Glazing, Daylighting, and Polycarbonate Sheeting Systems

An American Institute of Architects Continuing Education Program

Credit for this course is
1 AIA/CES LU/HSW/SD Hour and 1 GBCI CE Hour

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CONTINUING EDUCATION AIA

An American Institute of Architects (AIA) Continuing Education Program

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- Course Format: This is a structured, web-based course with a final exam.
- Course Credit: 1 AIA Health Safety & Welfare (HSW), Sustainable Design (SD) Learning Unit (LU)
- Completion Certificate: A copy is sent to you by email or you can print one upon successful completion of a course. If you have any difficulties printing or receiving by email please send requests to certificate@greence.com
- Design professionals, please remember to print or save your certificate of completion after successfully completing a course conclusion quiz. Email confirmations will be sent to the email address you have provided in your GreenCE.com account.

Learning Objectives

By completing this course, the design professional will be able to:

- Explain the importance of daylighting to human health and well-being
- Describe the role of daylighting in sustainable design
- Define polycarbonate sheeting in terms of composition, u-value, performance, and sustainability
- Discuss Aerogel polycarbonate sheeting and its benefits
- List the benefits of good daylighting design in terms of occupant comfort, indoor air quality, and energy efficiency
- Explain the role of USGBC in building design
- Describe how specifying polycarbonate sheeting systems can contribute toward LEED certification

Introduction

The importance of daylighting

The Rise of Artificial Lighting

Lighting. This is a factor that most of us generally spend little time thinking about and usually address with the flip of a switch. At home, at work, at the supermarket…by desk lamp, chandelier, or fluorescents…**artificial** lighting has become **natural** to us. Yet this fact holds an amalgam of negative implications.

The Rise of Artificial Lighting

- Our dependence on artificial lighting is relatively recent. In the not-too-distant past, the day's activities still revolved around when the sun rose and set, and stars still shone brightly in big-city skies.
- It wasn't until the advent of the industrial revolution and the spread of coal-produced electricity and lighting that people's reliance on man-made illumination began to grow vastly.

Janet Thomson, 2003. *The Scot Who Lit The World: The Story Of William Murdoch, Inventor Of Gas Lighting*

Daylighting Health and Well-being

- Today, many of us work and live in spaces where even the artificial light is dark and confining. And this unfortunately means that many of us also do not get the much needed benefits of sun and daylighting that are crucial to our health and well-being.
- The lack of good daylighting has been linked to several mental and physical disorders. This is specifically related to the body's inability to produce vitamin D sufficiently due to lack of exposure to daylighting.

vs

Daylighting Health and Well-being

- Vitamin D is well-known for building healthy teeth and bones. However, the Vitamin D Council—a nonprofit organization dedicated to educating the world about the dangers of vitamin D deficiency—notes that vitamin D deficiency is also linked to:

  at least 17 varieties of cancer as well as heart disease, stroke, hypertension, autoimmune diseases, diabetes, depression, chronic pain, osteoarthritis, osteoporosis, muscle weakness, muscle wasting, birth defects, periodontal disease, and more.

- Vitamin D also largely contributes to a healthy immune system; a lack thereof inhibits healthy T cells from fighting off sickness and illnesses.

healthmatters.com

Understanding Vitamin D Cholecalciferol. vitamindcouncil.org. accessed Feb. 7, 2011

Daylighting Health and Well-being

- The hormonal and mood effects associated with a lack of daylighting have also been a rising concern addressed recently by numerous studies now largely considered in healthier building designs.
- For example, depression is often a symptom of Seasonal Affective Disorder (SAD) know to be induced by the reduction of time the sun is up with the onset of the fall and winter season in certain regions. But it is also thought to be present in many people working in poorly day-lit buildings.
- In addition, lack of sufficient daylighting and ventilation is often responsible for lower productivity and performance as well as overall happiness factor.

ivanhoe.com, accessed Feb. 7, 2011

Daylighting Benefits

- Because 90% of our time is spent indoors, daylighting and indoor environmental quality are a significant concern in today's building designs.
- Incorporating more windows, or glazing, into a well designed building not only holds significant benefits for human health and well-being, but also for energy savings and indoor air quality.
- Efficient glazing can reduce heating, ventilating, and cooling (HVAC) loads while utilizing operable windows for natural cooling also increases ventilation and indoor air quality.

Sustainability

- While *green* building may be the current *trend* in design and construction, it is quickly becoming the standard. With our world becoming more and more conscious of the impacts of human activity on our environment and our own well-being, building *green* will no longer be a consideration, but normal practice.
- The U.S. Green Building Council (USGBC) is one organization leading the way to a more sustainable future through advocacy, education, and the LEED® program (discussed later in this course) with the goal of reducing the impacts of construction and buildings on the environment and human health.
- The use of a translucent daylighting system can contribute significantly to achieving LEED certification for Green Building Construction.

Good Design and Polycarbonate Sheeting Systems

- There is no substitute for good basic design; appropriate design from the beginning that takes into consideration glazing material, placement, and orientation toward the sun is the first and most important step toward sustainability.
- Polycarbonate multi-wall sheeting systems are a design and sustainability conscious technology. Among other benefits, this technology is extremely durable, flexible to design needs, and can be used in a variety of applications. It is completely recyclable and often made of recycled materials.
- Polycarbonate systems diffuse the natural light—making indoor environments brighter and more pleasant for occupants. They are also often used in passive solar design, allowing the sun to heat a structure in the winter and keeping it cooler in the summer—resulting in significant energy savings.

Polycarbonate Sheeting Systems

Structure, performance, and standards

Terms You Should Know

Daylighting – *the controlled admission of natural light into a space through windows to reduce or eliminate electric lighting.*

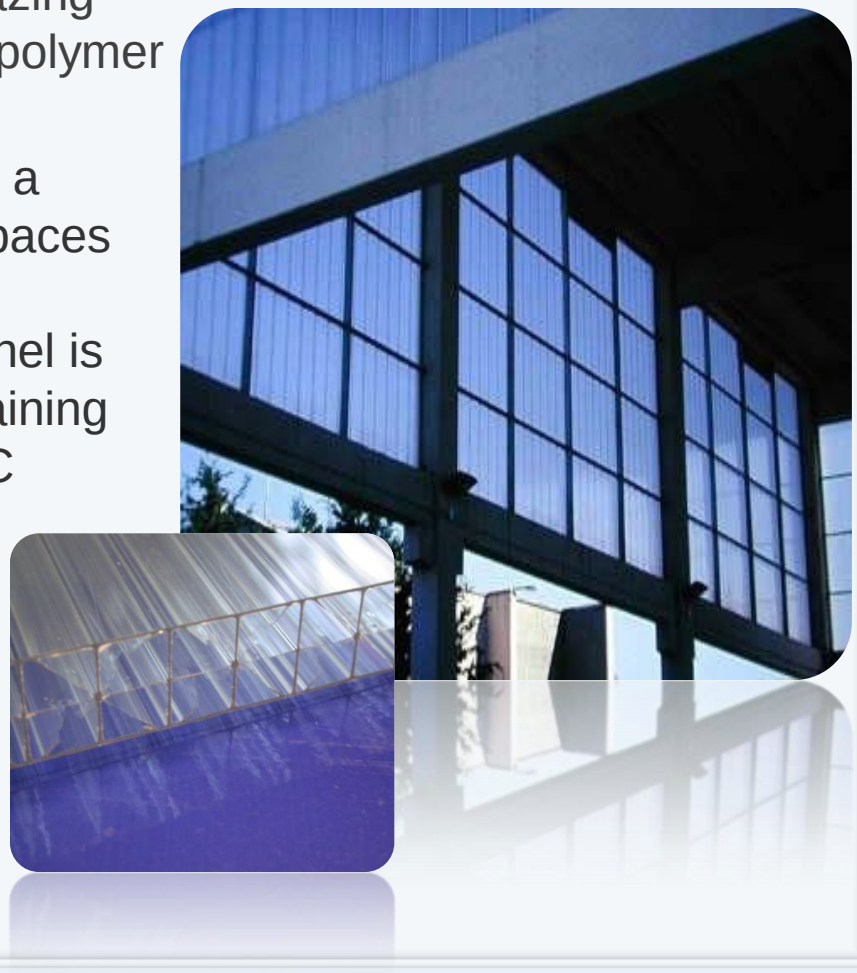
Glazing – *all windows, curtain walls, skylights, etc. in a building.*

Fenestration – *any opening in a building's envelope including windows, doors and skylights.*

The National Fenestration Rating Council, nfrc.org/fenestrationfacts
The National Institute of Building Sciences, wbdg.org/daylighting and wbdg.org/design_env_fenestration

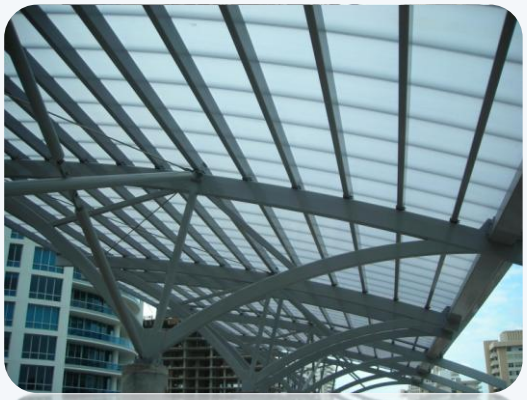
What Is Polycarbonate Sheeting?

- Polycarbonate (PC) sheeting used for glazing is a virtually unbreakable glazing material manufactured from melted polymer resin.
- PC materials are manufactured with a hollow-core structure, creating air spaces which act as insulation.
- The external side of the sheet or panel is co-extruded with a PC coating containing heavy UV absorbers. This allows PC sheeting to deliver various levels of light and thermal conduction.



U-Value

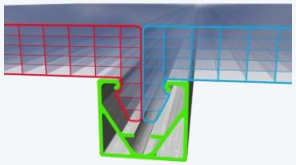
- Fenestration is key in moderating air handling requirements and creating a building with optimum energy performance.
- U-value indicates how the window will prevent thermal transfer when there is a difference between the interior and exterior building temperature both from inside out during the winter and outside in during the summer.
- Lower U-values mean better energy efficiency.



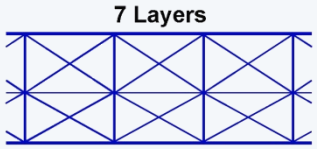
Benefits of Polycarbonate

PC systems provide low U-values and high diffuse light transmittance, limiting heat transfer and glare.

Policarb 16mm triple
LT Clear: 74%
U = 0.40 (R = 2.50)



arcoPlus 626
LT Clear: 65%
U = 0.264 (R = 3.79)



Policarb 32mm (1 ¼")
LT Clear: 66%
U = 0.24 (R = 4.17)

arcoPlus 547
LT Clear: 67%
U = 0.188 (R = 5.32)

Aerogel Polycarbonate Sheeting

- Aerogel is the lowest density solid material in the **world**—known for its insulation properties and often used for skylights. Aerogel PC attributes include:
  - Translucent, High light transmission
  - Thermal resistance value: R-8 in a single inch
  - Will not degrade over time, Color and UV stable
  - Non-combustible
  - Non-toxic, composed of 97% air
  - Hydrophobic/moisture resistant
  - Will not support the growth of mold
  - Totally recyclable
  - **Cradle to Cradle® (C2C) certified**

aerogel.org, sustainablefacility.com,
accessed on Feb. 8, 2001

C2C

- Governed by McDonough Braungart Design Chemistry (MBDC)—a global sustainability consulting and product certification firm—Cradle to Cradle is a certification and label that signifies a product's safety to humans and the environment and promotes a sustainable life cycle.
- When designing for sustainability, look for manufacturers who provide C2C PC products.

mbdc.com, accessed Feb. 8, 2011

Miami-Dade

- Miami-Dade certification is an internationally recognized storm standard indicating a products storm withstand ability.
- Polycarbonate sheeting was one of the first glazing materials to receive this certification.

Codes and Standards

- Polycarbonate systems have been tested and approved under the IBC as well as regional and local codes, such as the SBCCI, UBC, BOCA, ICBOk and Miami-Dade.
- These systems also undergo rigorous testing in order to meet OSHA guidelines per ASTM standards.

Quality Standards

PRODUCTION STANDARDS																	
Thickness (mm)	4	4.5	6	8	10	10	16	20	25	6	8	10	16RDC	20RDC	25RDC	25	32
Thickness (in)	5/32	3/16	1/4	5/16	3/8	3/8	5/8	3/4	1"	1/4	5/16	3/8	5/8	3/4	1"	1"	1.25"
Structure	2 LAYERS					3 LAYERS				4 LAYERS			5 LAYERS			7 LAYERS	
Width (ft)	4 ft and 6ft widths available; Call for any widths less than 72"															47 1/4"	
Length (ft)	Made in USA Products: Limited to Transportation Requirements																
Weight (lb/ft2)	0.164	0.205	0.266	0.307	0.348	0.430	0.553	0.650	0.665	0.286	0.317	0.358	0.522	0.635	0.654	0.655	0.716
U-Factor	0.68	0.68	0.61	0.58	0.52	0.47	0.4	0.38	0.34	0.53	0.48	0.44	0.36	0.33	0.31	0.26	0.24
Light transmission %																	
Clear	85	84	80	81	82	74	74	75	72	79	79	79	65	65	64	63	62
Bronze	57	57	51	65	65	41	37	35	35				30	30	40	35	35
Opal	58	58	57	57	57	52	52	52	35	50	50	50	40	40	40	42	42
Opal 30%			30	30	30	30	30	30								30	30
Reflecto						48		48					35		30	37	35
Blue			53	53	48		45										
Green			54	54	54		42										
Solar Factor %																	
Clear	83	82	80	82	82	75	75	77	78	81	81	72	68	68	63	61	60
Bronze	66	66	66	70	75	57	57	57	`			50	50	50		50	
Opal	66	66	66	65	64	62	63	63	51	51	51	45	45	50		54	
Opal 30%			47	47	46	45	44	43						37		35	
Reflecto						45		45				40		43		43	
Blue			66	70	70		65										
Green			66	70	70		60										
Shading coefficient (SC)																	
Clear	0.95	0.94	0.91	0.94	0.94	0.86	0.86	0.88	0.75	0.93	0.93	0.78	0.78	0.78	0.63	0.61	0.69
Bronze	0.76	0.76	0.76	0.8	0.86	0.65	0.65	0.65				0.57	0.57	0.57		0.57	
Opal	0.76	0.76	0.76	0.75	0.74	0.71	0.72	0.72	0.58	0.58	0.58	0.52	0.52	0.57		0.62	
Opal 30%			0.54	0.54	0.53	0.52	0.50	0.49						0.42		0.40	
Reflecto					0.52		0.52					0.46		0.59		0.49	
Blue			0.76	0.80	0.80		0.74										
Green			0.76	0.80	0.80		0.69										
Thermal Expansion	Allow 1/8" per 3' per 100 temperature differential for both length and width for Clear and Opal panels: 1/4" per 4' for Bronze panels																
Fire reaction	ASTM E84-01 (Flame Spread & Smoke Developed): **CLASS 'A' for 6, 8, 10, & 16mm**																

Applications

PC sheeting allows for total design flexibility, can be field fabricated, and is ideal in a variety of both indoor and outdoor applications including

- Roofs
- Skylights / Monitors
- Canopies/Walkways
- Vertical Glazing
  - Walls
  - Doors
  - Partitions
- Curtain walls
- Clerestories
- Illuminated Walls
- LED Lighting

The industry's widest applications of translucent daylighting technology

Sustainable Benefits of Daylighting Design

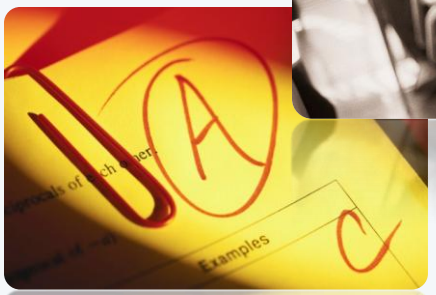
Indoor environmental quality, energy, and polycarbonate systems

Benefits of Daylighting

- We have already covered the disadvantages of a lack of sufficient daylighting. **So what about the benefits of daylighting systems?**
- Along with its significance for human health, PC daylighting systems also promote better indoor air quality and, as mentioned, energy savings.

Improved Learning

- The Heschong Mahone Daylighting Study of over 21,000 students showed a dramatic correlation between school environments with daylighting and student performance:
  - 20% faster progression in math
  - 26% faster progression in reading
  - Views out of windows increased performance by 5-10%
  - Skylights that DIFFUSED THE DAYLIGHT throughout increased improvement by 10-20%
  - Direct sun and glare created a negative effect.
- Is any place more concerned with effective environments than our schools? Many of them are considering mandating LEED certification.



Heschong-Mahone Group Study-Capistrano

Improved Business

- The Diffused Heschong-Mahone Group Study also showed daylighting increases retail sales, up to 40% for one major retailer.
- For another, daylighting achieved profits worth 19 times more than energy savings, possibly 45-100 times more.
- Wal-Mart, the world's largest retailer, doesn't place an average of 220 skylights in their super stores for no reason—they learned that merchandise simply sells better in the full spectrum of natural light.

Improved Productivity

- The fact that daylighting increases work performance and satisfaction is fairly well-known.
- The Heschong-Mahone Group Study notes that with access to an attractive window view, Call Center workers handle expedite calls 6% to 12% faster.
- Office workers test 10% to 25% better.
- However, glare potential decreased performance by 15% to 21%.
- Some experts suggest that improved productivity in schools and workplaces are an even greater cost benefit than improved energy efficiency.

Indoor Air Quality

- Air quality can have numerous effects on human wellbeing ranging from asthma to emotional distress. For businesses, this means reduced productivity and increased personnel costs in addition to other potential liabilities.
- Mold growth specifically can create health problems for building occupants ranging from nose and throat irritation to central nervous system issues. Some glazing can be susceptible to mold issues. Costs to remedy health problems or property damages caused by mold alone can be expensive and complex.
- Because PC sheeting systems repel water and condensation and do not support mold growth, these hold particular benefit for improving indoor air quality.

Sick Building Syndrome

- The EPA notes that sick building syndrome (SBS) is what occupants of a building experience when health symptoms arise for which:

  …no specific illness or cause can be identified...A 1984 World Health Organization Committee report suggested that up to 30 percent of new and remodeled buildings worldwide may be the subject of excessive complaints related to indoor air quality (IAQ)…Sometimes indoor air problems are a result of poor building design…

- The EPA lists inadequate ventilation first among major causes of SBS.

USGBC and EPA

- USGBC *Green Building and LEED Core Concepts (2009)* notes:

  …strategies that improve employee health and productivity over the long run can have a large return on investment. Moreover, preventing problems is generally much less expensive than dealing with any illnesses and loss of productivity stemming from poor indoor environmental quality.

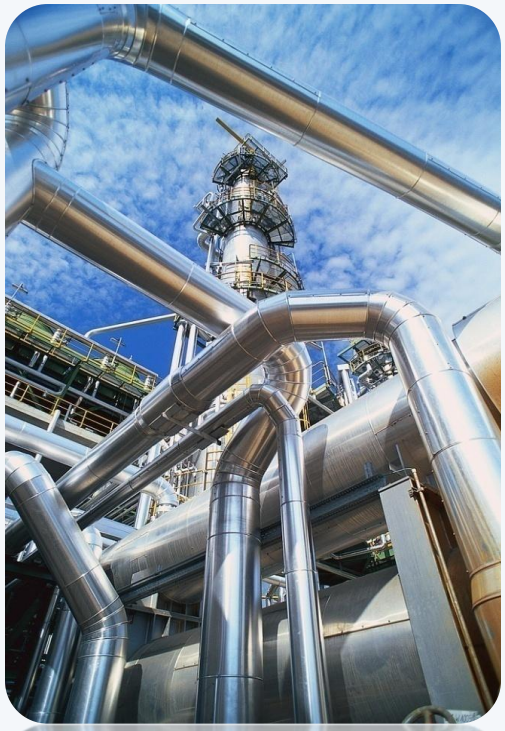
- According to the EPA:

  natural ventilation through operable windows can be an effective and energy-efficient way to supplement HVAC systems to provide outside air ventilation, cooling, and thermal comfort when conditions permit (e.g., temperature, humidity, outdoor air pollution levels, precipitation). Windows that open and close can enhance occupants' sense of well-being and feeling of control over their environment

Heating, Ventilation and Air-Conditioning (HVAC) Systems. epa.gov, accessed Feb. 8, 2011

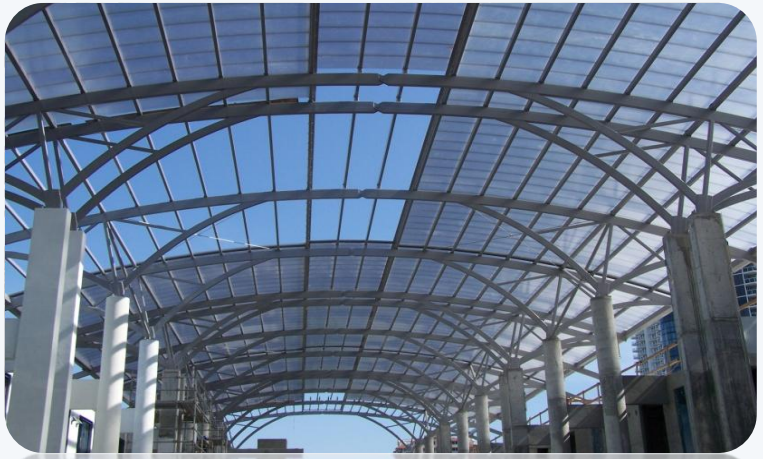
Daylighting and Energy

- If you didn’t know any better, windows might be the last place you’d look when thinking about energy savings. However, proper fenestration can reduce and even eliminate the energy consumption of buildings’ artificial lighting and HVAC systems.
- According to California’s Pacific Gas and Electric Company, “Daylighting design, when done with care, is the single most powerful strategy to reduce energy use in commercial and institutional buildings—from 30% to 60%.”
- As America’s energy crunch comes closer to crisis, the potential for ‘daylight savings’ is brighter than ever.



Artificial Lighting and Energy

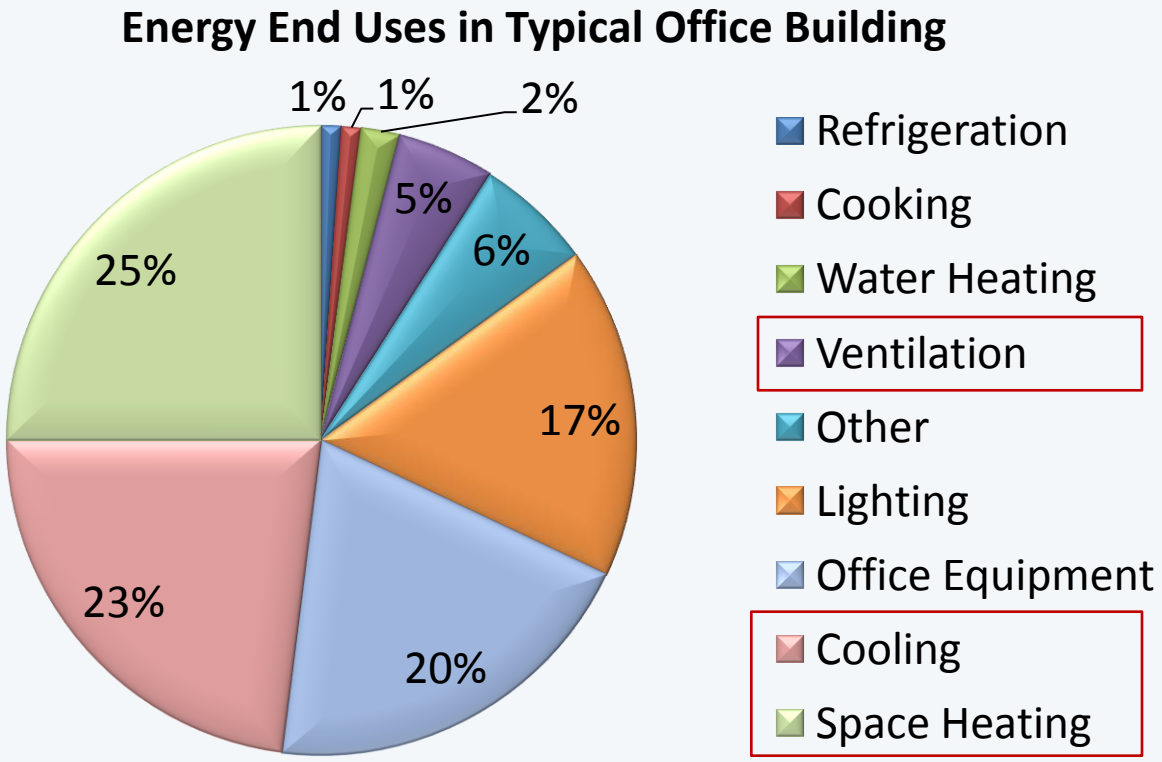
- Artificial lighting is a major energy-user in buildings—accounting for around 24% of energy used by commercial buildings.
- Designing in natural lighting systems such as PC roofs, skylights, entry canopies, walkway covers, curtain walls, operable windows, etc. can conserve up to 75% of a buildings energy use—lowering energy costs and the pollution associated with its production.



David Kozlowski, 2006. *Using Daylighting To Save On Energy Costs.* Accessed 17 Feb., 2011, www.facilitiesnet.com .

Impacts

In addition, the EPA recognizes that buildings account for a third of America's energy use. Of that, HVAC systems account for more than 50%.



Impacts

- HVAC energy use has quantifiable impacts on the environment. It not only contributes to greenhouse gas emissions, but also to the depletion of natural resources. This issue is perpetuated by energy inefficiency.
- Every time you adjust the thermostat, you are contributing to the 400 tons of pollution spewed into the sky every day.
- Improperly designed and specified daylighting can mean higher rates of energy consumption which translate to higher energy bills and/or operating costs.

So how can we conserve energy and reduce environmental impacts?

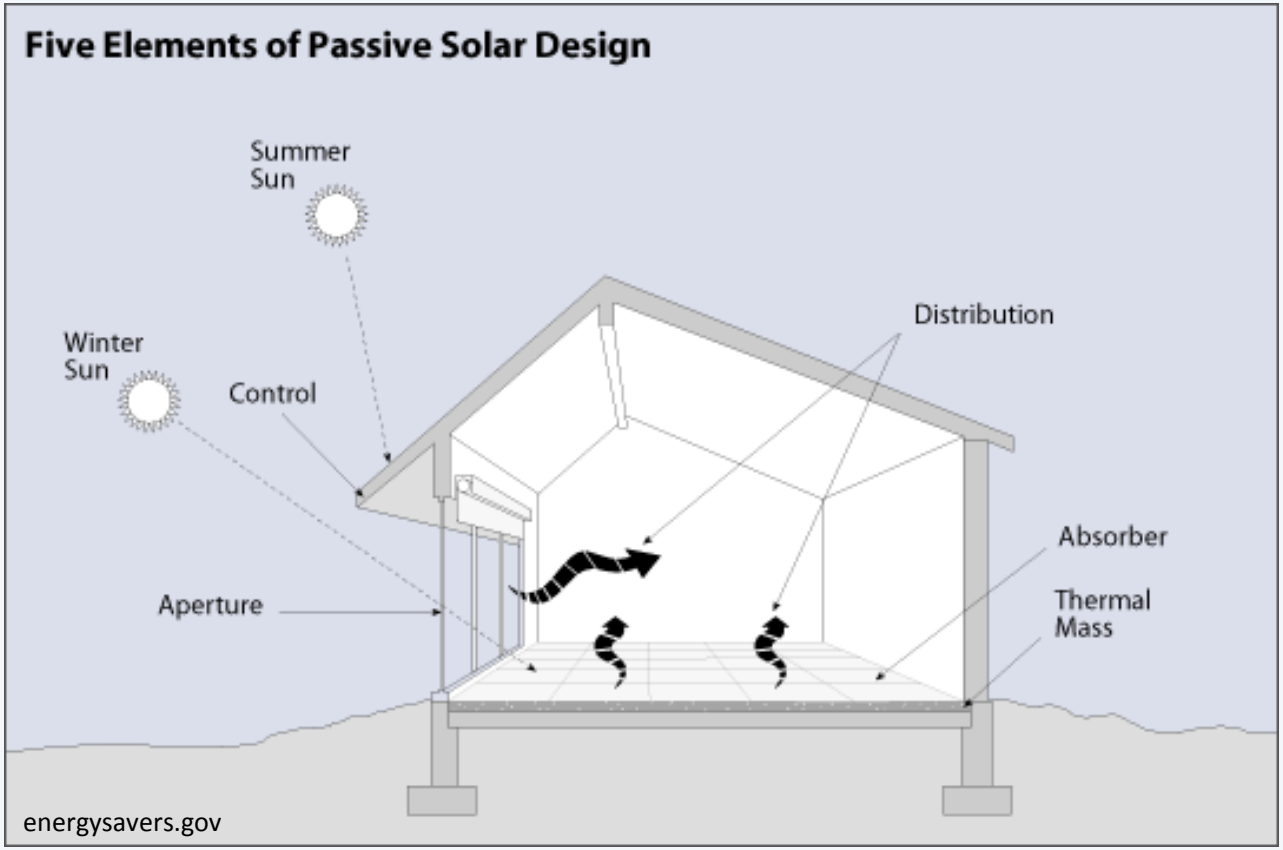
Improved Energy

- Glazing specification plays a key role in determining the building's overall thermal performance. Fenestration thermal performance requirements must be integrated with the design of the building's heating and cooling systems.
- PC sheeting systems limit heat gain from the outside during summer while allowing added thermal gain in the winter to minimize energy use and costs.
- The added insulation of these systems can also greatly aid in this conservation and savings.

Good Design

- The importance of **good design** cannot be emphasized enough—this means daylighting design which is climate appropriate, integrated with a buildings heating and cooling, takes into account glazing orientation toward the sun, utilizes high performance materials—such as PC glazing—to achieve design goals, etc.
- For instance, a design may incorporate glazing that is appropriately oriented to account for sun angle, depending on the climate. When the sun is higher in the sky during the summer, a building designed with a proper overhang would block most direct sun penetration out, minimizing solar heat gain and keeping the building cooler. However, sunlight would be able to stream directly in under the overhang during the winter when the sun is lower in the sky, helping to keep the building warmer.
- This is generally referred to as **passive solar design** (illustration on next slide).

Passive Solar Design

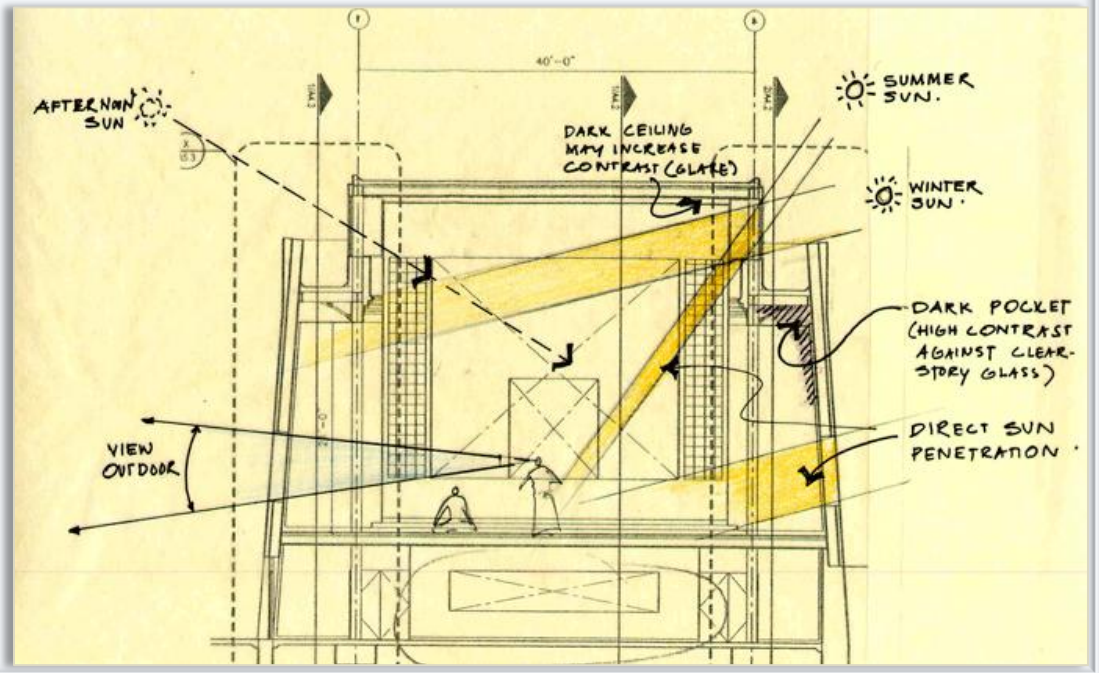


Better Design

The use of Polycarbonate systems actually accomplish sustainable goals more effectively than just simple good fenestration design because of the high performance UV protection, U-value, and light diffusion in addition to the hollow-core structure insulation design.

Better Design

Similar to the illustration from AEI's Sustainable Group shown here, PC glazing can eliminate the need for an overhang while achieving optimal passive solar design and daylighting for daytime use without need for artificial lighting (due to diffusion properties). PC glazing attributes enable these systems to go above and beyond the performance of most glass glazing, especially in terms of sustainability, in achieving optimal daylighting as well as building heating, ventilating, and cooling.



www.aeieng.com/services/sustainability/dali_lama.php

USGBC and LEED

Project certification, earning LEED points, applicable categories

USGBC and LEED

- U.S. Green Building Council (USGBC) is a nonprofit organization dedicated to creating a more sustainable future through advocacy, education, and the LEED program with the goal of reducing the impacts of construction and buildings on the environment.
- The Leadership in Energy and Environmental Design (LEED®) program provides guidelines, point systems, and certifications for environmentally responsible building across six main categories:
  - Sustainable Sites
  - Water Efficiency
  - Energy and Atmosphere
  - Materials and Resources
  - Indoor Environmental Quality
  - Innovation and Design

LEED

Specifying and incorporating polycarbonate sheeting systems into a building project can contribute to earning points toward LEED certification. Some of the possible categories that the system may contribute to include:

- Sustainable Sites
- Energy and Atmosphere
- Materials and Resources
- Indoor Environmental Quality
- Innovation in Design

Sustainable Sites

- SS Credit 7.2, Heat Island Effect (roof): *reduce heat islands to minimize impacts on microclimates and human and wildlife habitats.*
  - PC sheeting systems have a low solar reflectance index (SRI)
- SS Credit 8, Light Pollution Reduction: *minimize light trespass from the building and site, reduce sky-glow to increase night sky access, improve nighttime visibility through glare reduction and reduce development impact from lighting on nocturnal environments.*
  - The light-diffusing properties of PC systems reduce or eliminate glare and prevent direct beam illumination from the interior to the exterior.

LEED Reference Guide for Green Building Design and Construction, 2009.

Energy and Atmosphere

- EA Credit 1, Optimize Energy Performance: *achieve increasing levels of energy performance beyond the prerequisite standard to reduce environmental and economic impacts associated with excessive energy use.*
  - When integrated with both lighting and heating, cooling, and ventilating system design of a building, PC systems can significantly reduce HVAC and lighting loads—resulting in energy savings and conservation.

LEED Reference Guide for Green Building Design and Construction, 2009.

Materials and Resources

- MR Credit 4, Recycled Content: *increase demand for building products that incorporate recycled content materials, thereby reducing impacts resulting from extraction and processing of virgin materials*.
  - In addition to being completely recyclable, many PC sheeting materials are made from recycled materials in accordance with LEED guidelines.

LEED Reference Guide for Green Building Design and Construction, 2009.

Indoor Environmental Quality

- IEQ Credit 8.1, Daylight and Views: *provide for the building occupants with a connection between indoor spaces and the outdoors through the introduction of daylight and views into the regularly occupied areas of the building* (75% of regularly occupied spaces).

and

- IEQ Credit 8.2, Daylight and Views: *provide building occupants a connection to the outdoors through the introduction of daylight and views into the regularly occupied areas of the building* (90% of regularly occupied spaces).
  - Of course, probably the strongest case for LEED points can be made and earned by incorporating PC systems as part of an intelligent lighting design.
  - These systems not only provide more-than-adequate views to the outdoors, but also superiorly diffuse and distribute natural light throughout a space, eliminating the need for artificial light during daytime hours.

LEED Reference Guide for Green Building Design and Construction, 2009.

Innovation in Design

- ID Credit 1, Innovation in Design: *provide design teams and projects the opportunity to achieve exceptional performance above the requirements set by the LEED Green Building Rating System and/or innovative performance in Green Building categories not specifically addressed by the LEED Green Building Rating System.*
  - The versatility and design flexibility of PC sheeting systems allows and encourages their integration into innovative green building techniques and strategies in order to achieve exceptional performance in mentioned LEED categories.

LEED Reference Guide for Green Building Design and Construction, 2009.

Summary

What you should now know about daylighting, polycarbonate glazing, and sustainability

Summary

- Polycarbonate sheeting systems are not only ideal in a variety of residential and commercial applications, they are also totally design flexible, ideal in a variety of both commercial and residential applications, and are designed for sustainability.
- PC systems provide ample daylighting necessary for human health and well-being, improve indoor environmental quality, and contribute to energy efficiency.
- Remember…look for providers whose products are C2C labeled, Miami-Dade certified, provide high light transmission and withstand ability, and are completely recyclable. PC sheeting will deliver all of these attributes in addition to optimal performance.

Course Summary

Now, the design professional will be able to:

- Explain the importance of daylighting to human health and well-being
- Describe the role of daylighting in sustainable design
- Define polycarbonate sheeting in terms of makeup, u-value, performance, and sustainability
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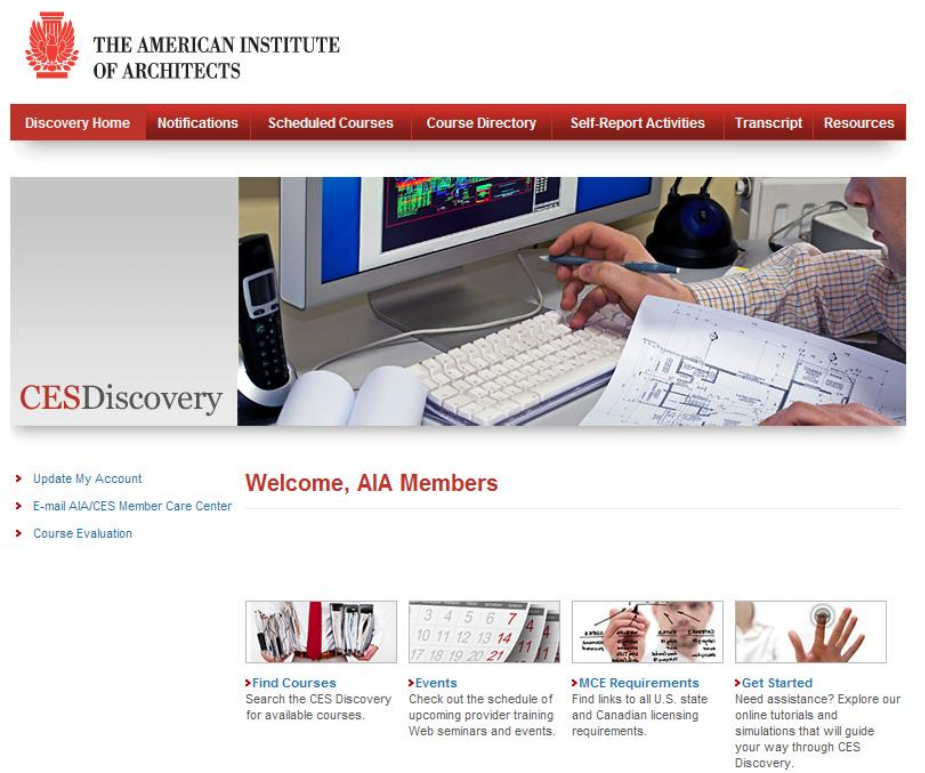
AIA Course Evaluation

In order to maintain high-quality learning experiences, please access the evaluation for this course by logging into CES Discovery and clicking on the Course Evaluation link on the left side of the page.



Glazing, Daylighting, and Polycarbonate Sheeting Systems

An American Institute of Architects Continuing Education Program

Credit for this course is
1 AIA/CES LU/HSW/SD Hour and 1 GBCI CE Hour

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CONTINUING EDUCATION AIA