Architectural Kinetics:
When Facades are Moving

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Kinetic facades, still an architectural novelty, have the potential to impact urban and architectural spaces tremendously. In the last twenty to thirty years the integration of elements animated by the wind, sun or water into building envelopes has increasingly been explored by cutting-edge designers and architects––both as an aesthetic element and as impetus for sustainable design. The scale and type of architectural kinetics ranges from the experimental to the monumental. Manifold questions of impact arise in relationship to moving facades and how they fit into the built environment. The co-authors investigated an international interdisciplinary group of noted architects, engineers, artists, and scientists in an inquiry that considered the present and future of kinetic applications in facade design. We focused on a selection of projects that involve kinetic mechanisms and explore potential already realized and evolving visions. A dearth of literature can be found on the subject to date, hence our goal was to better understand the status quo of the genre, to position designs, mechanics and intentions in a common context. Excluded from the framework of this essay were large-scale LED video screens, projections and lighting design as a means to animate facades.

Historic Framework of Changeability in Architecture

Architecture is typically associated with longevity and permanence and therefore might be considered largely immobile. At the same time, buildings always had to respond to different conditions and users' needs during day and night, changing seasons and overall climate. Architects and engineers have been fascinated by the idea of mobile parts beyond windows or doors, and have worked on creating responsive spaces that would carry their messages and respond to human needs. The recent architectural discourse shows an increased interest in kinetics. Moving and responsive membranes, intelligent facades and adaptive buildings are discussed on many levels. The more traditional approaches to movement in architecture frequently involve changes related to program and use, the optical effects of changing light and shadow or the effects of weathering and aging or actual decay. This exploration is concerned with moving parts and elements that are frequently linked to a mapping of the environment, reading of specific context conditions and user interaction. It deals with elements tied to sensors and data collected, measured and visualized, having environmental impact or offering an artistic message. The design of kinetic facades requires innovative design parameters: architect and theorist Jules Moloney writes: "For kinetic facades it is argued that composition shifts to the design of patterns of movement – the manner in which parts move in relation to each other over time" [1]. The tectonics of kinetic facades differs from traditional designs. Moving parts come with different requirements for construction, maintenance and upkeep than static systems.

The term kinetics is used in chemistry or biochemistry and is concerned with measuring and analyzing the rates of reactions and the impact of a combination of elements. In architecture, this reactive potential has been translated into movement of architectural parts that respond to a stimulus. In the field of physics, kinetics describes the production of forces in producing or changing motion. For architectural skins and facades, the stimulus can be environmental (sun, wind, earth movement etc.), data driven (measuring and initiating a reaction) or user driven. The goals might be linked to protection from sun and other climatic elements, narrative and informative or entertainment. The architect Socrates Yiannoudes offers the following definition of architectural kinetic systems:

> [...] kinetic structures are physical constructions consisting of moveable interconnected parts that can rearrange their relative positions, according to demand, either manually or through feedback control systems. The result is an overall change of the physical configuration of the structures, which is determined by the set relations of their internal components and their inbuilt kinetic mechanisms. The latter may range from mechanisms of deployment, folding and extension, to rolling, sliding and nesting techniques, and from scissor-type mechanisms and inflatables, to tensile systems embedded with electromagnetic, pneumatic or hydraulic actuators [2].

Current digital technologies allow the creation of complex links between data collected and reacting hardware components. Rising awareness about energy consumption and pollution as well as the desire for interior comfort result in mobile façade elements that shield from the sun or wind turbines that contribute to a building's energy needs. Natural ventilation can be combined with mechanical systems or moving mirrors and other reflective materials might re-direct sunlight to the interior.

The need to share information and consumer industries result in lit signs and billboards that carry changing messages––all movement in our urban spaces providing an overlay paralleling the movement of users.

A Short History

Architects have long dreamt of moving parts in architecture envisioning the possibility of spaces that change and adapt to accommodate varying activities and conditions. The Modern Movement explored the notion of a building as a machine responding to the phenomena of industrialization, mass production and rationalization of life in general. The formal aspects of movements and motion is expressed in Italian Futurism and German Expressionism where buildings seemingly are in motion displaying dynamic forms and smooth surfaces possibly as a reaction to mechanized transport and fast moving events of the early 20th century.

Buildings for many years suggested movement by displaying a regular or musical rhythm in their facades. The colonnade

^ Erich Mendelsohn, Einstein Tower, Potsdam, Germany

^ Gerrit Rietveld, Truus Schröder, Schröder House, Utrecht, Netherlands

of Antiquity and the Renaissance displays rhythmic column arrangements based on refined proportions, moving eye and viewer. Steen Eiler Rasmussen writes: "If you feel that a line is rhythmic it means that by following it with your eyes you have an experience that can be compared with the experience of rhythmic ice-skating, for instance." [3]. Rasmussen also points to the Spanish Steps in Rome as an architecture that appears to move and supports human movement without moving itself. Le Corbusier's collaborator, the composer Ianis Xennakis, designed façades suggestive of musical movement for the monastery of La Tourette near Lyon, France.

The impact of actual moving parts within building facades adds another component to human perception. Kinetic facades are changing appearance and sometimes even formal configuration or pattern based on use conditions or evolving daylight and seasons. Similar to an organism that exhibits different behaviors, moving elements bring buildings and streetscape to life. Static forms are replaced with a built process leading to a range of forms, thus bringing buildings closer to nature. Based on the modernist paradigm of the free façade, moving parts will be especially relevant in building skins, Two major areas can be established within the field of kinetic facades: performative in reaction to energy requirements or solar management and formal or experiential as a medium for people to interact with or enjoy as embedded artwork.

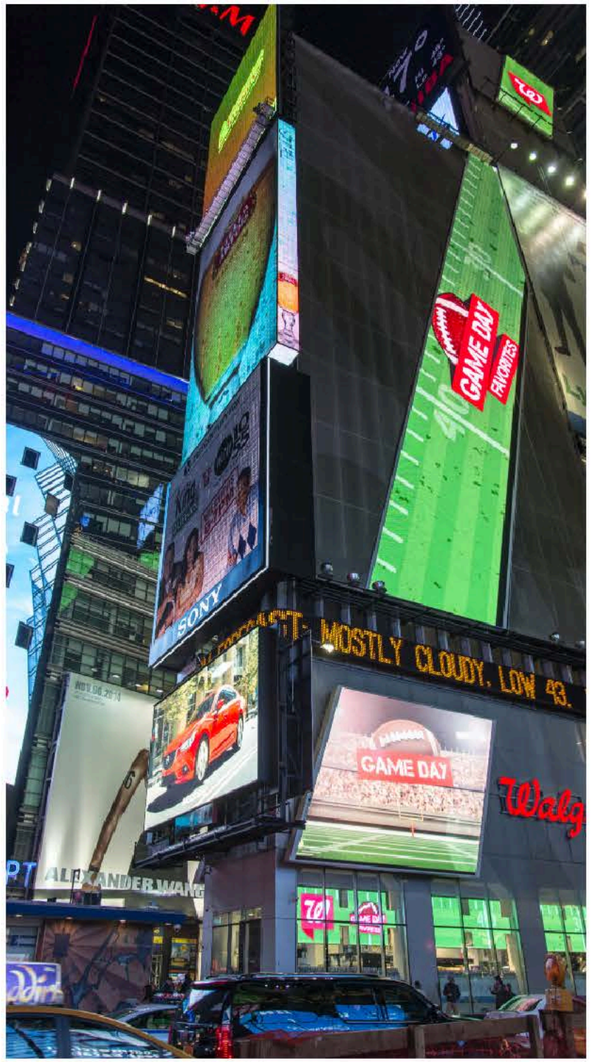
Buildings have been featuring movement and transformation at a small scale. Houses used to have wooden shutters to protect from intrusion and intensive climatic conditions. Layers of fabric, curtains and blinds serve as insulation and shading, and can be manipulated by the user. Windows and doors open and close to allow entry of people, goods and sunlight. Some historic examples however paved the road to contemporary kinetic facades. In the early 20th Century in the Dutch city Utrecht, Gerrit Rietveld and Truus Schröder designed a house with moving interior walls that permit different spatial configurations for day and night conditions, thus opening up a large living space or offering small intimate bedrooms at night. Erich Mendelsohn expressed movement without actually moving elements in Potsdam, Germany's Einstein Tower observatory with its dynamic form and "fast" profile. Rayner Banham traced the development of architecture along the lines of technological innovations and built-in machinery, for example central heating, ventilation or moving systems of circulation such as the elevator. Digital technologies add potential to the connection between sensors and reactive forces.z

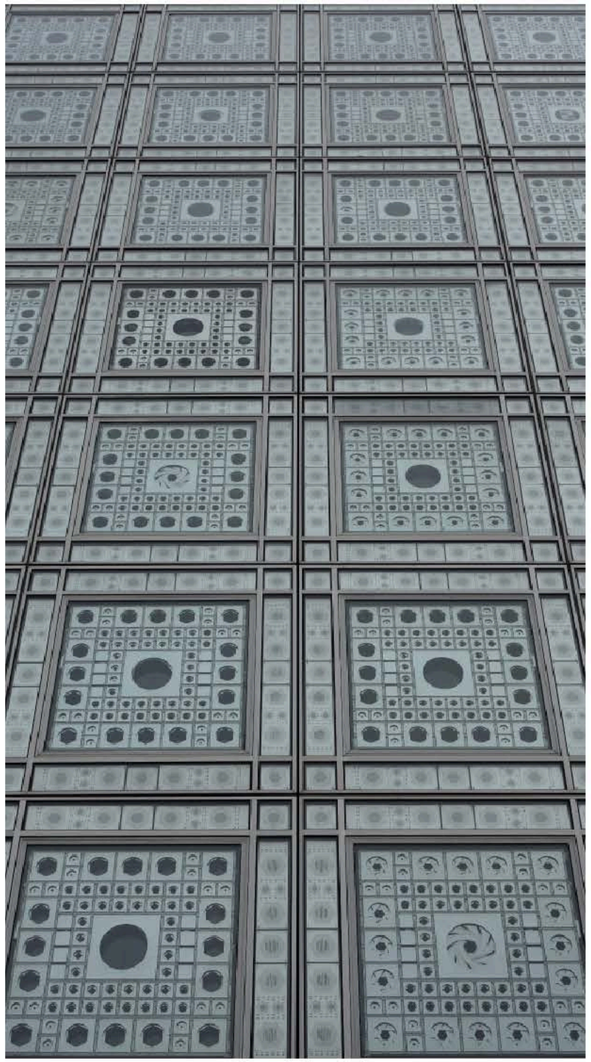
Narrative and Attempt of a Chronology

Functionality, urban design context and aesthetics are key considerations of architectural design. The social or psychological impacts of our built environment are increasingly investigated as well, instigated by the groundbreaking research of Jan Gehl and William H. Whyte. The contextual dialog is becoming increasingly interdisciplinary, which has found placemaking as its platform for communication. In looking at kinetic building envelopes, the question arises how these facades engage people and what kind of an effect they have on the place or the urban context.

Placemaking theory has a focus on the psychological impact of the built environment and on social interaction in public places. Kinetic facades, by the nature of their physical activation, attract any viewer's attention. Alan B. Jacobs talks about the importance of considering eye movement in the experience and design of successful streets, an asset he has termed "qualities that engage the eyes" [4]. Traditionally, the changing light conditions of lively surfaces offer an interactive experience for people:

> Generally, it is many different surfaces over which light





^ Times Square, New York City, NY, USA (Left)
Jean Nouvel, Institut du Monde Arabe, Paris, France, 1988 (Right)
Steven Holl and Vito Acconci, Storefront for Art and Architecture, New York, USA. 1993 (Bottom)

> constantly moves that keeps the eyes engaged; separate buildings, many separate windows or doors, or surface changes. Or it can be the surfaces themselves that move and therefore attract the eye, if only for a split second, before something else gains momentary ascendency: people, leaves, signs. Visual complexity is what is required, but it must not be so complex as to become chaotic or disorienting [5].

Jacobs points out the mesmerizing effect of visually complex, moving surfaces as part of the experiential principle. Typically, the owners or municipalities where such buildings exist have a keen interest in both great design and in attracting public interaction. These elements individualize buildings and create sense of place, both at the local scale but also in a citywide context. The architectural uniqueness sets them apart and initiates dialog at every level. The passer-by becomes engaged as an acteur on the permanent stage of the cityscape. As often, more is less. By no means should all buildings be equipped with kinetic elements. Visual overload and a stressful experience would be the result.

The temporal offers an opportunity for engagement and continual change. Moving parts on buildings catch the viewer's attention and make a familiar facade vary over the course of the day. A kinetic system offers an experience: the viewer can "read" the reasons for movement or can in some cases contribute. West 8's Schouwburgplein Square in Rotterdam in the Netherlands allows visitors to move the large lanterns that illuminate the plaza framed by concert, film and event venues. Times Square in New York City is a well-known place, visited by millions of tourists every year. Its messages, lit billboards, advertisement and blinking images give the sense of something happening but are at the same time testimony of capitalist decoration, a culture of speedy passing rather than slow contemplation. Moving lights and images work as an urban spectacle. The Times Square Advertising Coalition, in an effort to showcase contemporary art in addition to advertising, replaces the commercials with video art for three minutes during Midnight Moment, a nightly digital art exhibition across all electronic billboards throughout Times Square from 11:57pm to midnight since 2012. Only during this brief, off-hour window of time artistic expression replaces commercial advertising.

How light affects façades in the course of the day and during different weather conditions continues to offer changing views of the cityscape. As a means to relate a narrative moving facades have been extremely impactful. Often, they enhance or serve as an aperture to a building's program or they make nature visible, such as water or air currents. Contemporary kinetic façade designs enhanced with artistic or commercial art elements have added a new dynamic to experiencing architecture. On contemporary moving facades, software aesthetics and computing compete with electrical or strictly mechanical systems. The new design vocabulary features the modular parts of sculptural surfaces activated by the wind (e.g. Ned Kahn), water (e.g. Blur Building, Diller & Scofidio) motors (e.g. Institute du Monde Arabe, Jean Nouvel; MegaFon Pavilion, Asif Khan; San Francisco Public Utilities Commission, KMD Architects) as well as architectural elements like louvers or rotating, sliding building elements (e.g. Storefront for Art and Architecture, Steven Holl and Vito Acconci; One Ocean Thematic Pavilion, soma; Demonstration Building, P+ Studio). Following below is a chronological spotlight on some of the visionaries and their projects serves as an overview of recent innovations, leading designers, clients and buildings.

Institut du Monde Arabe in Paris, France, 1988

In 1988 Jean Nouvel designed a kinetic façade for the Institut du Monde Arabe in Paris, France. The façade features a square grid filled with mechanical apertures that respond to sunlight by narrowing their openings and simultaneously displaying changing patterns across the interior of the building. The façade appears with a different pattern depending on the time of day and weather. On a cloudy day, the apertures show many openings; on a sunny day, the metallic sheets close down to very small pinholes. Nouvel's Agbar tower in Barcelona, Spain pushes further the idea of a dynamic sun shading system with a skin pattern that reacts to sensors measuring the temperature and closing exterior blinds as necessary. At night, LED lights paint luminous images on the facade, a reversal of the shading devices active during the day. Both buildings combine expression and performance.

Storefront for Art and Architecture in New York City, 1993

The Storefront for Art and Architecture in New York City is a gallery space built to house a nonprofit organization that organizes exhibitions and events around architecture, art and design. Designed by New York architect Steven Holl in partnership with artist Vito Acconci, the project was completed in 1993. The facade acts as a mobile exhibition system featuring a large rotating wall within its facade panels to make the objects shown accessible to passers-by on the streets of Manhattan. Since the actual space is very small, the moving elements extend the available square footage into a viewing room that stitches the interior and exterior together. The openings are an expansion of a conventional window, manually operated with the simple goal to share materials and statements about art and architecture.

Blur Building in Yverdon-les-Bains, Switzerland, 2002

For the temporary media pavilion at the Swiss EXPO 2002 at the base of Lake Neuchatel in Yverdon-les-Bains, Switzerland the New York architecture firm Diller+Scofidio took a different approach, using a skin made from water and setting up an unusual experience. The Blur Building's façade was composed not of moving mechanical parts but of tiny droplets of water generated by over 30,000 nozzles, which expelled a fine mist of water from the lake and turned it into a façade cloud that shrouded the metal armature of the pavilion space. A refined set of sensor and digital interactions scripted the user's experience, taking into account data collected at the entry to the ramp that recognized and tracked the visitors. Users wore a "braincoat", a digital raincoat that stored movement data. Linked to the profiles, the data collected in the computer system would change the garment's color depending on compatibility to other visitors. Instead of offering formal excitement the building offered "nothing." The architects wrote:

> Similarly, our response was intent on delivering nothing. We gave the site back to itself disguised as architecture. In the 'cafe', visitors could drink the building (and thus the site) in the form of packaged water. Instead of a media rich, high definition visual environment, upon entering blur, one can see nothing and hear nothing. The sound of the building being perpetually remade through 30,000 high-pressure fog nozzles was dominant. Vision was foregrounded as the paramount sense through its repression" [6].

The application of moving parts led to the unusual depiction of a weather phenomenon, materialized atmosphere that is of the site and ultimately inhabitable.

Technorama/Swiss Science Center in Winterthur, Switzerland, 2002

Ned Kahn completed his first international commission in Winterthur, Switzerland, together with the local architectural firm, Durig & Rami in 2002. The Technorama/Swiss Science Center is a science museum offering interactive exhibits on natural phenomena. The common interests of the museum administration, the architects and the artist found an ideal convergence, which led to the active participation of the staff in the development of the facade for the building. The outcome is a screen structure mounted on the semi-transparent building envelope. It is composed of thousands of small, suspended aluminum panels that are animated by air currents, thus visualizing the complex patterns of nature. A sizable plaza in front of the museum provides an ideal viewing platform for the Technorama façade. Since the early 2000s, Ned Kahn has completed 60 major works. His most recent project, in partnership with Moshe Safdie architects, covers major portions of the building envelope of LuOne, a large-scale, 6-story shopping mall and 21-story office tower complex in downtown Shanghai, China.

The beginnings of Ned Kahn's artistic development can be viewed on the façade of the University of Colorado at Boulder's School of Engineering (ITL). At four by four feet, Kahn's Slice of Wind (1996) is an early experimental panel composed of 10,000 small round metal discs set in a frame. Button-sized reflective elements dangle freely as they move with the air currents, simultaneously reflecting light as the parts move. Slice of Wind was followed just four years later by the 260 feet long and 6 stories tall Gateway Village parking garage in Charlotte, NC, where 80,000 small aluminum plates animate the entire length of the structure to reveal the wind currents. In the interior, the reflections project shadows akin to rustling trees onto the walls--pure poetry for the user. A key design aspect was to provide ventilation and shade for the 50% open building.

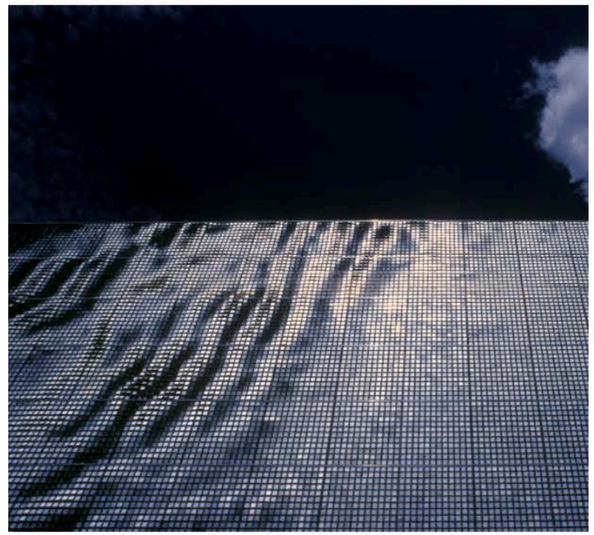
The name Ned Kahn has become synonymous with kinetic facades. Today, the California artist collaborates worldwide with leading architects and engineers on a variety of building facades, ranging from museums, office and commercial buildings including parking garages to infrastructure. Besides wind, Kahn has also worked with fog and the flow of water to create similar, large-scale effects. Ned Kahn's fascination lies at the intersection of science and art. He is inspired by atmospheric physics, geology, astronomy, and fluid motion:

> I strive to create artworks that enable viewers to observe and interact with natural processes. I am less interested in creating an alternative reality than I am in capturing, through my art, the mysteriousness of the world around us. My artworks frequently incorporate flowing water, fog, sand and light to create complex and continually changing systems. Many of these works can be seen as "observatories" in that they frame and enhance our perception of natural phenomena. I am intrigued with the way patterns can emerge when things flow. These patterns are not static objects, they are patterns of behavior – recurring themes in nature [7].

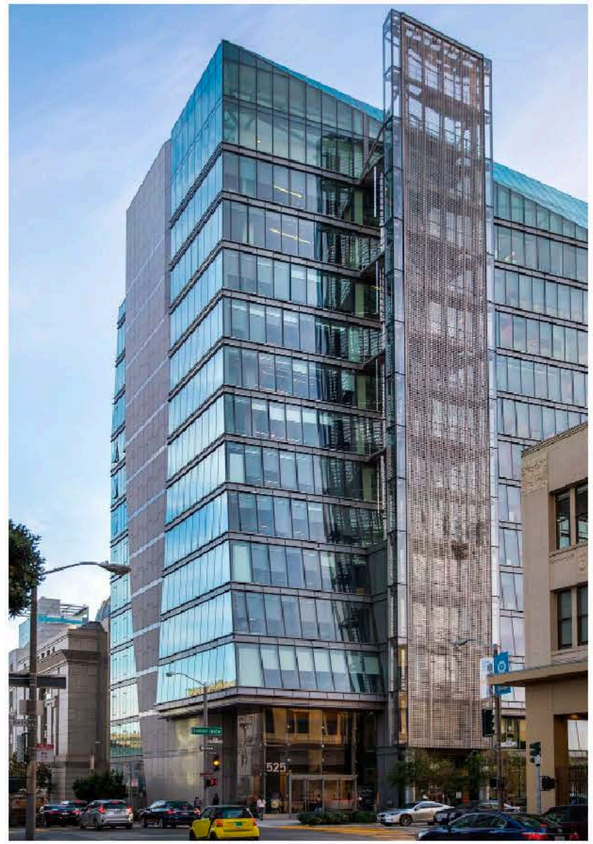
Kahn's wind-activated facades make the movement of the wind visible and further establish the similarity to the movement of water surfaces activated by the wind. His wind-activated façade designs are purely mechanical. They are aesthetic, mesmerizing and science experiment all at once.

PUC Building in San Francisco, 2012

Many buildings display moving elements to accommodate the environment and perform better with operable windows and doors allowing air movement through them and a more comfortable climate inside. Increasing productivity or reducing consumption while visualizing the flow of energy is the goal of the PUC Building at 525 Golden Gate in San Francisco, designed by KMD Architects. Completed in 2012, the building houses the Public Utilities



^ Diller+Scofidio, Blur Building, Swiss EXPO Yverdon-les-Bains, Switzerland, 2002 (Left)
Ned Kahn, Technorama/Swiss Science Center Facade, Winterthur, Switzerland, 2002 (Right)



^ Ned Kahn, Technorama/Swiss Science Center Facade, Winterthur, Switzerland, 2002 (Left)
KMD Architects, Public Utilities Commission Building, San Francisco, California, USA, 2012 (Right)

Commission's administration and combines a variety of sustainable systems. Natural ventilation is combined with vertical wind turbines and photovoltaic panels to harvest energy from wind and sun. The technology is not free of challenges, but was meant to be educational and to serve as a demonstration project. Experimentation with energy-related kinetic systems will lead to more viable versions, and provide users with a more interactive type of office building than commonly seen today.

One Ocean at the Theme Pavilion Expo, Yeosu, South Korea, 2012

Expressing the Expo's theme "The living Ocean and Coast", the One Ocean pavilion by Austrian architects soma features a façade structure that sports lamellas acting like gills along the side of the organic form of the pavilion. According to the architects the kinetic façade evokes "sensuous experiences through analogue means. During daytime the lamellas are used to control light conditions in the Best Practice Area powered by solar panels on the roof of the building. After sunset the analogue visual effect of the moving lamellas is intensified by LEDs" [8]. This building is reminiscent of large ocean creatures and uses its organic volume to blend with surrounding topography. The kinetic façade exhibits several layers of material and experiences representing natural phenomena through its configuration. One Ocean's complex engineering was developed in partnership with the University of Stuttgart.

MegaFon Pavilion at the Winter Olympics and Paralympics, Sochi, Russia, 2014

Like Ned Kahn, Asif Khan, a London-based architect of Pakistani and Tanzanian heritage, works at the intersection of architecture, the arts and science. Born in 1979, he launched his own practice in 2007. For the London 2012 Olympic Games he designed the Coca-Cola Beatbox Pavilion, his first collaboration with the Swiss engineering firm iart. Based on this precedent, his first major international commission became the MegaFon Pavilion at the 2014 Sochi Winter Olympic games. The façade, also an iart collaboration, made history: MegaFaces generates a changing parade of three-dimensional portraits, a participatory kinetic portrait 'gallery'. To do so, a visitor captures five self-portraits at slightly different angles. The images are then transformed into a 3D profile by 10,000 telescopic cylinders, which transform the images into a 20-second, raised portrait profile. The LED-lit actuators [9] are located underneath the building envelope's elastic skin. Asif Khan explains:

> Facial impressions are created once every minute and are relayed to the kinetic facade from multi-camera 3D scans made in proprietary instant 3D photo booths installed within the building and in public locations across Russia. An electronic queuing system manages the face data and enables participants' names to be displayed within and in front of the pavilion on screens, which indicate the time their face will appear. The system also sends a SMS message to participants with this information. A scaling and positioning algorithm was developed which transforms the faces on-the-fly considering day lighting, scale, rotation, form and additional colour. Each of the facade transformations is filmed and the feed is simultaneously chopped into individual clips. Participants are emailed permanent link to their video [10].

^ Soma, One Ocean Theme Pavilion, Expo, Yeosu, South Korea, 2012

Software is the key driver of the MegaFaces installation, allowing the individual controlling of each translucent RGB-LED light. Dubbed the 'Mount Rushmore of the digital age', the randomness of the participatory experience allows all individuals to have a presence on a public stage, however brief it may be. In the age of digital communication tools, universal access is an opportunity that can also turn into risk and liability if usurped by the ill-concerted. Asif Khan's groundbreaking design received the 2014 Cannes Lions Grand Prix for Innovation––the first architect to be bestowed with this award. Currently, he is developing the new Museum of London together with his colleague, Stanton Williams.

P+ Demonstration Building, Green Building EXPO, Wujin, China, 2015

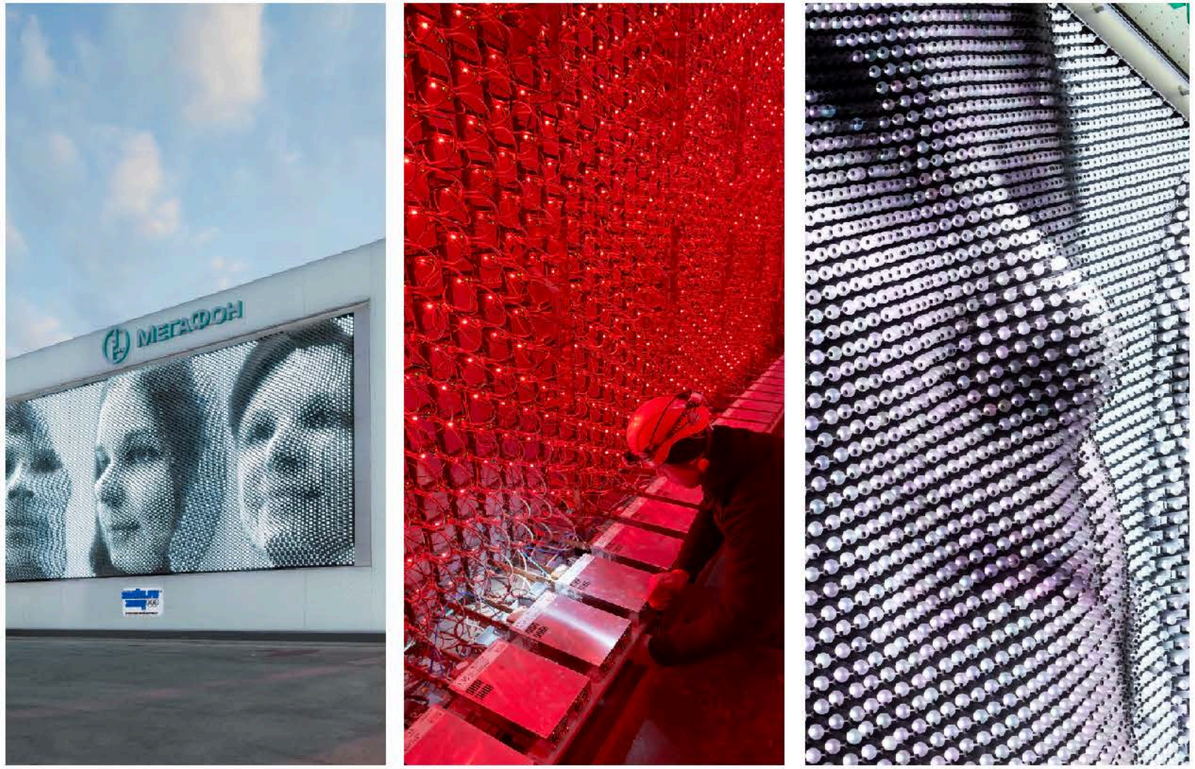
Kinetic research at the cutting edge of design without a breakthrough for commercial applications, is paving the way towards a more sustainable future of energy autonomy for the individual consumer. In 2015, a new prototype building, the P+ Demonstration Building, by the international P+ Studio research and design cooperative was constructed in Wujin, Changzhou Province at China's first government accredited "Green Building EXPO". The project, which received two stars as part of China's new Three Star Green Building Design Label, is situated inside a new research park that showcases and tests sustainable build¬ings and emerging technologies, prototypes as well as products.

A smart louver system of façade membranes on the mixed-use building's south façade is designed to control optimum indoor environmental quality. Paired with the introduction of a solar chimney to provide natural ventilation, the movable exterior blinds reduce energy loads during the warmer months and provide passive heating during the colder months. "The building itself has two distinct faces, the South, with its overhangs and smart louver systems designed to maintain stable internal temperatures and prevent overheating, and the North, which acts as an environmental buffer zone and creates a unique viewing platform from which to experience the rest of the park" [11]. Dedicated to testing new green technologies, the 6,500-square-foot mixed-use building was realized programmatically in the form of exhibit, meeting, office and residential space. This interdisciplinary effort seeks to create a platform of exchange for diverse partners from the private sectors, academia and government agencies.

Another initiative by Michael Pelken and his P+ team is the Turbine House with its vertical wind turbine for a building with a circular floor plan. The rotor could be incorporated inside the core axial shaft of a cantilevered balcony. Research on the Turbine House project continues and a prototype yet needs to be constructed.

GROW by SMIT Design

Integration of solar and wind power into building facades has been the objective of SMIT Design (Sustainably Minded Interactive Technology). Born out of an undergraduate studies and graduate thesis project by the brother-and-sister-team of Samuel and Teresita Cochran, this sustainable design initiative took inspiration from ivy growing on buildings. The outcome was GROW, a novel concept of



^ Asif Khan, Megafon Pavilion at the Sochi 2014 Winter Olympics and Paralympics, Russia (Left, Middle, Right)

^ P+ Studio, P+ Demonstration Building, Wujin, China, 2015 (Left, Bottom)
P+ Studio, Turbine House, rendering (Right)

a hybrid energy delivery device that harnesses both solar and wind energy. "Using a series of flexible solar cells as leaves, GROW takes the shape of ivy growing on a building--the leaves are solar cells while the wind that causes them to flutter is harvested as viable energy using a series of piezoelectric generators on the underside of each leaf" [12]. This prototype, exhibited as part of the 2013 exhibition Applied Design, is in the collection of the Museum of Modern Art in New York [13]. The project appears to be dormant at the moment, offering potential for further exploration.

Experimentation and Opportunities for Sustainable Design

What are the parameters for moving facades? The motivation for the integration of kinetic elements can be driven by energy generation, thus improving functionality and the application of sustainable energy technologies. This promising proposition offers great, unfulfilled potential. Innovation and experimentation are obviously part of the world expos' agenda. Prototypes are continuously being developed and more widespread commercial applications can be anticipated, as demonstrated with the featured buildings by Diller+Scofidio, P+ Studio and soma at international expositions. The architectural commissions by the Institut du Monde Arab and the municipality of San Francisco are still rare, noteworthy efforts to promote sustainable design. Often, the fear of potential, additional maintenance costs thwarts the best of intentions at the outset. Much remains to be accomplished to further develop, educate and change often deeply set, negative perceptions. Unfortunately, some planned commercial developments have also proposed sustainable design features as sheer window dressing. A prominent example is the 2008 proposed Anara Tower in Dubai by Atkins Architects. The 1,968-foot tall, 135 floor skyscraper is designed to appear like a giant wind turbine, although without the commitment to produce energy.

Summary and Outlook

The examples introduced above share the presence of multiple moving parts in architectural facades, some performative, others experiential. Many of the reactive façades make the spaces of the building usable and well-conditioned, limit glare and heat gain and at the same time display a spectacle of intrinsic elements to watch and view. The impact of movement frequently includes the reintroduction of "play" and playfulness, random consequences and varying rhythm that is impacted either by the environment, the wind, the sun or the different minds of the users. The buildings shown engage the environment, react to it and thus display a simple narrative that might link them firmly to their place while employing high tech solutions. Stagnant architecture is difficult to engage in while poetry is found in the leaves blowing off a tree and in the shadows cast into its leafy canopy with the wind lightly moving it all. Kinetic architecture might get buildings a step closer to the phenomena of nature in allowing the parts to move, react and play.

Kinetic facades hold great potential for the future, particularly in terms of advancing the technology of building envelopes in the age of global warming. While the executed facades do not all have this aspect as a focus, moving elements on buildings could offer important sustainable design solutions for the future. The involvement of digital design and fabrication tools brings innovation to the built environment but seems to remain in an experimental stage, especially in the realm of façade technology and design. Engineering, art and architecture move closer together to design and build the interfaces and kinetic systems.

Reviewing only a small selection of kinetic facades it becomes obvious that the messages are mixed and varieties are many. They share difficulties and maintenance requirements that come with more complex technologies. The danger of failure can be seen in some older projects. All examined facades share the poetry of movement that brings buildings to life beyond the daily reflections of light and shadow. They are not still objects or a graphic image of a flat street front, but three-dimensional with depth. By mapping data and responding to environmental conditions they become site specific at a time that searches for regional identities.

Kinetic facades can turn mute boxes into dynamic participants within the urban context, sharing spectacle and creating a place to visit and see. Kinetic systems overcome the static character of architecture and allow an exploration that brings us closer to nature and its phenomena, thus creating dynamic environments. We found the West coast of the United States seems to attract more experimental kinetics than colder parts of the country with seasons that could impact the longevity and functionality of complex mechanics. Many unanswered questions remain, but our initial inquiry can serve as a point of departure for continued research. Innovative, responsive kinetic facades can and will have an impact on our built context and new, groundbreaking design applications. / Note p. 136, Image Ref. 136.