TOWN OF PAYSON
BUILDING ADVISORY BOARD
MINUTES OF THE PUBLIC MEETING
APRIL 13, 2012

A	Chairman Bossert called the duly posted public meeting of the Building Advisory Board to order at 8:05 a.m. in the Town Council Chambers.	Meeting Time & Place
B	MEMBERS PRESENT: Ralph Bossert; Bret Balog; Gary deSzendeffy; Rob Myer; and Todd Brahm. ABSENT: Herm Holtz and Bill Easton	Roll Call
C	STAFF PRESENT: Ray LaHaye, Chief Building Official; Don Monteath, Permit Technician; Bob Lockhart, Fire Marshal; and Chris Floyd, Executive Assistant.	Staff Present
D	Bret Balog moved, seconded by Rob Myer, to approve the minutes of the March 23, 2012 meeting, pages 438-439. Motion carried 4-0. (Gary deSzendeffy was not present for this vote.)	Approval of Minutes
E	Presentation by Forrest Fielder, Energy Specialist, regarding 2012 International Energy Conservation Code (IECC). The Town will be considering adoption (with possible amendments) of the 2012 IECC sometime in late 2012 or 2013. (PowerPoint presentation attached)	2012 IECC
F	Several members of the Board asked questions, for clarification purposes, that were answered by Forrest Fielder and staff.	Questions
G	With no further items on the agenda, Chairman Bossert adjourned the Building Advisory Board meeting at approximately 4:00 p.m.	Adjournment

NOTE: The Board recessed/reconvened at the following times:

The Board recessed at 9:09 a.m.

The Board reconvened at 9:22 a.m. with all Board members present.

The Board recessed at 10:52 a.m.

The Board reconvened at 11:05 a.m. with all Board members present.

The Board took a lunch recess at 12:12 p.m.

The Board reconvened at 1:33 p.m. with all Board members present.

Due to unforeseen circumstances the Board recessed at 2:19 p.m. and relocated to the police department conference room and reconvened at 2:40 p.m. with all Board members present.

Ralph Bossert, Chairman

5-18-12
Approved

Chris Floyd, Executive Assistant

Town of Payson
Development Review Board
International Energy Conservation Code
April 13-14, 2012

Presenter
Forrest Fielder
fielder_4@msn.com

Course Objectives

- Understand the **context** of energy conservation - historic, current, and projected
- Understand the **development** of the nation's model Energy Conservation Code
- Understand the **building science basis** of the IECC
- Understand the **application** of the IECC to new and existing construction
- Understand the **technical requirements** of the IECC

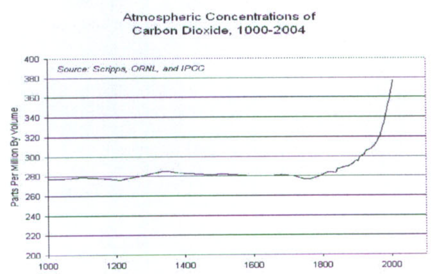
Context

Place the IECC in the larger context of planning for our energy future

- Illustrate the growth of our dependence on energy
- Lay out projections for energy demand
- Demonstrate the connections between forms of energy
- Illustrate the conservation potential in all applications
- Explain the difference between "site" and "source" energy, and why this is important
- Explain "direct cost/indirect cost", and "1st cost/life cycle cost". Explain "scalability".

Transformation to the Age of Energy

Atmospheric CO2



Definitions

- **Energy** – the ability of a physical system to exert a force over a distance on another physical system, often measured in joules.
- **Energy intensity** – units of energy expended per units of economic activity, i.e. watt/$GDP
- **BTU** – the amount of energy needed to heat one pound of water one degree F at sea level.
- **Kilowatt** – energy expended at one thousand joules per second, 1.34 horsepower, or the approximate amount of energy received by one square meter of Earth at midday.
- **ERO(E)I** – energy returned on (energy) invested
- **URR** - ultimately recoverable reserves, typically of fossil fuels
- **Scalability** – the capability of a system to increase total throughput under increased load when resources are added, or the ability of a technology to accept increased volume without impacting the contribution margin (revenue minus variable costs)
- **Conventional** – extracted with traditional methods, i.e. vertically-drilled oil and gas wells

Definitions

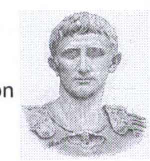
- **Renewable** – energy which comes from natural resources such as sunlight, wind, rain, tides, and geothermal activity, and which is naturally replenished. Represents ~16% of global energy supply (10% biomass, 3.4% hydro, other)
- **Site** – heat or electricity consumed by a building as reflected in utility bills, delivered to a facility as either primary energy (raw fuel burned to create heat or electricity), or as secondary energy (heat or electricity converted from a raw fuel and delivered from a grid or other district source) . Natural gas piped to a building to heat water is an example of primary energy, while natural gas supplied to an electrical generating station connected to the grid is an example of secondary energy.
- **Source** – primary energy consumed accounting for losses incurred in the storage, transport, and delivery of fuel to the building, or secondary energy consumed accounting for losses incurred in the production, transmission, or delivery of energy to the site. Represents the total amount of raw fuel required to operate the building.
- **Commercially available** – characterized by market formation and completed infrastructure

Our Dependence on Energy

- Energy is the master resource – a practical observation derived from our everyday experience, as the source of dynamism in systems.
- Energy is fungible – interchangeable among it's varied forms.
- Energy is quantifiable and measurable – units defined in terms of each other, and of the capacity to do work.

Our Dependence on Energy

The Thermodynamics of Empire –
Roman Empire 44BC-476AD



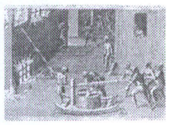
- The first "complex" civilization, based on **mastery** of organization, innovation, institutions and social order
- The first complex infrastructure for the generation and distribution of energy – principally, food – with surpluses sufficient to allow the growth of cities
- Roman conquest purposed to the glory of Rome, and to the creation of an imperial "food engine"

Our Dependence on Energy

The Thermodynamics of Empire –

Engineering an empire – innovation in mechanics and metallurgy for construction and manufacturing

- ✓ Converting food into mechanical energy – cranes, hoists, grinding wheels, pumps
- ✓ Converting hydrocarbons - wood, coals – into heat, for smelting and forging



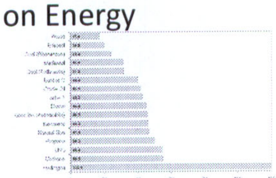
Our Dependence on Energy

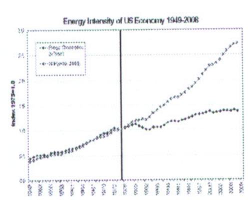
The Thermodynamics of Empire –
The Decline and Fall –
The First Energy Crisis?

- Rome's empire built on the conquest of productive lands and natural resources, the building of an efficient infrastructure to exploit these resources, and the social and civic complexity thus made possible.
- Peak energy – the energy demand of empire could only be met by energy resources that became increasingly difficult to obtain.

Our Dependence on Energy

Energy density is the "raw material" part of the picture - on the input side, measuring heat content by weight.

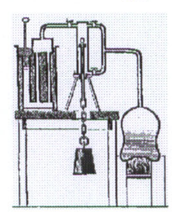




Energy intensity is the "end use" part of the picture, on the output side, measuring conversion efficiency in economic metrics

Transformation to the Age of Energy

The Industrial Revolution



- 1687 – Isaac Newton's Principia – laws of motion, gravitation
- 1775 – James Watt's steam engine converts hydrocarbons into mechanical energy for transportation/mfgr
- 1797-1873 – Rumford/Carnot/Clausius/Gibbs/ Thomson – 1st/2nd laws of thermodynamics
- Early 1800's – innovation in coal uses: coal gas, kerosene
- 1859 – Col Edwin Drake, Titusville, PA The world's first oil well – "black gold"
- 1860 - Lenoir's internal combustion engine
- 1885 – Karl Benz' first "motorcar"
- Late 1800's – oil refining technology
- 1902 – Ransom Olds/Henry Ford – mass production mfgr

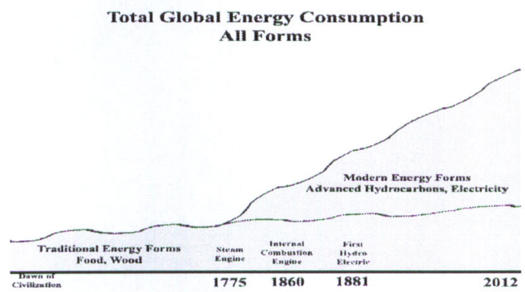
Transformation to the Age of Energy

The "Second" Industrial Revolution

- 1752 – Benjamin Franklin converts lightning into….a media event?
- 1821 – Michael Faraday's electric motor
- 1873 – Zenobe Gramme – 1st commercially successful DC motor
- 1878 – Thomas Edison – electric light
- 1887 – Nicola Tesla – 1st commercially successful AC motor
- 1800s – Ohm, Volta, Ampere, Maxwell and many others investigate the fundamental nature of electricity
- 1881 – Niagara Falls – 1st hydroelectric generation

April 13, 2012 Payson Development Review Board 13

Transformation to the Age of Energy

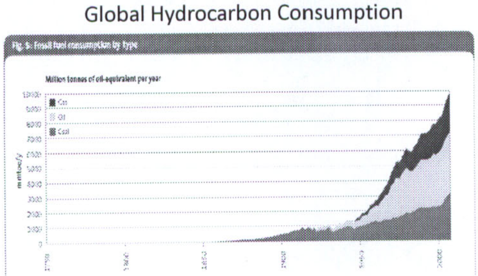


April 13, 2012 Payson Development Review Board 14

Transformation to the Age of Energy

In the Wake of the Industrial Revolution

Global Hydrocarbon Consumption

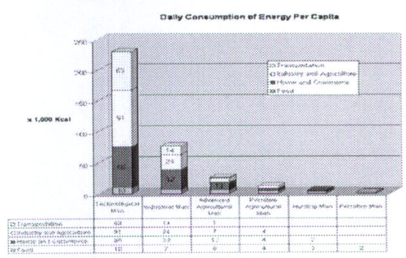


April 13, 2012 Payson Development Review Board 15

Transformation to the Age of Energy

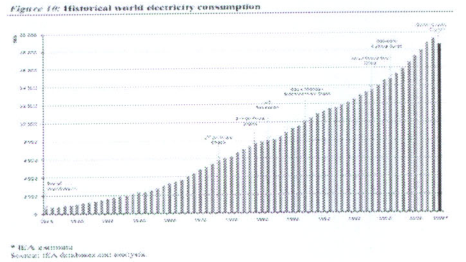
In the Wake of the Industrial Revolution

Energy Consumption per Capita

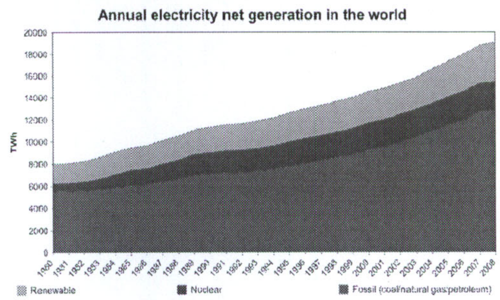


April 13, 2012 Payson Development Review Board 16

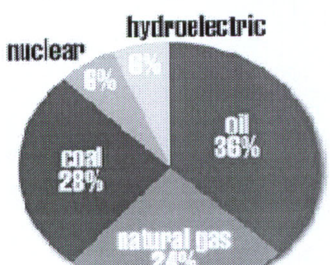
Transformation to the Age of Energy
In the Wake of the Industrial Revolution
Global Electrical Consumption



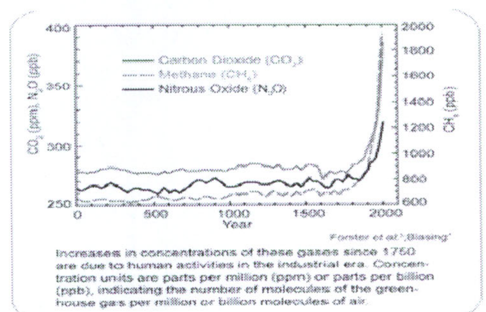
Transformation to the Age of Energy
In the Wake of the Industrial Revolution



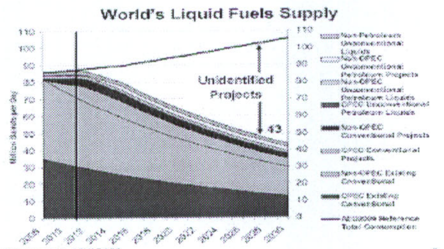
Transformation to the Age of Energy
In the Wake of the Industrial Revolution
Global Energy Sources



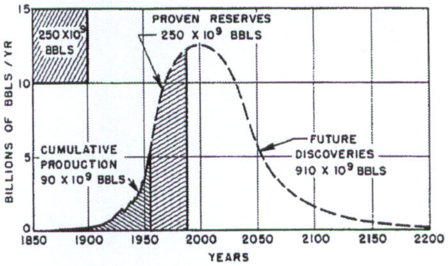
Transformation to the Age of Energy
Atmospheric CO2



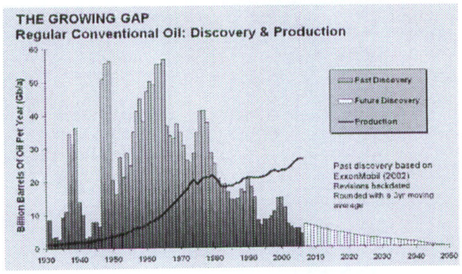
Projections for the Age of Energy
In the Wake of the Industrial Revolution
Global Liquid Fuel Sources



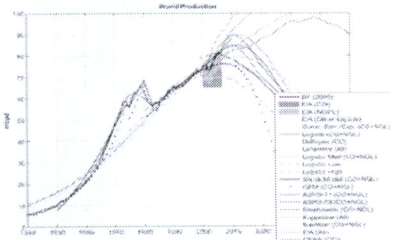
Projections for the Age of Energy
The Peaking Effect
Hubbert's Curve



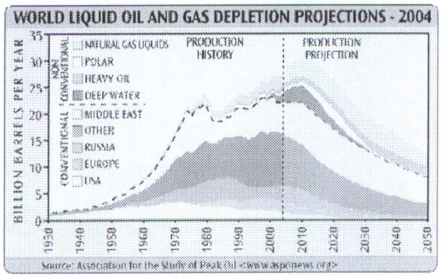
Projections for the Age of Energy
The Peaking Effect
Discovery and Production



Projections for the Age of Energy
The Peaking Effect
Discovery and Production

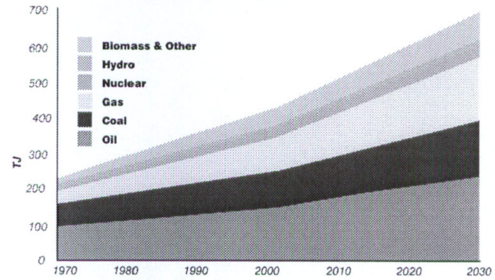


Projections for the Age of Energy
The Peaking Effect
Global peak Energy?



April 13, 2012 Payson Development Review Board 25

Projections for the Age of Energy
The Peaking Effect
Global Energy Demand



April 13, 2012 Payson Development Review Board 26

Projections for the Age of Energy
Summary

- Energy is the master resource.
- Energy is fungible among it's varied forms.
- The energy we depend on is finite – it's quantities and extraction rates can be reasonably estimated.
- Energy fuels growth – sustaining growth requires increasing energy inputs
- There is no comprehensive plan to replace hydrocarbons as our primary energy source.

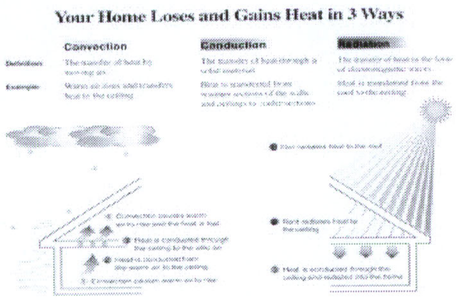
April 13, 2012 Payson Development Review Board 27

Solutions?

when we return...

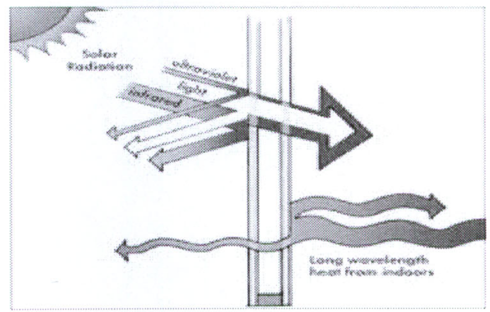
April 13, 2012 Payson Development Review Board 28

Building Science Basics
Heat Loss/Gain in buildings



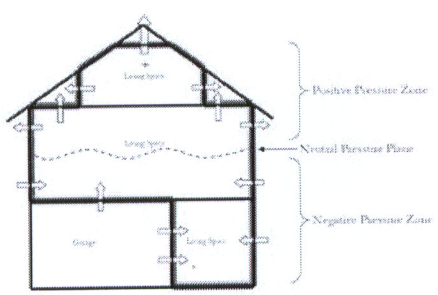
April 13, 2012 Payson Development Review Board 29

Building Science Basics
Heat Loss/Gain in buildings – Radiant transfer



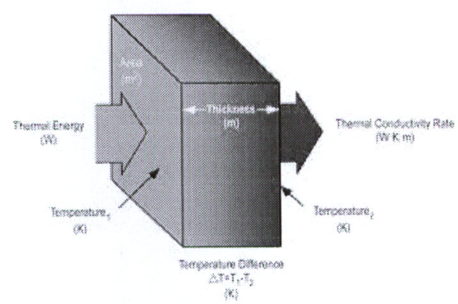
April 13, 2012 Payson Development Review Board 30

Building Science Basics
The Stack Effect



April 13, 2012 Payson Development Review Board 31

Building Science Basics
Conductive transfer



April 13, 2012 Payson Development Review Board 32

2012 IECC

International Energy Conservation Code

Update from the 2009 & from the 2006

Forrest Fielder
fielder_4@msn.com

Course Outline

- Under stand the development of the IECC/IRC
- Chang es to the Residential Provisions in the 2012 IECC
- Chang es to the Commercial Provisions in the 2012 IECC
- T ransitioning from the 2006 IECC and the 2009 IECC to the 2012 IECC

Understanding the Importance of the IECC in the Built Environment

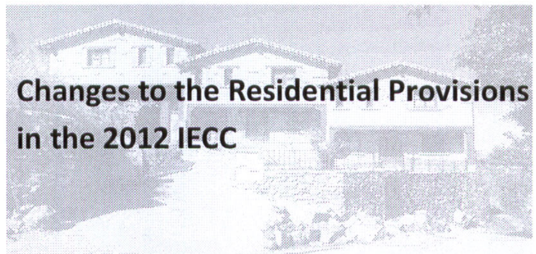
- Establishes a common foundation for evaluating, regulating, and incentivizing building performance, technologies, design, and construction.
- Promotes more widespread decisions and actions that lead to efficient buildings.
- Helps drive the development and deployment of new building technologies and design strategies.
- Provides a cost effective step toward mitigating problems associated with growing demand for energy and power resources.
- Locks in the use of energy efficient technologies that have been proven through incentive programs, freeing up resources to focus on additional technologies.

Importance of the IECC in the Built Environment

- Provides a common basis on which to educate the building design and construction communities in energy efficiency.
- Safeguards owners and tenants from long-term financial burdens that can result from short-term design and construction decisions.
- Continues to progress in terms of stringency, scope, and enforcement emphasis – all of which provide new jobs or opportunities to enhance the skills of the current workforce.
- Helps protect the environment from unnecessary emissions.
- Reduces the vast amount of energy that is needlessly consumed each year to heat, cool, light, ventilate, and provide hot water for newly constructed residential and commercial buildings that lack energy efficient features.

Importance of the IECC in the Built Environment

- Buildings fundamentally have an impact on people's lives, economic well being, and the United States' dependence on foreign oil, national security and the health of the planet. In the United States, residential and commercial buildings together use more energy and emit more carbon dioxide than either the industrial or transportation section.
- Total Carbon Dioxide Emissions from Energy Consumption by Sector (2008) – Buildings 39% Transportation 34% Industry 27%
- Buildings use 39% of our total energy, two-thirds of our electricity, and one-eighth of our water. In light of these fundamental environmental issues, and the increasing cost of energy and our current economic challenges, building energy efficiency is a key component of sound public policy.



2012 IECC Residential Provisions

Learning Objectives:

- Learn about the major changes in requirements to the 2012 IECC for residential buildings.
- Review the insulation and fenestration changes based on climate zone.
- Understand the details on how the air leakage requirements have changed.
- Define the requirements for hot water piping and size.

Major Changes from the 2006 IECC to the 2009 IECC

- ✓ Moisture control requirements moved to the IRC (R601.3)
- ✓ Exemptions for 15sf glazed fenestration and opaque doors may not be used in the UA tradeoff calculation.
- ✓ Envelope air tightness requirements added – blower door or envelope inspection required (402.4.2 and Table 402.2.2)
- ✓ (2) of (3) options for recessed lighting eliminated – testing per ASTM E283 now required. Site-built option deleted.
- ✓ Specific mandatory requirements for elements of mechanical systems specified, replacing Sec 403 (Mandatory) language.
- ✓ Minimum R-8 for attic "supply" ducts – all others min R-6, except if located in conditioned space.
- ✓ New requirements for snow melt systems and heated pools.
- ✓ High efficacy lighting required for 50% of permanently installed fixtures
- ✓ For performance design, exception added for multiple orientations
- ✓ For performance design, mechanical tradeoffs disallowed, i.e. proposed design =standard design

Major Changes from the 2009 IECC to the 2012 IECC

- ✓ ~30% more energy efficient than 2006 IECC
- ✓ Consolidated with IRC energy chapter (actually a change to the IRC, not the IECC)
- ✓ Mandatory whole-house pressure test
- ✓ More stringent duct leakage test
- ✓ DHW distribution system requirements
- ✓ Mandatory lighting requirements
- ✓ Key non-change – retains prohibition on envelope/equipment tradeoff
- ✓ Limitations on performance design

Certificate

R401.3 (Mandatory)

- Permanently posted on or in the electrical distribution panel, by the builder or RDP.
- Don't cover or obstruct the visibility of other required labels
- Includes the following:
  - R-values of insulation installed for the thermal building envelope, including ducts outside conditioned spaces
  - U-factors and SHGC for fenestration
  - Results from any required duct system and building envelope air leakage testing
  - HVAC efficiencies and types
  - SWH equipment

2009/2012 IECC Residential Scoping

- **Provisions apply to**
- ✓ *Building Thermal Envelope* – Opaque elements - Walls, Ceilings, Floors Fenestration – Windows, Doors, Skylights Air leakage (Infiltration) – Thermal Envelope, Fireplaces, Windows
- ✓ *Systems* – Controls, Ducts, Mechanical Piping, Hot Water Systems, Mechanical Ventilation, Equipment Sizing, Snow Melting, Pools
- ✓ *Electrical Power and Lighting* – Lighting Equipment

2009/2012 IECC Residential Compliance

Compliance paths

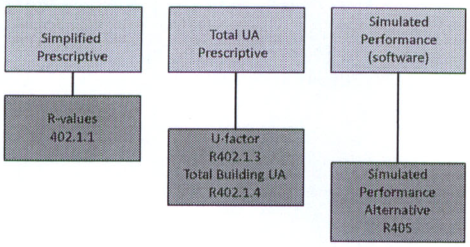
R401.2 Projects shall comply with sections identified as "mandatory" and with either sections identified as "prescriptive" or the performance approach in Section R405.

Mandatory – certificate, air leakage, controls, duct sealing, mechanical system piping insulation, mechanical ventilation, equipment sizing, building cavities, circulating hot water system controls, pools, lighting efficacy.

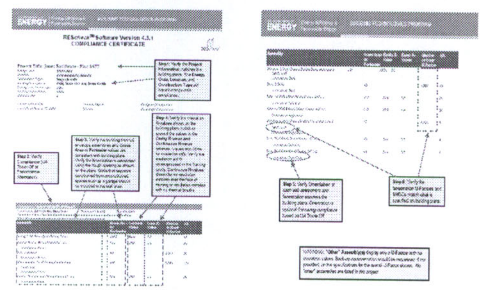
Prescriptive – R-values/Total UA, specific insulation requirements, fenestration, duct insulation, hot water system piping

Performance – Proposed has annual energy costs less than or equal to the standard reference. Must meet all mandatory requirements.

2009/2012 IECC Compliance –
Three Options?



Total UA Alternative - REScheck



Insulation and Fenestration Requirements by Climate Zone

TABLE R402.1.1
INSULATION AND FENESTRATION REQUIREMENTS BY COMPONENT[a]

CLIMATE ZONE	FENESTRATION U-FACTOR[b]	SKYLIGHT[b] U-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING R-VALUE	WOOD FRAME WALL R-VALUE	MASS WALL R-VALUE[i]	FLOOR R-VALUE	BASEMENT[c] WALL R-VALUE	SLAB[d] R-VALUE & DEPTH	CRAWL SPACE[c] WALL R-VALUE
1	NR	0.75	0.25	30	13	3/4	13	0	0	0
2	0.40	0.65	0.25	38	13	4/6	13	0	0	0
3	0.35	0.55	0.25	38	20 or 13+5[h]	8/13	19	5/13[f]	0	5/13
4 except Marine	0.35	0.55	0.40	49	20 or 13+5[h]	8/13	19	10/13	10, 2 ft	10/13
5 and Marine 4	0.32	0.55	NR	49	20 or 13+5[h]	13/17	30[g]	15/19	10, 2 ft	15/19
6	0.32	0.55	NR	49	20+5 or 13+10[h]	15/20	30[g]	15/19	10, 4 ft	15/19
7 and 8	0.32	0.55	NR	49	20+5 or 13+10[h]	19/21	38[g]	15/19	10, 4 ft	15/19

For SI: 1 foot = 304.8 mm.

a. R-values are minimums. U-factors and SHGC are maximums. When insulation is installed in a cavity which is less than the label or design thickness of the insulation, the installed R-value of the insulation shall not be less than the R-value specified in the table.

b. The fenestration U-factor column excludes skylights. The SHGC column applies to all glazed fenestration. Exception: Skylights may be excluded from glazed fenestration SHGC requirements in Climate Zones 1 through 3 where the SHGC for such skylights does not exceed 0.30.

c. "15/19" means R-15 continuous insulation on the interior or exterior of the home or R-19 cavity insulation at the interior of the basement wall. "15/19" shall be permitted to be met with R-13 cavity insulation on the interior of the basement wall plus R-5 continuous insulation on the interior or exterior of the home. "10/13" means R-10 continuous insulation on the interior or exterior of the home or R-13 cavity insulation at the interior of the basement wall.

d. R-5 shall be added to the required slab edge R-values for heated slabs. Insulation depth shall be the depth of the footing or 2 feet, whichever is less in Climate Zones 1 through 3 for heated slabs.

e. There are no SHGC requirements in the Marine Zone.

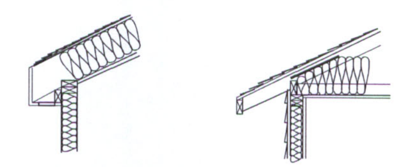
f. Basement wall insulation is not required in warm-humid locations as defined by Figure R301.1 and Table R301.1.

g. Or insulation sufficient to fill the framing cavity, R-19 minimum.

h. First value is cavity insulation, second is continuous insulation or insulated siding, so "13+5" means R-13 cavity insulation plus R-5 continuous insulation or insulated siding. If structural sheathing covers 40 percent or less of the exterior, continuous insulation R-value shall be permitted to be reduced by no more than R-3 in the locations where structural sheathing is used – to maintain a consistent total sheathing thickness.

i. The second R-value applies when more than half the insulation is on the interior of the mass wall.

Ceiling R-value



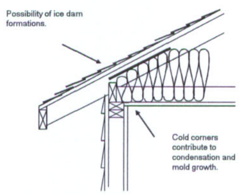
Ceiling R-value Requirements Based on Ceiling Assembly Type

- Ceilings with attic spaces
- Ceilings without attic spaces

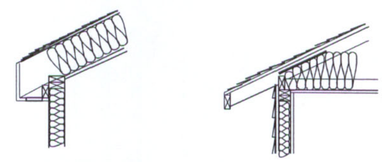
Ceiling R-value - Ceilings With Attic Spaces

Options for meeting requirements
- Standard truss system
  - Install R-value of insulation to meet the requirements specified in Table 402.1.1/N1102.1

Potential Cold Climate Issues:



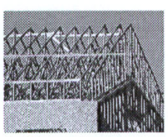
Ceiling R-value

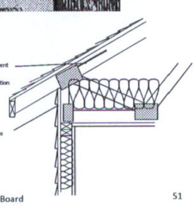


Ceiling R-value Requirements Based on Ceiling Assembly Type
- Ceilings with attic spaces
- Ceilings without attic spaces

Ceiling R-value - Ceilings With Attic Spaces

- Options for meeting requirements
  - Oversized Truss / Energy Truss / Raised Heel Truss
  - Substitute R- 30 for R-38 Insulation
  - Substitute R- 38 for R-49 Insulation
- Goal – Provide full height, uncompressed insulation over exterior wall plate at the eaves





Eave Baffle
R402.2.3

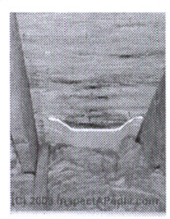
For air permeable insulations in vented attics

•Installed adjacent to soffit and eave vents

•To maintain an opening ≥ size of vent

•To extend over top of attic insulation

•May be of any solid material



Wood-Frame Walls
R402.1

TABLE R402.1.1
INSULATION AND FENESTRATION REQUIREMENTS

CLIMATE ZONE	FENESTRATION U-FACTOR[b]	SKYLIGHT[b] U-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING R-VALUE	WOOD FRAME WALL R-VALUE
1	NR	0.75	0.25	30	13
2	0.40	0.65	0.25	38	13
3	0.35	0.55	0.25	38	20 or 13+5[h]
4 except Marine	0.35	0.55	0.40	49	20 or 13+5[h]
5 and Marine 4	0.32	0.55	NR	49	20 or 13+5[h]
6	0.32	0.55	NR	49	20+5 or 13+10[h]
7 and 8	0.32	0.55	NR	49	20+5 or 13+10[h]

h. First value is cavity insulation, second is continuous insulation or insulated siding, so "13+5" means R-13 cavity insulation plus R-5 continuous insulation or insulated siding. If structural sheathing covers 40 percent or less of the exterior, continuous insulation R-value shall be permitted to be reduced by no more than R-3 in the locations where structural sheathing is used – to maintain a consistent total sheathing thickness.

April 13, 2012 Payson Development Review Board 53

Requirements by Climate Zone
U-Factor Table

TABLE R402.1.3
EQUIVALENT U-FACTORS[a]

CLIMATE ZONE	FENESTRATION U-FACTOR	SKYLIGHT U-FACTOR	CEILING U-FACTOR	FRAME WALL U-FACTOR	MASS WALL U-FACTOR[b]	FLOOR U-FACTOR	BASEMENT WALL U-FACTOR	CRAWL SPACE WALL U-FACTOR
1	0.50	0.75	0.035	0.082	0.197	0.064	0.360	0.477
2	0.40	0.65	0.030	0.082	0.165	0.064	0.360	0.477
3	0.35	0.55	0.030	0.057	0.098	0.047	0.091[c]	0.136
4 except Marine	0.35	0.55	0.026	0.057	0.098	0.047	0.050	0.065
5 and Marine 4	0.32	0.55	0.026	0.057	0.082	0.033	0.050	0.055
6	0.32	0.55	0.026	0.048	0.060	0.033	0.050	0.055
7 and 8	0.32	0.55	0.026	0.048	0.057	0.028	0.050	0.055

a. Nonfenestration U-factors shall be obtained from measurement, calculation or an approved source.
b. When more than half the insulation is on the interior, the mass wall U-factors shall be a maximum of 0.17 in Climate Zone 1, 0.14 in Climate Zone 2, 0.12 in Climate Zone 3, 0.087 in Climate Zone 4 except Marine, 0.065 in Climate Zone 5 and Marine 4, and 0.057 in Climate Zones 6 through 8.
c. Basement wall U-factor of 0.360 in warm-humid locations as defined by Figure R301.1 and Table R301.1.

April 13, 2012 Payson Development Review Board 54

Mass Wall Requirements
R402.2.5

TABLE R402.1.1
INSULATION AND FENESTRATION REQUIREMENTS BY CO

CLIMATE ZONE	FENESTRATION U-FACTOR[b]	SKYLIGHT[b] U-FACTOR	GLAZED FENESTRATION SHGC[b, e]	CEILING R-VALUE	WOOD FRAME WALL R-VALUE	MASS WALL R-VALUE[i]
1	NR	0.75	0.25	30	13	3/4
2	0.40	0.65	0.25	38	13	4/6
3	[illegible]	[illegible]	[illegible]	[illegible]	20 or 13+5[h]	8/13
4 except Marine	[illegible]	[illegible]	[illegible]	[illegible]	20 or 13+5[h]	8/13
5 and Marine 4	[illegible]	[illegible]	[illegible]	[illegible]	20 or 13+5[h]	13/17
6	[illegible]	[illegible]	[illegible]	[illegible]	20+5 or 13+10[h]	15/20
7 and 8	[illegible]	[illegible]	[illegible]	[illegible]	20+5 or 13+10[h]	19/21

Second (higher) number applies when more than half the R-value is on the interior of the mass (i.e., when the thermal mass is insulated from the conditioned space)

April 13, 2012 Payson Development Review Board 55

Mass Walls
R402.2.5 - U-Factor

Climate Zones	U-Factor Minimum
1	0.17
2	0.14
3	0.12
4 except Marine	0.087
4 Marine and 5	0.065
6-8	0.065

Provisions:

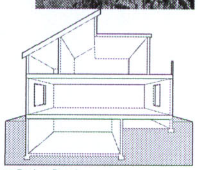
- When more than half the insulation is on the interior, the mass wall U-factors are as shown above – see footnote in Table 402.1.3

April 13, 2012 Payson Development Review Board 56

Basement Walls
R402.2.8

Climate Zones	R-Value
1-2	0
3	5/13
4	10/13
4c-8	15/19

Insulated from top of basement wall down to 10 ft below grade or basement floor, whichever is less



- ≥ 50% below grade
- Otherwise treat as above-grade wall

Steel-Frame Walls
R402.2.6

TABLE R402.2.6
STEEL-FRAME CEILING, WALL AND FLOOR INSULATION (R-VALUE)

WOOD FRAME R-VALUE REQUIREMENT	COLD-FORMED STEEL EQUIVALENT R-VALUE[a]
Steel Truss Ceilings[b]	
R-30	R-38 or R-30 + 3 or R-26 + 5
R-38	R-49 or R-38 + 3
R-49	R-38 + 3
Steel Joist Ceilings[b]	
R-30	R-38 in 2 × 4 or 2 × 6 or 2 × 8 R-49 in any framing
R-38	R-49 in 2 × 4 or 2 × 6 or 2 × 8 or 2 × 10
Steel-Framed Wall 16" O.C.	
R-13	R-13 + 4.2 or R-19 + 2.1 or R-21 + 2.8 or R-0 + 9.3 or R-15 + 3.8 or R-21 + 3.1
R-13 + 3	R-0 + 11.2 or R-13 + 6.1 or R-15 + 5.7 or R-19 + 5.0 or R-21 + 4.7
R-20	R-0 + 14.0 or R-13 + 8.9 or R-15 + 8.5 or R-19 + 7.8 or R-19 + 6.2 or R-21 + 7.5
R-20 + 5	R-13 + 12.7 or R-15 + 12.3 or R-19 + 11.6 or R-21 + 11.3 or R-25 + 10.9
R-21	R-0 + 14.6 or R-13 + 9.5 or R-15 + 9.1 or R-19 + 8.4 or R-21 + 8.1 or R-25 + 7.7
Steel Framed Wall, 24" O.C.	
R-13	R-0 + 9.3 or R-13 + 3.0 or R-15 + 2.4
R-13 + 3	R-0 + 11.2 or R-13 + 4.9 or R-15 + 4.3 or R-19 + 3.5 or R-21 + 3.1
R-20	R-0 + 14.0 or R-13 + 7.7 or R-15 + 7.1 or R-19 + 6.3 or R-21 + 5.9
R-20 + 5	R-13 + 11.5 or R-15 + 10.9 or R-19 + 10.1 or R-21 + 9.7 or R-25 + 9.1
R-21	R-0 + 14.6 or R-13 + 8.3 or R-15 + 7.7 or R-19 + 6.9 or R-21 + 6.5 or R-25 + 5.9
Steel Joist Floor	
R-13	R-19 in 2 × 6, or R-19 + 6 in 2 × 8 or 2 × 10
R-19	R-19 + 6 in 2 × 6, or R-19 + 12 in 2 × 8 or 2 × 10

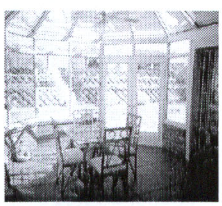
a. Cavity insulation R-value is listed first, followed by continuous insulation R-value.
b. Insulation exceeding the height of the framing shall cover the framing.

Sunrooms
R402.2.12

Less stringent insulation R-value and glazing U-factor requirements

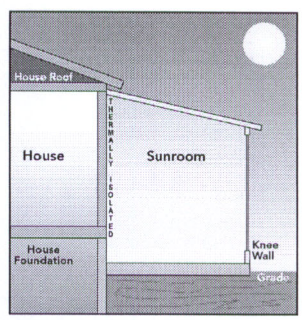
Sunroom definition:

- One story structure
- Glazing area >40% glazing of gross exterior wall and roof area
- Separate heating or cooling system or zone
- Must be thermally isolated (closeable doors or windows to the rest of the house)
- Can always meet Table R402.1.1 requirements with unlimited glass



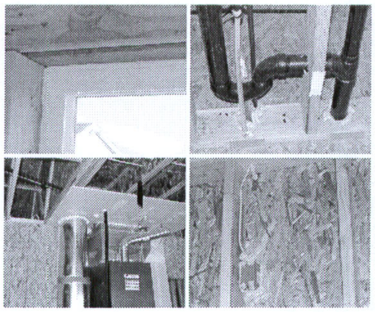
Sunrooms

- Ceiling Insulation
  - Zones 1-4 R-19
  - Zones 5-8 R-24
- Wall Insulation (Min.)
  - All zones R-13
- Fenestration U-Factor (Max.)
  - Zones 4-8 0.45
- Skylight U-Factor (Max.)
  - Zones 4-8 0.70



Air Leakage Control

R402.4 (Mandatory)



Building thermal envelope

Building Thermal Envelope

R402.4.1 – Air Leakage

Two requirements to demonstrate compliance:

- Whole-house pressure test

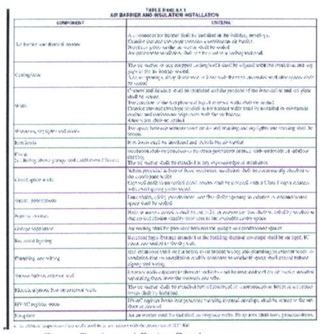
Air Leakage Rate	Climate Zone	Test Pressure
≤ 5 ACH	1-2	50 Pascals
≤ 3 ACH	3-8	50 Pascals

- Testing may occur any time after creation of all building envelope penetrations
- 2009 – inspect or test at 7 ACH.

Building Thermal Envelope

R402.4.1 – Air Leakage

- Field verification of items listed in Table R402.4.1.1



Systems

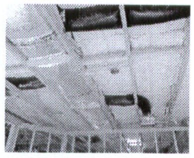
R403

Section R403.1 - Controls (mandatory)

- Each heating or cooling system shall have a thermostat
- For forced-air systems, a programmable thermostat is required, with a setback range of 55°F to 85°F, and initial programming of 70°F (heating) and 78°F (cooling)
- Heat pumps with supplementary electric heat shall have controls to prevent operation of the supplemental heat when the heat pump can meet the load.

Duct Sealing
R403.2.2

- Sealing
  - Joints and seams to comply with IMC or IRC
  - All ducts, air handlers, and filter boxes to be sealed *(Section R403.2.2)*

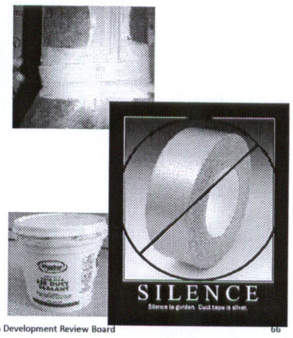


- Exceptions
  - No additional joint seals required for air-impermeable spray foam product
  - Where duct connection is partially inaccessible, 3 screws or rivets to be equally spaced on exposed portion of joint to prevent a hinge effect
  - Continuously welded and locking-type longitudinal joints and seams in ducts operating at static pressures < 2 in. w.c. pressure classification don't require additional closure systems

Duct Sealing
R403.2.2

Heating and Cooling Equipment Duct Sealing Section 403.2.2 IECC and M1601.4.1 IRC

- Can seal with tapes, mastics, gasketing and other approved closure devices **(UL181)**
- Rigid fibrous glass ducts
  - Pressure sensitive tapes UL 181 A "181 A-P"
  - Mastic UL 181 A "181 A-M"
  - Heat sensitive tape UL 181 A "181 A-H"
- Flexible air duct
  - Pressure sensitive tape UL 181B "181B-FX"
  - Mastic UL 181B "181B-M"



Duct Tightness Testing
R403.2.2

Duct tightness shall be verified by either of the following:

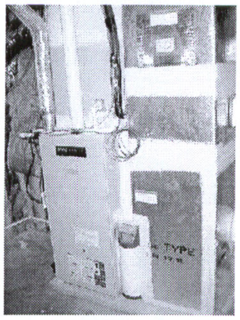
- Post construction test
  - Total leakage: ≤4 cfm/per 100 ft^2 of conditioned floor area
    - tested at a pressure differential of 0.1 in w.g. (25Pa) across entire system, including manufacturer's air handler enclosure
  - All register boots taped or otherwise sealed
- Rough-in test
  - Total leakage ≤4 cfm/per 100 ft^2 of conditioned floor area
    - tested at a pressure differential of 0.1 in w.g. (25Pa) across roughed-in system, including manufacturer's air handler enclosure
    - all register boots taped or otherwise sealed
    - if air handler not installed at time of test
      - Total air leakage ≤3 cfm/per 100 ft^2

Exceptions: Duct tightness test is not required if the air handler and all ducts are located within building thermal envelope

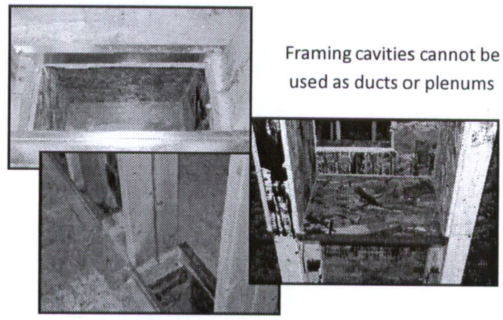
Duct Tightness Tests
R403.2.2

Sealed Air Handler
R403.2.2.1

Air handlers to have a manufacturer's designation for an air leakage of ≤ 2% of design air flow rate per ASHRAE 193



Building Cavities
R403.2.3



Framing cavities cannot be used as ducts or plenums

Mechanical System Piping Insulation
R403.3

- R-3 required on
  - HVAC systems
    - Exception: Piping that conveys fluids between 55 and 105°F
- If exposed to weather,
  - protect from damage, including
    - Sunlight
    - Moisture
    - Equipment maintenance
    - Wind
  - Provide shielding from solar radiation that can cause degradation of material
  - Adhesive tape is not allowed

Hot Water Piping Insulation
R403.4.2

- R-3 required on
  - Piping > ¾ in. nominal diameter
  - Piping serving more than one dwelling unit
  - Piping from the water heater to kitchen outlets
  - Piping located outside the conditioned space
  - Piping from the water heater to a distribution manifold
  - Piping under a floor slab
  - Buried piping

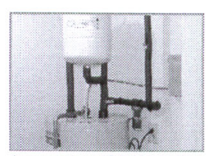


Image courtesy of Britt/Makela Group

  - Supply and return piping in re-circulating systems other than demand recirculation systems
  - Piping with run lengths > maximum run lengths for nominal pipe diameter in Table R403.4.2
  - All remaining piping to be at least R-3 or meet run length requirements in Table R403.4.2

Hot Water Piping Insulation

R403.4.2

TABLE R403.4.2
MAXIMUM RUN LENGTH (feet)[a]

Nominal Pipe Diameter of Largest Diameter Pipe in the Run (inch)	$^3/_8$	$^1/_2$	$^3/_4$	$> ^3/_4$
Maximum Run Length	30	20	10	5

For SI: 1 inch = 25.4 mm, 1 foot 304.8 mm.

a. Total length of all piping from the distribution manifold or the recirculation loop to a point of use.

Mechanical Ventilation

R403.5

- Ventilation
  - Building to have ventilation meeting IRC or IMC or with other approved means
  - Outdoor air intakes and exhausts shall have automatic or gravity dampers that close when the ventilation system is not operating
- Whole-house mechanical ventilation system fans to meet efficacy in Table R403.5.1
  - **Exception**
    - When fans are integral to tested and listed HVAC equipment, powered by electronically commutated motor

TABLE R403.5.1
MECHANICAL VENTILATION SYSTEM FAN EFFICACY

FAN LOCATION	AIR FLOW RATE MINIMUM (CFM)	MINIMUM EFFICACY (CFM/WATT)	AIR FLOW RATE MAXIMUM (CFM)
Range hoods	Any	2.8 cfm/watt	Any
In-line fan	Any	2.8 cfm/watt	Any
Bathroom, utility room	10	1.4 cfm/watt	< 90
Bathroom, utility room	90	2.8 cfm/watt	Any

For SI: 1 cfm = 28.3 L/min.

Mechanical Ventilation

R403.5

M1507.3 Whole-house mechanical ventilation system. Whole-house mechanical ventilation systems shall be designed in accordance with Sections M1507.3.1 through M1507.3.3.

M1507.3.1 System design. The whole-house ventilation system shall consist of one or more supply or exhaust fans or a combination of such and associated ducts and controls. Where local supply or exhaust fans are used as part of such a system, they shall be tested and rated in accordance with HVI 916, and the fans' rated flow at 0.25 in w.c. static pressure shall equal or exceed the required ventilation rate determined by Section M1507.3.3. Outdoor air ducts connected to the return side of an air handler shall be considered to provide supply ventilation.

M1507.3.2 System Controls. The whole-house mechanical ventilation system shall be provided with controls that enable manual override.

M1507.3.3 Mechanical ventilation rate. The whole-house mechanical ventilation system shall provide outdoor air at a continuous rate not less than that determined in accordance with Table M1507.3.3(1).

Exception: The whole-house mechanical ventilation system is permitted to operate intermittently where the system has controls that enable operation for not less than 25% of each 4 hour segment and the ventilation rate prescribed in Table M1507.3.3(1) is multiplied by the factor determined in accordance with Table M1507.3.3(2).

TABLE M1507.3.3(1)
CONTINUOUS WHOLE-HOUSE MECHANICAL VENTILATION SYSTEM AIRFLOW RATE REQUIREMENTS

Dwelling Unit Floor Area (square feet)	Number of Bedrooms				
	0-1	2-3	4-5	6-7	>7
	Airflow in CFM				
≤1500	30	45	60	75	90
1501-3000	45	60	75	90	105
3001-4500	60	75	90	105	120
4501-6000	75	90	105	120	135
6001-7500	90	105	120	135	150
>7500	105	120	135	150	165

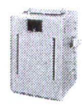
Equipment Sizing

R403.6

- Equipment Sizing
  - IECC references Section M1401.3 of the IRC
  - Load calculations determine the proper capacity (size) of equipment
    - Goal is big enough to ensure comfort but no bigger
  - Calculations shall be performed in accordance with ACCA Manual J & S or other approved methods

Pools and In-ground Permanently Installed Spas - *R403.9*

- Heaters
  - with a readily accessible on-off switch mounted outside heater so heater can be shut off without adjusting thermostat setting
  - fired by natural gas not allowed to have continuously burning pilot lights



- Time switches (or other control method) to automatically turn off and on heaters and pumps according to a preset schedule installed on all heaters and pumps
- Note: heaters, pumps, and motors with built-in timers meet the requirement
  - Exceptions
    - Public health standards requiring 24-hour pump operation
    - Pumps operating pools with solar-waste-heat recovery heating systems

Pool Covers
R403.9.3

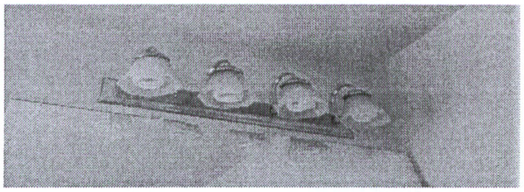
On heated pools and in-ground permanently installed spas

- Vapor-retardant cover

•**Exception:**
- If >70% of energy from site-recovered energy

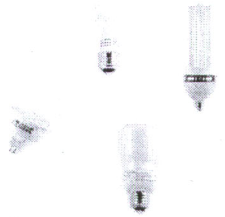
Lighting Equipment
R404.1

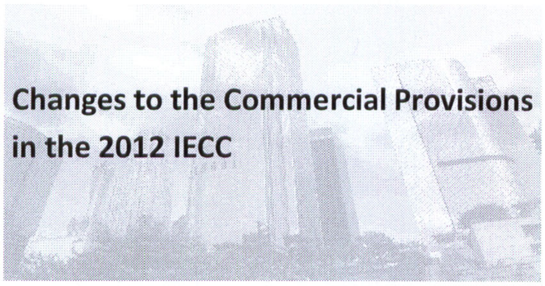
A minimum of 75 % of the lamps in permanently installed lighting fixtures shall be high-efficacy lamps or 75% of permanently installed lighting fixtures to contain only high efficacy lamps. Exception: low voltage lighting



High Efficacy Required
R404.1

- Applies to permanently installed lighting fixtures
- Requires 75% to be
  - Compact Fluorescent
  - T-8 Linear Fluorescent
  - Meet minimum efficacy requirements
- Applies to interior and exterior lighting





2012 IECC Commercial Provisions

Learning Objectives:

- Learn about the major changes in requirements to the 2012 IECC for commercial buildings.
- Review the insulation and fenestration changes based on climate zone.
- Understand the specific requirements for continuous air barriers.
- Identify the new HVAC commissioning requirements and when does it apply.

Major Changes from the 2006 IECC to the 2009 IECC

- ✓ Moisture control requirements moved to the IRC (R601.3)
- ✓ Exemptions for 15sf glazed fenestration and opaque doors may not be used in the UA tradeoff calculation.
- ✓ Envelope air tightness requirements added – blower door or envelope inspection required (402.4.2 and Table 402.2.2)
- ✓ (2) of (3) options for recessed lighting eliminated – testing per ASTM E283 now required. Site-built option deleted.
- ✓ Specific mandatory requirements for elements of mechanical systems specified, replacing Sec 403 (Mandatory) language.
- ✓ Minimum R-8 for attic "supply" ducts – all others min R-6, except if located in conditioned space.
- ✓ New requirements for snow melt systems and heated pools.
- ✓ High efficacy lighting required for 50% of permanently installed fixtures
- ✓ For performance design, exception added for multiple orientations
- ✓ For performance design, mechanical tradeoffs disallowed, i.e. proposed design =standard design

Major Changes from the IECC 2006 to the 2009 IECC

- ✓ **Specific Insulation requirements** - per Table 502.2(1), with increased stringency in many climate zones and assembly types, with comparable changes in U-factor Table 502.1.2. In some CZs, "Group R" is more stringent than "All other".
- ✓ **Fenestration criteria –** per Table 502.3, with minor changes in vertical fenestration U-factor/SHGC in CZ 7-8, and in skylight U-factor/SHGC in CZ 1-3
- ✓ **HVAC equipment performance requirements –** increased efficiency across most equipment types/sizes.
- ✓ **Demand control ventilation -** for spaces > 500sf

Major Changes from the IECC 2006 to the 2009 IECC

- ✓**Allowable fan floor horsepower** – new provisions , for fan system motors > 5hp.
- ✓**Economized requirements** – added for CZs 3A and 4A.
- ✓**Daylight zone controls** – added for daylight zones (see new definition)
- ✓**Total connected interior lighting power** – several new exempt spaces added.
- ✓**Exterior building lighting power** – Zone factor added for allowable LPDs, based on location.
- ✓**Total building performance** – extensive re-write of section

April 13, 2012 Payson Development Review Board 85

Major Changes from the IECC 2009 to the 2012 IECC

- ✓**Roof solar reflectance and thermal emittance** – requirements for low albedo roofing in cooling climate zones
- ✓**Opaque element requirements** – more stringent for some components in some climate zones, incl unheated slabs in CZ4.
- ✓**Maximum vertical fenestration** – reduced from 40% to 30%
- ✓**Skylights <u>required</u>** – in some building types, under some conditions
- ✓**Fenestration U-value/SHGC** – more stringent in some CZs.
- ✓**Air barrier requirements and compliance options** – extensive re-write of section

April 13, 2012 Payson Development Review Board 86

Major Changes from the IECC 2009 to the 2012 IECC

- ✓**Equipment efficiencies** – complete replacement of section, with more stringent efficiency reqs
- ✓**Vestibules** – important clarifications about required locations
- ✓**Energy recovery ventilation** – required in more building types and CZs.
- ✓**Piping in mechanical systems** – more detailed requirements for pipe sizes/lengths/locations
- ✓**Lighting controls** – more detail of control strategies and locations, incl daylight zones
- ✓**Additional efficiency package options** – required for prescriptive compliance
- ✓**Commissioning** – requirement added for large buildings

April 13, 2012 Payson Development Review Board 87

Commercial Compliance Options
C401.2

1 90.1-2010

OR

2 C402 - Envelope
C403 - Mechanical
C404 - SWH
C405 - Lighting
AND
Pick One:
- C406.2 – Eff. HVAC Performance
- or
- C406.3 – Eff. Lighting Systems
- or
- C406.4 – On-site Renewable Energy

OR

3 C407 – Total Building Performance
- C402.4 – Air Leakage
- C403.2 – Provisions applicable to all mechanical systems
- C404 - SWH
- Lighting Mandatory Sections
  - C405.2
  - C405.3
  - C405.4
  - C405.6
  - C405.7
- Building energy cost to be ≤ 85% of standard reference design building

April 13, 2012 Payson Development Review Board 88

Requirements by Climate Zone
U-Factor Table - Table C402.1.2

TABLE C402.1.2
OPAQUE THERMAL ENVELOPE ASSEMBLY REQUIREMENTS[a]

CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R	All other	Group R
Roofs																
Insulation entirely above deck	U-0.048	U-0.048	U-0.048	U-0.048	U-0.048	U-0.048	U-0.039	U-0.039	U-0.039	U-0.039	U-0.032	U-0.032	U-0.028	U-0.028	U-0.028	U-0.028
Metal buildings	U-0.044	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.035	U-0.031	U-0.031	U-0.029	U-0.029	U-0.029	U-0.029
Attic and other	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.027	U-0.021	U-0.021	U-0.021	U-0.021	U-0.021	U-0.021	U-0.021
Walls, Above Grade																
Mass	U-0.142	U-0.142	U-0.142	U-0.123	U-0.110	U-0.104	U-0.104	U-0.090	U-0.078	U-0.078	U-0.078	U-0.071	U-0.061	U-0.061	U-0.061	U-0.061
Metal building	U-0.079	U-0.079	U-0.079	U-0.079	U-0.079	U-0.052	U-0.052	U-0.052	U-0.052	U-0.052	U-0.052	U-0.052	U-0.052	U-0.039	U-0.052	U-0.039
Metal framed	U-0.077	U-0.077	U-0.077	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.057	U-0.064	U-0.052	U-0.045	U-0.045
Wood framed and other	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.064	U-0.051	U-0.051	U-0.051	U-0.051	U-0.036	U-0.036
Walls, Below Grade																
Below-grade wall[b]	C-1.140	C-1.140	C-1.140	C-1.140	C-1.140	C-1.140	C-0.119	C-0.119	C-0.119	C-0.119	C-0.119	C-0.119	C-0.092	C-0.092	C-0.092	C-0.092
Floors																
Mass	U-0.322	U-0.322	U-0.107	U-0.087	U-0.076	U-0.076	U-0.076	U-0.074	U-0.074	U-0.064	U-0.064	U-0.057	U-0.055	U-0.051	U-0.055	U-0.051
Joist/framing	U-0.066	U-0.066	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033	U-0.033
Slab-on-Grade Floors																
Unheated slabs	F-0.73	F-0.73	F-0.73	F-0.73	F-0.73	F-0.73	F-0.54	F-0.54	F-0.54	F-0.54	F-0.54	F-0.52	F-0.40	F-0.40	F-0.40	F-0.40
Heated slabs	F-0.70	F-0.70	F-0.70	F-0.70	F-0.70	F-0.70	F-0.65	F-0.65	F-0.58	F-0.58	F-0.58	F-0.55	F-0.55	F-0.55	F-0.55	F-0.55

a. Use of opaque assembly U-factors, C-factors, and F-factors from ANSI/ASHRAE/IESNA 90.1 Appendix A shall be permitted, provided the construction complies with the applicable construction details from ANSI/ASHRAE/IESNA 90.1 Appendix A.
b. Where heated slabs are below grade, below-grade walls shall comply with the F-factor requirements for heated slabs.

Requirements by Climate Zone
R-Value Table - Table C402.2

TABLE C402.2
OPAQUE THERMAL ENVELOPE REQUIREMENTS

CLIMATE ZONE	1		2		3		4 EXCEPT MARINE		5 AND MARINE 4		6		7		8	
	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R	All Other	Group R
Roofs																
Insulation entirely above deck	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Metal buildings (with R-5 thermal blocks)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Attic and other	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Walls, Above Grade																
Mass	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Metal building	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Metal framed	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Wood framed and other	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Walls, Below Grade																
Below-grade wall	NR	NR	NR	NR	NR	NR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Floors																
Mass	NR	NR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Joist/Framing	NR	NR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Slab-on-Grade Floors																
Unheated slabs	NR	NR	NR	NR	NR	NR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Heated slabs	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Opaque Doors																
Swinging	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Roll-up or sliding	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

For SI: 1 inch = 25.4 mm, ci = Continuous insulation, NR = No requirement.

Roof Assembly
C402.2.1

Roof R-values are based on assembly type / insulation placement, per Table C402.2

- Insulation entirely above deck
- Metal buildings
- Attic and other

Skylight curbs to be insulated to the level of roofs with insulation entirely above deck or R-5, whichever is less

✓ Exception: unit skylight curbs included as a component of an NFRC 100 rated assembly

High Albedo Roofs - Cool Roofs

- Required in CZ 1-3 for roofs ≤ 2:12
- Roofs can qualify using one of four minimum roof reflectance and emittance options
- Several exceptions

Three-year aged solar reflectance[b] of 0.55 and three-year aged thermal emittance[c] of 0.75
Initial solar reflectance[b] of 0.70 and initial thermal emittance[c] of 0.75
Three-year-aged solar reflectance index[d] of 64
Initial solar reflectance index[d] of 82

High Albedo Roofs – Exceptions
C402.2.1.1

- Portions of roofs that include or are covered by:
  - –PV systems or components
  - –Solar air or water heating systems or components
  - –R oof gardens or landscaped roofs
  - –Above-r oof decks or walkways
  - –Skylights
  - –HV AC systems, components, and other opaque objects mounted above the roof
- Portions of roofs shaded during peak sun angle on June 21 by permanent features of the building or adjacent buildings
- Ballasted roofs with minimum stone ballast of 17 lbs/ft^2 or 23 lbs/ft^2 pavers
- Roofs, where a minimum of 75% of the roof area meets one of the above exceptions

Building Envelope Requirements
Fenestration - Table C402.3

TABLE C402.3
BUILDING ENVELOPE REQUIREMENTS: FENESTRATION

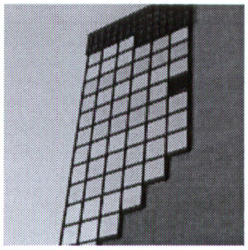
CLIMATE ZONE	1	2	3	4 EXCEPT MARINE	5 AND MARINE 4	6	7	8
Vertical fenestration								
U-factor								
Fixed fenestration	0.50	0.50	0.46	0.38	0.38	0.36	0.29	0.29
Operable fenestration	0.65	0.65	0.60	0.45	0.45	0.43	0.37	0.37
Entrance doors	1.10	0.83	0.77	0.77	0.77	0.77	0.77	0.77
SHGC								
SHGC	0.25	0.25	0.25	0.40	0.40	0.40	0.45	0.45
Skylights								
U-factor	0.75	0.65	0.55	0.50	0.50	0.50	0.50	0.50
SHGC	0.35	0.35	0.35	0.40	0.40	0.40	NR	NR

NR = No requirement.

Vertical Fenestration Requirement
C402.3.1 – Prescriptive (Max area)

Percentage of Vertical Fenestration Area to Gross Wall Area

- Allowed up to 30% maximum of above grade wall
  - In Climate Zones 1-6, up to 40% maximum of above grade wall with daylighting controls



Increased Vertical Fenestration with Daylighting Controls - *C402.3.1.1*

- Up to 40% vertical fenestration area allowed in Climate zones 1-6, provided
  - – No less than 50% of the conditioned floor area is within a daylight zone
  - – Automatic daylighting controls are installed in daylight zones; and
  - – VT of vertical fenestration is ≥ 1.1 times SHGC

Exception:

Fenestration that is outside the scope of NFRC 200 isn't required to comply with VT

Increased Skylight Area with Daylighting Controls - *C402.3.1.2*

- Limited to ≤ 3% of Roof Area
- Up to 5% allowed if automatic daylighting controls installed in daylight zones under skylights

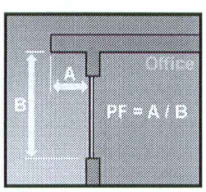
Minimum Skylight Fenestration Area
C402.3.2

- In certain types of enclosed spaces > 10,000 ft^2 directly under a roof with ceiling heights > 15 ft
  - total daylight zone under skylights to not be < ½ the floor area and to provide a minimum skylight area to daylight zone of either
    - Minimum of 3% of skylight area with a skylight VLT at least 0.40 **OR**
    - Provide a minimum skylight effective aperture of at least 1%
- **Exceptions**
- Climate zones 6-8
- Spaces with LPDs < 0.5 W/ft^2
- Documented shaded spaces
- Daylight area under rooftop monitors is > 50% of floor area

Fenestration SHGC Requirements

The Effect of Overhangs on Fenestration SHGC

- Overhangs allow a higher SHGC product to be installed
- Projection factor must be calculated
- When different windows or glass doors have different PFs
  - Evaluate separately



SHGC Adjustment
C402.3.3.1

- When PF ≥ 0.2, the required maximum SHGC in Table C402.3 must be adjusted by multiplying the required maximum SHGC by the multiplier in Table C402.3.3.1

TABLE C402.3.3.1
SHGC ADJUSTMENT MULTIPLIERS

PROJECTION FACTOR	ORIENTED WITHIN 45 DEGREES OF TRUE NORTH	ALL OTHER ORIENTATION
0.2 ≤ PF < 0.5	1.1	1.2
PF ≤ 0.5	1.2	1.6

Increased Vertical Fenestration SHGC
C402.3.3.2

- In Climate Zones 1-3, vertical fenestration entirely located not less than 6 ft above the finished floor is permitted a maximum SHGC of 0.40

Increased Skylight SHGC
C402.3.3.3

- In Climate Zones 1-6, skylights above daylight zones with automated daylight controls are permitted a maximum SHGC of 0.60

Increased Skylight U-Factor
C402.3.3.4

- Skylights above daylight zones with automated daylight controls are permitted a maximum U-factor of:
  - 0.9 in Climate Zones 1-3
  - 0.75 in Climate Zones 4-8

Air Leakage
C402.4

- Air barriers – C402.4.1
- Air barrier penetrations – C402.4.2
- Fenestration air leakage - C402.4.3
- Doors & Access openings to shafts, etc. – C402.4.4
- Air intakes, exhaust openings, stairways and shafts - C402.4.5
- Loading dock weatherseals - C402.4.6
- Vestibules - C402.4.7
- Recessed lighting - C402.4.8

Air Barriers and Construction
C402.4.1 and C402.4.1.1

- Continuous air barrier required except in:
  - Climate zones 1-3
- Air barrier requirements:
  - Placement allowed
    - Inside of building envelope
    - Outside of building envelope
    - Located within assemblies composing envelope OR
    - Any combination thereof
  - Continuous for all assemblies part of the thermal envelope and across joints and assemblies
  - Joints and seams to be sealed per C402.4.2
  - Recessed lighting to comply with C402.4.8.
  - Where similar objects are installed that penetrate the air barrier, make provisions to maintain the air barrier's integrity

Air Barrier Compliance Options
C402.4.1.2

Three ways to comply with air barrier requirements:

- Materials – list of 15 materials
- Assemblies – tested, or two masonry assemblies deemed to comply
- Building test at .40 cfm.sf @75Pa.

Air Barrier Materials (Compliance)
C402.4.1.2.1

Materials with air permeance ≤ 0.004 cfm/ft^2 under pressure differential of 0.3 in. w.g. tested in accordance with ASTM E 2178. These materials meet this requirement:

[illegible]	[illegible]
Plywood	3/8 in.
Oriented strand board	3/8 in.
Extruded polystyrene insulation board	½ in.
Foil-faced urethane insulation board	½ in.
Closed cell spray foam minimum density of 1.5 pcf	1-1/2 in.
Open cell spray foam density between 0.4 and 1.5 pcf	4.5 in.
Exterior gypsum sheathing or interior gypsum board	½ in.
Cement board	½ in.
Built up roofing membrane	
Modified bituminous roof membrane	
Fully adhered single-ply roof membrane	
A Portland cement/sand parge, stucco, or gypsum plaster	5/8 in.
Cast-in-place and precast concrete	
Sheet metal or aluminum	

Air Barrier Assemblies (Compliance)
C402.4.1.2.2

OR

Assemblies of materials and components (sealants, tapes, etc.) with average air leakage ≤ 0.04 cfm/ft^2 under pressure differential of 0.3 in. w.g. tested in accordance with ASTM E 2357, 1677 or 283

These assemblies meet this requirement:

- Concrete masonry walls coated with one application either of block filler and two applications of a paint or sealer coating OR
- Portland cement/sand parge, stucco or plaster minimum ½ thick

Air Barrier Tests (Compliance)
C402.4.1.2.3

OR

Air leakage rate of completed building tested and confirmed to not exceed 0.40 cfm/ft^2 at a pressure differential of 0.3 inches water gauge per ASTM E779 or equivalent method approved by code official

Air Leakage of Fenestration
C402.4.3

Fenestration Assembly	cfm/ft^2	Test Procedure
Windows, sliding glass doors, and swinging doors	0.20	AAMA/WDMA/CSA 101/I.S.2/A440 or NFRC 400
Skylights - with condensation weepage openings	0.30	
Skylights – all other	0.20	
Curtain walls and storefront glazing	0.06	NFRC 400 or ASTM E283 at 1.57 psf
Commercial glazed swinging entrance doors	1.00	
Revolving doors	1.00	
Garage doors	0.4	ANSI/DASMA 105, NFRC 400, or ASTM E283 at 1.57 psf
Rolling doors	1.00	

- **Exceptions**
  - Field-fabricated fenestration assemblies
  - Fenestration in buildings that meet the building test for air barrier compliance option

Air Intakes, Exhaust Openings, Stairways, and Shafts *C402.4.5*

- C402.4.5.1 – Stair way/shaft vents require Class 1 motorized dampers with (max) 4cfm/sf leakage, w/ controls to open automatically upon activation of a fire alarm system, or upon loss of power
- C402.4.5.2 – Outdoor air intakes/exhausts require Class 1A motorized dampers with (max) 4cfm/sf leakage. Exceptions for 1)gravity dampers @ 20cfm/sf for exhaust/relief dampers, bldgs < 3 stories above grade, bldgs or any height in CZ 1-3, and 2)when design intake or exhaust capacity does not exceed 300 cfm. Dampers <24" in either dimension may test at 40cfm/sf.

Vestibules
C402.4.7

- All building entrances, incl those adjacent to revolving doors, with exceptions for

1. CZs 1&2
2. Doors not intended to be used by the public – mechanical/electrical equip rooms, and employee entrances
3. Doors opening from a sleeping/dwelling unit
4. Doors from a space <3000sf
5. Revolving doors
6. Doors for vehicular movement or material handling

HVAC Load Calculations
C403.2.1

Heating and cooling load sizing calculations required:

- ASHRAE/ACCA Standard 183
- Other approved computation procedures – using design parameters specified in Chapter 3
  - Exterior design conditions
    - •Specified by ASHRAE
  - Interior design conditions
    - •Specified by Section 302 of the IECC
      - ≤ 72ºF for heating load
      - ≥ 75ºF for cooling load

HVAC Performance
C403.2.3

Water-cooled centrifugal chilling packages:

- Adjustment calculation for systems not operating at AHRI Standard 550/590 test conditions
  - 44 degree F leaving chilled water temperature
  - 85 degree F entering water temperature
  - 3 gpm/ton condenser water flow

Table 403.2.3(2) -

EQUIPMENT TYPE	SIZE CATEGORY	Heating Section Type	SUBCATEGORY OR RATING CONDITION	MINIMUM EFFICIENCY	TEST PROCEDURE
Air cooled, (Cooling mode)	≥ 65,000 Btu/h and < 135,000 Btu/h	Electric Resistance (or none)	Split system and single package	11.0 EER 11.2 IEER	AHRI 340/360
		All Other		10.8 EER 11.0 IEER	
	≥ 135,000 Btu/h and < 240,000 Btu/h	Electric Resistance (or none)	Split system and single package	10.6 EER 10.7 IEER	
		All Other		10.4 EER 10.5 IEER	
	≥ 240,000 Btu/h	Electric Resistance (or none)	Split system and single package	9.5 EER 9.6 IEER	
		All Other		9.3 EER 9.4 IEER	

Automatic Start Capabilities
C403.2.4.3.3

Automatic start controls for each HVAC system

- Capable of automatically adjusting daily start time to bring each space to desired occupied temperature immediately prior to scheduled occupancy

Demand Controlled Ventilation

C403.2.5.1

DCV must be provided for each zone with spaces > 500 ft² and the average occupant load > 25 people/1000 ft² of floor area where the HVAC system has:

- An air-side economizer,
- Automatic modulating control of the outdoor air damper, or
- A design outdoor airflow > 3,000 cfm

Demand control ventilation (DCV): a ventilation system capability that provides for the automatic reduction of outdoor air intake below design rates when the actual occupancy of spaces served by the system is less than design occupancy.

Energy Recovery Ventilation Systems

C403.2.6

- Applies to fan systems with supply airflow rates > values in Table C403.2.6
- Exhaust air recovery efficiency must be ≥ 50%
- When an air economizer is required
  - include a bypass or controls that permit operation of economizer per C403.4

Energy Recovery Ventilation Systems

C403.2.6 (Mandatory)

Exceptions:

- Where energy recovery ventilation systems prohibited by the IMC
- Lab fume hood system with at least one of the following:
  - VAV hood exhaust and room supply systems capable of reducing exhaust and makeup air volume to ≤ 50% of design values
  - Direct makeup (auxiliary) air supply equal to at least 75% of exhaust rate, heated no warmer than 2ºF below room setpoint, cooled to no cooler than 3ºF above room setpoint, no humidification added, and no simultaneous heating and cooling use for dehumidification control
- Systems serving uncooled spaces and heated to < 60ºF
- Where > 60% of outdoor heating energy is from site-recovered or site solar energy
- Heating energy recovery in Climate Zones 1-2
- Cooling energy recovery in Climate Zones 3C, 4C, 5B, 5C, 6B, 7, and 8
- Systems requiring dehumidification that employ energy recovery in series with the cooling coil
- Where largest source of air exhausted at a single location at building exterior is < 75% of design outside air flow rate
- Systems operating at < 20 hours per week

Piping Insulation

C403.2.8

All piping serving heating or cooling system must be insulated in accordance with Table C403.2.8

Minimum Pipe Insulation
(thickness in inches)

FLUID OPERATING TEMPERATURE RANGE AND USAGE (°F)	INSULATION CONDUCTIVITY		NOMINAL PIPE OR TUBE SIZE (inches)				
	Conductivity Btu · in./(h · ft² · °F)	Mean Rating Temperature, °F	< 1	1 to < 1½	1½ to < 4	4 to < 8	≤ 8
> 350	0.32 – 0.34	250	4.5	5.0	5.0	5.0	5.0
251 – 350	0.29 – 0.32	200	3.0	4.0	4.5	4.5	4.5
201 – 250	0.27 – 0.30	150	2.5	2.5	2.5	3.0	3.0

(Partial table)

Piping Insulation
C403.2.8

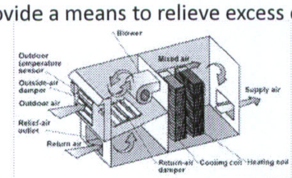
<u>Exceptions:</u>
- Piping internal to HVAC equipment *(including fan coil units)* factory installed and tested
- Piping for fluid in temperature range
  - 60 < temp < 105°F
- Piping for fluid not heated or cooled by electricity or fossil fuels
- Strainers, control valves, and balancing valves associated with piping ≤ 1" in diameter
- Direct buried piping for fluids ≤ 60°F

Mechanical Systems Commissioning and Completion - *C403.2.9*

- HVAC Commissioning
- Applies to buildings with a total building equipment capacity ≥:
  - 480,000 Btu/h cooling capacity, or
  - 600,000 Btu/h heating capacity
- Requires:
  - Commissioning plan
  - Systems adjusting and balancing
  - Functional performance testing
    - Equipment
    - Controls
    - Economizers
  - Preliminary commissioning report
  - Construction documents and O&M Manuals
  - Final commissioning report and air balancing report

Simple HVAC Systems & Equipment
C403.3

- Must include economizers dependent on climate zone
- Capable of providing 100-percent outdoor air even if additional mechanical cooling is required *(integrated economizer)*
- Must provide a means to relieve excess outdoor air



Economizers
C403.3.1

Table C403.3.1(1)

CLIMATE ZONES	ECONOMIZER REQUIREMENT
1A, 1B	No requirement
2A, 2B, 3A, 3B, 3C, 4A, 4B, 4C, 5A, 5B, 5C, 6A, 6B, 7, 8	Economizers on cooling systems ≥ 33,000 Btu/h[a]

[a] The total capacity of all systems without economizers shall not exceed 300,000 Btu/h per building, or 20 percent of its air economizer capacity, whichever is greater

Economizers
C403.3.1

Exceptions (economizers not required)

- Individual fan-cooling units with supply capacity < Table C403.3.1(1)
- Where > 25% of air designed to be supplied by the system is to spaces that are designed to be humidified > 35°F dew-point temperature to satisfy process needs
- Systems that serve residential spaces where system capacity is < 5 times requirement in Table C403.3.1(1)
- Systems expected to operate < 20 hours/week
- Where use of outdoor air for cooling will affect supermarket open refrigerated casework systems
- Where cooling efficiency meets of exceeds efficiency requirements in Table C403.3.1(2)

Economizers
C403.3.1

Trade-off high cooling efficiency for economizer

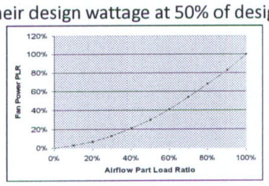
Table C403.3.1(2)

CLIMATE ZONES	COOLING EQUIPMENT PERFORMANCE IMPROVEMENT (EER OR IPLV)
2B	10% Efficiency Improvement
3B	15% Efficiency Improvement
4B	20% Efficiency Improvement

Variable Air Volume Fan Control
C403.4.2 – Complex systems

Individual VAV fans with motors ≥ 7.5hp must be:

- Driven by a mechanical or electrical variable speed drive **OR**
- Driven by a vane-axial fan with variable-pitch blades **OR**
- Have controls or devices to result in fan motor demand ≤ 30% of their design wattage at 50% of design airflow



Pools and In-ground Permanently Installed Spas - *C404.7*

- Heaters (C404.7.1)
  - Readily accessible on-off switch mounted outside heater so heater can be shut off without adjusting thermostat setting
  - Natural gas or LPG fired pool heaters will not have continuously burning pilot lights
- Time switches or other control method (C404.7.2)
  - Automatic controls required to turn heaters and pumps on a preset schedule
  - **Exceptions**
    - Where public health standards require 24 hour operation
    - Where pumps are required to operate solar and waste heat recovery pool heating systems

Note: heaters, pumps and motors with built-in timers meet this requirement

Covers
C404.7.3

Heated pools and in-ground permanently installed spas required to have a cover
- Cover must be vapor retardant

•**Exception**
- Pools deriving > 70% energy for heating from site-recovered energy

April 13, 2012 Payson Development Review Board 129

What's Covered Under Electrical Power and Lighting Systems Requirements?

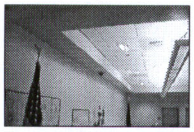
Mandatory Interior Lighting requirements
- Required Controls
- Wattage/Efficiency Limits

•Interior Lighting Power Allowances (watts/ft^2)

•Exterior Lighting Controls
- Required Controls
- Lamp Efficiency

•Exterior Lighting Power Allowances (watts/ft^2)

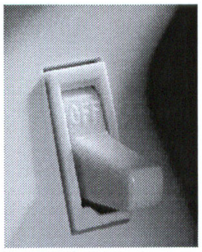
•Electric Metering



April 13, 2012 Payson Development Review Board 130

Lighting Controls
C405.2 –

Independent Lighting Control required for each space surrounded by floor-to-ceiling partitions
- Must be located in the space served,
  - OR -
- Switched from a remote location
  - Must have indicator that identifies the lights served and their status (off or on)
- **Exceptions**
  - Security or emergency areas that must be continuously lighted
  - Lighting in stairways or corridors that are elements of the means of egress



April 13, 2012 Payson Development Review Board 131

Interior Lighting Control
C405.2.1.2 **- Light Reduction**

Light Reduction Controls must allow the occupant to reduce connected lighting:

- By at least 50%
- In a reasonably uniform illumination pattern

April 13, 2012 Payson Development Review Board 132

Interior Lighting Control
Light Reduction Exemptions

Light Reduction Control **Not** required for the following:

- Areas with only one luminaire with rated power < 100 W
- Areas controlled by occupancy sensor
- Corridors, equipment rooms, storerooms, restrooms, public lobbies, electrical or mechanical rooms
- Sleeping units
- Spaces with <0.6 w/ft^2
- Daylight spaces complying with Section C405.2.2.3.2

Interior Lighting Control
C405.2.2 – Additional

Each area required to have a manual control to also have controls meeting:

C405.2.2.1 – Automatic time switch control devices, with override switching/criteria (exception for emergency egress lighting and occupancy sensors), and

C405.2.2.2 – Occupancy sensors, (exception for full automatic-on in some spaces), and

C405.2.2.3 – Daylight zone control

Exempted spaces

- Sleeping units
- Lighting for patient care
- When an automatic shutoff would endanger occupant safety or security
- Lighting intended for continuous operation

Daylight Zone Control Requirements
C405.2.2.3

Daylight Zones
- Must have individual control of the lights independent of general area lighting and
- Controlled per C405.2.2.3.1 manual daylighting controls or C405.2.2.3.2 automatic daylighting controls
- Each daylight control zone to be ≤ 2500 ft^2

•Contiguous daylight zones adjacent to vertical fenestration
- Can be controlled by a single controlling device if the zone doesn't include areas facing more than two adjacent orientations *(i.e., north, east, south, west)*

•Daylight zones under skylights > 15 ft from the perimeter
- Must be controlled separately from daylight zones adjacent to vertical fenestration

•**Exception**
- Daylight spaces 1) enclosed by walls or ceiling height partitions and 2) containing two or fewer light fixtures
  - not required to have a separate switch for general area lighting

Note: required controls may be manual or automatic

Interior Lighting Power Allowance
C405.5.2

Two methods to determine allowance:

- Building Area Method
  - Floor area for each building area type x value for the area
  - "area" defined as all contiguous spaces that accommodate or are associated with a single building area type as per the table
  - When used for an entire building, each building area type to be treated as a separate area
- Space-by-Space Method
  - Floor area of each space x value for the area
  - Then sum the allowances for all the spaces
  - Tradeoffs among spaces are allowed

Building Area Method Table

TABLE C405.5.2(1)
INTERIOR LIGHTING POWER ALLOWANCES:
BUILDING AREA METHOD

BUILDING AREA TYPE	LPD (w/ft²)
Automotive facility	0.9
Convention center	1.2
Courthouse	1.2
Dining: bar lounge/leisure	1.3
Dining: cafeteria/fast food	1.4
Dining: family	1.6
Dormitory	1.0
Exercise center	1.0
Fire station	0.8
Gymnasium	1.1
Health care clinic	1.0
Hospital	1.2
Hotel	1.0
Library	1.3
Manufacturing facility	1.3
Motel	1.0
Motion picture theater	1.2
Multifamily	0.7
Museum	1.1
Office	0.9
Parking garage	0.3
Penitentiary	1.0
Performing arts theater	1.6
Police station	1.0
Post office	1.1
Religious building	1.3
Retail	1.4
School/university	1.2
Sports arena	1.1
Town hall	1.1
Transportation	1.0
Warehouse	0.6
Workshop	1.4

Space by Space Method Table

TABLE C405.5.2(2)
INTERIOR LIGHTING POWER ALLOWANCES:
SPACE-BY-SPACE METHOD

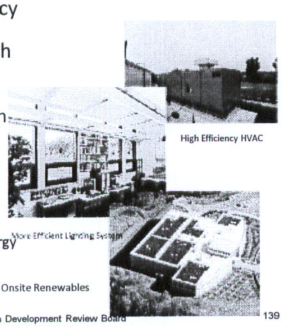
COMMON SPACE-BY-SPACE TYPES	LPD (w/ft²)
Atrium – First 40 feet in height	0.03 per ft. ht.
Atrium – Above 40 feet in height	0.02 per ft. ht.
Audience/seating area – permanent	
For auditorium	0.9
For performing arts theater	2.6
For motion picture theater	1.2
Classroom/lecture/training	1.30
Conference/meeting/multipurpose	1.2
Corridor/transition	0.7
Dining area	
Bar/lounge/leisure dining	1.40
Family dining area	1.40
Dressing/fitting room performing arts theater	1.1
Electrical/mechanical	1.10
Food preparation	1.20
Laboratory for classrooms	1.3
Laboratory for medical/industrial/research	1.8
Lobby	1.10
Lobby for performing arts theater	3.3
Lobby for motion picture theater	1.0
Locker room	0.80
Lounge recreation	0.8
Office – enclosed	1.1
Office – open plan	1.0
Restroom	1.0
Sales area	1.6
Stairway	0.70
Storage	0.8
Workshop	1.60

(partial table)

Additional Efficiency Requirements

C406

- One Additional Efficiency Feature Must Be Selected to Comply with the IECC
  - More efficient lighting system (consistent with 90.1-2010), or
  - More efficient HVAC system
  - Installation of onsite renewables
    - 3% of the regulated energy



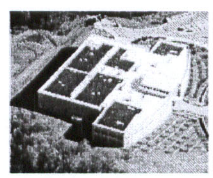
High Efficiency HVAC

More Efficient Lighting System

Onsite Renewables

Additional Efficiency Requirements

- Installation of onsite renewables compliance options:
- Option 1: Provide ≥ 1.75 btu's, or 0.50 watts, per square foot of conditioned floor area.
- Option 2: Provide ≥ 3 percent of the energy used within the building for building mechanical and service water heating equipment and lighting regulated in Chapter 5.



Onsite Renewables

Additional Resources

Websites:

- International Codes Council www.iccsafe.org/
- US Department of Energy www.energycodes.gov/
- National Fenestration Rating Council, Inc www.nfrc.org
- New Buildings Institute www.newbuildings.org
- United State Department of Energy, Building Codes Program
- Submit a question at Ask an Energy Codes Expert
- Locate compliance software - visit U.S. Department of Energy's Building Energy Software Tools Directory for more information.
- International Codes Council (ICC), Code clarification for ICC Members - 1-888-ICC-SAFE (1-888-422-7233)
- Simplyinsulate.com
- CONTACT INFO: Forrest Fielder, fielder_4@msn.com