Welcome to Webinar Wednesday

Varitec Technical Institute - 2024

Presenter: Dan Hahne
(Varitec: Director of High-Performance HVAC Solutions)

Program Coordinator: Kellie Huff
(Varitec: Marketing Manager)

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July 10th	ASHRAE 90.1
August 21st	Pyschrometrics Deconstructed Part 1
September 18th	100% OSA & VRV
October 23rd	Pyschrometrics Deconstructed Part 2
November 20th	100% OSA & Underfloor

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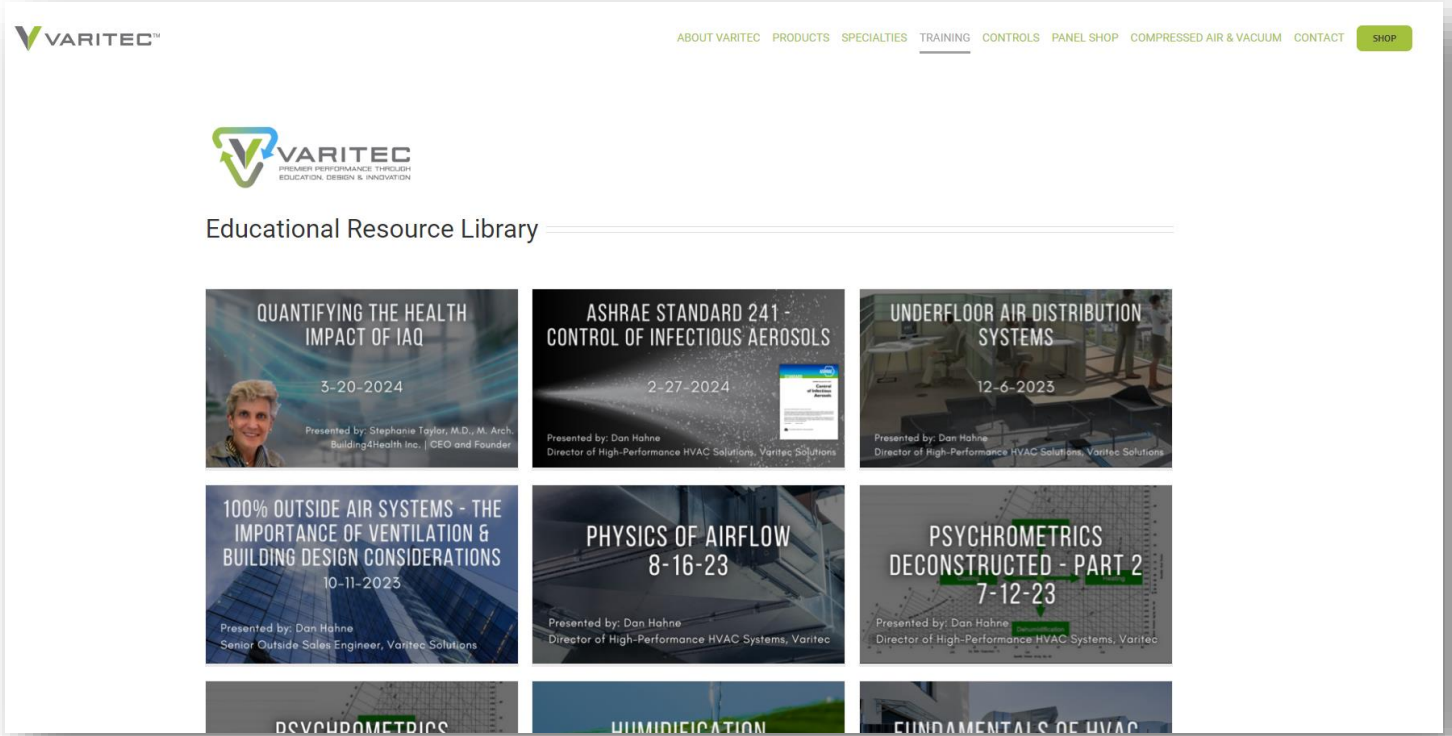

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Housekeeping Items:

- **We are recording this session**
- **Please ask questions in the chat**
- **If you need PDH or AIA credit, make sure your name is displayed correctly. If you are calling in, send me an email to let me know you attended.**

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ASHRAE Standard 90.1-2022

Energy Standard for Sites and Buildings Except Low-Rise Residential Buildings

Presented by: Dan Hahne
Varitec: Director of High-Performance HVAC Solutions

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Introduction

- **Education:**
  - **University of Arizona:** Chemical Engineering
    - 1974 thru 1976
  - **University College London** BFA Degree (Sculpture)
    - 1978 thru 1983
  - **Boston University** – MFA Degree (Sculpture)
    - 1983 thru 1985

- **Industry:**
  - **Norman S. Wright SW:** Estimator/Sales
    - 1985 thru 1999
  - **Air Specialty Products:** Outside Sales
    - 2000 thru 2008
  - **Air Specialty Products/ThermAir Systems:** Sales Engineer
    - 2009 thru 2016
  - **Varitec Solutions:**
    - Senior Sales Engineer
      - 2016 - 2022
    - Director of High-Performance HVAC Solutions/Educator
      - 2022 thru present

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Introduction

- **ASHRAE:**
  - ASHRAE Member: 2009 thru 2024
  - ASHRAE Standard 200-2015: Methods for Testing Chilled Beams: Voting Member
  - ASHRAE TC-1.7P: Ongoing Building Commissioning Committee: Voting Member
  - **ASHRAE Distinguished Lecturer – July 2024**

- **Publications: Engineered Systems (ES) Magazine**
  - **August 2023:** *Creating an Innovative Building Design through Creative, Adaptive Architecture, Engineering and Collaboration* (co-authors: Conrad Brown P.E., Mathew Peairs, P.E.
  - **December 2022:** *100% Outside Air Systems – Passive Radiant Cooling and Heating Systems* (co-author: Darren Alexander, P.E.
  - **July 2022:** *100% Outside Variable Refrigerant Air Systems - A Sustainable Hybrid Approach for Superior IAQ*
  - **October 2021: Health Care Design**
    - *Beyond Code Minimum – Creating Healthier, More Efficient Environments* (co-author: Fletcher Clarcq, P.E.)

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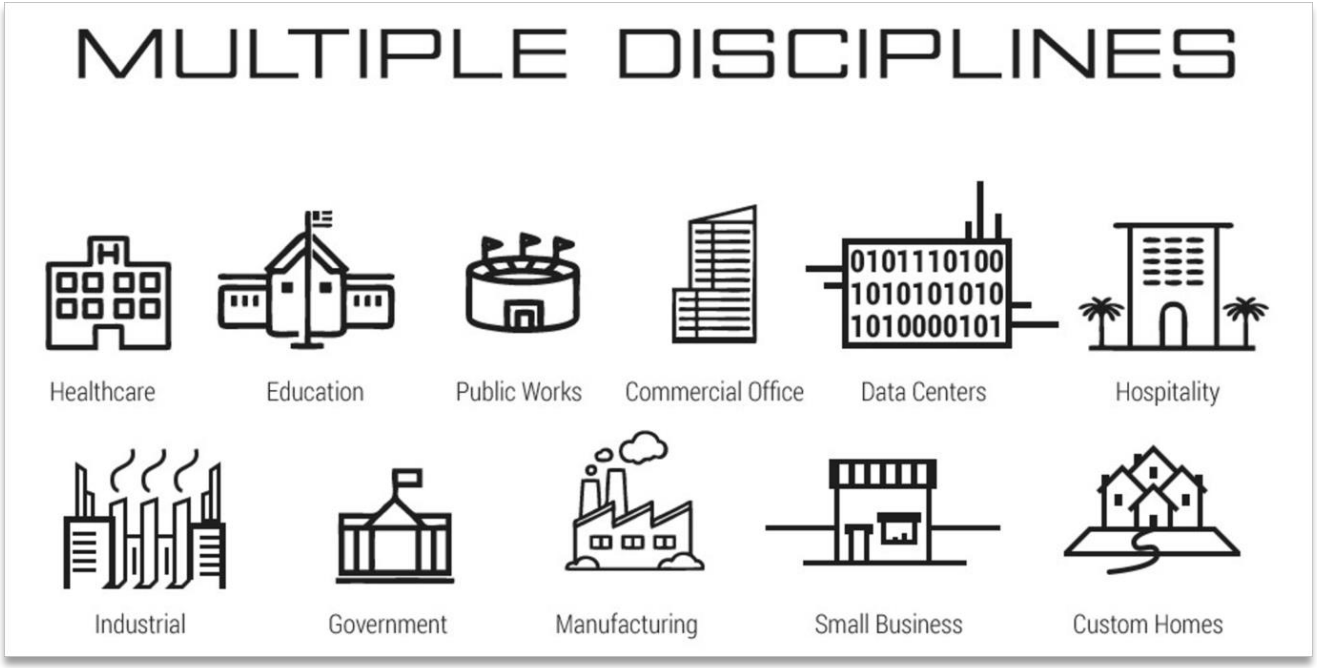

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SHAPING THE FUTURE OF HVAC

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Mission:

To provide an educational platform for continued learning in the HVAC industry with a focus on high performance buildings and innovative technologies for a better built environment.

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Newsletter: The Conduit


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The Conduit: IEQ & Net Zero Through HVAC | June 2024

TODAY'S DEVELOPMENTS FOR TOMORROW'S WORLD

What you need to read this month

In this month's newsletter, we bring you a range of exciting updates from the environmental and HVAC sectors. The EPA has awarded $10.6 million to enhance wildfire smoke preparedness in community buildings, prioritizing vulnerable communities. Arizona's latest air quality data reveal ongoing challenges and efforts to improve health and economic outcomes. The DOE has introduced a new definition for zero emissions buildings, pushing for cleaner, more efficient construction practices. Texas A&M researchers have developed a data-driven model to optimize HVAC systems, significantly improving thermal comfort in office buildings. Finally, a groundbreaking blueprint by QUT experts sets out national indoor air quality standards for public buildings, aiming to safeguard health and productivity. Dive into these articles to learn more about these significant advancements.

Varitec: supporting our community for a better tomorrow.

Want to submit an article for next month? Click Here

EPA Awards $10.6M for Wildfire Smoke Preparedness

The EPA has allocated $10.6 million in grants to nine projects focused on enhancing wildfire smoke preparedness in community buildings. These grants aim to mitigate health risks by improving air quality through HVAC upgrades, deploying portable air cleaners, and providing outreach and training. The funding supports public and non-profit organizations across various states, including Arizona, California, and Montana, prioritizing vulnerable communities.

Read More

Arizona's Air Quality: New Data Highlights Challenges and Progress

Health and Well-Being

Recent data from the Arizona Department of Environmental Quality reveal ongoing air quality challenges in Arizona, particularly concerning ozone and particulate matter (PM10 and PM2.5). Poor air quality significantly impacts health, especially in Phoenix and Pinal County, and poses economic development risks. Efforts are being made to mitigate pollution through public transit promotion and stricter regulations, with 80% of Arizonans supporting better air quality initiatives.

Read More

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AIA HSW/LU Accredited Presentations

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Varitec Technical Institute: Educational Curriculum

Fundamentals of HVAC Systems: Toward 100% Outside Air Designs for Greater Efficiency and Enhanced IAQ

Session #1: Health and Well-Being: One Breath at a Time (AIA HSW)

Session #2: Fundamentals of HVAC Systems (AIA HSW)

Session #3: Toward Healthier Buildings: Humidification (AIA HSW)

Session #4: Psychrometrics Deconstructed Part #1 (AIA HSW)

Session #5: Psychrometrics Deconstructed Part #2 (AIA HSW)

Session #6: Thermally Stratified Environments (AIA HSW)

Session #7: Underfloor Air Systems – Principles, Design and New Technology (AIA HSW)

Session #8: 100% Outside Air Systems – The Importance of Ventilation & Design Considerations (AIA HSW)

Session #9: 100% OSA Systems – Active Chilled Beams (AIA HSW)

Session #10: 100% Outside Air Systems - Passive Chilled Beam and Radiant Cooling & Heating Technology (AIA HSW)

Session #11: 100% Outside Air Systems: Variable Refrigerant Technology (AIA HSW)

Webinar Wednesdays


Live Webinar

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ASHRAE STANDARD 90.1-2022

Wednesday, July 10th, 2024
@ 12pm MT(AZ)

REGISTER NOW!

Presenter:
Dan Hahne | Varitec Solutions
Director of High-Performance HVAC Solutions

Jul 10

Webinar: ASHRAE 90.1

On March 6th 2024, the Federal Register published an article to publicly notify the U.S. Department of Energy (DOE) has reviewed and issued the determination that *ANSI/ASHRAE/IES Standard 90.1-2022* will improve commercial building energy efficiency. The "DOE analysis indicates that buildings meeting Standard 90.1-2022, as compared with those meeting the previous 2019 edition, would result in a national average site energy savings of 9.8 percent of commercial building energy consumption…" However, many, if not most, Southwestern municipalities have adopted code IECC-2018 (Standard 90.1-2016) and IMC-2018 if not earlier code editions. The 2022 Standard edition has 89 amendments to the 2019 Standard plus another group of amendments brought forth in the 2019 version compared to the 2016 Standard still adopted by most "*Authorities Having Jurisdiction*".

Varitec's Director of High-Performance HVAC Solutions, Dan Hahne will present on:

- The DOE's *Energy Savings Analysis* report published in February 2024 that communicates the reasons for its "determination"
- Identify the relationship between IECC and Standard 90.1 and list **current code** editions many Arizona Municipalities have adopted
- Review purpose and scope of Standard 90.1-2022
- Review the Standard's Section 4 Compliance language and identify new design requirements defined by the Standard
- Examine code language changes and additions compared to Standard 90.1-2016, i.e. building envelopes, heating, ventilating, and air conditioning systems, power,
- Explore how Standard 90.1-2022 will impact HVAC designs by lowering thermal (sensible) energy loads and, consequently, building air flow rates.
- Review Normative Appendix G and Appendix I: Performance Rating Method and other metrics in conjunction with Appendix G and, if time permits, other influencing appendices

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Today's Agenda:

- Department of Energy: *ANSI/ASHRAE/IES Standard 90.1-2022: Energy Savings Analysis*
- International Energy Conservation Council (IECC)-2021 Code
- ASHRAE Standard 90.1: Timeline and Future Trend
- Standard 90.1-2022: Foreword, Purpose and Scope
- Standard 90.1-2022: Section 4 – Administration & Enforcement
- Standard 90.1-2022: Section 4.2 – Compliance
- Standard 90.1-2022: Section 5 – Building Envelope
- Standard 90.1-2022: Section 6 – Heating, Ventilating & Air Conditioning
- Standard 90.1-2022: Section 10 – Other Equipment
- Standard 90.1-2022: HVAC Airflow impact & Design Considerations

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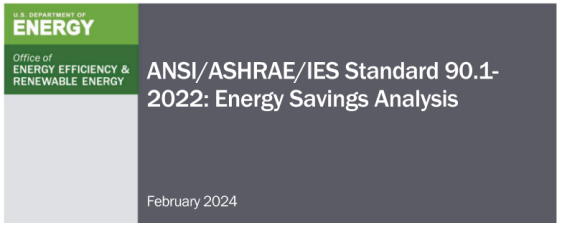
Department of Energy (DOE):

ANSI/ASHRAE/IES Standard 90.1-2022: Energy Savings Analysis



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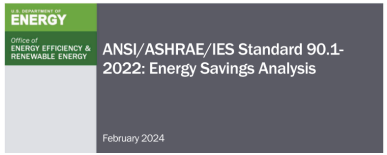
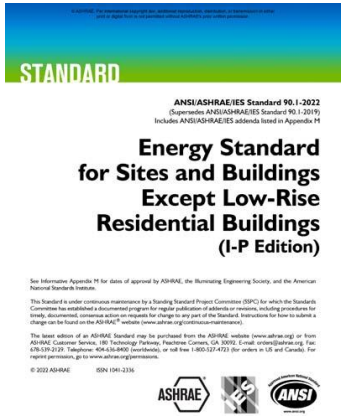
DOE: Energy Savings Analysis

Executive Summary:

- “**Title III of the Energy Conservation and Production Act**…establishes **requirements for DOE to review** consensus-based **building energy conservation standards**.”
- “…**whenever the ANSI/ASHRAE/IESNA Standard 90.1-1989**, or any successor to that code, is revised, **the Secretary of Energy must make a determination,** not later than 12 months after such a revision, **whether the revised code would improve energy efficiency in commercial buildings**…” “
- **ASHRAE published Standard 90.1-2022 in January 2023**, triggering the statutorily required DOE review process.”

U.S. DEPARTMENT OF ENERGY





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DOE: Energy Savings Analysis

ASHRAE Standard 90.1-2022 & DOE:

FEDERAL REGISTER
The Daily Journal of the United States Government

- **Federal Register: March 6, 2024**
  - **Determination Regarding Energy Efficiency Improvements in ANSI/ASHRAE/IES Standard 90.1-2022**
    - **Summary: "***The U.S. Department of Energy (DOE) has reviewed* ***ANSI/ASHRAE/IES Standard 90.1-2022:…and determined the updated edition would improve energy efficiency in commercial buildings.*****"**

US Department of Energy

ASHRAE

- *"DOE analysis indicates that buildings meeting Standard 90.1-2022, as compared with buildings meeting the previous 2019 edition,* ***would result in a national average site energy savings of 9.8 percent of commercial building energy consumption…"***
- *"****Under the Energy Conservation and Production Act****,…each State is* ***required to review*** *the provisions of their commercial building code…and* ***update their codes to meet Standard 90.1-2022****…"*

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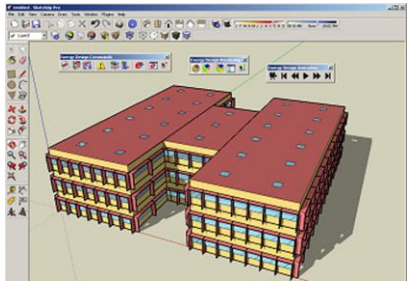
DOE: Energy Savings Analysis

Methodology:

- **How did the DOE arrive at its determination?**
  - A combination of **"Qualitative** and **Quantitative** assessments

- **Qualitative:** "The…analysis was a comparative **review of the textual requirements of the Standard**, examining specific changes (known as **"addenda"**) made between Standard 90.1-2022 and the previous 2019 edition. **Addenda with direct impact on energy use were identified and their anticipated impact on energy use was determined.**"

(Graphics: DOE EnergyPlus)



- **Quantitative:** "…examined the impact of addenda having a direct impact on energy use. **The quantitative phase uses whole-building energy simulation** and **relies upon the established DOE methodology for energy analysis**, which is based on **16 representative building types across all U.S. climate zones, as defined by Standard 90.1**…"

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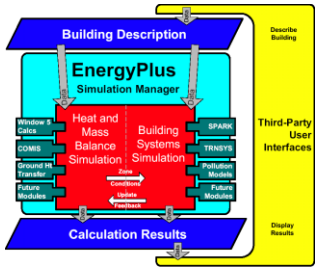
DOE: Energy Savings Analysis

3.3 Quantitative Analysis: Standard 90.1 Energy Use Impact

- **"Whole-building energy models** were used to **quantify the impact of addenda on energy use"**
- "Individual **building models were created to represent** each unique combination of **mandatory and prescriptive requirements for Standard 90.1-2019** for each of the **16 prototype building in each of the 16 climate zones**".



(Graphics: Berkeley Lab)

- "Each of these "compliant" models was then duplicated, with the second version amended only to incorporate the **new requirements of Standard 90.1-2022**
- "The models were simulated using ***EnergyPlus Version 22.1.0*** **(DOE 2022).**"

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DOE: Energy Savings Analysis

3.3 Quantitative Analysis: Applied Climate Data

- The DOE analysis references **ASHRAE Standard 169-2013** for regional climate data showing **Arizona's Maricopa County to be Zone 2B.**
- **NOTE: ASHRAE Standard 169-2012020 changes Arizona's Maricopa County climate zone designation from Zone 2B to Zone 1B**

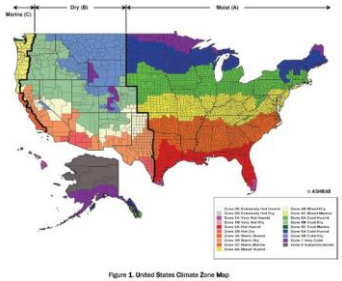


Figure 1. United States Climate Zone Map

(ASHRAE Standard 169-2013-Climatic Data for Building Design Standards)

- **Standard 169-2012020 re-designation will result in subsequent changes to future Standard 90.1 editions.**

Maricopa				1B
	BUCKEYE	720644	33.417	-112.683
	LUKE AFB	722785	33.533	-112.383
	PHOENIX DEER VALLEY	722784	33.688	-112.082
	PHOENIX SKY HARBOR	722780	33.428	-112.004
	SCOTTSDALE	722789	33.623	-111.911

(ASHRAE Standard 169-2020-Climatic Data for Building Design Standards)

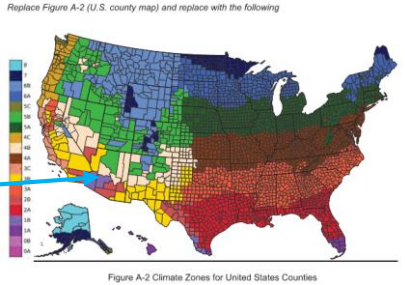


Figure A-2 Climate Zones for United States Counties

(ASHRAE Standard 169-2020-Climatic Data for Building Design Standards)

DOE: Energy Savings Analysis

4.1 Qualitative Analysis: Results

- "The qualitative analysis concluded that **39 of the 89 addenda had a direct impact on energy use…in commercial buildings**."

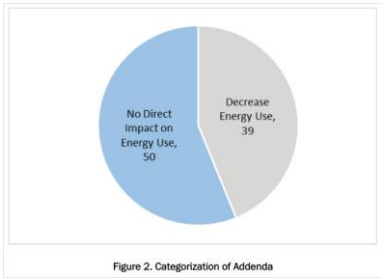
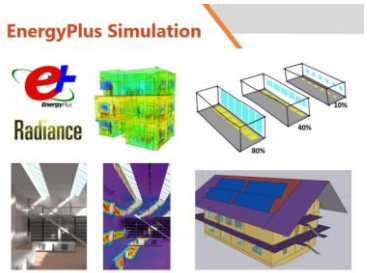


Figure 2. Categorization of Addenda

4.2 Quantitative Analysis: Results

- "**A summary of the quantitative analysis** results…**is provided in Table 5**."
  - "**Gross Energy Savings:** the total energy consumed by end uses in the building on the building site."
  - "**Net Energy**": the energy provided to the building by the grid and is calculated as the difference between on-site renewable energy generation



DOE: Energy Savings Analysis

4.2 Quantitative Analysis Results:

- **Weighted National Average Simulation Summary Results:**
  - **"Site" Gross Energy Savings: 2022 vs 2019 = 9.8%**
  - **"Site" Net Energy Savings (including renewable energy): 2022 vs 2019 = 14.0%**

Table 5. Weighted National Average Simulation Summary Results

	Gross Energy Savings			Net Energy Savings (including renewable energy)		
Annual Result Metric	90.1-2019	90.1-2022	2022 vs 2019	90.1-2019	90.1-2022	2022 vs 2019
Site Energy [kBtu/ft2-yr]	47.8	43.1	9.8%	47.8	41.1	14.0%
Source Energy [kBtu/ft2-yr]	108.5	98.3	9.4%	108.5	92.5	14.7%
Energy Cost [$/ft²-yr]	$1.35	$1.23	8.9%	$1.35	$1.15	14.8%
Emissions [tons/kft2-yr]	7.5	6.8	9.3%	7.5	6.4	14.7%

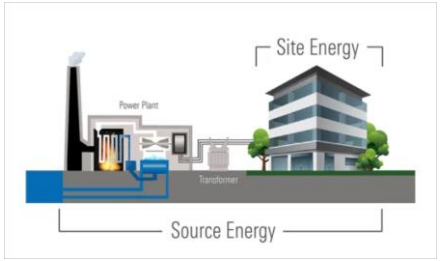
DOE: Energy Savings Analysis

4.2 Quantitative Analysis Results:

- Table 7: Estimated Gross **Energy Use Intensity (EUI)** by Building Type
  - Large Office
    - **Site EUI (kBtu/ft²yr)** 2019 vs 2022 = 3.7 EUI Reduction
    - **Source EUI (kBtu/ft²yr)** 2019 vs 2022 = 10.1 EUI Reduction

Table 7. Estimated Gross Energy Use Intensity by Building Type – Standard 90.1-2019

Building Type	Prototype Building	Whole Building Energy Metrics				
		Floor Area Weight	Site EUI (kBtu/ft²-yr)	Source EUI (kBtu/ft²-yr)	ECI ($/ft²-yr)	Carbon Emissions (tons/kft²-yr)
Office	Small Office	3.8%	28.2	78.3	$1.01	5.7
	Medium Office	5.0%	30.8	79.6	$1.02	5.7
	Large Office	3.9%	53.9	147.6	$1.90	10.7
Retail	Standalone Retail	10.9%	46.8	103.7	$1.29	7.1
	Strip Mall	3.7%	50.2	121.4	$1.53	8.6
Education	Primary School	4.8%	43.9	101.6	$1.27	7.1
	Secondary School	10.9%	39.1	94.0	$1.18	6.6
Healthcare	Outpatient Healthcare	3.4%	99.6	228.9	$2.86	15.9
	Hospital	4.5%	100.4	236.7	$2.97	16.6
Lodging	Small Hotel	1.6%	61.3	119.0	$1.44	7.8
	Large Hotel	4.2%	84.4	164.8	$1.99	10.9
Warehouse	Warehouse	18.6%	13.8	27.1	$0.33	1.8
Food Service	Quick-Service Restaurant	0.3%	502.2	860.8	$10.09	54.1
	Full-Service Restaurant	1.0%	341.5	641.8	$7.70	41.8
Apartment	Mid-Rise Apartment	13.7%	39.3	103.6	$1.33	7.5
	High-Rise Apartment	9.6%	45.3	95.3	$1.17	6.5
National Weighted Average		100%	47.8	108.5	$1.35	7.5



ENERGY STAR

Table 8. Estimated Gross Energy Use Intensity by Building Type – Standard 90.1-2022

Building Type	Prototype Building	Whole Building Energy Metrics				
		Floor Area Weight	Site EUI (kBtu/ft2-yr)	Source EUI (kBtu/ft²-yr)	ECI ($/ft²-yr)	Carbon Emissions (tons/kft²-yr)
Office	Small Office	3.8%	25.7	71.4	$0.92	5.2
	Medium Office	5.0%	27.5	70.4	$0.90	5.0
	Large Office	3.9%	50.2	137.5	$1.77	10.0
Retail	Standalone Retail	10.9%	39.3	87.9	$1.09	6.1
	Strip Mall	3.7%	40.6	99.7	$1.26	7.1
Education	Primary School	4.8%	41.6	97.0	$1.22	6.8
	Secondary School	10.9%	36.4	87.7	$1.11	6.2
Healthcare	Outpatient Healthcare	3.4%	90.8	207.8	$2.60	14.4
	Hospital	4.5%	93.0	218.9	$2.75	15.3
Lodging	Small Hotel	1.6%	53.9	105.2	$1.27	6.9
	Large Hotel	4.2%	75.0	148.1	$1.80	9.8
Warehouse	Warehouse	18.6%	12.8	25.0	$0.30	1.6
Food Service	Quick-Service Restaurant	0.3%	469.4	808.9	$9.50	50.9
	Full-Service Restaurant	1.0%	316.5	600.0	$7.21	39.2
Apartment	Mid-Rise Apartment	13.7%	35.5	94.2	$1.21	6.8
	High-Rise Apartment	9.6%	40.0	85.3	$1.05	5.8
National Weighted Average		100%	43.1	98.3	$1.23	6.8

* Site EUI: "…the amount of heat and electricity consumed by a building as reflected in your utility bills."
* Source EUI: "the **total amount of raw fuel** that is required to operate the building. It incorporates all transmission, delivery, and production losses…"

*(Energy Star: *The Difference between Site & Source Energy)*

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ASHRAE Standard 90.1: Timeline and Future Direction

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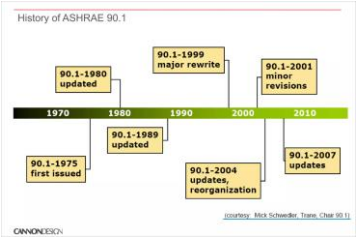
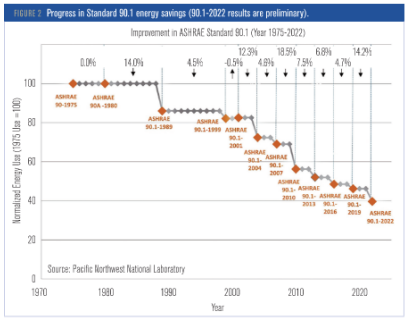
Timeline and Future Direction

ASHRAE Standard 90.1

- **Why did ASHRAE created Standard 90.1?**
  - To create “a consensus standard to provide minimum requirements for the energy-efficient design of new and renovated or retrofitted building.”
  - **When:** **Standard 90** ***Optimum Energy Utilization Through Technology*** was published in 1975 in response to the 1970’s energy crisis



(Graphic: Canon Design)



- **In 2001 is was put on a 3 year maintenance program and** renamed to **Standard 90.1**
- **ASHRAE’s Decarbonization Goal: By 2030 to “at least halve” building 2015 GHG emissions and to be net zero by 2050**

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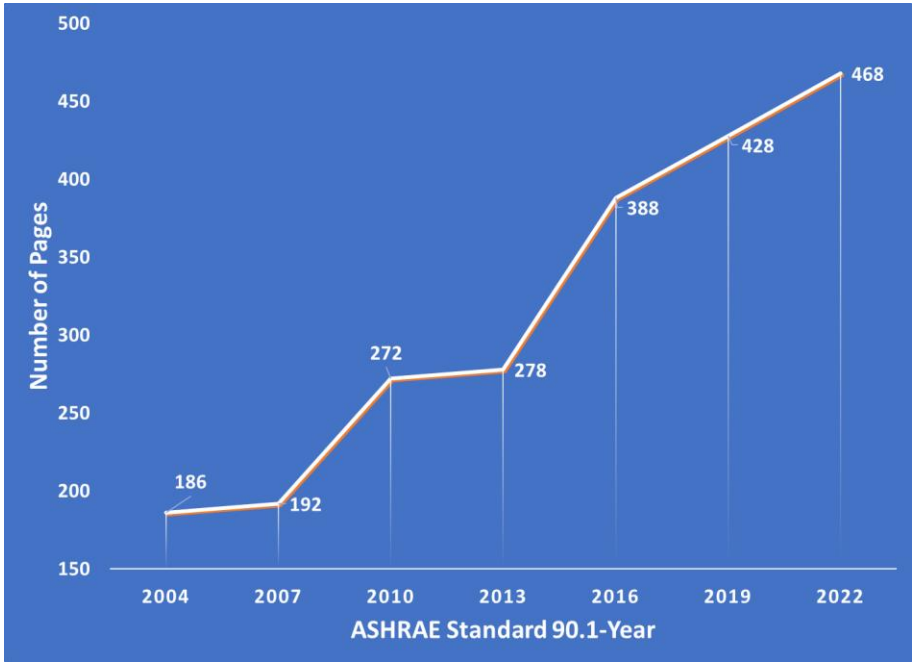
Timeline and Future Direction

ASHRAE Standard 90.1-2022 Expansion



(Courtesy: Jeff Seewald, Daikin)

Approaching 500 pages

Wherever one throws the dart of conscious attention relevant material becomes apparent

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International Energy Conservation Council (IECC) - 2021

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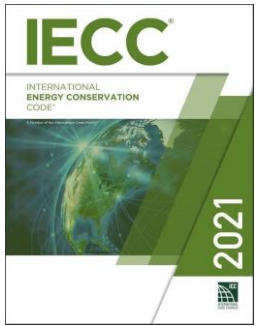
IECC - 2021

International Code Council (ICC)

- **Goal:** to develop a single set of national model construction codes

- **International Energy Conservation Code (IECC) was created by the ICC in year 2000**
  - **Purpose:** to address energy conservation requirements for all aspects of energy uses in both commercial and residential construction
  - **The code is updated every 3 years** to provide an ongoing standard of best practices for energy efficiency



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IECC - 2021

IECC Code & ASHRAE Standard 90.1: Compliance

- **IECC code Section 401.2, requires that one of the following must be met:**

1. **Compliance with ASHRAE 90.1;**
2. Satisfying prescriptive requirements for Building Envelope Requirements, Building Mechanical Systems, Service Water Heater…etc.
3. Demonstrating that the building energy cost is 85% of the standard reference design

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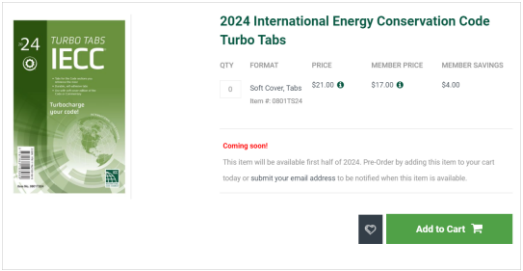
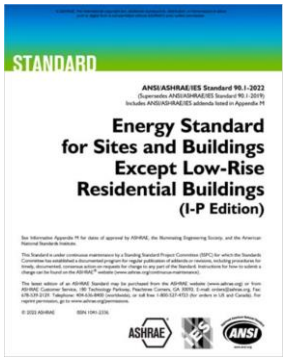
IECC - 2021

IECC Code & ASHRAE Standard 90.1:

- **IECC updated code versions are published two years after each ASHRAE 90.1 edition**
  - Example: IECC (2018) lists ASHRE Standard 90.1-2016 as a compliance path
  - When will IECC (2024) be published?





- When **IECC (2024)** is published, **ASHRAE Standard 90.1-2022** will be adopted as a compliant path

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IECC - 2021

IECC Code & ASHRAE Standard 90.1:

- Arizona Municipal Code Adoption List:
  - **Complied by ASHRAE Central Arizona Chapter**

MUNICIPALITY	BUILDING CODE	MECHANICAL CODE	PLUMBING CODE	FIRE CODE	ELECTRICAL CODE	ENERGY CODE	CONTACT INFO (search for specific code amendments online)
Avondale	2018 IBC	2018 IMC	2018 IPC	2018 IFC	2017 NEC	2018 IECC	623-333-4000 https://www.avondaleaz.gov/government/departments/development-services/building-division
Buckeye	2018 IBC	2018 IMC	2018 IPC	2018 IFC	2017 NEC	2018 IECC	623-349-6000 https://www.buckeyeaz.gov/business/development-services/building-safety
Casa Grande	2018 IBC	2018 IMC	2018 IPC	2018 IFC	2017 NEC	2018 IECC	520-421-8630 https://casagrandeaz.gov/245/Regulatory-Bill-of-Rights-Directory-of-D
Cave Creek	2021 IBC	2021 IMC	2021 IPC	2021 IFC	2020 NEC	2021 IECC	480-488-6637 https://www.cavecreekaz.gov/578/Building-Safety
Chandler	2021 IBC	2021 IMC	2021 IPC	2021 IFC	2020 NEC	2021 IECC	480-782-3000 https://www.chandleraz.gov/government/departments/development-services/building-safety-plan-review-permits-and-inspections
Coolidge	2006 IBC	2006 UMC	2006 IPC & 2006 IFGC	2006 IFC	2002 NEC	2006 IECC	520-723-6075 https://www.coolidgeaz.com/?SEC=420C0420-478D-4093-8E66-6944B9B39E6E
Flagstaff	2018 IBC	2018 IMC	2018 IPC	2018 IFC	2017 NEC	2018 IECC	928-779-7631 https://www.flagstaff.az.gov/DocumentCenter/View/61174/2019-Adopted-Building-Codes?bidId=
Fountain Hills	2018 IBC	2018 IMC	2018 IPC	2018 IFC	2017 NEC	2018 IECC	480-837-2003 https://www.fountainhillsaz.gov/208/Adopted-Codes

- City of Phoenix (2024): **2018 IECC**, 2018 IBC and 2018 IMC

Phoenix	2018 IBC	2018 IMC	2018 IPC	2018 IFC	2017 NEC	2018 IECC	623-773-7225 https://www.phoenix.gov/pdd/devcode/buildingcode

ASHRAE Standard 90.1-2022: Foreword, Section #1 & #2: Purpose & Scope

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Foreword, Purpose and Scope

Foreword:

- **“The 2022 edition of Standard 90.1 incorporates more than 80 addenda to the 2019 edition and includes numerous energy-saving measures.”**

Table 1. Number of Addenda affecting Various Sections in Standard 90.1-2022

Section of 90.1-2022	Number of Addenda
5. Building Envelope	7
6. Heating, Ventilating, and Air Conditioning	26
7. Service Water Heating	2
8. Power	2
9. Lighting	13
10. Other Equipment	3
11. Additional Efficiency Requirements	1
Performance Compliance (including Sections 4.2.1.1, 12, and Appendices L and G)	29
Others	6
Total	89

Foreword: General

- “The scope…has been expanded **to include sites** as well as buildings, **enabling regulation of energy use** associated with the building but **not the building itself.**…”

- “A **minimum prescriptive requirement (Section 10.5) for on-site renewable energy** has been added. This requirement includes exceptions…where PV installations would be problematic.”

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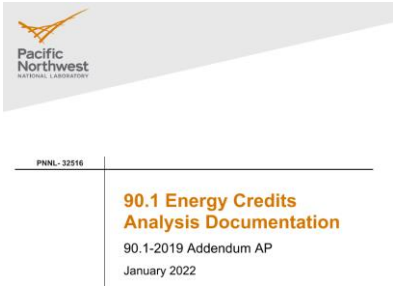
Foreword, Purpose and Scope

Foreword: General

- **Building "Energy Credits": Definition**
  - "Energy credits provide for additional required **prescriptive savings** that are **more flexible than base prescriptive requirements**"



- "**A new energy credit requirement (new Section 11)**… that enables approximately 4% to 5% cost-effective energy savings through **33 different energy-saving measures**."

- "…**in the 2021 International Energy Conservation Code, energy credit measures were expanded** from selecting 1 of 8 alternate options **to 15 available energy saving measures** that can be flexibly selected to achieve a 5% level of energy savings.

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Foreword, Purpose and Scope

Foreword: 90.1-2022, 90.1-2019 & 90.1-2016 Comparison

- **Administration and Enforcement:**
  - "There were no major changes to administration and enforcement."
    - **"Notable Changes" to these Sections:**
      - **Building Envelope**
      - **Lighting and Power**
      - **Mechanical**
      - **Performance Rating Method (Appendix G)**
      - **Both Performance-Based Compliance Paths (Section 12 [Energy Cost Budget Method] and Appendix G)**
      - **New Normative Appendix J: Sets of Performance Curves**

(Helios Educational Foundation: Architekton)

(Helios Educational Foundation: Architekton)

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Foreword, Purpose and Scope

1. Purpose:

1.1 To establish the ***minimum-efficiency*** **requirements** of *buildings* other than *low-rise residential buildings,* and sites for:

a. design, *construction*, and a plan for operation and maintenance

b. utilization of *on-site renewable energy* resources.

(DOE Better Buildings)

2. Scope:

2.1 This standard provides

(Alliance Commercial)

a. **minimum energy- efficient requirements** for the design and construction, and **plan for operation and maintenance** of

1. New *buildings* and their *systems*

2. New portions of *buildings* and their *systems*

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Foreword, Purpose and Scope

2. Scope: 2022 – Minimum Energy Line 5 added

2.1 This standard provides

a. **minimum energy- efficient requirements** for the design and construction, and **plan for operation and maintenance** of

3. **New *systems* and *equipment* specifically identified in this standard that are part of a *site***

4. New *systems* and *equipment* in *existing buildings*, and

5. **New *equipment* or *building systems* specifically identified in this standard that are part of *process applications**.**

***Process Application:** "a manufacturing, industrial, or commercial procedure or activity where the primary purpose is other than conditioning* spaces *and maintain comfort and amenities for the occupants of a building"*

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ASHRAE Standard 90.1-2022 Section 4: Administration and Enforcement

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Administration and Enforcement

4. Administration and Enforcement:

4.1 General: 2022 vs 2016

4.1.1 Scope

(ASU ISTB-7: Graywolf DBM Global)

- 4.1.1.1 New Buildings.
- 4.1.1.2 Additions to Existing Buildings.
- 4.1.1.3 Alterations of Existing Buildings.
- 4.1.1.4 Replacement of Portions of Existing Buildings.
- 4.1.1.5 Changes in Space Conditioning.

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Administration and Enforcement

4. Administration and Enforcement:

(Photo by: SolarMaster)

4.1 General: 2022 Addition

4.1.1 Scope: (New Site Paragraph)

4.1.1.6 "Sites and New Site Systems and Equipment. *Sites*, with or without a contiguous *building* or *buildings*, and *site systems* and *equipment* using or producing *energy*, such as *site* lighting, motors for *pumps* (for example, fountain *pumps* and water movement *equipment*), and transportation *equipment* (for example, elevators and escalators) **shall comply with the standard as described in Section 4.2 for *systems* and *equipment*** specifically identified in the standard."

(Photo by: Terrapass)

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Administration and Enforcement

4. Administration and Enforcement:

4.1 General: 2022 vs 2016

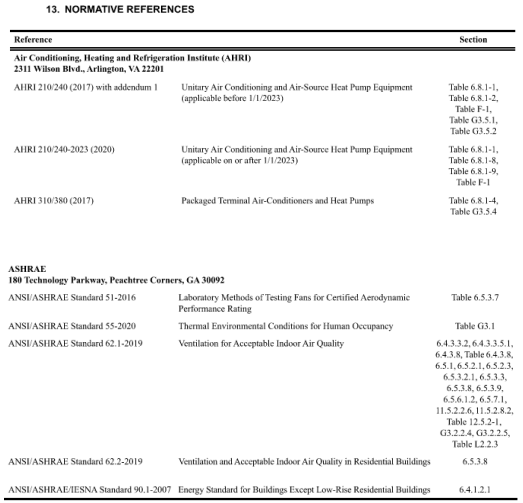
4.1.6 Referenced Standards. The standards referenced in this standard and listed in **Section 13** shall be considered part of the requirements of this standard…Where differences occur between the provision of this standard and referenced standards, **the provisions of this standard shall apply**.

4.1.7 Normative Appendices. (Unchanged)

4.1.8 Informative Appendices. (Unchanged)

4.1.9 Referenced Standard Reproduction Annex. (Unchanged)

(Section 13: Normative References)



13. NORMATIVE REFERENCES

Reference		Section
Air Conditioning, Heating and Refrigeration Institute (AHRI) **2311 Wilson Blvd., Arlington, VA 22201**		
AHRI 210/240 (2017) with addendum 1	Unitary Air Conditioning and Air-Source Heat Pump Equipment (applicable before 1/1/2023)	Table 6.8.1-1, Table 6.8.1-2, Table F-1, Table G3.5.1, Table G3.5.2
AHRI 210/240-2023 (2020)	Unitary Air Conditioning and Air-Source Heat Pump Equipment (applicable on or after 1/1/2023)	Table 6.8.1-1, Table 6.8.1-8, Table 6.8.1-9, Table F-1
AHRI 310/380 (2017)	Packaged Terminal Air-Conditioners and Heat Pumps	Table 6.8.1-4, Table G3.5.4
ASHRAE **180 Technology Parkway, Peachtree Corners, GA 30092**		
ANSI/ASHRAE Standard 51-2016	Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating	Table 6.5.3.7
ANSI/ASHRAE Standard 55-2020	Thermal Environmental Conditions for Human Occupancy	Table G3.1
ANSI/ASHRAE Standard 62.1-2019	Ventilation for Acceptable Indoor Air Quality	6.4.3.3.2, 6.4.3.3.5.1, 6.4.3.8, Table 6.4.3.8, 6.5.1, 6.5.2.1, 6.5.2.3, 6.5.3.2.1, 6.5.3.3, 6.5.3.8, 6.5.3.9, 6.5.6.1.2, 6.5.7.1, 11.5.2.2.6, 11.5.2.8.2, Table 12.5.2-1, G3.2.2.4, G3.2.2.5, Table L2.2.3
ANSI/ASHRAE Standard 62.2-2019	Ventilation and Acceptable Indoor Air Quality in Residential Buildings	6.5.3.8
ANSI/ASHRAE/IESNA Standard 90.1-2007	Energy Standard for Buildings Except Low-Rise Residential Buildings	6.4.1.2.1

*Designation Section 13 was changed from Section 12 referenced in 90.1-2016

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ASHRAE Standard 90.1-2022 Section 4.2: Compliance

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Compliance

4.2 Compliance:

4.2.1 Compliance Paths:

4.2.1.1 New Buildings. New *buildings* shall **comply with Section 4.2.2 through 4.2.5 and either the provisions of**

Prescriptive →

a. **Section 5,** "Building Envelope"; **6, "Heating, Ventilating, and Air Conditioning";** 7, "Service Water Heating"; 8, "Power"; 9, "lighting";10, "other Equipment; and **11, "Additional Efficiency Requirements** or

Performance →

b. **Section 12*,** "Energy Cost Budget Method," or

Performance →

c. **Normative Appendix G,** The **Performance Cost Index (PCI)** of new buildings,…to existing buildings shall be less than or equal to the **Performance Cost Index Target (PCI_t)** when calculated in accordance with the following**

*Section 12 was referenced as Section 11 in 2016 version

** Language changed in Standard 90.1-2019 version

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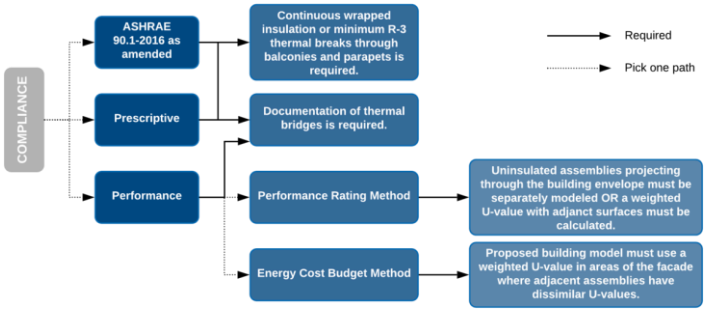
Compliance

Mandatory

4.2 Compliance:

4.2.1 Compliance Paths:

4.2.1.1 New Buildings. New *buildings* shall **comply with Section 4.2.2 through 4.2.5:**



(Graphic: Schock group

4.2.2 Compliance Documentation

4.2.3 Labeling of Material and Equipment

4.2.4 Inspections

4.2.5 Verification, Testing, and Commissioning

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Compliance

Prescriptive

4.2 Compliance:

- **Prescriptive Path Definition:** "…a compliance method in the commercial building energy code ASHRAE Standard 90.1 that establishes criteria for **energy related characteristics of individual building components.**

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

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure[a]
Air conditioners, air cooled (continued)	≥240,000 Btu/h and <760,000 Btu/h	*Electric resistance* (or none)	Split *system* and single package	10.0 *EER* 11.6 *IEER* before 1/1/2023 13.2 *IEER* after 1/1/2023	AHRI 340/360
		All other		9.8 *EER* 11.4 *IEER* before 1/1/2023 13.0 *IEER* after 1/1/2023	
	≥760,000 Btu/h	*Electric resistance* (or none)		9.7 *EER* 11.2 *IEER* before 1/1/2023 12.5 *IEER* after 1/1/2023	
		All other		9.5 *EER* 11.0 *IEER* before 1/1/2023 12.3 *IEER* after 1/1/2023	

(ASHRAE 90.1 Table 6.8.1-1)

- **Section Examples:**
  - **"Building Envelope":** Minimum R-values of insulation and maximum U-factors and solar heat gain coefficients of fenestration
  - **"Heating, Ventilating, and Air Conditioning":** Minimum SEER2, ISMRE, IPLV Performance ratings and economizer requirements
  - **"Lighting":** Maximum lighting power allowance

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Compliance

Prescriptive

Mandatory

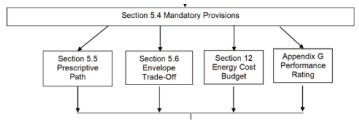
4.2 Compliance: Prescriptive Path

4.2.1 Compliance Paths

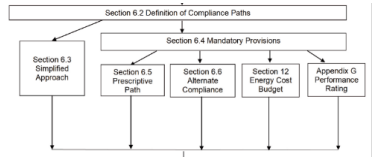
Note: The prescriptive path will provide MINIMUM efficiency levels for code compliance

4.2.1.1(a):

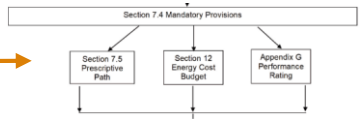
Section 5, “Building Envelope”;



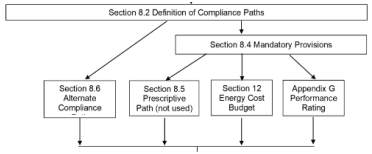
Section 6, “Heating, Ventilating, and Air Conditioning”;



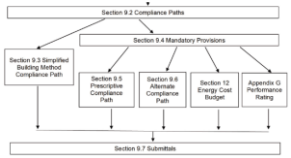
Section 7, “Service Water Heating”;



Section 8, “Power”;



Section 9, “Lighting’”



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Compliance

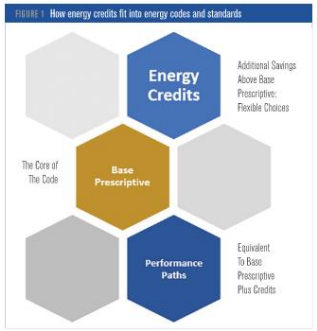
Prescriptive

Mandatory

4.2 Compliance:

4.2.1 Compliance Paths: (90.1-2022 Added Section)

- **Section 11: Additional Efficiency Requirements**
  - A **new mandatory section** which has 33 energy- efficient measures from which a design can choose to satisfy the total required “Energy Credits” for a given building type and climate zone



  - **Energy credits are a prescriptive requirement in addition to the base energy code requirements.**
  - Instead of all measures being required, the building designer can select from a menu of options to achieve a required level of energy **performance…to target approximately 5% increased energy cost savings**.”

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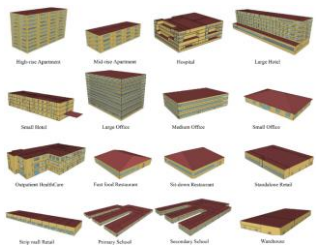
Compliance

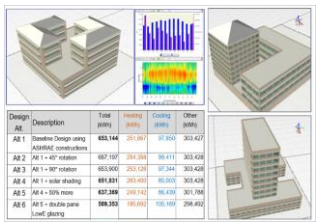
Performance

4.2 Compliance: Performance Path

- **4.2.1.1(b) Section 12: Energy Cost Budget (ECB) Method**



(ASHRAE 90.1 Building Models)



(Graphic: Simergy)

- **ECB Method Scope (Section 12.1.1)**
  - "…is an alternative to the prescriptive provisions of this standard. It may be employed for evaluating the compliance of all *proposed designs* except designs with no mechanical *system.*"
  - **Allows for trade-offs of prescriptive measures providing building performance target is met**
  - "**Building-type-specific targets** were developed with **a goal of 5% total energy cost savings**.*"
  - ***Informative Note:*** To fully utilize…a *building energy* model during the design process, the methodology described in **ASHRAE Standard 209** should be considered..

*Pacific Northwest National Laboratory (PNNL) 90.1 Energy Credits Analysis Documentation (90.1-2019 Addendum AP)

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Compliance

Performance

4.2 Compliance: Performance Path

- **4.2.1.1(b) Section 12: Energy Cost Budget (ECB) Method**
  - **Compliance:** The proposed *building* design shall comply with all of the following:
    - **a. Sections 5.2.1, 6.2.1, 7.2.1, 8.2.1, 9.2.1, and 10.2.1**
    - b. The design *energy* cost shall comply with the following:

$$\textit{Design Energy Cost} \leq \textit{Energy Cost Budget} \times (1 - EC_{req} / 1000 \times A_{adj})$$

(ASHRAE 90.1 Section 11 ECB Tables)

Table 11.5.1-1 Energy Credit Requirements by Building Use Type

Building Use Type [a]	Climate Zone																	
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily [b]	50	50	50	50	50	50	46	50	50	48	50	46	50	50	49	50	50	50	50
Health care [c]	50	46	47	46	47	45	49	47	50	46	46	50	50	50	50	50	50	50	50
Hotel/motel	50	45	47	46	49	48	46	47	50	48	50	50	47	46	47	49	46	50	50
Office [d]	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Restaurant [e]	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Retail	50	50	50	50	50	50	50	50	50	50	50	50	49	50	47	48	45	42	46
Education [f]	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	46
Warehouse [g]	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Other [h]	39	36	37	37	35	34	30	32	33	28	32	30	29	31	30	29	30	29	29

Table 11.5.1-2 Renewable Adjustment Credits

Building Use Type	PV_{adj} by Climate Zone																		PV_{max} W/ft²
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8	
Multifamily	6	7	8	7	8	18	16	19	20	13	13	14	6	9	13	6	7	6	5	0.1
Health care	3	3	3	3	3	4	3	4	7	5	7	3	2	3	3	3	3	2	2	0.1
Hotel/motel	4	8	9	9	9	12	10	13	8	9	10	8	8	12	9	9	10	8	5	0.1
Office	6	6	7	7	12	8	8	9	10	7	9	7	6	8	7	6	7	6	5	0.1
Restaurant	1	1	1	1	1	2	1	2	2	1	2	1	1	1	1	1	1	1	1	0.1
Retail	5	5	6	6	7	8	14	17	16	7	14	12	10	14	12	10	12	10	7	0.1
Education	5	6	7	6	7	9	16	14	12	11	11	9	11	11	9	12	10	12	10	0.1
Warehouse	20	20	20	20	20	20	20	20	20	19	20	20	14	20	20	12	17	12	10	0.1
Other	6	6	7	7	7	8	7	9	9	7	9	7	5	8	7	6	7	5	4	0.1

- **Where:**
- EC_{req} = *energy* credits required for the *building* in accordance with **Section 11.5.1**
- A_{adj} = Where the project includes *additions* or *alterations* use an adjustment factor as follows; otherwise use 1.0:

$$A_{adj} = \frac{\textit{Addition Gross Floor Area + Alteration Gross Floor Area}}{\textbf{Modeled } \textit{gross floor area}}$$

- *Design Energy Cost* = as calculated in Section 12.5
- *Energy cost budget* = as calculated in Section 12.5

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Compliance

Performance

4.2 Compliance: Performance Path

- 4.2.1.1(b) **Section 12:** Energy Cost Budget Method
  - 12.5 Calculations of Design Energy Cost and Energy Cost Budget
    - **Simulated modeling requirements** to calculate *Design Energy Cost* and *Energy Cost Budgets* are **to be found in Table 12.5.1**
      - **12.5.2 HVAC Systems.** The *HVAC system* type and related performance parameters for the ***budget building design***… determined from **Figure 12.5.2**, the *system* descriptions in Table **12.5.2-1** and accompanying notes, and the following rules:
        - **b. Minimum Equipment Efficiency.**
        - **c. Supply Fan Energy in Certain Package Equipment.**
        - **d. Minimum Outdoor Air Ventilation Rate.**
        - **e. Economizers.**

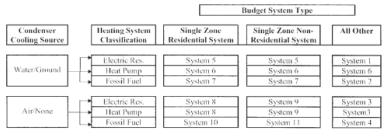

Figure 12.5.2 HVAC systems map.

Table 12.5.2-1 Budget System Descriptions

System No.	System Type	Fan Control	Cooling Type	Heating Type
1	*VAV* with parallel fan-powered boxes[a]	*VAV*[d]	Chilled water[e]	*Electric resistance*
2	*VAV* with reheat[b]	*VAV*[d]	Chilled water[e]	Hot-water *fossil fuel* boiler[f]
3	Packaged *VAV* with parallel fan-powered boxes[a]	*VAV*[d]	Direct expansion[e]	*Electric resistance*
4	Packaged *VAV* with reheat[b]	*VAV*[d]	Direct expansion[e]	Hot-water *fossil fuel* boiler[f]
5	Two-pipe fan coil	Single- or two-speed fan [c]	Chilled water[e]	*Electric resistance*
6	Water-source heat pump	Single- or two-speed fan [c]	Direct expansion[e]	Electric heat pump and boiler[g]
7	Four-pipe fan-coil	Single- or two-speed fan [c]	Chilled water[e]	Hot-water *fossil fuel* boiler[f]
8	*Packaged terminal heat pump*	Single-speed fan[c]	Direct expansion[e]	Electric heat pump[h]
9	Packaged rooftop heat pump	Single- or two-speed fan [c]	Direct expansion[e]	Electric heat pump[h]
10	*Packaged terminal air conditioner*	Single-speed fan[c]	Direct expansion	Hot-water *fossil fuel* boiler[f]
11	Packaged rooftop air conditioner	Single- or two-speed fan [c]	Direct expansion	*Fossil fuel* furnace

*Section 12 was referenced as Section 11 in 2016 version

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Compliance

Performance

4.2 Compliance: High Performance Buildings

- **4.2.1.1 (c) Normative Appendix G:**
  - The **Performance Cost Index (PCI)** of new buildings, additions to existing buildings, and/or alterations to existing buildings shall be less than or equal to the **Performance Cost Index Target (PCI_t)** when calculated in accordance with the following*

$$PCI_t = [BBUEC + (BPF \times BBREC) - PRE^{**}] / BBP$$

PCI	=	Performance Cost Index calculated in accordance with **Section G1.2.2**
BBUEC	=	**baseline *building* unregulated *energy* cost**, the portion of the annual *energy* cost of a *baseline building design* that is due to *unregulated energy use*
BPF	=	***building* performance factor** from **Table 4.2.1.1…**
BBREC	=	**baseline *building* regulated *energy* cost**, the portion of the annual *energy* cost of a *baseline building design* that is due to *regulated energy use*

* Section G1.2.2 *Performance Cost Index* = $\frac{\textit{Proposed building performance}}{\textit{Baseline building performance}}$

VARITEC™

Compliance

Performance

4.2 Compliance: High-Performance Buildings

- **4.2.1.1(c) Normative Appendix G**
  - **The Renewable Energy Component**

(Photo: FacilitesNet)

$$PCI_t = [BBUEC + (BPF \times BBREC) - PRE] / BBP$$

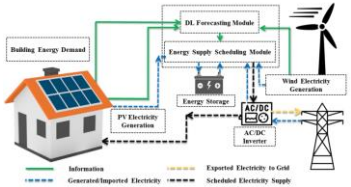
PRE = $PBP_{nre} - PBP_{pre}$

PBP = *proposed building performance,* including the reduced, annual *purchased energy* cost associated with all *on-site renewable energy* generation *systems*

PBP_{nre} = *proposed building performance* without any credit for reduced annual *energy* costs from *on-site renewable energy* generation *systems*

PBP_{pre} = *proposed building performance*, *excluding any renewable* energy system in the *proposed design* and including an *on-site renewable energy system* that meets but does not exceed the requirements of Section 10.5.1.1. modeled following the requirements for a ***budget building design**** in **Table 12.5.1**, row 15

BBP = *baseline building performance ($/year annual energy cost for a baseline building design.)*



(Graphic: ResearchGate (Azad Nabavi))d

**** budget building design:** a computer representation of a hypothetical design based on the actual proposed design.*

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Compliance

Performance

4.2 Compliance: High-Performance Buildings

- **4.2.1.1(c) Normative Appendix G**
  - **4.2.1.1 New Buildings.** New *buildings* shall comply with Section 4.2.2

BPF = *building* performance factor from **Table 4.2.1.1…**

Note:

- **Section 13 references ASHRAE Standard 169-2013 for regional climate zone**
- **Note: Maricopa County is listed as Zone 2B in the 169-2013 version**

Table 4.2.1.1 Building Performance Factor (BPF)

Building Area Type	Climate Zone																		
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Multifamily	0.69	0.68	0.71	0.70	0.72	0.72	0.71	0.76	0.63	0.69	0.76	0.71	0.66	0.72	0.71	0.65	0.67	0.65	0.67
Healthcare/hospital	0.69	0.69	0.70	0.68	0.67	0.65	0.65	0.66	0.64	0.64	0.66	0.63	0.67	0.65	0.65	0.66	0.67	0.68	0.70
Hotel/motel	0.66	0.66	0.69	0.65	0.65	0.64	0.64	0.65	0.65	0.63	0.65	0.63	0.62	0.63	0.62	0.61	0.62	0.59	0.58
Office	0.54	0.54	0.53	0.52	0.52	0.52	0.50	0.54	0.48	0.48	0.53	0.48	0.49	0.52	0.48	0.48	0.49	0.46	0.48
Restaurant	0.62	0.59	0.57	0.57	0.57	0.53	0.57	0.53	0.51	0.55	0.54	0.54	0.57	0.56	0.55	0.59	0.58	0.61	0.64
Retail	0.51	0.49	0.48	0.48	0.44	0.43	0.43	0.43	0.44	0.42	0.43	0.46	0.43	0.42	0.47	0.43	0.43	0.41	0.44
School	0.52	0.57	0.57	0.56	0.52	0.53	0.52	0.49	0.50	0.46	0.47	0.47	0.47	0.46	0.46	0.46	0.44	0.45	0.45
Warehouse	0.26	0.26	0.22	0.25	0.21	0.22	0.25	0.21	0.19	0.25	0.22	0.22	0.28	0.24	0.22	0.31	0.28	0.29	0.32
All others	0.62	0.60	0.62	0.59	0.55	0.51	0.53	0.52	0.55	0.53	0.52	0.55	0.53	0.53	0.56	0.54	0.54	0.54	0.54

- **Standard 169-2020 changed Maricopa County to Climate Zone 1B.**

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Compliance

Mandatory

4.2 Compliance:

4.2.2 Compliance Documentation: (No changes)

4.2.2.1 Construction Details: Compliant documents shall show all the pertinent data and features of the *building, equipment,* and *systems* in sufficient detail to permit a determination of compliance by the *building official* and to indicate compliance with the requirements of this standard.

4.2.2.2 Supplemental Information

4.2.2.3 Manuals

4.2.3 Labeling of Material and Equipment. (No changes)

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Compliance

Mandatory

4.2 Compliance:

4.2.4 Inspections: (New to the 2016 and 2019 Standards)

4.2.4.1 Fenestration Inspections.

4.2.4.2 Opaque Assembly Thermal Insulation Inspections.

4.2.4.3 Continuous-Air-Barrier Inspections.

(Photo: Façade + Envelope)

4.2.4.4 Operable Fenestration and Door Inspections

4.2.4.5 Loading-Dock Weatherseals Inspections

4.2.4.6 Other Inspections

VARITEC™

Compliance

Mandatory

4.2 Compliance:

4.2.5 Verification, Testing, and Commissioning. Building *systems*, controls, and the *building envelope* shall comply with Sections 4.2.5.1, 4.2.5.2, and 4.2.5.3.

Informative Notes:

1. There are **additional requirements within specific sections of this standard** regarding documentation, procedures, independence of providers, and reporting. **Requirements in individual sections are in addition to the general requirements** provided in Section 4.2.5.
2. See **Informative Appendix H for additional *commissioning* guidance**

VARITEC™

Compliance

Mandatory

4.2 Compliance:

4.2.5 Verification, Testing, and Commissioning.

(Significantly expanded upon from the 2016 Standard)

4.2.5.1 Building Systems Verification and Testing Requirements. Verification or ***functional performance testing (FPT)*** to confirm compliance with required provisions of this standard shall be performed on *building systems*, controls, and the *building envelope*, as required by Sections 5.9.1, 6.9.1, 7.9.1, 8.9.1, 9.9.1, 10.9.1, 12.2(e), and G1.2.1(e). Where testing is required but specific *FPT* procedures are not specified in this standard, testing shall use *generally accepted engineering standards* acceptable to the *building official.*

4.2.5.1.1 Information on Building Permit Application.

VARITEC™

Compliance

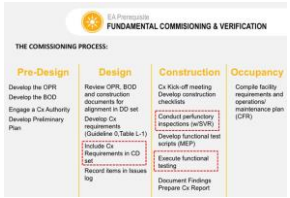
Mandatory

4.2 Compliance:

4.2.5 Verification, Testing, and Commissioning.

(Significantly expanded upon from the 2016 Standard)

4.2.5.2 Building Commissioning Requirements.



4.2.5.2.1 Commissioning Activities Prior to Building Permit Issuance. The following activities shall be completed prior to issuance of a *building* permit:

a. A copy of the *commissioning* plan shall be submitted to the owner. A copy of the *commissioning* plan shall be submitted with the *building* permit application if requested by the *building official.*

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Compliance

Mandatory

4.2 Compliance:

4.2.5.2 Building Commissioning Requirements.

4.2.5.2.1 Commissioning Activities Prior to Building Permit Issuance.

The following activities shall be completed prior to issuance of a *building* permit:

b. **A *commissioning provider* shall be designated** by the owner to manage *commissioning* activities **prior to completion of *construction documents.*** The *construction documents* shall identify the *commissioning provider.*

c. The *commissioning provider* shall submit the design review report to the owner.

d. ***Construction* phase *commissioning* requirements shall be incorporated into *construction documents.***

e. …etc.…etc.

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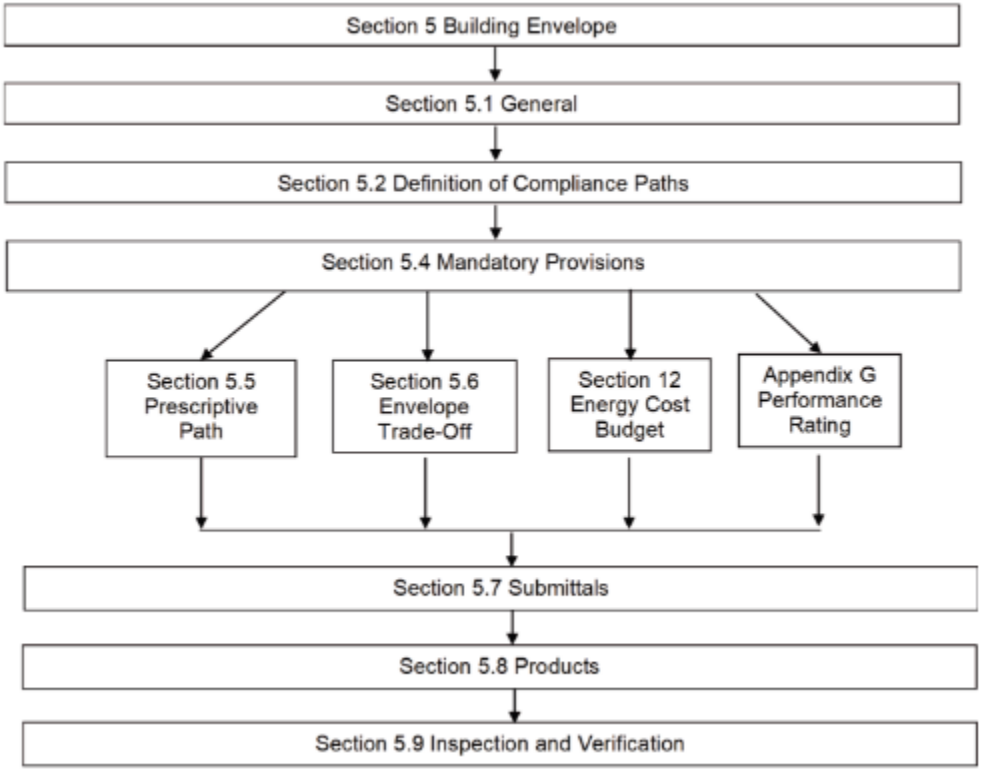
ASHRAE Standard 90.1-2022 Section 5: Building Envelope

VARITEC™

Building Envelope



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Building Envelope

5. Building Envelope:

5.2 Compliance Paths:

5.2.1 Requirements for All Compliance Paths. The *building envelope* shall comply with **Sections 5.1, "General"; 5.4, "Mandatory Provisions"; 5.7, "Submittals"; 5.8, "Product Information and Installation Requirements"; and 5.9, "Verification, Testing, and Commissioning."** **(No Changes from 2016 Standard)**

Prescriptive →

5.2.2 Additional Requirements to Comply with Section 5. The building envelope shall comply with either:

Performance →

a. Section 5.5, **"Prescriptive Building Envelope Compliance Path,"** provided that the fenestration area does not exceed the maximum allowed by Section 5.5.4.2

b. Section 5.6, **"Building Envelope Trade-Off Compliance Path."**

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Building Envelope

Mandatory

5. Building Envelope:

5.3 Simplified Building Compliance Path (Not Used)

5.4 Mandatory Provisions:

5.4.1 Insulation. Where insulation is required…it shall comply with the requirements found in Section 5.8.1.

5.4.2 Fenestration and Doors. Procedures for determining fenestration and door performance are described in Section 5.8.2…

5.4.3 Air Leakage.

a. Air leakage control for the building envelope shall comply with this section. Materials and assemblies that are part of the continuous air barrier and fenestration and doors shall comply with Section 5.8.3.

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Building Envelope

Mandatory

5. Building Envelope: 5.4 Mandatory Provisions

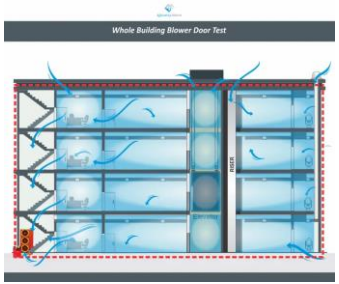
5.4.3 Air Leakage.

b. The *exterior building envelope* and the *semiexterior building envelope* **shall have a continuous air barrier complying with Sections 5.4.3.2 and 5.4.3.2**

5.4.3.1 Whole Building Leakage:

5.4.3.1.1 New Buildings **less than 10,000 ft² or gross conditioned floor area** shall comply with measured air leakage requirements in Section 5.4.3.1.4.

5.4.3.1.2 New buildings not less than 10,000 ft² or gross conditioned floor area shall comply with one of the following:



(Graphic:: Efficiency Matrix)

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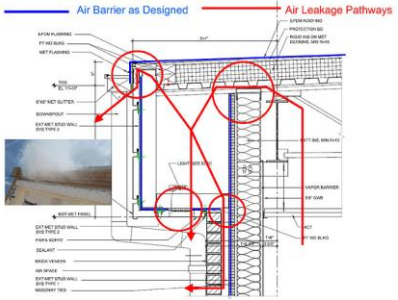
Building Envelope

Mandatory

5. Building Envelope: 5.4 Mandatory Provisions

5.4.3.1 Whole Building Leakage:

a. Measured air leakage requirements in **Section 5.4.3.1.4**
b. **A continuous air barrier design and installation verification program performed in accordance with Section 5.9.1.2**



5.4.3.1.4 Measured Air Leakage. Where measured air leakage is used for compliance, **the rate of air leakage of the building envelope shall not exceed 0.35 cfm/ft² under a pressure differential of 75 Pa (0.3 in. of water)…**

a. Whole-building pressurization testing shall be conducted in accordance with ASTM E3158…and be performed by an independent third-party verification and testing provider…

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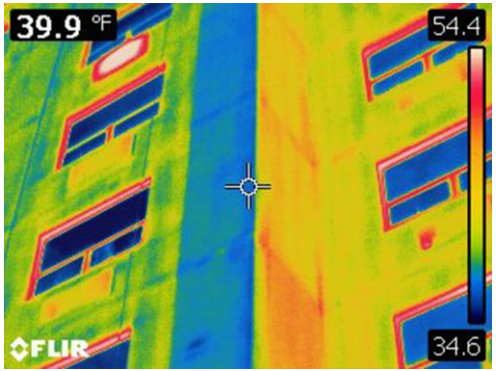
Building Envelope

Mandatory

5. Building Envelope: 5.4 Mandatory Provisions

5.4.3.1.4 Measured Air Leakage

c. Where the **measured air leakage rate exceeds 0.35 cfm/ft² but does not exceed 0.45 cfm/ft²**, a diagnostic evaluation, such as a smoke tracer or infrared imaging, shall be conducted while the building is pressurized.



(Graphic: BECS)

5.4.3.1.4 Measured Air Leakage.

c. In addition, a visual inspection of the air barrier shall be conducted, and any leaks noted shall be sealed if such sealing can be made without destruction of existing building components

d. **Where the measured air leakage rate exceeds 0.45 cfm/ft²,** corrective actions must be made to the envelope.

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Building Envelope

Prescriptive

5.5 Prescriptive Building Envelope Compliance Path

5.5.1 Exterior Building Envelope. For a conditioned space, the exterior building envelope shall **comply with either the nonresidential or residential requirements in Tables 5.5-0 through 5.5-8** for the appropriate climate

5.5.3 Opaque Areas. For all *opaque* surfaces except doors, compliance shall be demonstrated by one of the following two methods:

Table A3.1-1 Assembly U-Factors for Above-Grade Concrete Walls and Masonry Walls *(Continued)*

Framing Type and Depth	Rated R-Value of Insulation Alone	Assembly U-Factors for 8 in. Normal Weight 145 lb/ft³ Solid Concrete Walls	Assembly U-Factors for 8 in. Medium Weight 115 lb/ft³ Concrete Block Walls: Solid Grouted	Assembly U-Factors for 8 in. Medium Weight 115 lb/ft³ Concrete Block Walls: Partially Grouted (Cores Uninsulated Except Where Specified)
	R-0	U-0.740	U-0.580	U-0.480
No Framing	Ungrouted Cores Filled with Loose-Fill Insulation	NA	NA	U-0.350
No framing	R-5.0	U-0.157	U-0.149	U-0.141
No framing	R-6.0	U-0.136	U-0.129	U-0.124
No framing	R-7.0	U-0.120	U-0.115	U-0.110
No framing	R-8.0	U-0.107	U-0.103	U-0.099
No framing	R-9.0	U-0.097	U-0.093	U-0.090
No framing	R-10.0	U-0.088	U-0.085	U-0.083

(Table A3.1-1 Assembly U-Factors)

a. Minimum rated R-value of insulation for the thermal resistance of the added insulation… (Normative Appendix A)

b. Maximum U-factor, C-factor, or F-factor for the entire assembly…Normative Appendix A)

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Building Envelope

Prescriptive

5.5 Prescriptive Building Envelope Compliance Path

5.5.4 Fenestration

5.5.4.3 Fenestration U-Factor. *Fenestration* shall have a **U-factor** not greater than that specified in **Tables 5.5-0 through 5.5-8**

5.5.4.4 Fenestration Solar Heat Gain Coefficient (SHGC)

(Table 5.5.4.4.1 SHGC Multipliers for Permanent Projections)

Table 5.5.4.4.1 SHGC Multipliers for Permanent Projections

Projection Factor (PF)	SHGC Multiplier (South, East, and West *Orientations*)
0 to 0.10	1.00
>0.10 to 0.20	0.91
>0.20 to 0.30	0.82
>0.30 to 0.40	0.74
>0.40 to 0.50	0.67
>0.50 to 0.60	0.61
>0.60 to 0.70	0.56
>0.70 to 0.80	0.51
>0.80 to 0.90	0.47
>0.90 to 1.00	0.44

5.5.5 Linear Thermal Bridges and Point Thermal Bridges Where linear thermal bridges and point thermal bridges occur as described in Sections 5.5.5.1 through 5.5.5.5 they shall

a. Comply with the applicable requirements of Sections 5.5.5.1 through 5.5.5.5 or

b. Not exceed the mitigated psi-factors or chi-factors in Table A10.1

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Building Envelope

Performance

5.6 Building Envelope Trade-Off Compliance Path:

5.6.1 The *building envelope* complies with the standard if

a. The *proposed design* satisfies the provisions of Sections 5.1, 5.4, 5.7, 5.8, and 5.9 and

b. The ***proposed envelope performance factor*** **of the** ***proposed design*** **is less than or equal to the** ***proposed envelope performance factor*** **of the** ***base design***

5.6.1.2 Trade-Offs Limited to Building Permit

5.6.1.3 ***Envelope performance factor*** shall be calculated using the procedures of **Normative Appendix C (Methodology for Building Envelope Trade-Off Option in Section 5.6)**

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Building Envelope

Performance

Section 12: Energy Cost Budget Method

12.2 Compliance

a. Sections 5.2.1, 6.2.1, .2.1, 8.2.1, 9.2.1, and 10.2.1

b. The design *energy* cost shall comply with the following:

$$\textit{Design Energy Cost} \leq \textit{Energy Cost Budget} \times (1 - EC_{req} / 1000 \times A_{adj})$$

$$A_{adj} = \frac{\textit{Addition Gross Floor Area + Alteration Gross Floor Area}}{\textit{Modeled gross floor area}}$$

12.2(d) **1.** The *building envelope* complies with Section 5.5, "Prescriptive Building Envelope Compliance Path."

2. Using Section 5.6, "Building Envelope Trade-Off Compliance Option," the *proposed envelop performance factor shall not exceed the base envelope performance factor by more than 15% in multi-family residential…For all other building area types, the limit shall be 7%...*

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Building Envelope

Performance

Section 12: Energy Cost Budget Method

Table 12.5.1 Modeling Requirements for Calculating Design Energy Cost and Energy Cost Budget

Table 12.5.1 Modeling Requirements for Calculating Design Energy Cost and Energy Cost Budget *(Continued)*

Proposed Design (Column A) Design Energy Cost (DEC)	Budget Building Design (Column B) Energy Cost Budget (ECB)
5. Building Envelope	
a. All components of the *building envelope* in the *proposed design* shall be modeled as shown on architectural drawings or as built for *existing building envelopes*. All *opaque building envelope* components shall be modeled accounting for thermal mass effects. **Exception:** The following *building* elements are permitted to differ from architectural drawings. 1. Each *linear thermal bridge* and *point thermal bridge* as identified in Section 5.5.5 shall be modeled using either of the following techniques: a. A separate model of the assembly within the *energy* simulation model. b. Adjustment of the clear-field *U-factor* in accordance with Section A10.2. 2. Each uninsulated assembly not identified in Section 5.5.5 shall be modeled using either of the following techniques: a. A separate model of the assembly within the *energy* simulation model. b. The *U-factors* of uninsulated assemblies can be averaged with larger adjacent surfaces of the same *class of construction* using an area-weighted average method. This average *U-factor* is modeled within the *energy* simulation model. 3. Any other *building envelope* assembly, not subject to the requirements of Section 5.5.5, that covers less than 5% of the total area of that *class of construction* need not be separately described, provided that it is similar to an assembly being modeled. If not separately described, the *U-factors* of these assemblies shall be averaged with larger adjacent surfaces using an area-weighted average method. This average *U-factor* shall be modeled within the *energy* simulation model.	The *budget building design* shall have identical *conditioned floor area* and identical exterior dimensions and *orientations* as the *proposed design*, except as follows: a. *Opaque* assemblies, such as *roof*, *floors*, *doors*, and *walls*, shall be modeled as having the same *heat capacity* as the *proposed design* but with the minimum *U-factor* required in Section 5.5 for new *buildings* or additions and Section 5.1.4 for *alterations*. b. Where *linear thermal bridges* and *point thermal bridges*, as identified in Sections 5.5.5.1 through 5.5.5.5, are included in the *proposed design*, they shall be modeled by adjusting the *U-factor* of the parent assembly in accordance with the default values in Section A10. If the *proposed design* does not have *linear thermal bridges* and *point thermal bridges*, as identified in Sections 5.5.5.1 through 5.5.5.5, they shall not be modeled in the *budget building design*. If the balcony length in the *proposed design* exceeds the maximum allowed by Sections 5.5.5.2.2, the area shall be reduced proportionally for each balcony until the limit set in Sections 5.5.5.2.2 is met. c. The exterior *roof* surfaces shall be modeled with a solar reflectance and thermal *emittance* as required in Section 5.5.3.1.4(a). All other *roofs*, including *roofs* exempted from the requirements in Section 5.5.3.1.4, shall be modeled the same as the *proposed design*. The *above-grade wall* surfaces of *buildings* shall be modeled with a solar reflectance and thermal *emittance* as required in Section 5.5.3.2.2 and 5.5.3.2.2(a). All other *above-grade walls*, including those exempt from the requirements in Section 5.5.3.2.2, shall be

12.5.1 ECB Method “Building Envelope” building design requirements for evaluating if the ***Design Energy Cost*** **is in compliance to the *energy cost budget* simulation**

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Building Envelope

Other Standard 90.1-2022 Building Envelope Changes:

- *Requirements were added that address the impacts of thermal bridges in building envelopes, with a new Informative Appendix K providing supplemental information on application*
- *A solar reflectance requirement for walls was added for Climate Zone 0.*
- *Specific provisions were added to distinguish roof replacements from other types of alterations*
- *A new reference was added for steel-framed walls to allow use of ANSI/AISI S250 for U-factor determination*
- *Added a definition for insulated metal panels (IMPs)*
- *Normative Appendix A was reformatted to clarify the requirements for thermal performance calculations*

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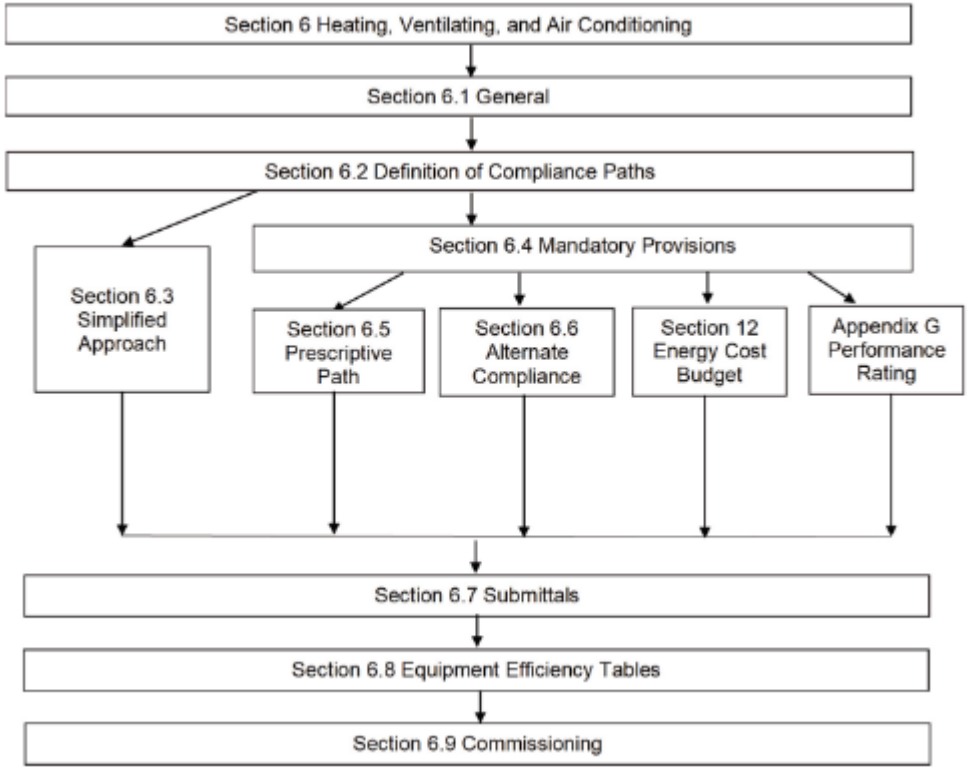
ASHRAE Standard 90.1-2022 Section 6: Heating, Ventilating, and Air Conditioning

Heating, Ventilating & Air Conditioning



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Heating, Ventilating & Air Conditioning

6.1 General: (Language the same as the 2016 Standard)

6.1.1 Scope. Section 6 specifies requirements for mechanical *equipment* and *systems.*

6.1.2 New Buildings. Mechanical *equipment* and *systems* serving the heating, cooling, ventilating, or refrigeration needs of new *buildings* shall comply with the requirements of this section as described in Section 6.2

6.1.3 Additions to Existing Buildings: *Mechanical* equipment *and* systems *serving the heating, cooling, ventilating, or refrigeration needs of* additions to *existing systems* and *equipment* shall not be required to comply with this standard. However, any new *systems* or *equipment* installed must comply with specific requirements applicable to those *systems* and *equipment.*

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Heating, Ventilating & Air Conditioning

6.1 General: (Language the same as the 2016 Standard)

6.1.4 Alterations to Building Envelopes

6.1.4.1 New HVACR *equipment* as a direct replacement of existing HVACR equipment shall comply with the following sections as applicable for the *equipment* being replaced **(No changes from 2016 Standard)**

Exceptions 6.1.4 **(No changes from 2016 Standard)**

6.1.5 Climate. Climate zones shall be determined in accordance with Section 5.2.5. **(Refers to Standard 169-2013)**

5.1.5 Climate. Determine the climate zone for the location. For U.S. locations, follow the procedure in Section 5.1.5.1. For international locations, follow the procedure in Section 5.1.5.2.

5.1.5.1 United States Locations. For locations in the United States and its territories, use ASHRAE Standard 169, Table B-1, "U.S. Climate Zones by State and County," to determine the assigned climate zone and, where required, the assigned climate zone letter.

Exception to 5.1.5.1: If there are recorded historical climatic data available for a *construction site*, they may be used to determine compliance if approved by the *building official*.

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Heating, Ventilating & Air Conditioning

6.2 Compliance Paths: Mechanical *equipment* and *systems* providing heating, cooling, ventilating, or refrigeration **shall comply with Sections 6.2.1 and 6.2.2**

6.2.1 Requirements for all Compliance Paths. Mechanical equipment and systems shall comply with all of the following:

a. Section 6.1, "General"

b. Section 6.4, "Mandatory Provisions"

Exception to 6.2.1.(b): When compliance is shown **using Section 6.2.2(a) ("Simplified Approach Building Compliance Path)**, compliance with Section 6.4 is not required unless required in Section 6.3.2.

c. Section 6.7, "Submittals"

d. Section 6.8, "Minimum Equipment Efficiency Tables

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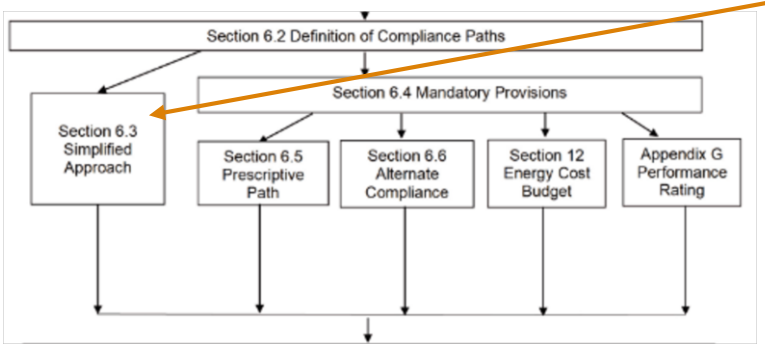
Heating, Ventilating & Air Conditioning

6.2 Compliance Paths:

Prescriptive

- **6.2.2 Additional Requirements to Comply with Section 6.** Refrigeration ***equipment*** **and** ***systems*** shall comply with **Section 6.5, "Prescriptive Compliance Path."** **All** ***building HVAC systems*** shall comply with one of the following:



- **Section 6.3 "Simplified Approach Building Compliance Path for HVAC Systems"***
- **Section 6.4 "Mandatory Provisions"**
- **Section 6.5 "Prescriptive Compliance Path"**
- **Section 6.6.1 "Computer Room System Path"**
- **Section 6.6.2 "Mechanical System Performance Path"**

***Note: Simplified Approach is exempt from Section 6.4 Mandatory Provisions**

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Heating, Ventilating & Air Conditioning

6.3 Simplified Approach Building Compliance Path…:

- **6.3.1 Scope. The simplified approach is an optional path for compliance when the following conditions are met:**

Prescriptive

a. The *building* is two stories or fewer in height.
b. *Gross floor* area is less than 25,000 ft².
c. Each *HVAC system* in the building complies with the requirements listed in Section 6.3.2.

- **6.3.2 Criteria.** The ***HVAC system* must meet all** of the following **criteria** (Par. a through t). **(Table changes to the 2016 Standard)**

c. Cooling…shall be provided by a unitary packaged or split-*system* air conditioner that is either air cooled or evaporatively cooled with ***efficiency* meeting the requirements shown in Table 6.8.1-6.8.12 or Table 6.8.1-4…**

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	AHRI210/240-2017 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

Note: After 1-01-23 SEER rating are to comply to SEER2 performance

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6.3 Simplified Approach Building Compliance Path…:

Prescriptive

- **6.3.2 Criteria.** (Continued)

  e. Added line: …Heating equipment shall also comply with Section 6.4.1.4

  i. The *system* controls shall not permit *reheat* or any other form of simultaneous heating and cooling for humidity control

  i. Exception to 6.3.2(i): Humidity control assisted by hot-gas *reheat* or heat from 100% *site-recovered energy* is permitted

  j. *Systems* serving *spaces*…that do not require continuous operation, with a **cooling or heating capacity greater than 7000 Btu/h (15000 Btu/h in 2016 Standard)** shall comply with Sections 6.4.3.3.1 and 6.4.3.3.2.

  k. Added: *Systems* serving *residential spaces* other than hotel/motel guest rooms shall comply with Sections 6.4.3.3.1 and 6.4.3.3.2 except for *electric resistance heaters* rated at 2 hp or less…

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6.4 Mandatory Provisions*

Mandatory

6.4.1 Equipment Efficiencies, Verification, and Labeling Requirements

6.4.1.1 Minimum Equipment Efficiencies – Listed Equipment – Standard Rating and Operating Condition

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

Equipment Type	Size Category	Heating Section Type	Subcategory or Rating Condition	Minimum Efficiency	Te
Air conditioners, air cooled (continued)	≥240,000 Btu/h and <760,000 Btu/h	*Electric resistance* (or none)	Split *system* and single package	10.0 *EER* 11.6 *IEER* before 1/1/2023 13.2 *IEER* after 1/1/2023	
		All other		9.8 *EER* 11.4 *IEER* before 1/1/2023 13.0 *IEER* after 1/1/2023	
	≥760,000 Btu/h	*Electric resistance* (or none)		9.7 *EER* 11.2 *IEER* before 1/1/2023 12.5 *IEER* after 1/1/2023	
		All other		9.5 *EER* 11.0 *IEER* before 1/1/2023 12.3 *IEER* after 1/1/2023	
Air conditioners, water cooled	<65,000 Btu/h	All	Split *system* and single package	12.1 *EER* 12.3 *IEER*	
	≥65,000 Btu/h and <135,000 Btu/h	*Electric resistance* (or none)		12.1 *EER* 13.9 *IEER*	
		All other		11.9 *EER* 13.7 *IEER*	
	≥135,000 Btu/h and <240,000 Btu/h	*Electric resistance* (or none)		12.5 *EER* 13.9 *IEER*	
		All other		12.3 *EER* 13.7 *IEER*	

(Table 6.8.1-1: Electrically Operated Unitary Air Conditioners)

- Eq*uipment* shown in **Tables 6.8.1-1 through 6.8.1-21** shall have a minimum performance at the specified rating conditions..
- ***SEER2 / HSPF2* ratings to be applied after January 1, 2023 in lieu of *SEER / HSPF***
- ***SEER2 / HSPF2*** input values are now obtained under more realistic testing conditions; e.g. higher static pressure

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6.4 Mandatory Provisions*

Mandatory

Table 6.8.1-14 Electrically Operated DX-DOAS Units, Single-Package and Remote Condenser, with Energy Recovery

Table 6.8.1-13 Electrically Operated DX-DOAS Units, Single-Package and Remote Condenser, without Energy Recovery—Minimum Efficiency Requirements

Equipment Type	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure
Air cooled (dehumidification mode)		4.0 *ISMRE*	AHRI 920
Air source heat pumps (dehumidification mode)		4.0 *ISMRE*	AHRI 920
Water cooled (dehumidification mode)	Cooling tower condenser water	4.9 *ISMRE*	AHRI 920
	Chilled Water	6.0 *ISMRE*	
Air source heat pump (heating mode)		2.7 *ISCOP*	AHRI 920
Water source heat pump (dehumidification mode)	Ground source, closed loop	4.8 *ISMRE*	AHRI 920
	Ground-water source	5.0 *ISMRE*	
	Water source	4.0 *ISMRE*	
Water source heat pump (heating mode)	Ground source, closed loop	2.0 *ISCOP*	AHRI 920
	Ground-water source	3.2 *ISCOP*	
	Water source	3.5 *ISCOP*	

Table 6.8.1-14 Electrically Operated DX-DOAS Units, Single-Package and Remote Condenser, with Energy Recovery—Minimum Efficiency Requirements

Equipment Type	Subcategory or Rating Condition	Minimum Efficiency	Test Procedure
Air cooled (dehumidification mode)		5.2 *ISMRE*	AHRI 920
Air source heat pumps (dehumidification mode)		5.2 *ISMRE*	AHRI 920
Water cooled (dehumidification mode)	Cooling tower condenser water	5.3 *ISMRE*	AHRI 920
	Chilled water	6.6 *ISMRE*	
Air source heat pump (heating mode)		3.3 *ISCOP*	AHRI 920
Water source heat pump (dehumidification mode)	Ground source, closed loop	5.2 *ISMRE*	AHRI 920
	Ground-water source	5.8 *ISMRE*	
	Water source	4.8 *ISMRE*	
Water source heat pump (heating mode)	Ground source, closed loop	3.8 *ISCOP*	AHRI 920
	Ground-water source	4.0 *ISCOP*	
	Water source	4.8 *ISCOP*	

- **Integrated Seasonal Moisture Removal Efficiency *(ISMRE) for DX-DOAS Units***
  - *"…a seasonal efficiency number that is combined value based on the formulat listed in AHRI Standard 920 of the four dehumidification moisture removal efficiency (MRE) ratings required for DX-DOAS unit expressed in lb of moisture / kWh*

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6.4 Mandatory Provisions

Mandatory

- 6.4.2 Calculations
- 6.4.3 Controls & Diagnostics
  - 6.4.3.4 Ventilation System Controls
    - 6.4.3.4.3 Damper Leakage
  - 6.4.3.6 Humidification and Dehumidification Control
  - 6.4.3.7 Freeze Protection and Snow/Ice Melting Systems
  - 6.4.3.8 Ventilation Controls for High-Occupancy Areas

Demand control ventilation (DCV) is required for *spaces* larger that the floor area shown in Table 6.4.3.8 based on occupant airflow component

Table 6.4.3.4.3 Maximum Damper Leakage[a,b], cfm per ft² at 1.0 in. of water

Climate Zone	Outdoor Air Intake		Exhaust/Relief	
	Nonmotorized [a]	Motorized	Nonmotorized [c]	Motorized
0, 1, 2				
Any height	20	4	20	4
3				
Any height	20	10	20	10
4, 5B, 5C				
Fewer than three *stories*	20 [d]	10	20	10
Three or more *stories*	20 [d]	10	20 [d]	10
5A, 6, 7, 8				
Fewer than three *stories*	20 [d]	4	20	4
Three or more *stories*	20 [d]	4	20 [d]	4

Table 6.4.3.8 Demand Control Ventilation (DCV) Floor Area Thresholds

Climate Zone	Occupant Outdoor Airflow Component (cfm/1000 ft²) [a]					
	100 to 199	200 to 399	≥400	100 to 199	200 to 399	≥400
	Minimum Space Floor Area in ft² where DCV Is Required					
	Areas without Exhaust Air Energy Recovery			Areas with Exhaust Air Energy Recovery [b]		
7, 8	400	200	150	800	400	250
5A, 6A, 6B	600	250	150	1400	900	400
0A, 0B, 1B, 3A, 4A, 5B, 5C	800	400	250	2000	1000	500
2A, 2B, 4C	1100	600	300	2300	1100	600
3B, 4B	1500	700	400	5200	2350	1250
1A	2400	1100	600	5800	2600	1400
3C	7000	3000	1700	12,000	6000	3000

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6.4 Mandatory Provisions

Mandatory

- 6.4.4 HVAC System Construction and Insulation
  - 6.4.4.1 Insulation
    - 6.4.4.1.2 Duct and Plenum Insulation
    - 6.4.4.1.3 Piping Insulation
    - etc. etc.
  - 6.4.4.2 Ductwork and Plenum Leakage

- 6.4.5 Walk-In Coolers and Walk-In Freezers
- 6.4.6 Refrigerated Display Case
- 6.4.7 Liquid-to-Liquid Heat Exchangers

(Photo: American Cooler Technologies)

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6.5 Prescriptive Compliance Path

Prescriptive

- **6.5.1 Economizers.** Each cooling system shall include either an *air economizer* or *fluid economizer* meeting the requirements of Sections 6.5.1.1 through 6.5.1.1
  - **Exception:** Economizers are not required for the following systems…etc.

Table 6.5.1-1 Minimum Fan-Cooling Unit Size for which an Economizer Is Required

Climate Zone	Cooling Capacity for which an Economizer Is Required	Application
0A, 0B, 1A, 1B	No economizer requirement	All
2A, 2B, 3A, 4A, 5A, 6A, 3B, 3C, 4B, 4C, 5B, 5C, 6B, 7, 8	≥33,000 Btu/h	Fan-cooling units located outside the *building*
	≥54,000 Btu/h	All other fan-cooling-unit locations

(Table 6.5.1-1 Minimum Fan-Cooling Unit Size for which an Economizer is Required)

- **"Cooling Capacity for which an Economizer is Required": Climate zone 2B (Maricopa County) is reduced from ≥ 54,000 Btu/h to ≥ 33,000 Btu/h**

- **Table 6.5.1.1.3 High-Limit Shutoff Control Settings for Economizers**
  - Limits are the same as stated in 90.1-2016

Table 6.5.1.1.3 High-Limit Shutoff Control Settings for Air Economizers [a]

Control Type	Allowed Only in Climate Zone at Listed Set Point	Required High-Limit Set Points (Economizer Off when): Equation	Description
Fixed dry-bulb temperature	0B, 1B, 2B, 3B, 3C, 4B, 4C, 5B, 5C, 6B, 7, 8	$T_{OA} > 75°F$	*Outdoor air* temperature exceeds 75°F
	5A, 6A	$T_{OA} > 70°F$	*Outdoor air* temperature exceeds 70°F
	0A, 1A, 2A, 3A, 4A,	$T_{OA} > 65°F$	*Outdoor air* temperature exceeds 65°F
Differential dry-bulb temperature	0B, 1B, 2B, 3B, 3C, 4B, 4C, 5A, 5B, 5C, 6A, 6B, 7, 8	$T_{OA} > T_{RA}$	*Outdoor air* temperature exceeds return air temperature
Fixed enthalpy with fixed dry-bulb temperature	All	$h_{OA} > 28$ Btu/lb [b] or $T_{OA} > 75°F$	*Outdoor air* enthalpy exceeds 28 Btu/lb [b] of dry air [b] or *outdoor air* temperature exceeds 75°F
Differential enthalpy with fixed dry-bulb temperature	All	$h_{OA} > h_{RA}$ or $T_{OA} > 75°F$	*Outdoor air* enthalpy exceeds return air enthalpy or *outdoor air* temperature exceeds 75°F

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6.5 Prescriptive Compliance Path

Prescriptive

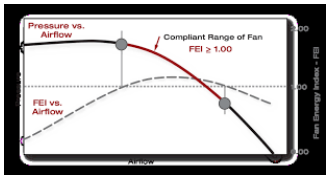
6.5.2 Simultaneous Heating and Cooling Limitation

6.5.2.1 Zone Controls

6.5.2.2 Hydronic System Controls

6.5.2.3 Dehumidification

6.5.2.4 Humidification



6.5.3 Air System Design and Control

6.5.3.1 Fan System Power and Efficiency

6.5.3.1.2 Fan Motor Selection

6.5.3.1.3 Fan Efficiency.

Constant Volume. Each fan and *fan array* shall have a *fan energy index (FEI)* of 1.00 or higher at its highest design airflow rate

Variable Volume. Each fan and *fan array* used for variable-air-volume system …shall have an FEI of 0.95 or higher at its highest design airflow rate

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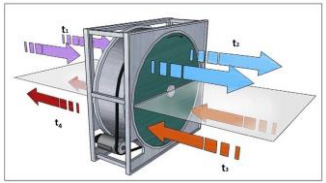
6.5 Prescriptive Compliance Path

Prescriptive

6.5.6 Energy Recovery

6.5.6.1 Exhaust Air Energy Recovery



(Graphic: Conserve)


(Graphic: Oxygen 8)

6.5.6.1.1 Nontransient Dwelling Units

6.5.6.1.2 Spaces Other than Nontransient Dwelling Units. …shall have an *energy* recovery *system* where the design supply fan airflow rate exceeds the value listed in **Tables 6.5.6.1.2-1 and 6.5.6.1.2-2**

Table 6.5.6.1.2-1 Exhaust Air Energy Recovery Requirements for Ventilation Systems Operating Less than 8000 Hours per Year

	% Outdoor Air at Full Design Airflow Rate							
	≥10% and <20%	≥20% and <30%	≥30% and <40%	≥40% and <50%	≥50% and <60%	≥60% and <70%	≥70% and <80%	≥80%
Climate Zone	Design Supply Fan Airflow Rate, cfm							
3B, 3C, 4B, 4C, 5B	NR	NR	NR	NR	NR	NR	NR	NR
0B, 1B, 2B,5C	NR	NR	NR	NR	≥26,000	≥12,000	≥5000	≥4000
6B	≥28,000	≥26,500	≥11,000	≥5500	≥4500	≥3500	≥2500	≥1500
0A, 1A, 2A, 3A, 4A, 5A, 6A	≥26,000	≥16,000	≥5500	≥4500	≥3500	≥2000	≥1000	≥120
7,8	≥4500	≥4000	≥2500	≥1000	≥140	≥120	≥100	≥80

NR—Not required

Table 6.5.6.1.2-2 Exhaust Air Energy Recovery Requirements for Ventilation Systems Operating Greater than or Equal to 8000 Hours per Year

	% Outdoor Air at Full Design Airflow Rate							
	≥10% and <20%	≥20% and <30%	≥30% and <40%	≥40% and <50%	≥50% and <60%	≥60% and <70%	≥70% and < 80%	≥80%
Climate Zone	Design Supply Fan Airflow Rate, cfm							
3C	NR	NR	NR	NR	NR	NR	NR	NR
0B, 1B, 2B, 3B, 4C, 5C	NR	≥19,500	≥9000	≥5000	≥4000	≥3000	≥1500	≥120
0A, 1A, 2A, 3A, 4B, 5B	≥2500	≥2000	≥1000	≥500	≥140	≥120	≥100	≥80
4A, 5A, 6A, 6B, 7, 8	≥200	≥130	≥100	≥80	≥70	≥60	≥50	≥40

NR—Not required

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6.6 Alternative Compliance Path

6.6.1 Computer Rooms Systems Path. The Computer Room System Path is an optional path for compliance where the following conditions are met:

(Photo: Energy Trust of Oregon)

a. HVAC system that only serves the heating, cooling, or ventilating needs of a *computer room* with IT *equipment* load greater than 10 kW shall comply with ASHRAE Standard 90.4 *Energy Standard for Data Centers*

b. All other *HVAC* systems shall comply with the applicable requirements in Section 6.5

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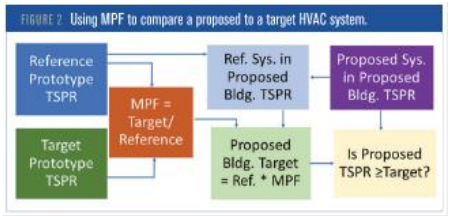
6.6 Alternative Compliance Path

Performance

6.6.2 Mechanical System Performance Path

6.6.2.1 Scope. The Mechanical System Performance Path is an optional path for compliance where the following conditions are met:



(Graphic: ASHRAE Journal)

a. All *systems* in the *building* that **meet the criteria in Section L1.1.1** shall comply with Section 6.6.2.2

b. All other HVAC *systems* shall comply with one of the following

   1. *HVAC* systems shall comply with applicable requirements in Section 6.5.
   2. *HVAC systems* that only serve heating, cooling or ventilating needs of a computer room with IT equipment with load greater than 10 kW…

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6.6 Alternative Compliance Path

Performance

6.6.2 Mechanical System Performance Path

6.6.2.2. Criteria.

- *HVAC Systems* in new *buildings, additions,* or *alterations* shall comply with the requirements in Section L2, “Mechanical System Performance Rating Method.”

$TSPR_p > TSPR_r / MPF$

Table 6.6.2.2 Mechanical Performance Factors (MPF)

Building Type	Climate Zone																			
	0A	0B	1A	1B	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	5C	6A	6B	7	8
Office (small and medium)[a]	0.72	0.71	0.70	0.70	0.68	0.65	0.71	0.66	0.62	0.69	0.64	0.65	0.72	0.66	0.65	0.74	0.70	0.75	0.77
Office (large)[a]	0.83	0.83	0.84	0.84	0.79	0.82	0.72	0.84	0.78	0.69	0.80	0.67	0.72	0.75	0.67	0.73	0.73	0.71	0.70
Retail	0.60	0.57	0.50	0.55	0.46	0.46	0.43	0.46	0.38	0.40	0.45	0.48	0.41	0.50	0.47	0.44	0.39	0.40	0.36
Hotel/motel	0.62	0.62	0.63	0.63	0.62	0.68	0.61	0.71	0.73	0.59	0.66	0.65	0.55	0.59	0.68	0.51	0.54	0.47	0.40
Multifamily/ dormitory	0.64	0.63	0.67	0.63	0.65	0.64	0.59	0.68	0.54	0.59	0.57	0.52	0.58	0.53	0.48	0.57	0.53	0.55	0.52
School/education	0.82	0.81	0.80	0.79	0.75	0.72	0.71	0.72	0.68	0.67	0.71	0.65	0.72	0.68	0.60	0.75	0.69	0.72	0.68

a. Office sizes defined in Section L1.1.1.1.

- The *proposed design total system performance ratio* ($TSPR_p$) of the *HVAC systems* using this method shall be greater than or equal to the *total system performance ratio* of the *TSPR reference building design ($TSPR_r$)* divided by the mechanical performance factor (MPF) when calculated in conformance with the following

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Standard 90.1-2022: Foreward

Mechanical Review:

- Required condensing boilers for new construction in order to achieve 90% or greater efficiency for large boilers (1 t0 10 million Btuh.) The thermal efficiency requirements for high-capacity gas-fired service water-heating equipment were also increased
- Established a *minimum enthalpy recovery ratio for energy recovery systems and specified operational requirements to ensure proper economized performance*
- *Revised demand control ventilation requirements to be based on climate zone and Standard 62.1 airflow requirements*
- *Modified the minimum efficiency requirements for air-source heat pumps and introduced a new metric, COPHR, for units that perform heat recovery during chiller operation*
- *Added the minimum energy efficiency requirements (and new CFEI metric) for large-diameter ceiling fans from 10 CFR 430*

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ASHRAE Standard 90.1-2022 Section 10: Other Equipment

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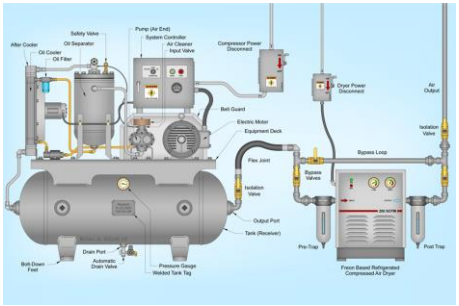
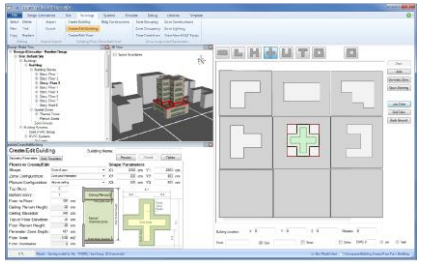
Other Equipment

Mandatory

Section 10 Other Equipment



- **Section 10.4.1: Motors**
- **Section 10.4.2: Service Water Booster Systems**
- **Section 10.4.3: Elevators**
- **Section 10.4.4: Escalators and Moving Walks**
- **Section 10.4.5: Air Curtains**
- **Section 10.4.6: Compressed Air Systems**
- **Section 10.4.7: Whole-Building Energy Monitoring:** Measurement devices shall be installed at the *building site* to monitor the *energy* use of each new *building*
  - **Section 10.4.7.1:** Monitoring: Measurement devices shall be installed to monitor the building use of the following types of energy supplied by a utility, energy provider, or plant that is not within the building:



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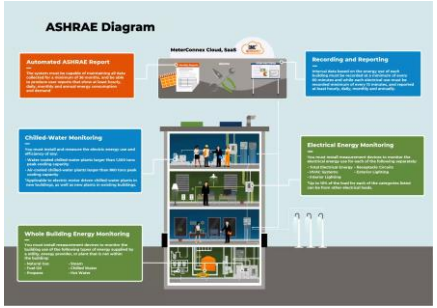
Other Equipment

Mandatory

Section 10 Other Equipment

- **Section 10.4.7.1: (cont.)**
  - A. Natural gas
  - *Fuel oil*
  - *Propane*
  - *Steam*
  - *Chilled water*
  - *Hot water*

(Photo: Chiller & Cooling Best Practices)



(Graphic: QMC)

- **Section 10.4.7.2: Recording and Reporting**: The energy use of each building on the building site shall be recorded at a minimum of every 60 minutes and reported at least hourly, daily, monthly, and annually. The system shall be capable of maintain all data collected for a minimum of 36 months and creating user reports showing at least hourly, daily, monthly, and annual energy consumption and demand.

- **Section 10.4.8**
  - Pumps

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Other Equipment

Mandatory

Section 10.5: Prescriptive Compliance Path

- **Section 10.5.1: Renewable Energy Resources.** Buildings shall be served by renewable energy resources complying with Section 10.4.1.1
  - **Section 10.5.1.1 On-Site Renewable Energy:** The *building site* shall have equipment for *on-site renewable energy* with a rated capacity of not less than 0.5 W/ft² or 1.7 Btu/h/ft² multiplied by the sum of the *gross conditioned floor area* for all floors up to the three largest floors.
  - **Exceptions to 10.5.1.1:**
    1. Any *building located* where an unshaded flat plat collector oriented toward the equator…receives an annual daily average incident solar radiation less than 1.1kBtu/ft² ·day.
    2. Any *building* where more than 80% of the *roof area* is covered by any combination of equipment…

ASHRAE Standard 90.1-2022 Thermal Energy Loads and HVAC System Impact

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DOE: Energy Savings Analysis

ASHRAE Standard 90.1-2022:

- The standard is a bold move to meet MEP-2030 net zero carbon initiatives
  - Raises energy efficiency levels another 9.8%
  - Increases minimum prescriptive building and equipment efficiencies while expanding performance based language for high-performance building designs
  - Beginning to bring ASHRAE Standard 36 into Section 6 for a more uniform national building controls system sequencing approach
  - Addresses performance validation through testing, verification and commissioning

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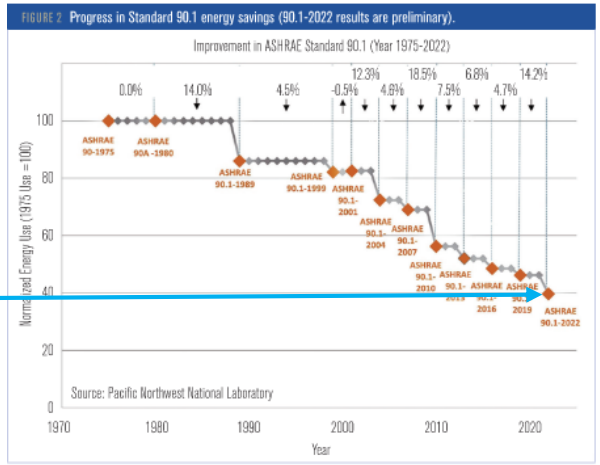
DOE: Energy Savings Analysis

DOE: Estimated Improvement to Residential & Commercial Energy Codes:

- **ASHRAE building performance trend over the years illustrates** over **50% energy reduction** since 1975.



- Thermal energy loads are being reduced due to tighter building skins, enhanced glazing, LED lighting technology and building control solutions and monitoring

- **Consequently, thermal (sensible) energy loads are being significantly reduced**

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DOE: Energy Savings Analysis

The Desert Southwest, Reduced Thermal Energy Loads and HVAC Systems:

- **What about Humidity during summer monsoon?**
  - Outdoor air dew points can remain at above 60F and even above 70F
  - Conventional HVAC designs of supplying 55F air off chilled water coils or up to 60F from packaged unitary coils adequate to control humidity
  - Reducing chilled water temperatures or oversizing of DX equipment is not an efficient solution.
- **Will rethinking HVAC designs be necessary to meet developing IECC code requirements?**
- **The answer: YES!**

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Questions?

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Thank you.

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