



State of Wisconsin Safety & Buildings Division

MEEA/BECP
Pilot Energy Study
90% Compliance
Commercial Building

MEEA/PNNL Contract

John Spalding
Energy/HVAC Matrix Chief
State of Wisconsin
Safety & Buildings' Division
Ph: 608-789-4693
E-mail: John.Spalding@wi.gov

Summary

62 Commercial Buildings were evaluated for compliance with the 2009 IECC/ASHRAE 90.1-2007 between October 1, 2010 and June 30, 2011. Of that number, 17 buildings were eventually dropped from the study for several reasons:

Building would not be completed within time frame and no similar building could be found to merge
Project “died” prior to construction ever starting

Building was completed or nearly so prior to first visit by Evaluator.

The overall average compliance rate for the final study is 95%. Two of the buildings were below 90% compliance while the rest were in a range of 92% - 100%. It is important to note that Wisconsin is still enforcing the 2006 IECC/ASHRAE 90.1-2004 (until Sept 1, 2011). This means that, in general, Wisconsin designers and Buildings are constructing projects exceeding the current minimum code requirements.

Due to the Wisconsin economy over the past several years, the mix of building sizes and the county locations varied somewhat from the original Random Building Generator. The final tally was 28 Small Building, 10 Medium Buildings, 4 Large Buildings, and 2 X-Large Buildings.

Evaluators

All evaluators are State of Wisconsin, Safety & Buildings’ Staff

- Steve Gothard, Credentialed Commercial and Residential Building Inspector.
- Randy Dahmen, P.E., Building Plan Reviewer, HVAC & Energy Code Consultant
- Jon Molzahn, Architect, Building Plan Reviewer
- John VanBuecken, Architect, Building Plan Reviewer
- Dave Fliess, Commercial Building & Multi-Family Building Plan Reviewer
- Char Martin, Credentialed Commercial and Residential Building Inspector.
- Teresa Black, Credentialed Commercial and Residential Building Inspector.
- Jack Miller, Building Plan Reviewer, Residential and Commercial Building Code Consultant
- John Pearce, Architect, Building Plan Reviewer
- Doug Erler, Architect, Building Plan Reviewer
- John Spalding, Architect, HVAC & Energy Matrix Chief

Random Building Generation

The system used to generate the random selection of buildings is based on a combination of the PNNL State Sample Generator and the Wisconsin Safety & Buildings’ Division Commercial Building Database “Regulated Objects”. See following pages for sample

Quantity and Size of Buildings per County as Generated by the BEC Random Building Generator
(based on a 3-year sample)

Location	Const. Starts	Percent of Total	Number of Buildings to be Sam- pled	Sample Size				
				Small	Medium	Large	X-Large	XX-Large
Climate Zone 6	443			13	13	12		
Brown County	32	9.7%	4	-	1	-		
Chippewa County	1	0.3%	0	2	-	-		
Columbia County	3	0.9%	0	1	-	-		
Dane County	85	25.8%	11	-	2	-		
Kenosha County	16	4.8%	2	-	1	-		
Marathon County	9	2.7%	1	1	1	-		
Milwaukee County	68	20.6%	9	3	4	4		
Monroe County	5	1.5%	1	-	-	1		
Outagamie County	16	4.8%	2	-	1	-		
Ozaukee County	14	4.2%	2	1	-	-		
Rock County	12	3.6%	2	-	2	2		
St. Croix County	4	1.2%	1	1	-	-		
Walworth County	7	2.1%	1	2	-	-		
Waukesha County	34	10.3%	5	-	-	2		
Winnebago County	18	5.5%	2	2	1	3		
Climate Zone 7	21			1	1	1		
Douglas County	5	1.5%	1	-	1	1		
Taylor County	1	0.3%	0	1	-	-		
State Totals	330	100.0%	44	28	28	26	0	0

Regulated Objects Database

Based on these selections, the Division started searching for appropriate buildings using the Regulated Objects database. A “Regulated Object” is considered any part of a building or other structure that Safety & Buildings regulates. Examples include Building, HVAC, Boilers, Plumbing, Lighting, Structure, Elevators, Pools, amusement rides, ski-lifts, etc.

Sample pages from the state Building Database demonstrating how a random sample of buildings is selected.

Regulated Objects

Edit Tools Action Services Reports Documents Maintain Window Help

Regulated Object Search

Search Results

Family/Type Criteria

Family: (SHOW ALL) Type: (SHOW ALL)

Single Search Criteria

Reg Obj ID:

Wang Obj ID:

Multiple Search Criteria

Reg Obj Description:

Site ID:

Land Owner Type:

Facility:

Inspection Required: ☐

Status:

Status Date: From: To:

Reinspection Date: From: To:

Code Applies Date: From: To:

PTS date: From: To:

PTO Expiration: Former: ☐ From: To:

Objects with PTO's: ☐ County:

☒ Site Address ☐ Building Address ☐ Both

Address:

City:

Zip:

Search Advanced ... Clear Cancel New

Beginning Search Page

The Safety & Buildings' "Regulated Objects" database system records every commercial and multi-family project in Wisconsin.

Specific parameters can be selected or the page can be left blank to generate a list of all buildings.

For this study, the "Code Applies Date" was selected to provide a list of all buildings plans reviewed between March 1, 2010 and July 30, 2010. Later, as some of the building samples were deleted for various reasons, the "Code Applies" end date was extended to October and finally February

Regulated Objects							
Regulated Object Search							
Family: Buildings & Structures		Type: Building ICC					
Reg Obj ID	Site ID	Address	Muni Type	Municipality	County	Cust ID	Lo F
1270233	757593	7599 HWY 16	CITY (2)	SPARTA	MONROE	1141156	
1270253	757594	ROLLING MEADOWS DR	CITY (2)	FOND DU LAC	FOND DU LAC	1141167	
1270326	757616	W4531 LAKE PARK DRIVE	TOWN (0)	TAYCHEEDAH	FOND DU LAC	7230	
1270337	757620	3508 7TH AVE	CITY (2)	KENOSHA	KENOSHA	532466	
1270355	7572507	618 E ALBERT ST	CITY (2)	PORTAGE	COLUMBIA	899168	
1270498	757650	S9685 HIGHWAY 12	TOWN (0)	BRIDGE CREEK	EAU CLAIRE	525990	
1270520	618252	501 CLIFFHAVEN RD	CITY (2)	PRAIRIE DU CHIEN	CRAWFORD		
1270522	757652	PARK ST	VILLAGE (1)	ETTRICK	TREMPEALEAU	534852	
1270524	757653	LOT 10 PROGRESS DR	TOWN (0)	BELGIUM	OZAUKEE	1141316	
1270528	757655	W7971 CTY ROAD Z	TOWN (0)	BEECHER	MARINETTE	1141317	
1270663	660043	7169 CTY RD O	TOWN (0)	ERIN	WASHINGTON	1020189	

Row: 58 of 1021

Selection page based on new projects reviewed between March 1, 2010 and July 30, 2010. From this screen, every 4th project was selected for inclusion. Any project can be opened to show the complete history, from Initial Construction through any additions and alterations. The various detail screens will show the Site Name and Location, Construction details, Designers' and Owners' Names, Addresses and other contact information. Finally, every piece of correspondence from the review scheduling letter to the final approval letter is saved on the transaction.

Regulated Objects	
Regulated Object, ID: 1268811 Building ICC	
Reg Object ID: 1268811	Description:
Family: Buildings & Structures	Type: Building ICC
General Info Type Details Multiple Comments General Site Facility Review Investigation Customers	
Site ID: 757252 County: EAU CLAIRE Muni Type: City Fire Department ID: Land Owner Type: Private Phone Number: () - No Mail Drop ☐	Muni Code: Site Name: MOGENSEN COMMERCIAL & RESIDENTIAL BUILDING Rec Deed Date: 00/00/0000 Date Verified: 00/00/0000 By: Municipality Name: EAU CLAIRE Geo Latitude: Geo Longitude: Site Alias Name:
Address: Pre-Direction Number Street Name Street Type Post-Direction 522 WATER ST	
Zip/City: 54701 - EAU CLAIRE	

Regulated Objects

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Regulated Object, ID: 1268811 Building ICC

Reg Object ID: 1268811 Description:

Family: Buildings & Structures Type: Building ICC

General Info Type Details Multiple Comments General Site Facility Review Investigation Customers

Component Submittal

	Req	Rec	Schd
Fire Alarm	☒	☒	☒
Fire Escape	☐	☐	☐
Fire Suppression	☒	☒	☒
HVAC ICC	☒	☒	☒
Interior Bleacher	☐	☐	☐
Kitchen Exhst Hood	☐	☐	☐
Laminated Wood	☐	☐	☐
Lighting Do Not Use	☐	☐	☐
Lighting, Emergency	☒	☒	☒
Lighting, Energy Cor	☒	☒	☒
Metal Building	☐	☐	☐
Paint Spray Booth	☐	☐	☐
Precast Plank	☒	☒	☒
Precast Wall	☐	☐	☐
Structural Steel	☐	☐	☐
Truss, Floor	☒	☒	☒

Plan Type: New Additional Occupancies: 3

Class of Construction: Type IIIB Exterior Noncombustible

Major Occupancy: Business

Occupancy Type:

- ☐ A-1 Theater Assembly
- ☒ A-2 Dining & Drinking
- ☐ A-3 Other Assembly Uses
- ☐ A-4 Indoor Sports Seating
- ☐ A-5 Outdoor Sports Seating
- ☒ B Business
- ☐ E Education & Day Care
- ☐ F-1 Factory Moderate-Hazard
- ☐ F-2 Factory Low-Hazard
- ☐ H-1 Detonation Hazard
- ☐ H-2 Deflagration Hazard
- ☐ H-3 Combustion Hazard
- ☐ H-4 Health Hazard
- ☐ H-5 Semiconductor Production

No. of areas separated by fire barriers or firewalls: 3

Allowable Area Determined By:

- ☒ Fire Barrier
- ☐ Fire Walls
- ☒ Separated Use
- ☐ Unlimited Area
- ☐ Unseparated Use

Sprinklered Type: Complete

Sprinkler Design:

- ☐ Multipurpose Piping
- ☒ NFPA-13 Sprinkler
- ☐ NFPA-13D
- ☐ NFPA-13R Residential

Details page provides quick information about overall scope and complexity of project. In some instances, projects were rejected in an attempt to follow the BECP Random Building Generator.

Regulated Objects

Edit Tools Action Services Reports Documents Maintain Window Help

Site, ID: 757252 Desc: MOGENSEN COMMERCIAL & RESIDENTIAL BUILDING, City of EAU CLAIRE, County of EAU CLAIRE

Site Id: 757252 Name: MOGENSEN COMMERCIAL & RESIDENTIAL BUILDING

EAU CLAIRE County City of EAU CLAIRE

General Site Legal Description Directions Comments Regulated Objects Facility Review Investigation

Family: (SHOW ALL) Type: (SHOW ALL)

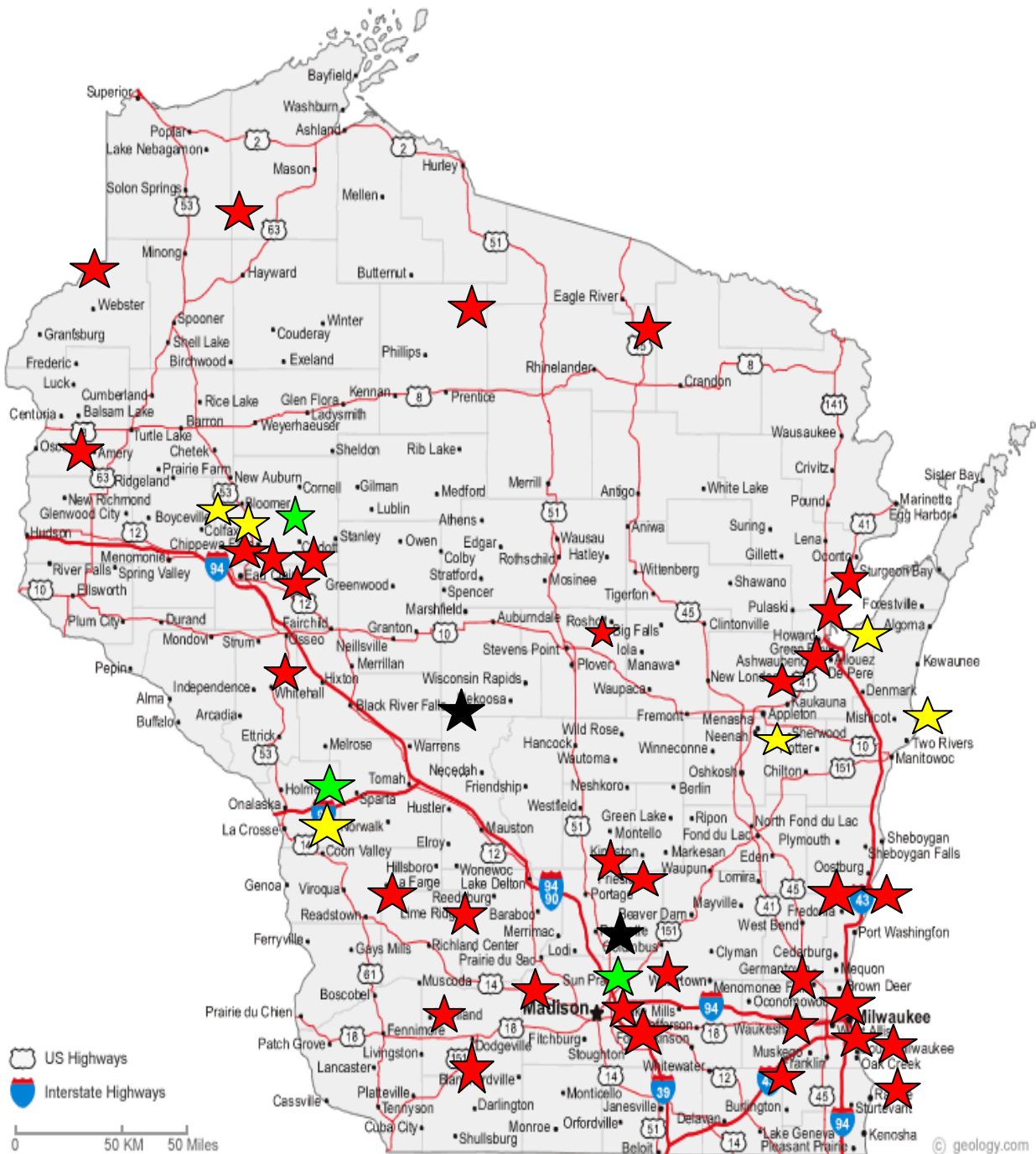
Reg Obj ID	Reg Object Type	Status	Reg Object Description	Zip Code	Muni Type	Municipality	County
I301205	Lighting, Energy Conservatio	Active			CITY (2)	EAU CLAIRE	EAU CLAIRE
I301206	Lighting, Emergency Egress	Active			CITY (2)	EAU CLAIRE	EAU CLAIRE
I268811	Building ICC	Active		It:54701	CITY (2)	EAU CLAIRE	EAU CLAIRE
I293709	Elevator	Active	Passenger 1	It:54701	CITY (2)	EAU CLAIRE	EAU CLAIRE
I303237	Truss, Floor	Active		It:54701	CITY (2)	EAU CLAIRE	EAU CLAIRE
I303238	Truss, Roof	Active		It:54701	CITY (2)	EAU CLAIRE	EAU CLAIRE
I298073	HVAC ICC System	Active		It:54701	CITY (2)	EAU CLAIRE	EAU CLAIRE
I283113	Precast Plank	Active		It:54701	CITY (2)	EAU CLAIRE	EAU CLAIRE
I294819	Lighting Do Not Use	Active		It:54701	CITY (2)	EAU CLAIRE	EAU CLAIRE
I285280	Fire Suppression	Active		It:54701	CITY (2)	EAU CLAIRE	EAU CLAIRE

Wisconsin Energy Code Enforcement

The State of Wisconsin has adopted the IBC, IMC, IECC, IFC and IEBC. Wisconsin's Codes are uniform statewide and are enforced statewide. With the exception of Milwaukee, Madison and Janesville, all plan review is conducted by the state Safety & Buildings Division. 25 plan reviewers, located at 5 offices throughout the state, review the Building, HVAC, and Energy Codes. Another group of 5 plan reviewers review all plumbing plans separately. Field Inspection is accomplished by 10 State Building Inspectors supplemented by 220 "Delegated Municipalities" (generally Villages and Cities that are authorized by the state to conduct inspections within their jurisdiction). All inspectors within these Villages and Cities are credentialed Building, HVAC & Electric Inspectors and most are also credentialed Plumbing Inspectors. Generally, at least one Inspector in the municipality is a licensed P.E. or Architect. Thru regular monthly meetings, the state and municipal inspectors discuss code clarifications and interpretations, so that all Review and Inspections throughout the state are as uniform as possible.

Current Status of Wisconsin Energy Code

Wisconsin currently enforces the 2006 IECC/ASHRAE 90.2-2004 with a few Wisconsin amendments. The amendments either add to the code's efficiency or modify the administrative portions to match Wisconsin Statutes. Wisconsin has now formally adopted the 2009 IECC/ASHRAE 90.1-2007. Enforcement will begin on September 1.



State of Wisconsin Energy Pilot Study Random Building Selection

-  **Small:** 1-2 Stories, single zone, up to 25,000 sq. ft.
-  **Medium:** Larger than 25,000 sq. ft. but smaller than 60,000
-  **Large:** Larger than 60,000 sq. ft. but smaller than 250,000 sq. ft
-  **X-Large:** Larger than 250,000 sq. ft. but smaller than 250,000 sq. ft

Sample Selected Projects



Foundation Insulation up to top of slab.

Glass label typical for site constructed fenestration



Furniture Store

This is a combination factory and retail store devoted to lawn and outdoor furniture. Except for Exit and Emergency Egress fixtures, the entire building is lit strictly by natural light. Using a combination of Light Tubes and North facing windows, this factory/retail is open from 8 AM to 6 PM six days a week in Spring, Summer and Fall.



Convenience Store

This Convenience Store is part of a major chain of about 250 stores throughout Wisconsin. In the past 10 years it has undertaken a major effort to design and build new stores that they say exceed the current code and are aiming to design per the 2012 IECC. The following include pictures of their older stores, stores from about the last 10 years and the newest store designs.



1970's & 80's Style



Current Store Interior Lighting
All fixtures are CFL, 2 Lamp T5 Fluorescent,
and LED

The chain is launching energy saving efforts across the state of Wisconsin. Since 2006, they have completed more than 335 energy-efficiency projects at over 200 of its Wisconsin locations. These efforts have saved more than 4.1 million kilowatt-hours of electricity and 1,600 therms of natural gas — enough energy to power 415 homes for a year. The gas and convenience store chain has also reduced its peak electric demand by 450 kilowatts. The chain will save about \$297,000 on its energy bills each year. Some of the biggest energy savers include:

Energy Management Systems

They installed energy management systems in more than 200 locations. Energy management systems can automatically adjust set-point temperatures to save energy based on season, time of day or day of week. They can also limit the use of outside air for ventilation when buildings are unoccupied, reducing the heating and cooling systems' operating time.

Refrigeration Waste Heat Recovery

Their system passes cold tap water through a heat exchanger, where coils filled with hot refrigerant heat the water. The heated water is then stored in an insulated water storage tank, similar to a typical water heater. This process provides them with some free hot water and substantial energy savings.

Indoor and Outdoor Lighting

Inside, they use high-performance 2-lamp T5 lighting throughout its stores. These systems are made up of a high-lumen, long-life T5 lamp and low-watt electronic ballast. This combination results in energy savings without reducing light output.

Outside, they use low-watt LED lights instead of its standard counterparts — reducing wattage up to 80 percent. On average, a gas station canopy has 30 lights and operates 3,600 hours per year. By using low-watt alternatives, they save 14,500 kilowatt-hours of electricity annually. The stores realize additional savings by controlling its lights with energy management systems so the lights turn off when not needed.



Pre-2009 Canopy Lighting –
Metal Halide

LED Area & Canopy Lighting.
Typically about 30 Fixtures per
Canopy



2-Lamp T5 Fluorescent Fixture with Energy
Savings ballast. Replaces former 4-Lamp T8
Lay-In Fixture



Exterior wall during construction.
Design works, but the success of the project is in following the details:

- Insulation
- Exterior Brick and EIFS
- Caulking with backer rod and primer where appropriate



Insulation installed on fire-rated suspended ceiling w/ hold-down clips.
Picture is at ceiling of garage insulating floor of offices above.
Credit was given based on the hold-down clips.

Multiple boiler arrangement.
System is designed to alternate first burner
on and to modulate burner input.



Retail store constructed of precast
insulated concrete panels. These
panels are growing in popularity in
lieu of concrete masonry walls.

Advantages:

Insulation values meet 2009 code
Walls can be constructed from foot-
ing to roof increasing the speed of
construction.

Walls can be set in any weather (es-
pecially valuable in Winter)



Mercantile Center - Constructed of Insu-
lated Poured Concrete forms and factory
built panelized walls. Plumbing, HVAC
& Electrical penetrations through exteri-
or walls held to a minimum. Poured
concrete walls in this area are 10 ft tall.
Panelized wood wall panels are staked in
the background



4-store "strip" shopping center. 6" Steel Stud with 1" Foam Insulation and Face Brick & EIFS Exterior, Gypsum Board Interior over 5-1/2" Fiberglass Insulation. Insulation originally only went up to just above ceiling. After Inspection Report was sent to contractor, designer and owner, insulation went up to roof



Combination Classrooms/Offices/Retail/Residence Hall Sunshades installed at midpoint of fenestration. Particularly good job of caulking the exterior - primer / backer rod / good depth of caulk. Quality of caulking varied widely among projects.

Suggestions for Possible Improvements to the Commercial Building Data Collection Checklist

1. Rearrange the checklist so that each subject includes a column for both Plan Review and Field Inspection

2009 IECC Section #	Framing / Rough-In Plan Review	Plan Review Value	Complies			Field Verified Value	Complies			Comments/ Assumptions
			Y	N	N/A		Y	N	N/A	
502.4.1, 502.4.2 [FR1] ³	Fenestration meets maxi- mum air leak- age require- ments.	cfm/ ft ²				cfm/ ft ²				
502.4.1, 502.4.2 [FR2] ³	Doors meet maximum air leakage re- quirements.	cfm/ ft ²				cfm/ ft ²				
502.4.1, 502.4.2 [FR3] ³	Fenestration and doors la- beled for air leakage.									
502.4.7 [FR4] ³	Vestibules in- stalled per ap- proved plans.									
502.2.1 [FR5] ¹	Roof insula- tion R-value.	R- Above deck Metal Attic				R- Above deck Metal Attic				
303.2 [FR6] ¹	Roof insula- tion R-value installed per manufacturer's instructions.									
502.3.1, 502.1.1 [FR7] ¹	Performance compliance approach sub- mitted for ver- tical fenestra- tion area >40% or skylight ar- ea >3%.									
502.3.2 [FR8] ¹	Vertical fenes- tration U- Factor.	U-				U-				
502.3.2 [FR9] ¹	Skylight fenes- tration U- Factor.	U-				U-				

2009 IECC Section #	Framing / Rough-In Plan Review	Plan Review Value	Complies			Field Verified Value	Complies			Comments/ Assumptions
			Y	N	N/A		Y	N	N/A	
502.3.2 [FR10] ¹	Vertical fenestration SHGC value.	SHGC:				SHGC:				
502.3.2 [FR11] ¹	Skylight SHGC value.	SHGC:				SHGC:				
303.1.3 [FR12] ²	Fenestration products rated in accordance with NFRC.									
303.1.3 [FR13] ¹	Fenestration products are certified as to performance. Labels or certificates provided.									

2. Edit the sheets to somewhat match the IBC and the CSI.

Foundations
Concrete
Masonry
Steel
Wood
Misc Insulation not listed above
Doors, Fenestration and Glass
Pools
Plumbing
HVAC
Electrical & Lighting

Until a reasonably priced, easy to obtain Air Leakage test for Storefronts and Curtain Walls is developed (IECC 502.4.2), an on-site visual inspection should be accepted for air leakage identification. Fixed, multi-glazed labeled glass in EPDM gaskets in Aluminum Frames, properly caulked, should be permitted either a pass/no-pass response or a default air leakage rate based on total perimeter length. Additionally, the exception to 502.4.1, which permits site-constructed windows and doors to be visually inspected per 502.4.3, appears to be in contradiction to 502.4.2.

Avoid the use of negative questions where the answer “yes” could be construed as meaning yes or no. As in the question below, checking either yes or no could be checked based on the context in which the inspector reads the question.

502.2.1 [IN17] ³	Insulation intended to meet the roof insulation requirements not installed on top of a suspended ceiling.				
--------------------------------	---	--	--	--	--

A better question would be (for example): “Is roof envelope insulation installed on top of suspended ceiling tiles?”

If technically feasible, it would be nice to have the “Score and Store” software allow for installing different “R-Values” for walls, roofs and fenestrations, together with the different areas for each and have the program automatically calculate the overall average value for that element. One of the big box stores in the study had four different “R-Values” for the walls around the building. A convenience store has two different “R-Values” for roof areas.

Lessons Learned from Energy Study

Both Reviewers and Inspectors need to be trained to spot potential problems with “U” and “R” values in COMcheck and HVAC Calculations. A minor deviation in the U-Value of exterior walls can make a 10% difference in the final compliance “Pass/Fail” system. Values for Doors, Windows, Precast Insulated Wall Panels and other manufactured materials need to have cut sheets submitted with the plans if there is a significant deviation from the default values. In addition, building envelopes that passed by less than 5% need close scrutiny. As a result of the study, the Division has changed procedures to require a copy of the COMcheck or other report, plus the cut sheets if applicable, to be sent to the Inspectors for verification in the field.

Use fewer auditors to conduct study. This would help ensure consistency. One of the discoveries made during the final check of the audits was the difference in “judgment calls” among the various inspectors and reviewers. Fewer auditors and more frequent monitoring would make for more accurate final reports and less editing at the end of the study.

In future studies, two different time spans would be used - one for smaller projects relatively quick to construct, and a longer time span (maybe 18 months to 2 years) for larger projects. Merging two different projects into one study, while feasible, does not account for differences in designers, owners, and contractors.

Inspectors are being trained to pay closer attention to details of the building construction. Of the complaints received on commercial projects, over half are HVAC related. Most of those HVAC problems are ultimately traced back to missing details in the building envelope, such as cold air blowing in through the control joints, windows, around doors, and at the floor/wall and wall/roof connections; and exhaust and intake dampers that do not seal tight. All of these items would be easy to do correctly at the initial construction, and would not cost any more. The retrofit, however, can be costly and require considerable destruction of the original construction.

Reviewers are being taught to check the COMcheck or other envelope calculations carefully against the HVAC Calculations. Wisconsin is somewhat unique in that the various components to the complete plans - Building, Structure, HVAC, Plumbing and Electrical, may be submitted separately by different designers. The Energy Envelope calculations are required to be submitted with the Building Plans (always required to be the first submittal). Occasionally, when a problem occurs in the field, a re-inspection of the plans will reveal differences between the values submitted with the building vs. the values submitted with the HVAC. This is a simple item that will be checked on future plan submittals.

Some basic errors in plan review and inspection were discovered, such as a missing vestibule, skylights shown on plans but not on COMcheck, missing simple lighting controls (light reduction, for example). In more than one case, the COMcheck as submitted was based on the footprint area of the building and not on the total area (typically in a one story building with basement). As a result, a simple one page checklist is being created and printed into pads for the reviewers to use and retain with the plan file set.