



**LIBART**



# Kinetic Architectural Systems



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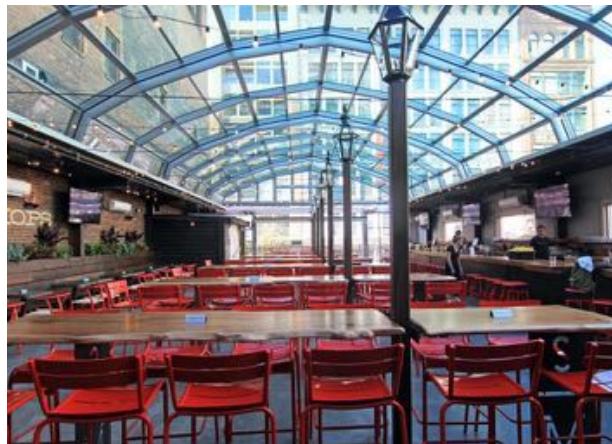
AIA course number: K1808J



# Kinetic Architectural Systems

## Description:

Kinetic architectural systems blur the separation between outdoor and indoor spaces, maximizing a living or working area and making it usable throughout the year. When retractable structures, roofs, skylights, windows, or doors are integrated into a building project, enclosed spaces are no longer limited to being indoor spaces only. This course discusses the types, application and functional requirements along with associated systems for incorporating motion in architecture to provide flexible living and working environments in any type of weather.



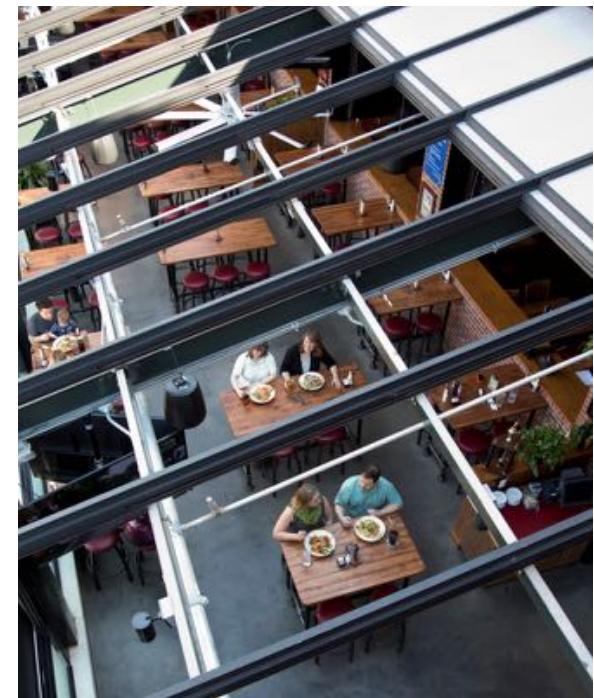
# Purpose and Learning Objectives

**Purpose:** Kinetic architectural systems blur the separation between outdoor and indoor spaces, maximizing a living or working area and making it usable throughout the year. When retractable structures, roofs, skylights, windows, or doors are integrated into a building project, enclosed spaces are no longer limited to being indoor spaces only. This course discusses the types, application and functional requirements along with associated systems for incorporating motion in architecture to provide flexible living and working environments in any type of weather.

## Learning Objectives:

At the end of this program, participants should be able to:

1. Define kinetic architecture and explain how it differs from static architecture, its evolution, and its introduction into North America, and explore occupant engagement and other associated benefits.
2. Describe the various structural types of kinetic architectural systems and how they can benefit the human experience.
3. Determine how kinetic architectural systems address today's dynamic, flexible, and constantly changing needs for architectural design.
4. Evaluate the criteria involved in selecting a suitable kinetic architectural system for a variety of applications offering year-round use and connection to outdoor natural elements while also providing protection to building occupants.
5. Discuss the design of kinetic architectural systems and specify the appropriate associated systems for project requirements involving function, climate and comfort, life safety, and changing weather conditions.



# What Is Kinetic Architecture?

Kinetic Architecture (KA) is defined as, A concept in creating spaces and objects that physically re-configure to meet changing needs. To address today's dynamic, flexible, and constant changing needs, kinetic architecture depends on motion for its effects. By incorporating motion in architecture, it allows occupants another dimension by which to interact with their surroundings.

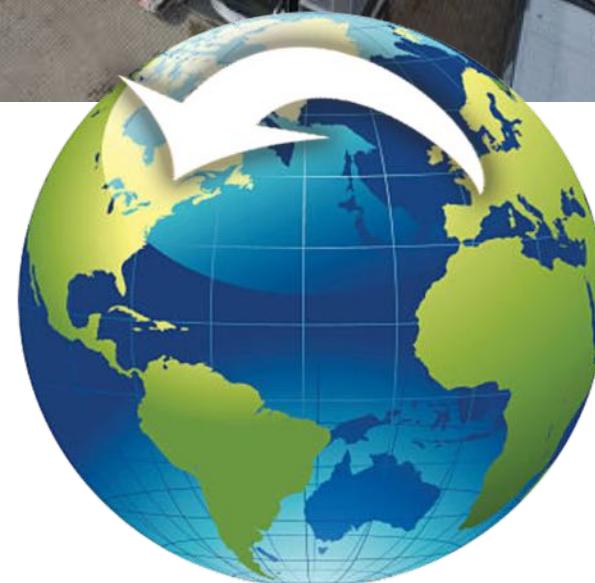
Dynamic moving building elements can serve to fulfill a functional requirement, e.g., to provide shade, daylighting, or protection; to meet the needs of building occupants; to create unique aesthetic effects. KA that moves to respond to environmental conditions, or provide open panoramic views can be seen in whole structures, roof-only applications, small to large-scale windows and doors. Kinetic architecture performs functions that would be impossible for static structures.



# Evolution of Kinetic Architecture

In his book, *A Dictionary of Architecture and Landscape Architecture*, 2nd ed., James Stevens Curl says that, “Architecture evolved in the belief that the static, permanent forms of traditional architecture were no longer suitable for use in times of major change. Kinetic architecture is supposed to be dynamic, adaptable, capable of being added to or reduced, and even disposable.”

KA has deep roots in Europe dating back as far back to the 1500's and has evolved over time to eventually be adopted in North America shortly after the turn of the century.



# Why Kinetic Architecture?

(WOW) Kinetic Architecture creates an ambiance to engage occupants that invites an emotional appeal and connects them to the outdoors. According to numerous studies people are often drawn to natural daylighting, open ventilations, and scenic views. The open feel, while still enjoying the indoor comforts can positively enhance the overall guest experience significantly thus, kinetic architecture is an engagement touchpoint.

(ROI) Depending on means of revenue, by incorporating kinetic architecture to a building allows the space to be utilized year-round regardless of environmental conditions, plus can provide a shorter cycle of ROI for the initial investment. Kinetic architecture also offers efficiency in space design to allow optimum space usage resulting in maximum revenue generation.



# WOW: Occupant Engagement

Numerous studies suggest restaurant goers typically prefer window seating. Humans are inherently attracted to natural daylighting and the associated positive benefits such as reduction in electricity and mechanical costs, better retail sales, increase in serotonin production which can improve mood, productivity and positivity. Natural daylighting can also promote calmness and regulates the human circadian rhythms.

The outdoor experience of the open air feel while still enjoying the indoor comforts also positively enhances the guest experience. Creating scenic views with little to no view restriction or obstruction provides another human connection with the outdoor elements.



# ROI: Revenue Generation

As discussed in the previous slide, operable glass kinetic architecture offers natural daylighting to assist in offsetting the costs for the dependency for full artificial lighting. By incorporating kinetic architectural glass installation benefits include: passive cooling, bringing in fresh outdoor air to offset rising temperatures of indoor air. This offsets the need for as much or even some mechanical cooling. Incorporation of UV-filtering, tinted or polycarbonate glazing options reduces heat gain and discomfort of glare. Thermochromic or electrochromic glass offers another option of tinting glass to reduce glare.

In many configurations, these operable glass solutions can continue to offer the open outdoor experience while protecting customers from weather related issues allowing year-round use. Employing vertical retracting window and door design maintains efficient space utilization ultimately maximizing revenue generation by not taking up any space at the floor, walls, or ceiling.



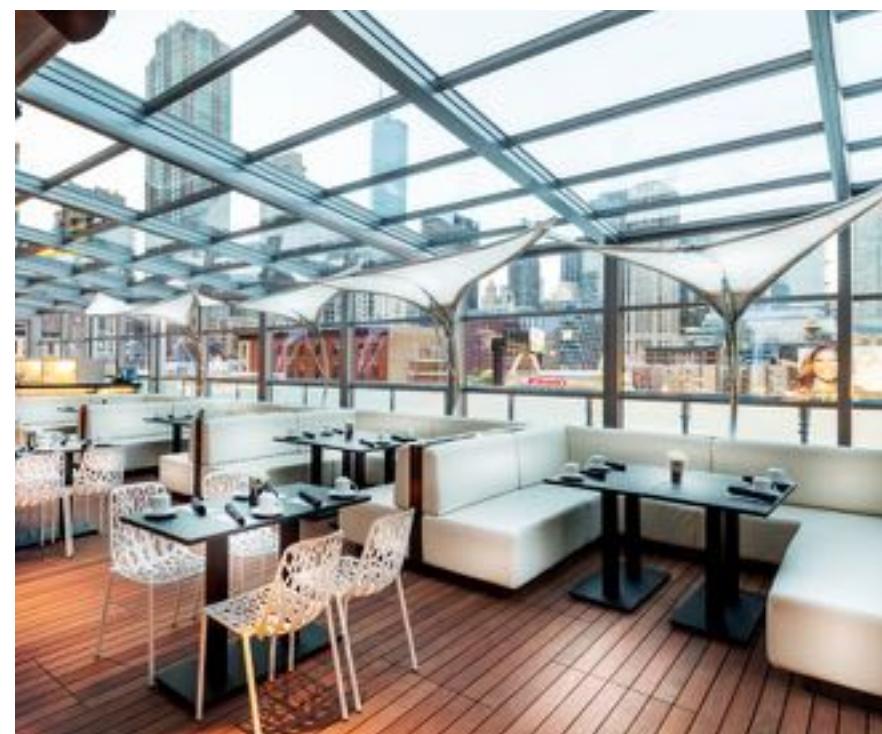
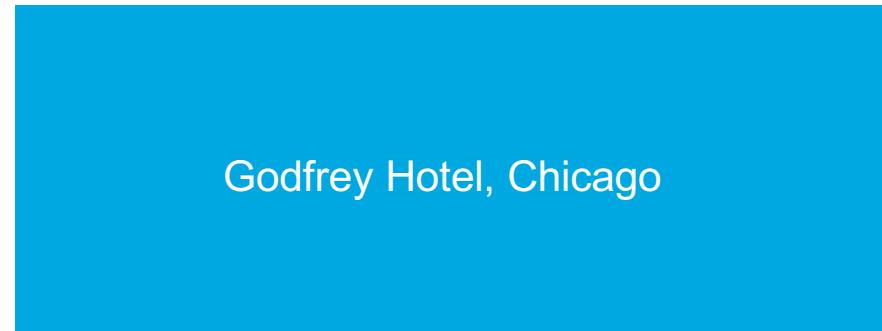
# Case Study: Return on Investment



Godfrey Hotel, Chicago



# Case Study: Return on Investment



## Case Study: Return on Investment

At 127 W. Huron in Chicago is the Godfrey Hotel. The planning and design of this boutique hotel was all about challenging traditional architectural designs. To complete this impressive structure a retractable enclosure was installed, effectively creating an indoor-outdoor roofscape. In only five months, the roofscape paid for itself—not just for the retractable roof, but the entire space. Events, daytime dining, and nightlife all happen on this floor terrace. The event space, with views of downtown Chicago, is rented out for corporate events and private parties throughout the year. In addition, the space is open to the public, not just hotel guests. The entire roofscape, when opened up, holds up to 750 guests; in the winter/off-season when the structure is closed, it holds up to 630 guests.



# Types of Structural Kinetic Architectural Systems

The five main categories of kinetic architectural systems are:



Retractable structures



Retractable skylights



Retractable roofs



Retractable windows  
and doors



Retractable glass railing  
and wind screens

kin-*et*-ic: of or relating to the motion of material bodies and the forces and the energy associated therewith.  
– source Merriam-Webster Dictionary.

# Retractable Structures

Retractable structures are composed of telescopic bays that are designed to be easily opened and closed. Sections of the walls and the roof move as a bay (unit) and can collect at either end. Retractable structures provide protection from the elements while continuing to offer natural daylight and spacious outdoor views. When opened, retractable structures provide an unobstructed view of the sky above, making them ideal for applications whose owners wish to use them year round.



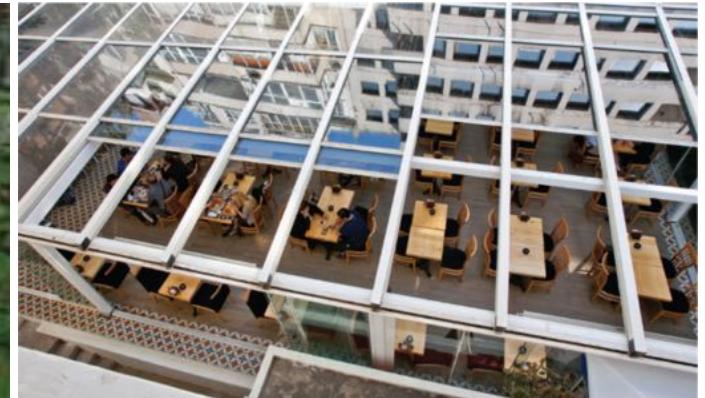
Retractable structures are also an ideal solution for restaurant patios that generate zero dollars of revenue when all but the most ideal weather conditions exist. When opened (bi-parting or unidirectional), retractable structures provide an unobstructed view.

# Retractable Structures

Walls and roof move as one unit

# Retractable Skylights

Retractable skylights are similar to a fixed skylight except they have the ability to open and close with the weather. They can be installed on a portion of the roof or they can be designed to be the roof. These systems provide plenty of fresh air and daylight although the structural framing members remain in place even when the panels are retracted to the open position. Due to its design and small number of moving parts, a retractable skylight system offers the best protection from weather intrusion. It can be combined with a retractable window and/or door system for a complete enclosure solution. Additionally, retractable skylights are not self-supporting and require a supporting sub-structure for support. With a supporting sub-structure it allows for greater flexibility for incorporating lighting, audio/visual, and fire suppression systems.



# Retractable Skylights

There are two main types of retractable skylights. One type operates on a single slope while the other operates on a double slope. Both designs offer the ability to collect the glazing panels at the eave or ridge of each slope. Due to its design, thermally-broken aluminum framing, and small number of moving parts, a retractable skylight system offer the best thermal, air and water performance. The type specified for a project will be a function of the overall span, as well as the adjacent architecture. Retractable skylights offer options for an opening of 66% or 75%.



# Retractable Roofing Systems

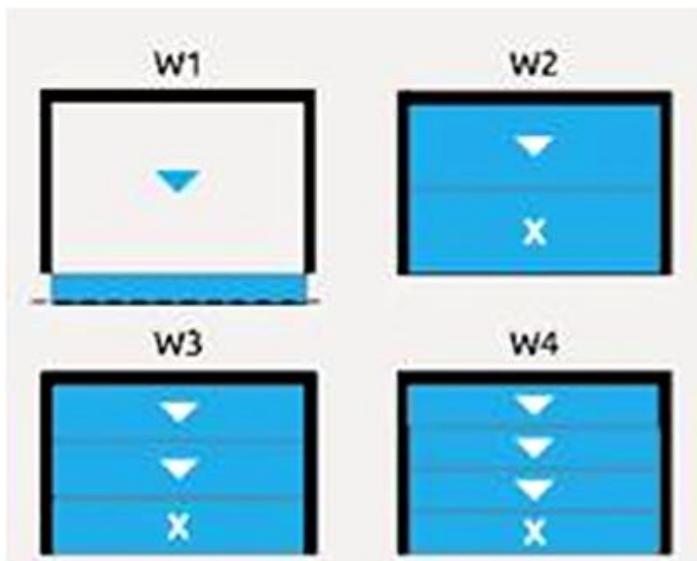
Retractable roofing systems provide a clear sky opening, similar to what you would see at a sports stadium but on a smaller scale. When you look up, all you see are the sun and the sky!

Roofing system retraction methods are similar to those previously discussed for retractable structures (biparting or unidirectional). Retractable roofing systems can be used for four season applications if the proper glazing is selected. They are commonly available in 70- or 90-degree side walls based on the span and site-specific engineering. The 70-degree side wall design delivers a stronger arch than those with 90-degree side walls.



# Retractable Windows

As mentioned earlier, retractable window and door systems are also called vertical glazing. The system usually has one to four panels per rough opening, and all panels collect at the bottom. A retractable window system usually has one to four panels per rough opening, and all panels collect at the bottom.



# Retractable Windows

Also, you'll notice that this system eliminates the need for an additional safety railing as the panels create a glass barrier. In a restaurant or bar application, the panels should be programmed to retract to a staggered position so that a wide ledge is not created. People are often tempted to set a drink down on a wide ledge, but as accidents do happen, a cup or glass could be knocked off only to land on a pedestrian at street level.

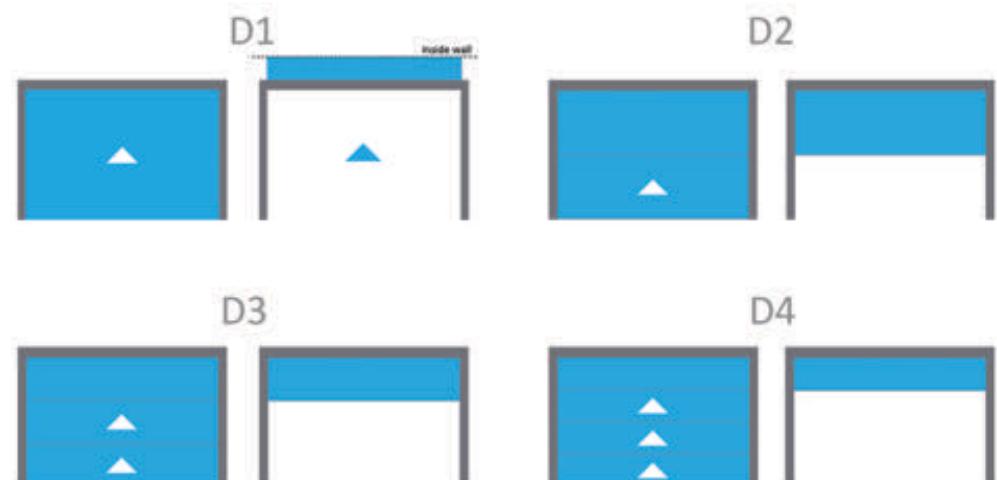
These systems can be used interior and exterior applications and are motorized due to the weight of the monolithic or insulated glass. Operation controls for these systems can be operated conveniently by wall-mounted switch, handheld remote control or tied into the building automation system.



# Retractable Doors

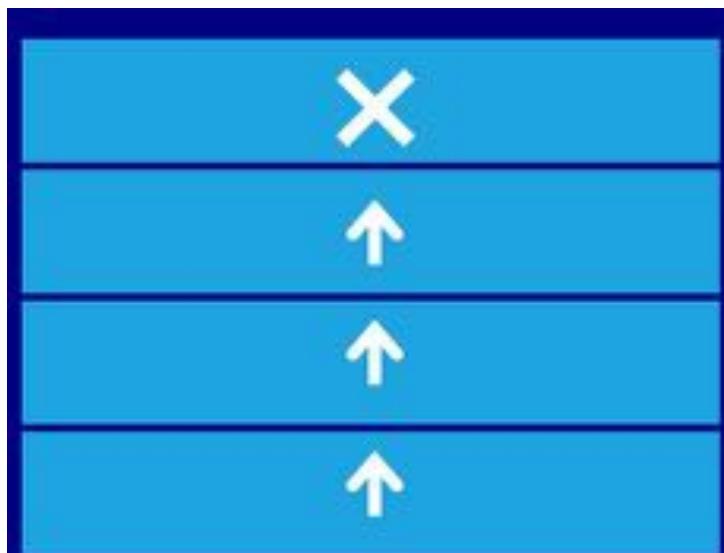
Retractable doors are ideal for applications on the first floor of a building or for any area that provides access for pedestrian traffic. Each system can be composed of one to four panels, and since they operate within their own plane the need to move adjacent furniture or guests is eliminated.

These systems can be used interior and exterior applications and are motorized due to the weight of the monolithic or insulated glass. Operation controls for these systems can be operated conveniently by wall-mounted switch, handheld remote control or tied into the building automation system.



# Retractable Doors

Care must be taken when designing the rough opening height so that a minimum of 7 ft of clearance if used in a pedestrian pass-through application.



# Retractable Doors

Retractable doors when designed for large format openings offer great thermal performance, weatherability, little obstruction to sightline, and offer efficiency in space design. With glass overhead doors tracks can affect ceiling space and alter a design and function. However, with retractable doors they also offer a concealed operation with the motors and drive system eliminating the need for external motor drive systems, chains, belts, tracks, springs, and other maintenance-prone mechanical features.

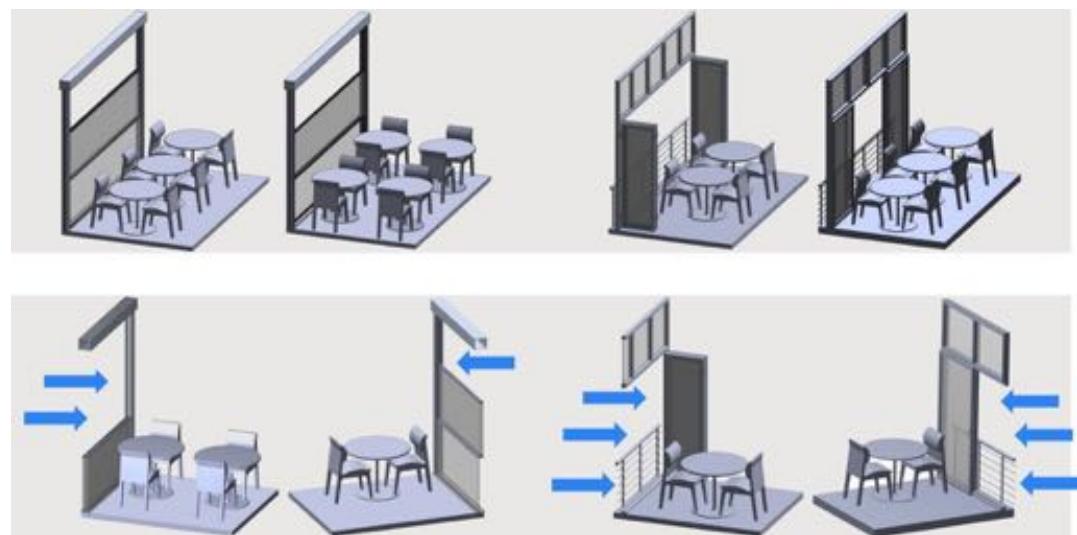


# Retractable Doors & Windows

Horizontal bi-folding doors are another retractable glazing option. While these types of doors provide the open air and convertible spaces that some designs demand, their largest disadvantage is that often adjacent tables/chairs and guests need to be relocated when opening or closing them.

Sometimes, they will also limit the available floor and wall space for seating, which has an adverse effect on revenue and ultimately, the bottom line. This can be a real show stopper at many hospitality venues.

An advantage to KA windows and doors is that they can be opened an inch, a foot, or all of the way, providing endless ventilation options.



# Retractable Doors

Another noticeable retractable door trend is the vertical folding door system. These types of retractable doors offer large expansive openings and when open create an eyebrow overhang. With a vertical retracting door solution the advantages are little obstruction to sightline, upgraded thermal performance, and a concealed operation for motor and drive systems. Efficiency in space design comes into play with a vertical retracting door system if the eyebrow aesthetic of a vertical folding door system is not the design intent.



# Retractable Glass Railing/Wind Screens

In areas where wind is to be kept to a minimum, kinetic glass railing wind screens provide open outdoors, maximum visibility, and refuge from wind. This type of system presents all the benefits of a glass balustrade, with the addition of a wind and rain shield when required. A vertical retracting glass railing wind screen utilizes a concealed, self-charging piston system that eliminates unsightly and maintenance-prone counter-weights, cables, and pulleys, maintaining a sleek aesthetic.



# Retractable Glass Railing/Wind Screens

Retractable glass railing and wind screens are functional moving glass systems with structural glass glazing technology. These systems utilize a smart retraction mechanism that enables manual retraction and extension with a single touch. This innovative system design, like most kinetic architecture, enables maximum use of space. The glass railing wind screen reduces wind and weather elements allowing utilization year-round. Flexibility in the system design allows for a fixed in place or portable applications.



# KA System Selection Criteria

This section of the course discusses the various criteria you'll want to consider when selecting an appropriate kinetic architectural system for a building project. The following considerations are explored:

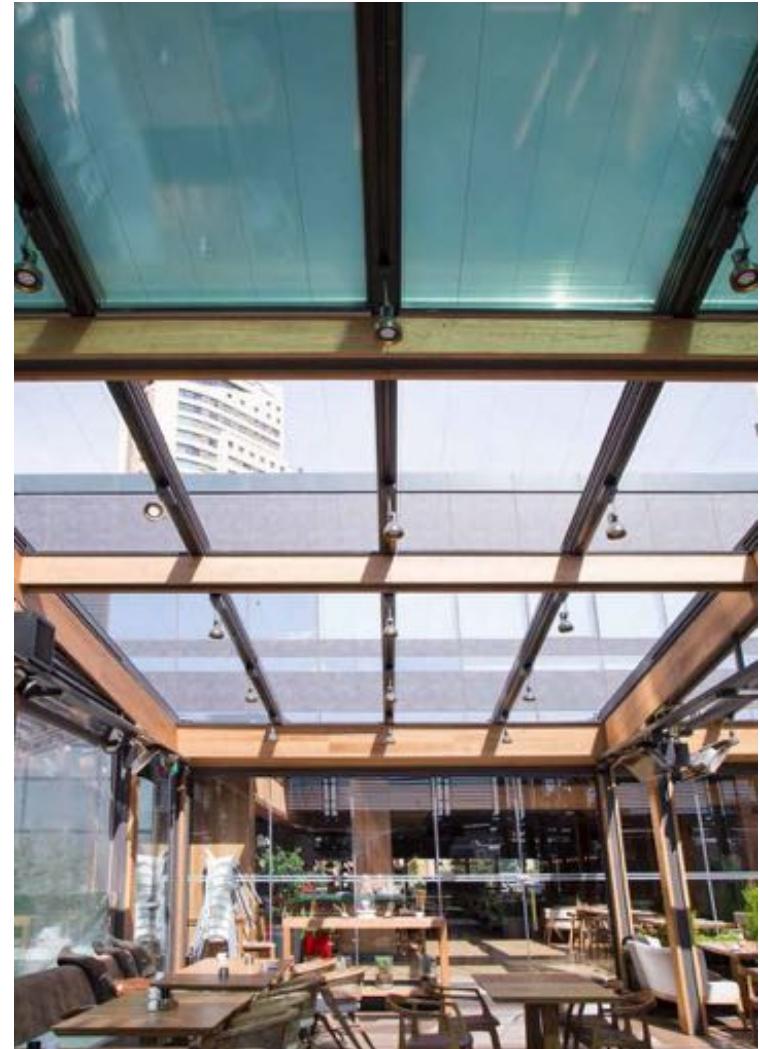
- Application
- Function
- Desire for open sky views
- Project budget
- Associated systems
- Adjacent architecture



# Selection Criteria: Application

What is the application? Does the space beneath the KA system have to be available for year-round use, or will three seasons be acceptable?

If year-round use is required, it is necessary to take a close look at the framing system to be sure that it has an integrated thermal break to eliminate the possibility of condensation. This will mean considering a retractable skylight system since most manufacturers offer a framing system with an integrated thermal break. These systems will keep HVAC (heating, ventilation, and air conditioning) costs down, delivering a lower cost of ownership.



# Selection Criteria: Function

What components need to move? The roof and/or the walls?

Will the walls and roof move as a unit? If this is the case, your choice will be limited to a KA retractable structure.



# Selection Criteria: How Much Open Sky?

If your client wants to see only the sun and sky when the KA system is in the open position, then a KA retractable structure or KA retractable roof should be selected. In the photo on the right, the retractable roof provides a clear, unobstructed view of the sky above. In contrast, the retractable skylights shown in the photo on the left provide partial views as the main framing members remain in place when the glazing panels are retracted to the open position.



## Selection Criteria: Budget

If a project budget is tight, a KA retractable structure is usually the best option. The reason for this is simple—KA retractable structures are a complete solution since they provide coverage for the walls and roof of a space. In addition, they require less site preparation since the only work that needs to be designed, engineered, and installed by a general contractor is the area where the rails are installed on either side of the arch.



# Selection Criteria: Budget

A retractable roof or skylight system will likely cost less than an entire KA retractable structure, but when the factors below are considered together, the project investment for a retractable roof or skylight system may be much higher overall.

- Since a retractable roof or skylight system only provides coverage for the roof area, it is necessary to consider the additional costs involved to cover the walls, including the installation of windows and doors.
- A retractable roof or skylight system may require a substantial amount of additional site preparation and engineering since they require steel substructures and/or parapet walls.



# KA System Selection Criteria: Adjacent Architecture

Adjacent architecture to be considered for kinetic architecture can be defined as foundations, supporting sub-structures, substrates, parapet walls, curbs, and vertical walls. Factors for available rail space, energy chains, and motorization need to be taken into account during the project design phase. Since a retractable roof or skylight system only provides coverage for the roof area, it is necessary to consider the additional costs involved to cover the walls, including the installation of windows and doors.

- For existing buildings, the site conditions coupled with function, engineering considerations, and budget will determine what type of system to be designed for the building.
- For new building conditions the factors of function, engineering considerations, and budget are more the determining factors of what type of system to be designed for the building.



# KA System Selection Criteria: Adjacent Architecture

Generally, because most overhead KA systems are composed of aluminum framing members, the loads imparted on adjacent architecture are not any more than conventional construction materials. This is mostly true for when the KA system is in the closed position. Once the system is in the open position, the overall design loads shift to a much smaller area, which may require additional support.

Typically, licensed engineering calculations are required by most building departments. Experienced KA manufacturers will provide a comprehensive engineering report that lists all relevant reactions and design loads for a project. Depending on the location of the project, these loads would include live loads - variable forces imposed on any structure, such as, snow, wind, dead loads, along with seismic considerations.



# KA Associated Systems:

Associated systems are integral for kinetic architecture as they assist in control of function, climate and comfort, life safety, and changing weather conditions.

- Electrical
- Lighting
- HVAC/Mechanical
- Fire suppression
- Controls



# Associated Systems: Mechanical

When designing the HVAC system for a KA system, the main issue to keep in mind is the high solar heat gain that will be experienced by the transparent glazing. This is also known as the “greenhouse effect” and it can place abnormally large demands on a building’s mechanical systems.

The main concern will be heating in the wintertime as most clients will elect to open these systems up in warmer weather. To reduce the potential for condensation, the HVAC system should be designed similar to the way a car defroster operates. Essentially, a conveyor belt of warm air is created across the inside surface of the KA system to carry any humidity away before it can condense on any of the cold surfaces.



# Associated Systems: Electrical

The two main electrical systems to address when designing a KA system are motorization and lighting.

Motorization can be handled by hardwiring the KA system into the building's system, or it can be designed as a self-contained and powered system.

If motorization is hardwired in, typical electrical requirements are 240 volt, 40 amp, and 3-phase service. There will most likely need to be an energy chain included in the design, for the retractable structures and roofs, so that the electrical can follow the motorized bays.

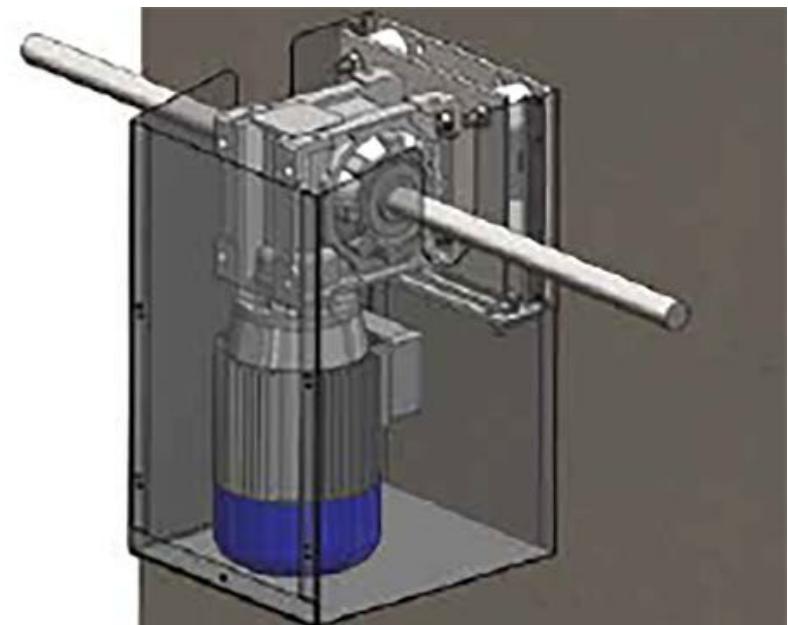


# Associated Systems: Electrical

Self-contained systems are powered by solar panels on the roof that charge low voltage battery packs.

The batteries then provide the power for the electrical motors. The added benefits to this type of power are that they typically do not require bonding as they are low voltage. Also, they can often be retrofitted after the initial installation, which gives your clients the opportunity to live with a manual system for awhile and see if a motorized system is really necessary. In any event, retractable skylights and roofs are always motorized due to their location.

Battery back-ups for hardwired systems can also be incorporated in the event there is a power outage. This will allow operation of the kinetic architectural system for weatherability and security.



# Associated Systems: Lighting

Lighting is another area that will need to be addressed. Oftentimes, the clear glazing lets in a lot of light so it can substantially reduce the amount of artificial light required in the space covered by the KA system. If additional lighting is desired, consider placing lighting in the floor or in adjacent architecture that does not move. If lighting is needed on the KA system itself, consider placement on stationary components.



# Associated Systems: Fire Suppression

Similar to lighting, consider placement of fire suppression systems on adjacent architecture or on stationary components of the KA system.

Consult your local jurisdiction to determine if your project is subject to the provisions of the Life Safety Code.



# KA System Associated Systems: Weather Sensors

Electronic rain and wind sensors add a level of protection for the building occupants and interior furnishings by creating an automatic system that will activate the closure of kinetic architecture in the event of undesirable weather.

Rain Sensor: Rain Sensor will automatically detect the moisture threshold in the air and activate for protection.

Wind Sensor: Wind Sensor will automatically detect the wind threshold and activate a kinetic system for protection.



# KA Associated Systems: Building Automation Systems

Building automation systems simplify a facility's operations and incorporate the controls of security, energy management, temperature controls, and fire safety systems. For kinetic architecture, by integrating into the building's centralized automation system, it simplifies the control process. Kinetic architecture can be controlled through a touchpad or PLC (programmable logic controller). More sophisticated systems can even allow to be controlled by mobile electronic devices.



# Pool Enclosure Project, Ooltewah, TN

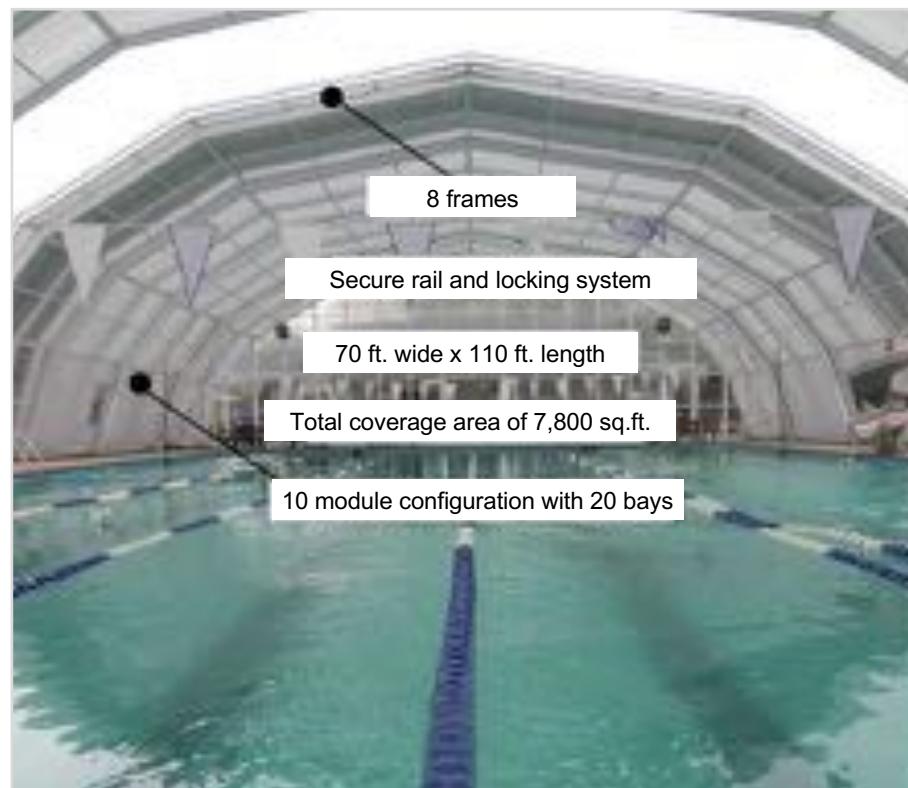
While the Ooltewah Swim Center was able to provide year-round swimming to their members through the use of an inflatable dome, the crew wanted a dependable, permanent pool enclosure. High winds and unexpected air leaks would interrupt service in the inflatable dome, and it required round-the-clock monitoring to avoid accidents.

The solution? A freestanding retractable structure measuring 70' wide and 110' long. The retractable structure with a 190 mm thick frame was designed with 70-degree side walls with gable end walls. It is motorized and utilizes a biparting retraction method, delivering extra space in the middle of the enclosure. The roof panels and side wall glazing is 16 mm multi-wall translucent polycarbonate, while the gable end walls feature a combination of 4 mm monolithic clear transparent polycarbonate and 10 mm clear twin wall translucent glazing.



# Pool Enclosure Project, Ooltewah, TN

Swimmers are now able to enjoy the warm air and clear waters at Ooltewah Swim Center all year long. Even during the coldest days in southeast Tennessee, “The Dome” protects swimmers, coaches, parents, and children from the unforgiving weather.



# Retractable Windows & Skylights Project, Raleigh, NC

Located in the heart of Raleigh, NC, this three-story ale house, new construction with fourth-floor observation deck and third-floor open air patio, was the first motorized, retractable window installation of its kind in North America. It also features motorized, retractable skylights and shades. The patio seats 200 of the restaurant's 420-person capacity and it features radiant heated floors.



# Retractable Windows & Skylights Project, Raleigh, NC

Each component of the system can be adjusted to provide the perfect combination of fresh air, sunlight, sound control, and protection from the elements. The innovative panoramic window system was used instead of the originally specified garage doors. Whereas garage doors would require an additional railing for safety, the panoramic windows retract down to form a glass wall. The downward retracting windows provide a full outside view when closed, as well as the desired window opening.



# Private Residence, Colorado Rockies Pool Haven

The owners of this private sanctuary wanted a space where they could relax and entertain their family and friends while viewing the surrounding majestic mountain scenery from their chaise lounge chairs. They knew that only the most beautiful backyard and leisure space would be worthy of such a high-end residential property.

Architect Robert R. Larsen, AIA, designed an upper-level deck overlooking a large wheelchair-accessible pool and entertainment space that could be enclosed by a lean-to retractable structure. The lean-to structure encloses 2,650 climate-controlled sq ft and is design engineered to endure the region's impressive annual snowfall average of 57", and offers enough protection from the elements that the area can be enjoyed during the harsh Colorado winters.



# Private Residence, Colorado Rockies Pool Haven

The lean-to retractable enclosure, 25' wide x 106' long, with a white frame features 16 bays and 8 modules. Extra framing members reinforce the structural integrity of the enclosure and add strength against the potential for snow loads of up to 50 lb/sq ft. Polycarbonate glazing, 4 mm clear, was installed on the sides and end, and the roof panels feature 10 mm clear, translucent polycarbonate glazing. The enclosure is motorized and closes in under two minutes.



# Other Applications

Although there is a strong case for kinetic architecture in the restaurant and hospitality market segments, other applications include but are not limited to:

- Observatories
- Pools/Natatoriums
- Residential
- PK-12/Higher Education
- Auto Dealerships
- Other Creative Applications

Other applications:



Retail shopping



Sport stadium



Industrial

# Course Summary

- Kinetic architecture (KA) allows for the use of living and working spaces regardless of the weather.
- The five main categories of structural kinetic architectural systems are retractable structures, retractable skylights and roofs, and retractable windows and doors, glass railing/wind screen otherwise known as vertical glazing.
- When selecting an appropriate kinetic architectural system for a building project, it is necessary to consider the application function, desire for open sky views, project budget, KA type and adjacent architecture.
- When designing a KA system, it is also necessary to specify associated mechanical, electrical, lighting, fire suppression systems and considerations for controls.



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Daylighting Reference: (Heschong Mahone Group 2002 Study – Daylighting Impacts on Retail Sales Performance)

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This concludes The American Institute of Architects  
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# Conclusion



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