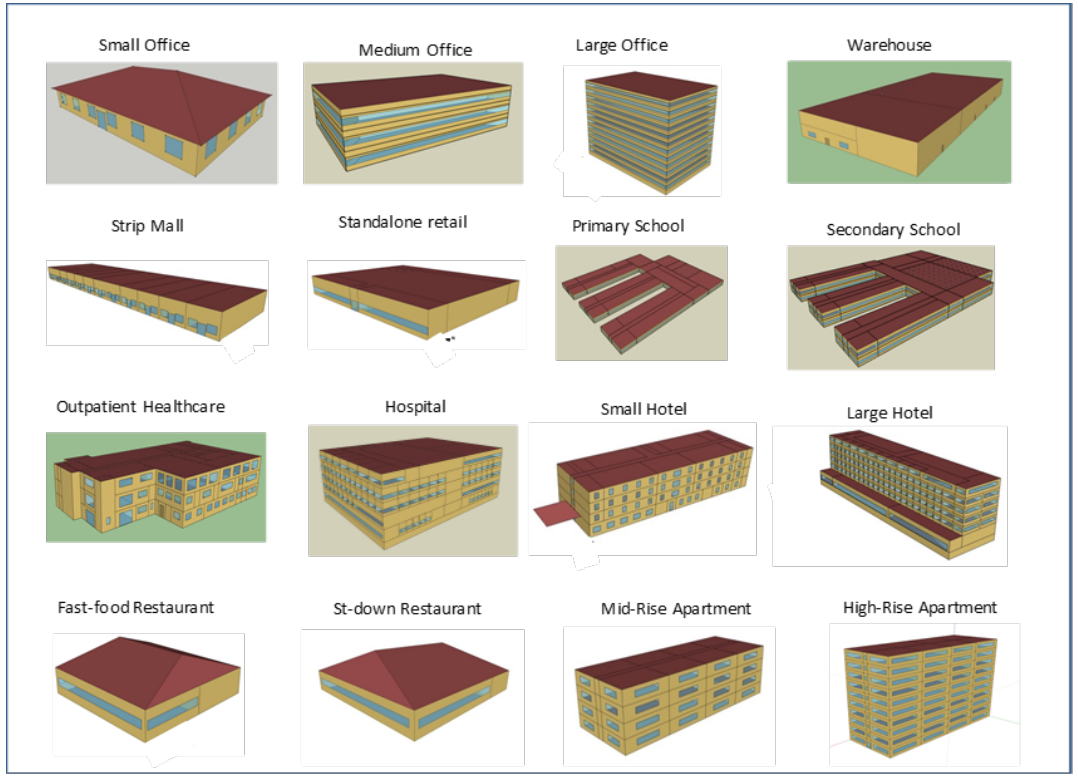
Most metrics are based on average design conditions (95 ºF ambient, 85 ºF condenser water) but the US gas 17 climate zones and the world has 19 climate zones as defined in the updated ASHRAE 169-2013



Building Type Impact on Efficiency

- For commercial the building loads are not all the same and vary significantly due to occupancy and use, and are changing due to envelope improvements, reduced lighting loads, increased plug loads and possible increased ventilation
- In ASHRAE 90.1 Mechanical Subcommittee they are spending more time understanding the impact of the buildings and ASHRAE has developed standardized buildings and reference cities

Reference Buildings

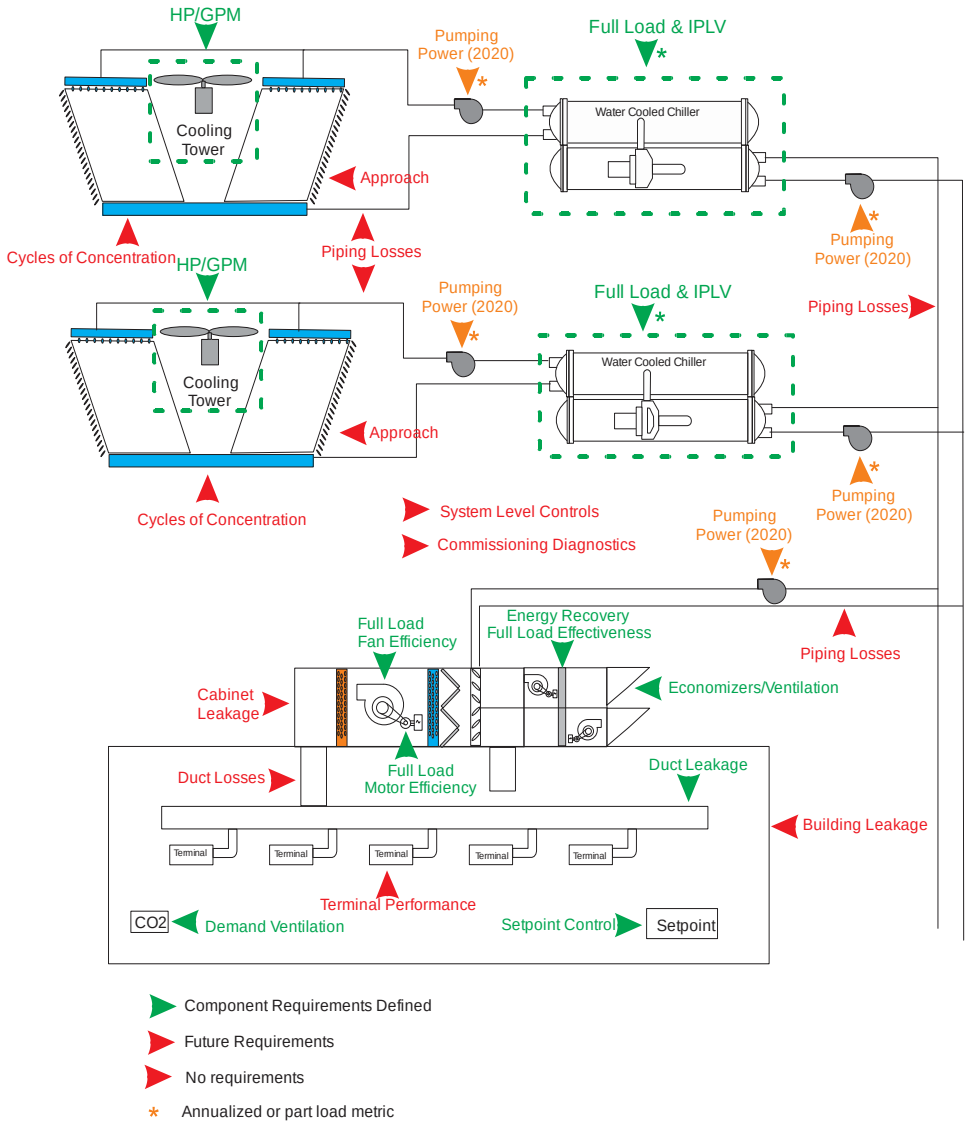


Reference Cities

CZ#	U.S. TMY3 equivalent	Canada CWEC equivalent	Global dataset
0A	no weather files	no weather files	Tan Son Hoa (Ho Chi Minh City/Saigon), Vietnam
0B	no weather files	no weather files	Dubai International Airport, United Arab Emirates
1A	~~Honolulu International Airport, Hawaii~~ Miami, International Airport	no weather files	Kaohsiung Int'l Airport, Taiwan
1B	no weather files	no weather files	New Delhi/Safdarjun, India
2A	MacDill AFB/Tampa. Florida	no weather files	Nanning, China
2B	Davis-Monthan AFB (Tucson), Arizona	no weather files	Cairo Airport, Egypt
3A	Atlanta Hartsfield Int'l Airport, Georgia	no weather files	Tokyo, Japan
3B	El Paso International Airport, Texas	no weather files	Amman Airport, Jordan
3C	San Diego/Brown Field. California	no weather files	Kunming, Ynnan, China Cape Town International Airport, South Africa
4A	New York J F Kennedy Intl Airport, New York	no weather files	Seoul, South Korea
4B	Albuquerque International Airport, New Mexico	no weather files	Shijiazhuang, China
4C	Seattle Seattle-Tacoma Int'l Airport, Washington	no appropriate weather files	Seattle Seattle-Tacoma Int'l Airport, Washington USA
5A	Buffalo Niagara Int'l Airport, ew York	Windsor Airport, Ontario Canada	Sapporo, Japan
5B	Buckley ANGB/Denver (Aurora), Colorado	Kamloops Airport, British Columbia	Yinchuan, China
5C	William R Fairchild Airport (Port Angeles), Washington	Comox, British, Columbia	Van, Turkey
6A	Rochester International Airport, Minnesota	Montreal/Pierre Elliott Trudeau Airport, Quebec Canda	Montreal/Pierre Elliott Trudeau Airport, Quebec Canada
6B	Great Falls International Airport, Montana	Medicine Hat Airport, Alberta Canada	Hohhot, China
7	International Falls International Airport, Minnesota	Winnipeg Richardson International Airport, Manitoba Canada	Ekaterinburg, Russia
8	Fairbanks International Airport, Alaska	Yellowknife Airport, Northwest Territories Canada	Magadan, Russia

Component Approach

- Current metrics are based on **appliance approach** and focused on components and prescriptive design requirements
- Metrics are primarily focused on **design day loads and temperature** but there is some movement to annualized and part load
- Typically only 1 common metric is used for the US (federal regulations limited to 1 metric for commercial units)
- Overall systems are not typically evaluated or optimized at a system level
- Creative solutions are not always rewarded for their beneficial improvement (i.e.. Economizers, hybrid systems, duct design, etc.,)
- No real focus on sustained performance



Recent Metrics Changes and New Approaches

For residential and light commercial products <65,000 Btu/h there have been changes to the metrics

In 2010 regional requirements were implemented for SEER and HSPF2)

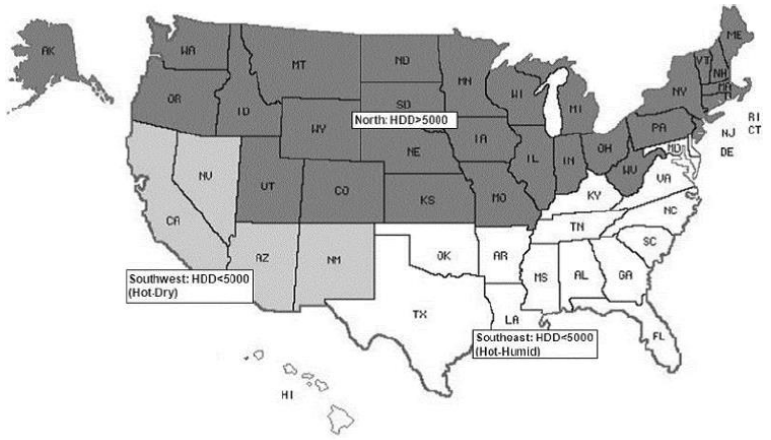
In 2023 a new metrics (SEER2 and HSPF2) will be used along with new more efficient regional requirements

Table 6.8.1-1 Electrically Operated Unitary Air Conditioners and *Condensing Units*—Minimum *Efficiency* Requirements

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum *Efficiency*	Test Procedure[a]
Air conditioners, air cooled	<65,000 Btu/h[b]	All	Split *system*, three phase and applications outside U.S. single phase[b]	13.0 *SEER* before 1/1/2023 13.4 *SEER2* after 1/1/2023	AHRI 210/240-2017 before 1/1/2023 AHRI 210/240-2023 after 1/1/2023
			Single-package, three phase and applications outside U.S. single phase[b]	14.0 *SEER* before 1/1/2023 13.4 *SEER2* after 1/1/2023	
Space constrained, air cooled	≤30,000 Btu/h[b]	All	Split *system*, three phase and applications outside U.S. single phase[b]	12.0 *SEER* before 1/1/2023 11.7 *SEER2* after 1/1/2023	AHRI 210/240-2017 before 1/1/2023 AHRI 210/240-2023 after 1/1/2023
			Single package, three phase and applications outside U.S. single phase[b]	12.0 *SEER* before 1/1/2023 11.7 *SEER2* after 1/1/2023	
Small duct, high velocity, air cooled	<65,000 Btu/h[b]	All	Split *system*, three phase and applications outside U.S. single phase[b]	12.0 *SEER* before 1/1/2023 12.0 *SEER2* after 1/1/2023	AHRI 210/240-2017 before 1/1/2023 AHRI 210/240-2023 after 1/1/2023
Air conditioners, air cooled	≥65,000 Btu/h and <135,000 Btu/h	*Electric resistance* (or none)	Split *system* and single package	11.2 *EER* 12.9 *IEER* before 1/1/2023 14.8 *IEER* after 1/1/2023	AHRI 340/360
		All other		11.0 *EER* 12.7 *IEER* before 1/1/2023 14.6 *IEER* after 1/1/2023	
	≥135,000 Btu/h and <240,000 Btu/h	*Electric resistance* (or none)		11.0 *EER* 12.4 *IEER* before 1/1/2023 14.2 *IEER* after 1/1/2023	
		All other		10.8 *EER* 12.2 *IEER* before 1/1/2023 14.0 *IEER* after 1/1/2023	

Table F-1 Minimum *Efficiency* Requirements for Single-Phase Central Air Conditioners and Heat Pumps for Sale in the U.S.

Product Class	Capacity Range	National Standards	Southeastern Region Standards[a]	Southwestern Region Standards[b]	Test Procedure[f]
Central Air Conditioners and Heat Pumps[c]					
Split-system air conditioners for U.S. applications	<45,000 Btu/h *single phase*	before 1/1/2023 *SEER* = 13.0 $P_{W,OFF} \leq 30$ W after 1/1/2023 *SEER2* = 13.4 $P_{W,OFF} \leq 30$ W	before 1/1/2023 *SEER* = 14.0 $P_{W,OFF} \leq 30$ W after 1/1/2023 *SEER2* = 14.3 $P_{W,OFF} \leq 30$ W	before 1/1/2023 *SEER* = 14.0 *EER* = 12.2 $P_{W,OFF} \leq 30$ W after 1/1/2023 *SEER2* = 14.3 *EER2* = 11.7/9.8[d] $P_{W,OFF} \leq 30$ W	AHRI 210/240-2017 before 1/1/2023 AHRI 210/240-2023 after 1/1/2023
Split-system air conditioners	≥45,000 Btu/h and <65,000 Btu/h *single phase*	before 1/1/2023 *SEER* = 13.0 $P_{W,OFF} \leq 30$ W after 1/1/2023 *SEER2* = 13.4 $P_{W,OFF} \leq 30$ W	before 1/1/2023 *SEER* = 14.0 $P_{W,OFF} \leq 30$ W after 1/1/2023 *SEER2* = 13.8 $P_{W,OFF} \leq 30$ W	before 1/1/2023 *SEER* = 14.0 *EER* = 11.7[d] $P_{W,OFF} \leq 30$ W after 1/1/2023 *SEER2* = 13.8 *EER2* = 11.2/9.8[e] $P_{W,OFF} \leq 30$ W	AHRI 210/240-2017 before 1/1/2023 AHRI 210/240-2023 after 1/1/2023



Recent Metrics Changes and New Approaches

- For commercial equipment in 2010, the IEER was implemented and DOE adopted for air cooled products (not for water cooled) and implemented it in 2018 as their primary metric and the industry and DOE have agreed on a **significant improvement in 2023**
- Integrated Energy Efficiency Ratio (IEER), is a metric that was defined to give a better representation of annual performance.

$$IEER = 0.020*A + 0.617*B + 0.238*C + 0.125*D$$

Where:
A = EER at 100% net capacity at design conditions
B = EER at 75% net capacity and reduced ambient
C = EER at 50% net capacity and reduced ambient
D = EER at 25% net capacity and reduced ambient

- The IEER is intended to be a weighted average of performance for typical buildings and was based on a weighted average of an office building, school building, and retail building in all US 17 climate zones.
- It is a **mechanical cooling only efficiency** metric and does not include economizers, energy recovery and ventilation only operation

This metric has had a significant impact on the industry as to how equipment is designed and including the use of fan speed control as well as compressor staging control to improve efficiency

Recent Metric Changes and New Approaches

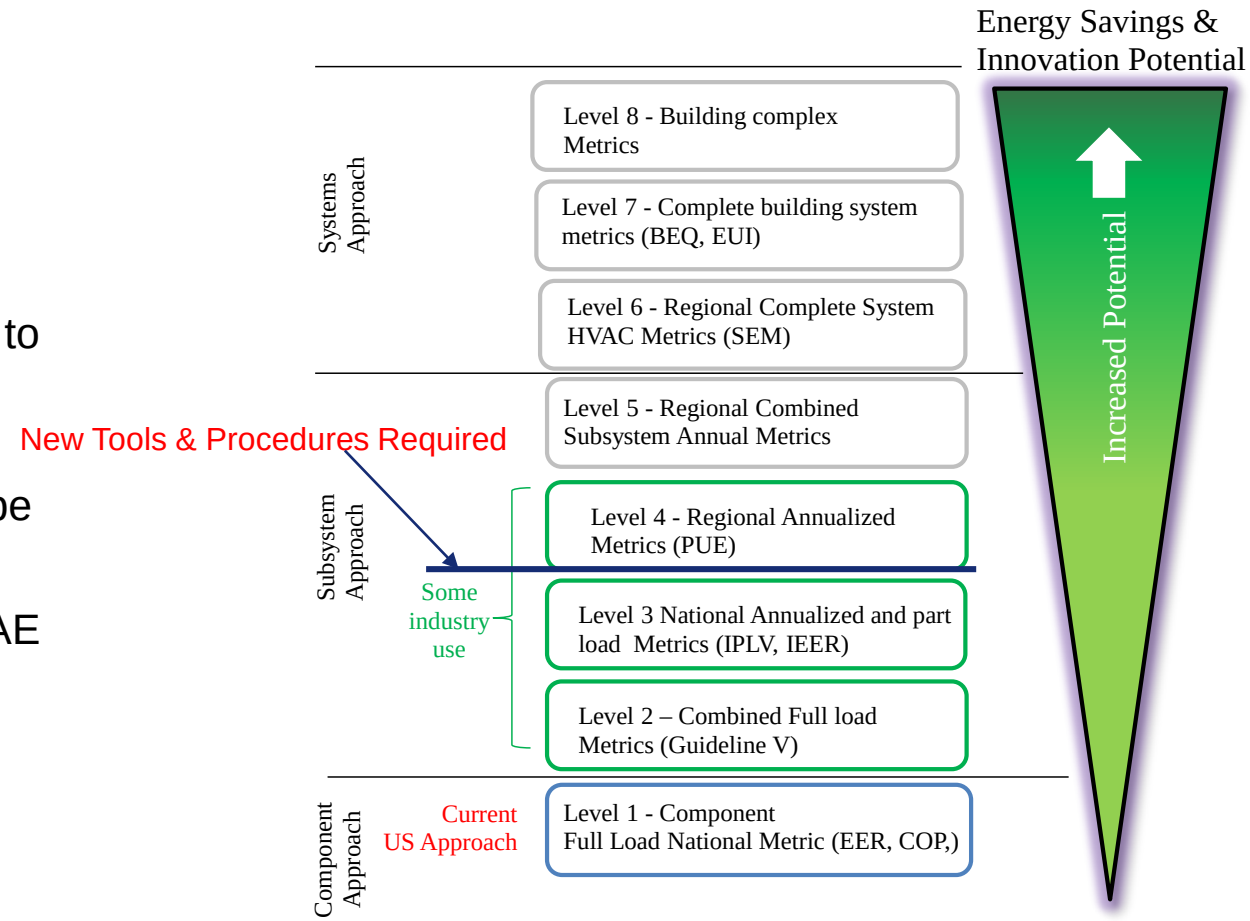
- For chillers, the use of an annualized part load metric has been in place for many years with the use of the IPLV and has become the primary metric of interest although the full load efficiency metric is still used
- The chiller ratings also have evolved to include two paths for compliance;
  - **Path A** – Full load intensive applications with a more efficiency full load metric and slightly less efficient IPLV
  - **Path B** – Part load intensive applications with a much higher full load metric and slightly less efficient IPLV
- With the use of variable speed the path B is gain more interest and use
- Chillers ratings and certification also have gone to a full map ratings and the last step in this process for air cooled chillers will be completed in starting on 1/1/2021. Water cooled have had full certified mapped ratings for many years
- Also the mapped rating envelop has expanded to include new higher temperatures for data centers and also to cover certification and compliance for chillers with freeze protection fluids
- Also a new category of chillers was just added to cover air source heat pumps chillers, water source heat pump chillers and heat reclaim chillers which are of a lot of interest for carbon neural and electrification and these are defined in table 6.8.1-16 in 2019 and will be further updated by a new addendum Y soon to be released for public review

Recent Metric Changes and New Approaches

- There have also been new products and new metrics added for the following products;
  - DOAS Units with ISMRE
  - VRF products with EER and SEER
  - Data Center CRAC Units with new ceiling mounted products and metrics for 3 different application conditions with (SCOP)
  - Data centers with PUE and also a new ASHRAE standard 90.4 metric (MLC)
  - Stand alone fan efficiency with the Fan Energy Index (FEI)

Defining System Metrics (HVAC&R)

- Alliance to Save Energy Definition - A ***building system*** has been defined "*as a combination of equipment, operations, controls, accessories, and means of interconnection that uses energy to perform a specific function*"
- The intent of a **mechanical systems approach** will be to move up the green potential figure where we believe more energy savings can be obtained
- But conventional tools and ratings metrics will need to be revised to allow for this approach
- New tools will be needed for modeling including ASHRAE 205 for equipment models and new simulation and compliance tools.
- New compliance tools are being developed.
- It also will likely enable and result in a move to regional requirements which for chillers is already occurring globally



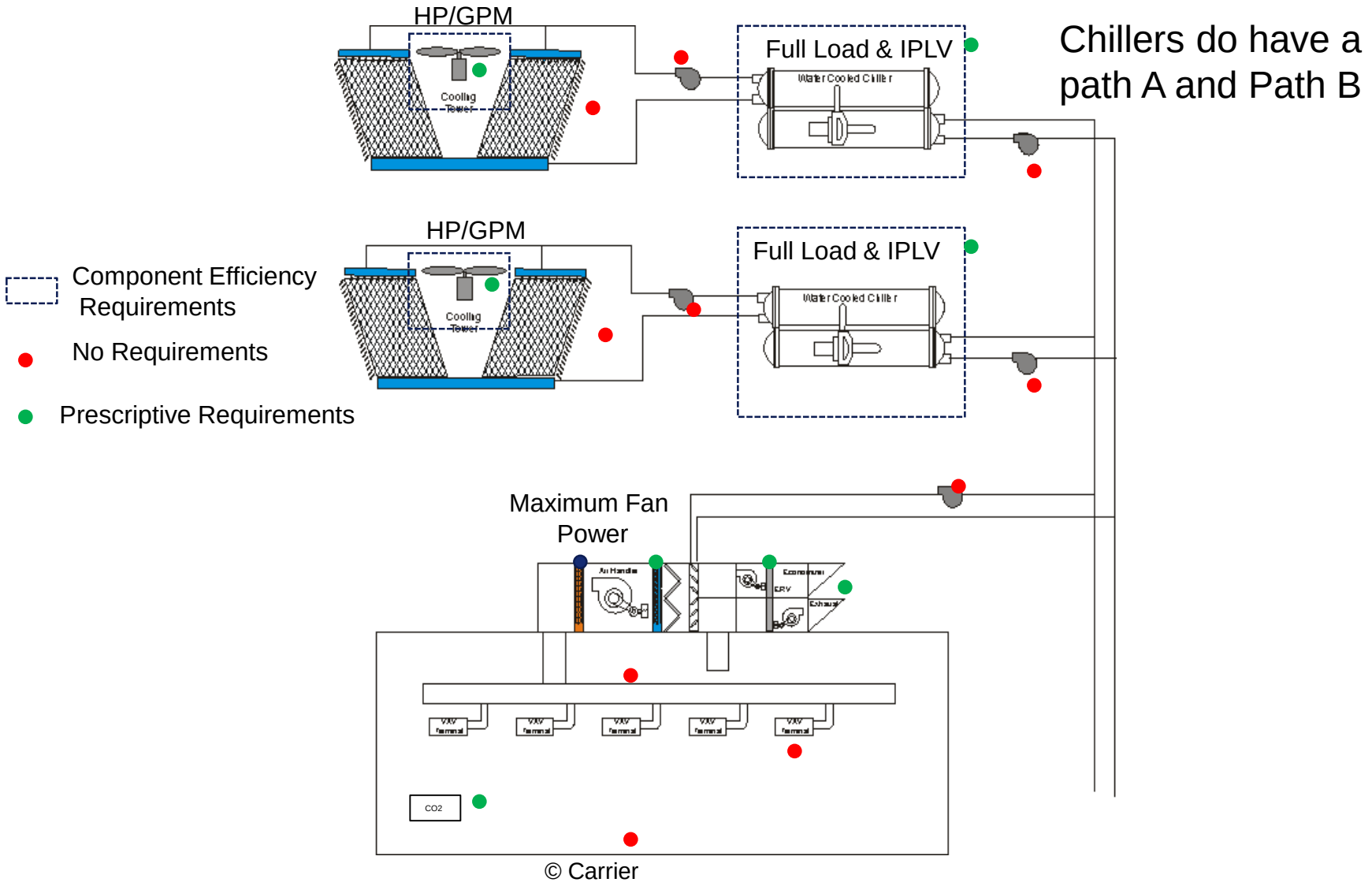
It also should be noted that a systems approach also could includes commissioning, monitoring, reporting and maintenance and factor in benefits of connected equipment. Connected equipment is a key enabler to this (**Outcome based approach to standard**)

Systems Approach to Energy Efficiency

- A key part of a subsystems and systems approach is to understand what is included in the system
- An approach that the AHRI Systems Steering Committee has used it to create system diagrams and this has been done for the following products/systems;
  - Water Cooled Chilled Water System
  - Commercial Rooftop
  - Commercial Supermarket
- Various approaches can be taken to what is in the system and what might be included in metrics
- Setting metrics will be a key part of a systems and subsystems approach even for the lower tier appliance approaches like SEER2, IEER2, GPLV, etc.
- System diagrams as well as building and equipment models are also very important to validation of new metrics (example validation of new VRF IEER metrics)

Defining System Boundaries – Chilled Water

Current ASHRAE 90.1 Chilled Water Regulations (Prescriptive Approach)

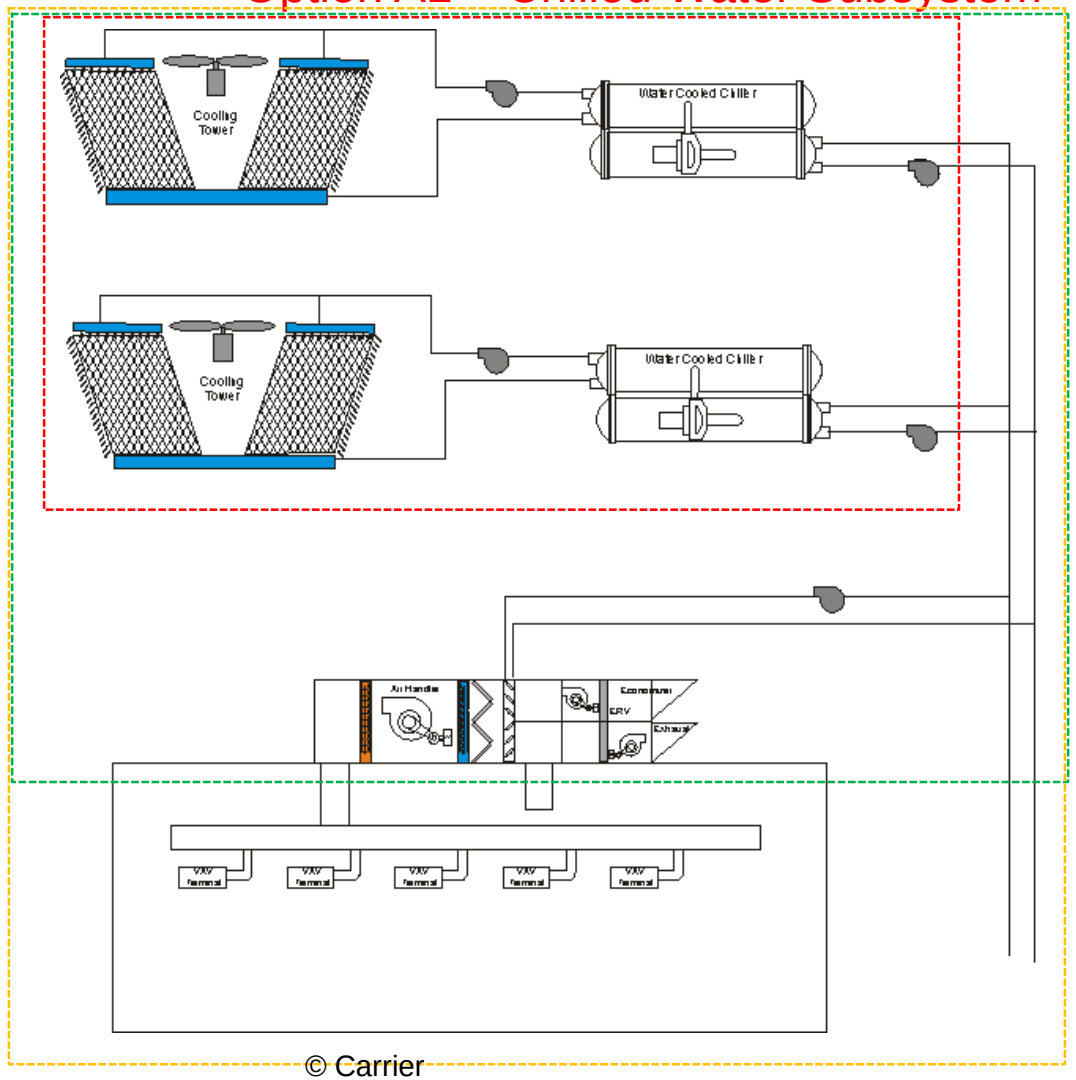


Chillers do have a path A and Path B

Chilled Water System/Subsystem Example

Possible Proposed Sub-Systems Approach

Option A1 – Chilled Water Subsystem



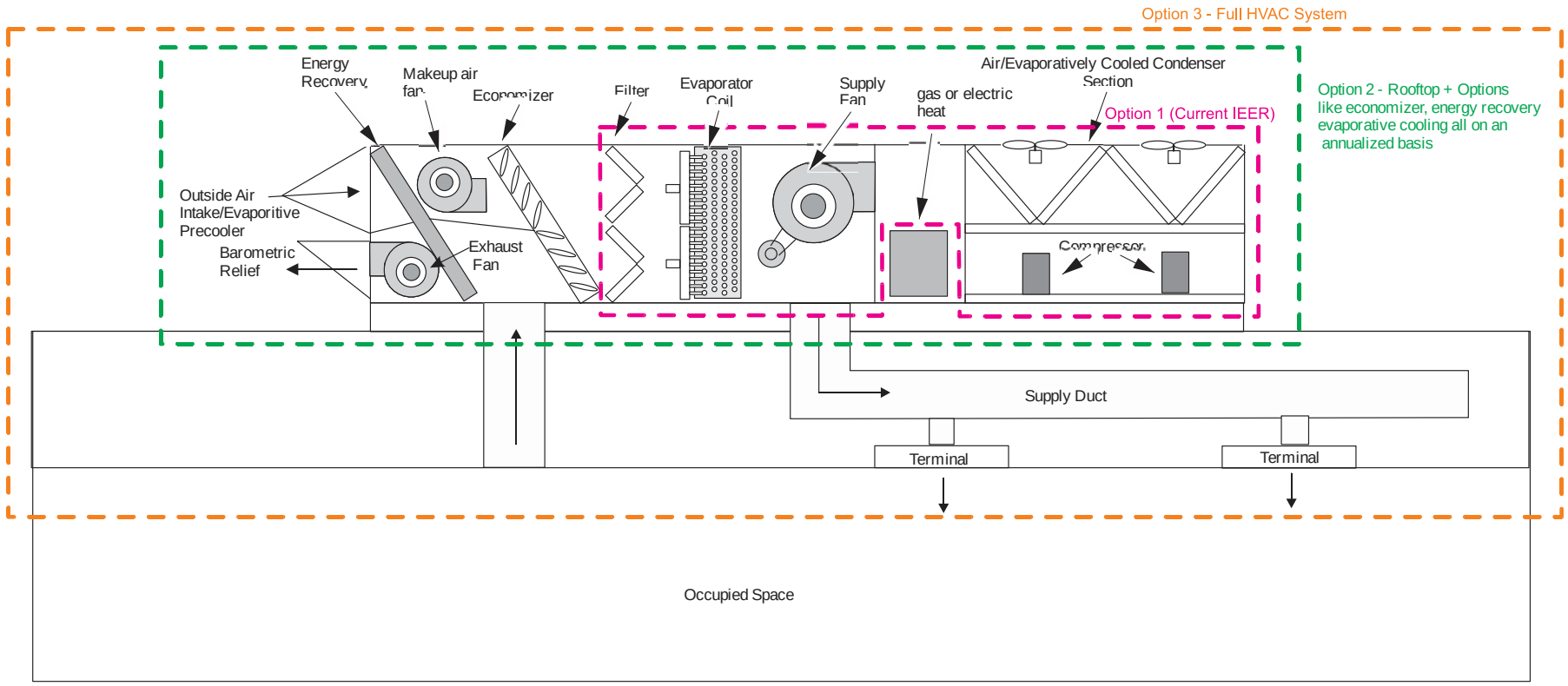
Option A2 – Chiller+tower+air handler

Option A3 – Complete System

There is a study underway to look at the air-cooled and water-cooled chiller factoring in single and multiple chillers, cooling towers, pumping power and regional requirements

Rooftop Benchmark Sub-System Example

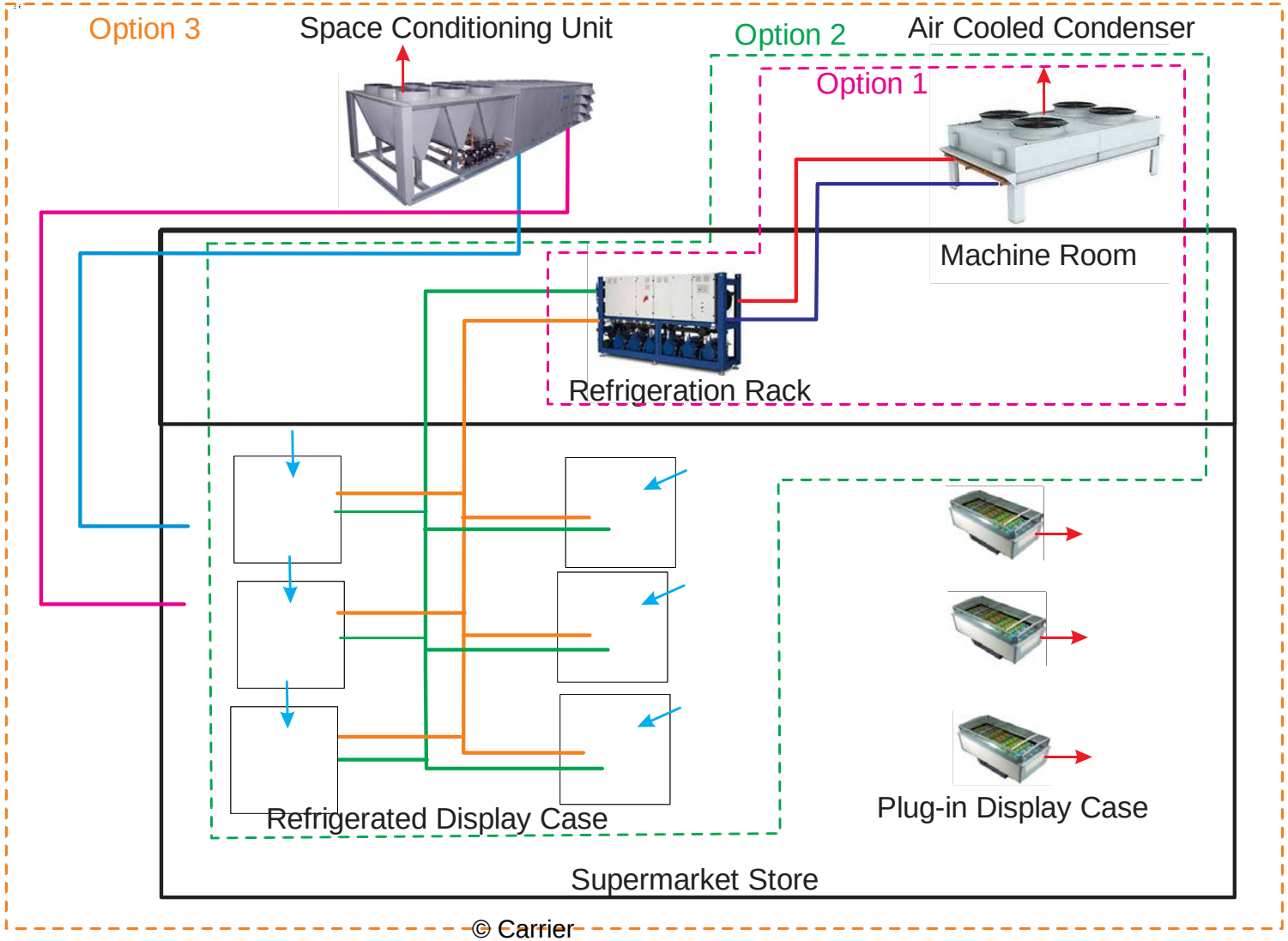
Example Rooftop System Diagram



There is a study underway to look at the rooftop option 1 to factor in economizer, ventilation and possibly heating in a new IEER2 metric

Supermarket System Approach Example

The following is an example of a Supermarket system level approach



New Metric and HVAC Initiatives

- The industry thru organizations like AHRI Systems Steering Committee, CSA 424, and Second European Directive are working on new approaches, new metrics and tools
  - **SEER2/HSPF2** – Completed and will be implemented in 2023
  - **Load Based Metrics** – Thru work started at Purdue in the HPBC the industry including CSA and AHRI have been working on a new approach to dynamically test and rate residential products vs a defined building load profile including cyclic performance and additional product features including thermostats and economizers
  - **Chiller GPLV** – Metric that includes more of the chillers, including multiple chillers and regional requirements (5 global regions). This could also include heating performance
  - **IEER2** – Next generation rooftop IEER including economizers, ventilation, heating, and regionality
  - **TSPR** – ASHRAE 90.1 with work form PNNL working on a mechanical systems approach for buildings as an alternate compliance path
  - **BEEM** – CSA approach to consider a simplified modeling tool for buildings based on work from Europe and the Second European Directive
  - **WSHP Annualized Metric** – AHRI has been working on a new metric for WSHP's similar to IEER
  - **AHRI Systems Steering Committee –** Focused on systems including new metrics, mapped ratings and certified maps
  - **CSA 424 Committee –** Focused on systems approaches to building for both residential and commercial
  - **Second European Directive** – Holistic systems approach to buildings
  - **ASHRAE 205** – Standardized approach to equipment models for use in simulation programs.

ASHRAE 205 – Equipment Models

- The ASHRAE 205 is a new standard that has been in development for several year and as been thru and advisory public review and 2 full reviews.
- It is close to being published but will be a continuous maintenance standard with appendices covering each product type.
- They have taken a different approach then currently modeling approaches used by programs like Energy Plus and DOE2 where correlation equations are used and instead, they are using large electronic tables and interpolation.
- In the tables the actual operational limits of the equipment are included which will prevent extrapolation of the ratings
- The new approach better models the new equipment with multiple stages and or variable capacity
- The data will also better consider modeling and features like indoor fan power will be separated from the refrigeration modeling
- New tools and changes to simulation models will have to be developed to use the data, but these are already being developed
- It also has been developed to allow electronic transfer of data
- AHRI is also working mapped ratings and certified mapped ratings to support ASHRAE 205

ASHRAE Standard 205P

Public Review Draft

Representation of Performance Data for HVAC&R and Other Facility Equipment

May 2020

(Complete Draft for Public Review)

This draft has been recommended for a public review by the responsible project committee. To submit a comment on this proposed standard, go to the ASHRAE website http://www.ashrae.org/public-review-drafts and access the online comment database.

The appearance of any technical data or editorial material in this public review document does not constitute endorsement, warranty, or guaranty by ASHRAE of any product, service, process, procedure, or design, and ASHRAE expressly disclaims such.

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QUESTIONS

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Renewable Energy in ASHRAE 90.1

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DOE Webinar Series

Looking to the Future – What's in Store for ASHRAE Standard 90.1?

November 12, 2020

Renewable Energy in ASHRAE 90.1

- Previous versions of ASHRAE 90.1:
  - No requirement, but can take credit for use of on-site renewable energy in Energy Cost Budget method (Chapter 11) or Performance Rating Method (Appendix G).
  - Credit limited to 5% of budget building energy cost.

Renewable Energy in ASHRAE 90.1

- ***New!*** Recently published addenda BY, CK, and CP to 90.1-2019.
  - **New minimum prescriptive requirement for on-site renewable energy on new buildings and additions.**
  - First time renewable energy is being required in a base national model energy code or standard (not just above-code or green building programs).
  - Prescriptive, so can also trade-off and make up for it in performance path.

- Not in the book version of 90.1-2019, but available for jurisdictions to adopt and use at https://www.ashrae.org/technical-resources/standards-and-guidelines/standards-addenda/addenda-to-standard-90-1-2019.
- Will also be incorporated in 90.1-2022 full edition.

New renewable energy requirement in 90.1

What is required?

- **The building or building site must provide on-site renewable energy systems with capacity of 0.25 W/ft^2 (0.85 Btu/ft^2) multiplied by the sum of the conditioned floor area of up to the 3 largest floors.**

What type of renewable energy?

- The requirement and cost effectiveness was developed around solar PV generation as the most ubiquitous and cost-effective renewable energy resource, but can use other types of renewable energy, or make up for it in performance path.
  - Prescriptive requirement in Addendum BY.
  - Addenda CK and CP adjust the calculation and requirement in Chapter 11 and Appendix G performance paths to be consistent.
- Clarified definition of *on-site renewable energy* and *renewable energy resources*.
  - Can be energy from solar, wind, biomass or hydro, or extracted from hot fluid or steam heated within the earth harvested at the building site.
  - Cannot take credit for off-site renewable energy at this time because limited by 90.1's current scope.

New renewable energy requirement in 90.1

What does this mean? Why 3 floors? How was the 0.25 W/ft^2 capacity set?

- Using 'up to the three largest floors' allows this requirement to apply to both short and tall buildings.
  - Works for both a 1 story warehouse with lots of roof space, and a 40 story urban tower with limited space.
- 0.25 W/ft^2 was shown to be cost effective in all solar zones under ASHRAE's scalar analysis for both smaller and larger system pricing, *without* any tax incentives or subsidies.
  - Using PNNL prototype buildings, installed cost of $2.65/W or lower passes scalar of 17.2 in all zones.
  - NREL 2018 cost benchmark report showed average small residential systems at $2.54/W (string inverter), commercial sized systems at $1.83/W, and costs continuing to drop.
- 0.25 W/ft^2 was also selected based on evaluation of roof space competition, and energy use at the building.
  - Requires less than 4% of roof area.
  - No assumption of net-metering. Sized to minimize net generation.
- Energy reduction is estimated at 4.5%, based on PNNL prototype models.

New renewable energy requirement in 90.1

What are the exceptions?

- Exceptions for buildings that are shaded and/or have insufficient solar irradiation.
- Exceptions for alterations and smaller buildings. Only applies to new buildings and additions where the three largest floors are over 10,000 ft^2.
- Exception for when > 80% of roof area covered by equipment, planters, vegetated space, skylights, or occupied roof deck.

On-Site Renewable Energy

- Can use different types of on-site renewable energy, but most common will likely be Rooftop PV, Ground-mounted PV, Building Integrated PV (BIPV), and perhaps micro wind turbines.

Thank You!

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