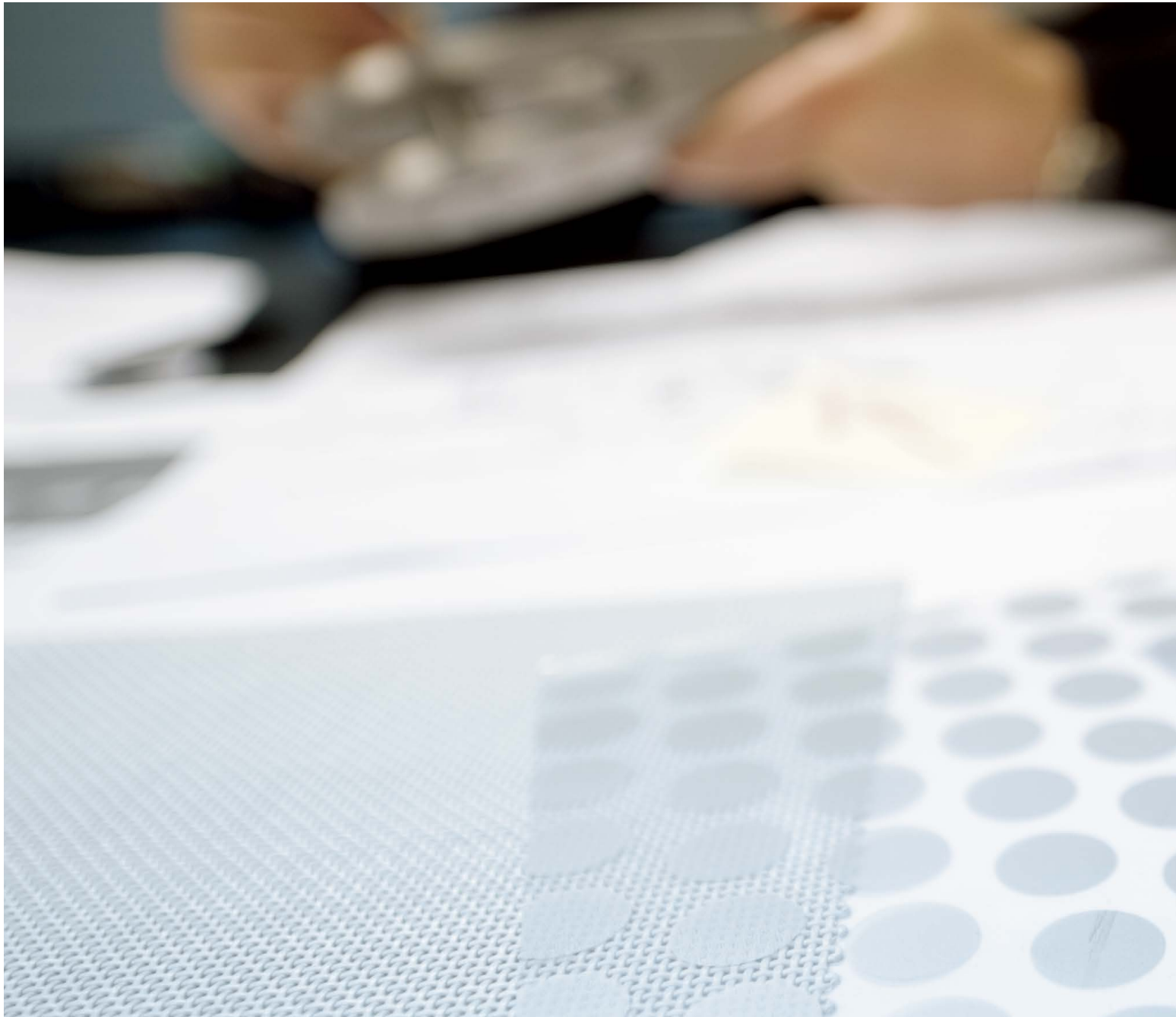




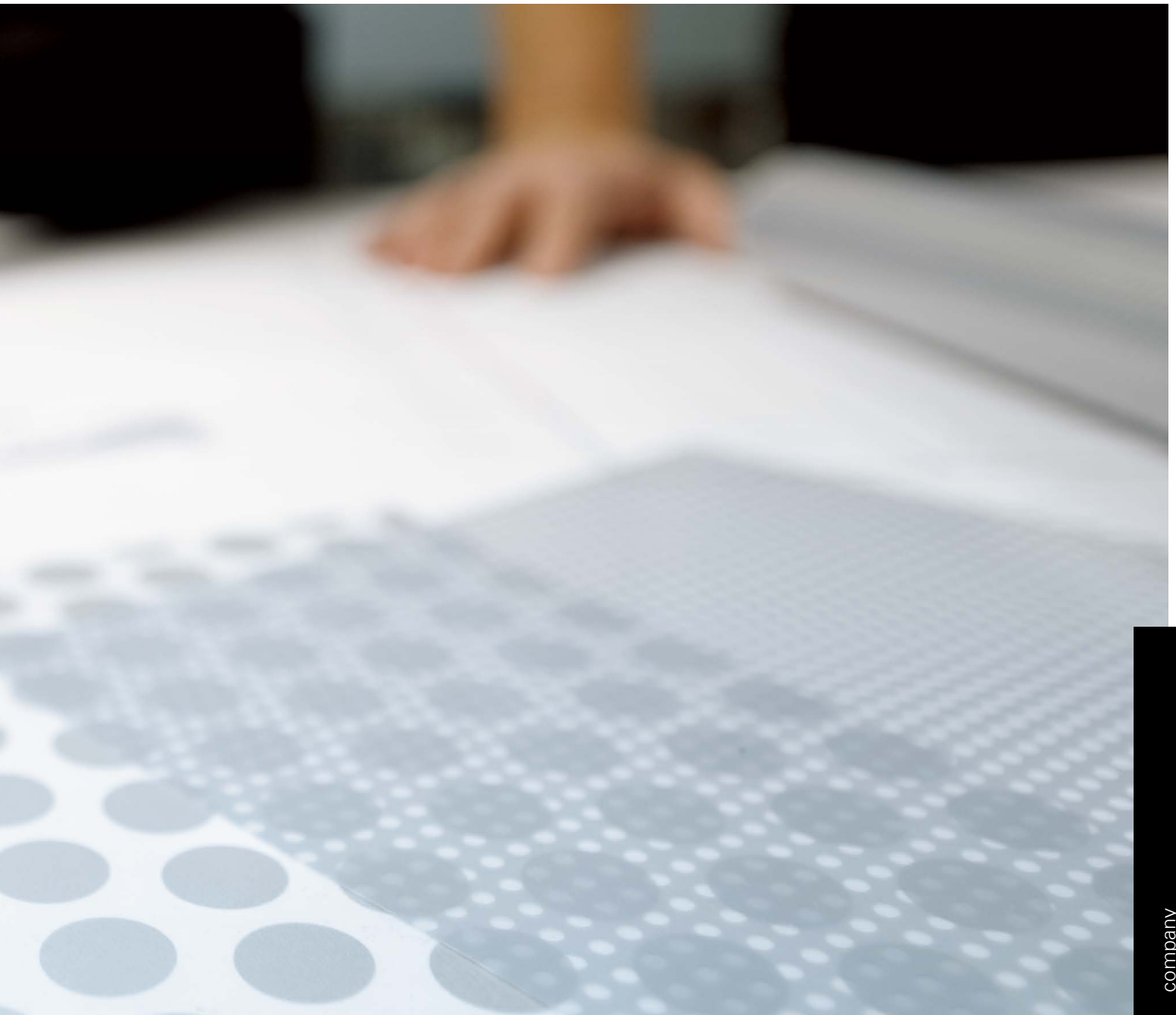
membrane architecture  
**icons of lightweight construction**

seele



The **seele group** of companies, with headquarters near Munich in Germany, is one of the world's top addresses for the design and construction of façades and complex building envelopes. This technology leader in façade construction was founded in 1984.

Our customers benefit from our in-depth knowledge of membranes as well as structures made from glass, steel, timber or aluminium, unified in just one company. In order to measure up to our own standards, we combine the development and manufacture of our building materials with technological expertise and the utmost individuality. For unique creative concepts.



## your expert for membrane structures.

**seele** is recognised as an expert when it comes to innovative, sustainable membrane architecture as well as lightweight plate and shell structures for new roof and façade solutions.

### **Advantages membrane structures by seele**

- Innovative materials, efficient load-bearing structures and intelligent systems
- Low in weight, big in ecology
- Sustainable throughout the life cycle
- Creating open spaces under pleasant climatic conditions

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# the lightweight membrane structures principle: low in weight, big in ecology.



**Light materials, efficient loadbearing structures and intelligent systems.** Carrying loads, lighting, aesthetics, building physics and even controlling illumination and interior climate are the functions of mono- or multi-functional membrane and ETFE film concepts. seele is able to create delicate, lightweight building membrane skins that have a very high loadbearing capacity yet also achieve a high aesthetic eloquence. The credibility of the designs is due to their good transparency, carefully distributed translucency or full shading, depending on needs.

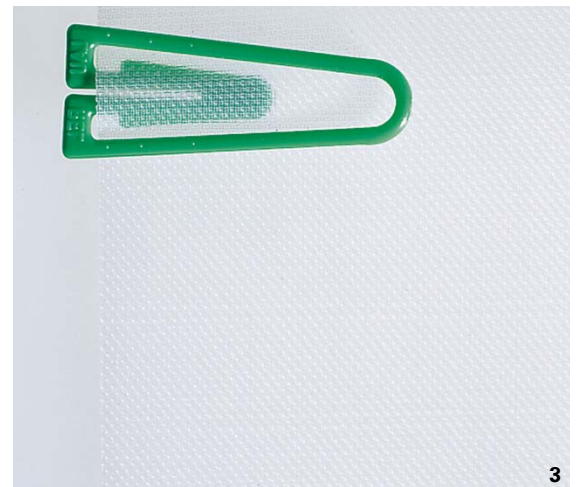
## **Sustainable throughout the life cycle.**

Membrane architecture is unprecedentedly sustainable because you need less material, the lifetime is long and the recycling rate is 100%. In particular, the sorting of the different materials is easy and they can be used in the same way – without the need for upcycling.

**1** The potential construction options include mechanically prestressed designs in which membranes are fitted in fixed frames. However, most of seele's membrane designs are pneumatically prestressed structures, so-called air-inflated structures.

**2** Custom printing or pigmented ETFE film can provide a shading function. The film becomes a creative part of the lighting design.

**3** Precision engineering: seele specifies especially high standards for processing ETFE film to achieve a membrane design with maximum performance.



**100% circular economy:** ETFE (ethylene tetrafluoroethylene) is a fluorine-based polymer and belongs to the same family as PTFE (commonly called Teflon®). ETFE films are very thin (100µm – 400µm), can be highly transparent (from 88 to 95 %) and allow the passage of the UV radiation responsible for promoting photosynthesis in plants. ETFE films are 100 % recyclable – something that cannot be said of many materials. Indeed, many other products are combinations of more than one material. But ETFE cladding is made from 100 % pure ETFE and remains a high quality ETFE product even after being melted.

**Membranes** are woven materials with a protective coating. The most common membrane materials are PVC-coated polyester and PTFE coated fibreglass. These materials are very strong and can therefore span large areas without support, which makes them ideal for creating spacious and translucent lightweight covers. Owing to their quick installation, they are also an ideal cladding material for many applications such as stadium roofs, arenas or transportation facilities.

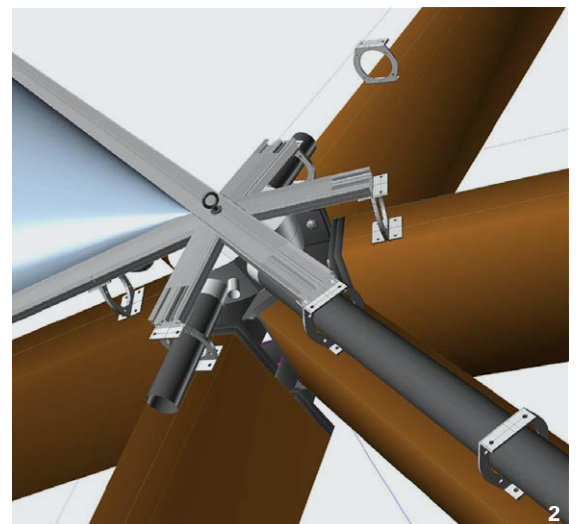
infrastructure

**through its simplicity and lightness,  
ETFE lends that final touch, leading to lower  
costs and better environmental efficiency.**

One of the new railway stations in London is the Canary Wharf Crossrail Station designed by Foster + Partners. Guaranteed to attract attention in this project is the roof of 778 triangular cushions supported by a timber structure. Never before have ETFE cushions been combined with timber on this scale. The double curvature of the timber structure in some places results in numerous different triangular formats into which the two-layer ETFE cushions must fit exactly. Depending on the required G-value, the cushions are printed with three different patterns of dots, and transparent or matt film was chosen for the inner layer under the outer layer.

**1** In the middle of the building the beams are vertical, but on both sides they tip over more and more towards the gable ends, finally cantilevering up to 30m out over the water.

**2** The complexity of the highly accurate 3D design work can be seen at the nodes. A new system of nodes and members was specially designed by seele for fixing the ETFE cushions.







Canary Wharf Crossrail Station, London (GB)

**Architects** Foster + Partners

- **10,000 sqm** membrane construction
- **778** two-layer, air-filled ETFE cushions
- **564** steel nodes





1

Vitam' Parc, Neydens (FR)

**Architects** L35 Arquitectos

- **4,500 sqm** three-layer ETFE roof
- **63 cushions** up to 26m long
- **500 sqm** three-layer ETFE cushion

The Spanish architectural practice L35 Arquitectos designed a spacious leisure centre for the French village of Neydens 9 km south-west of Geneva. It comprises a water park with indoor, outdoor and wellness facilities plus a sports centre, the heart of which is the climbing zone that extends over two storeys. The architects integrated the complex respectfully into the charming landscape of this region by reducing the volume of the structures, designing green roofs and choosing transparent envelopes.



sports facilities

**this translucency works the other way around too – for lighting effects, e.g. with LEDs, that allow the cladding to glow in various colours and achieve fantastic animation options.**



Membranes are ideal for sports arenas. They are very light in weight and protect against outside elements such as rain and solar radiation, yet still let in enough light to create a pleasant atmosphere. Their very low weights and long spans enable very cost-effective, energy-efficient systems. The primary structure remains slim, the cladding is quickly installed and the overall embodied energy is low. As the material is translucent, the roof lets natural light through, intensifying the feeling of openness for the visitors. This translucency works the other way around, too, allowing light sources such as LEDs to illuminate the cladding in different colours and achieve fantastic animation possibilities.

**1** The structural steelwork rises higher in the middle, which results in a roof curving in two directions. The delicate construction gives the climbers underneath the impression that they are climbing beneath an open sky.

**2** These ETFE cushions have to follow not only the curve of the arch trusses, but also the twist due to the different radii of adjacent arches. Cushions also form the façade at the eastern gable.



No.1 Court, Wimbledon (GB)

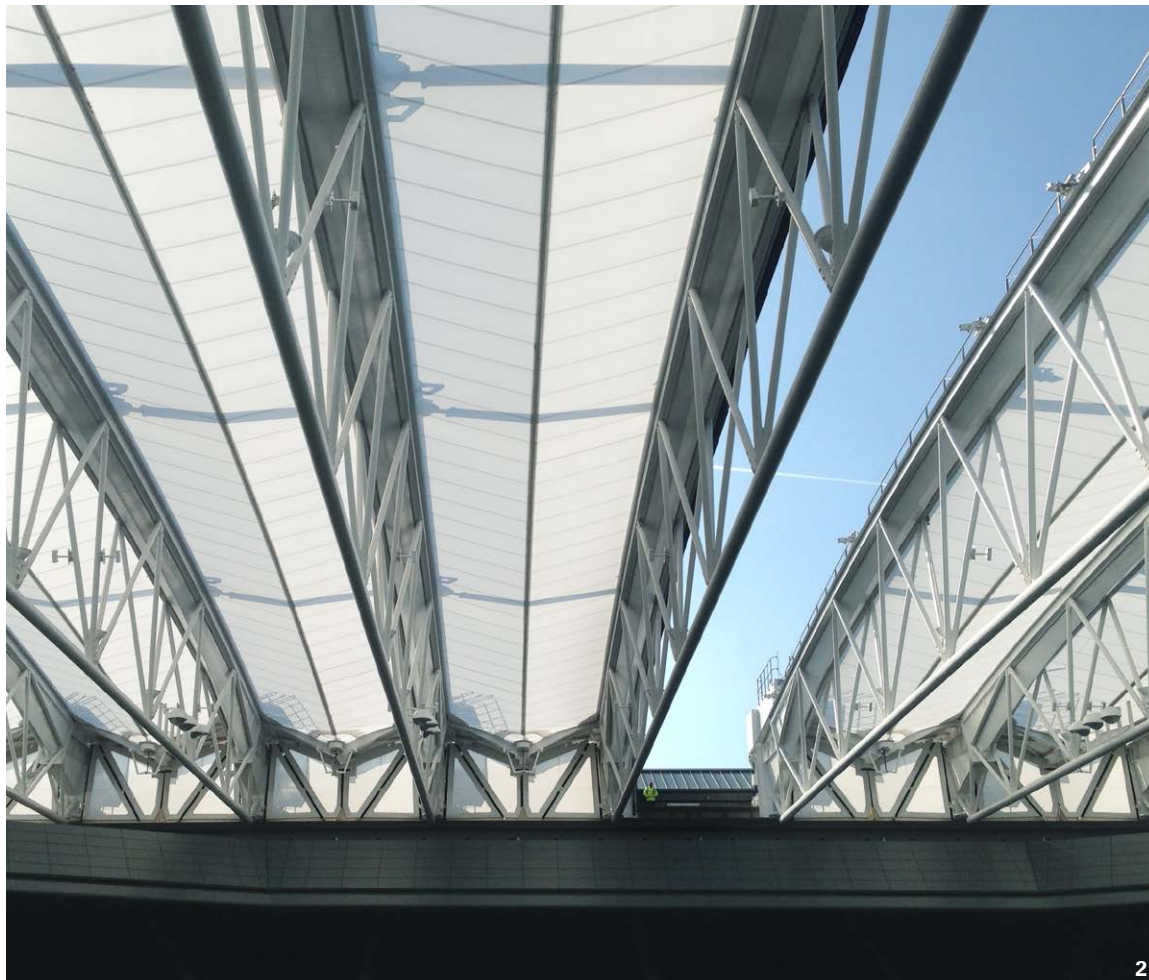
**Architects** KSS Group

- **6,000 sqm** retractable membrane
- roof closes in just **8 minutes**
- **5 km** aluminium profiles

**the no.1 court in wimbledon was enlarged as part of a general refurbishment. a new retractable roof was executed, so that matches can take place in any wheather condition.**

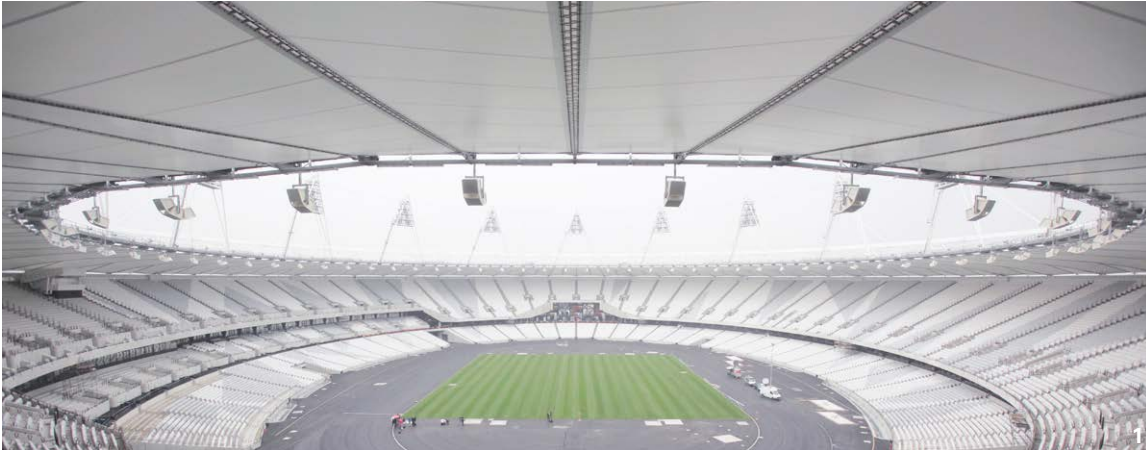
**Retractable membrane roof for Wimbledon** The heart of the No.1 Court refurbishment project is the 6,000 sqm retractable membrane roof over the entire stadium. A highly translucent material was needed so that even during rain, with the roof closed, the players could still enjoy optimum playing conditions. Therefore, a very exclusive material was chosen: a PTFE membrane woven from Teflon™ fibres. This material offers the best possible properties for this purpose, as it is translucent, extremely hardwearing and dust- and dirt-repellent.





- 1** The 6,000sqm membrane roof can be closed in just 8 minutes, which in future will prevent matches having to be interrupted during rain. Over a length of 65m, the membranes are fixed to the 11 steel trusses that span across the stadium. The membranes are tensioned by steel cables.
- 2** The roof required a total of 10 main membranes, 11 drainage membranes, 80 batwing membranes to warrant the waterproofing of the sides of the roof and a vertical membrane to close the southern end of the roof.





Olympic Stadium, London (GB)

**Architects** Populous

**1** The steel truss at the top of the structure forms a compression ring to which the extremely lightweight membrane roof is tied back.

**2** The challenge for the erection crews was to attach the membrane sections to wire ropes that were not yet in their final positions.

**3** Further cables span between the tension and compression rings to support the 112 sections of the roof membrane.







3

sports facilities



### Bird's Nest Olympic Stadium, Beijing (CN)

**Architects** Herzog & de Meuron

**4** The powerful and dynamic combination of shimmering steel elements running in different directions and membrane panels creates a unique sports facility.

**5** The one-layer ETFE film with a thickness of 250  $\mu\text{m}$  is printed with a pattern of silver-grey dots to reduce the amount of incoming daylight. The total membrane area of 38,000 sqm is made up of 880 individual panels in sizes of up to 216 sqm.



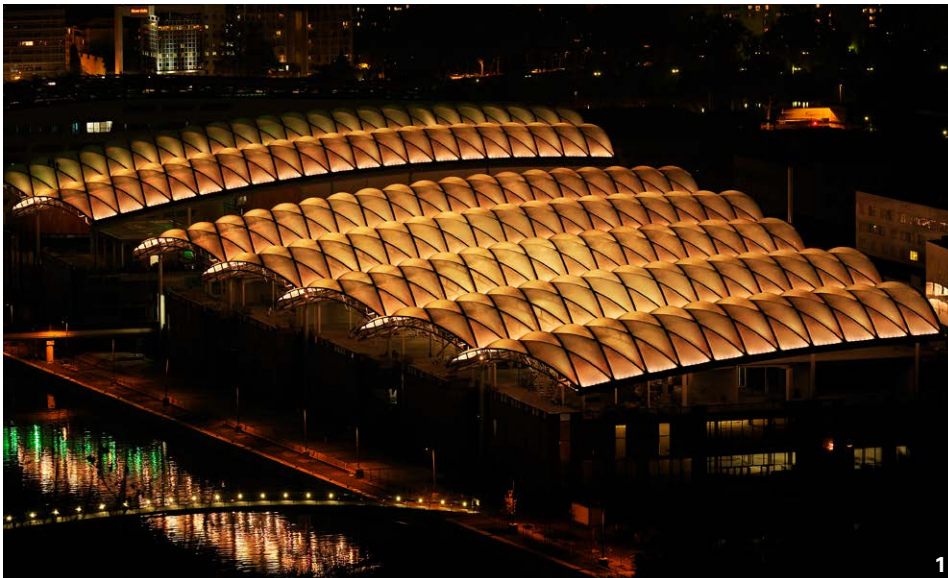
## retail & malls

### Confluence Shopping & Leisure Complex, Lyon (FR)

**Architects** Jean Paul Viguier

**1** The LED lighting in the roof – in all the colours of the rainbow – is a spectacular additional feature of the 22,000sqm of ETFE cushions.

**2** The light from the LEDs mounted on the transverse axes is reflected by a pattern of white dots printed on the underside of the outer layer of the film.



**modern shopping malls stand for more than just shopping, instead are a central magnet offering eating and leisure facilities, places where people like to linger and spend quality time.**

Offering large and comfortable open public spaces is a key factor for attracting consumers. ETFE roof structures respond to this demand. With their large spans and transparency, the supporting structure disappears, giving the impression of being outside while still being protected from the weather, whether hot or cold. Features such as printing or the integration of LEDs add to the design options, enabling the creation of unique designs suited to each mall. This lightweight characteristic also optimises the overall building costs, from roof down to foundation, which is an important factor in such a competitive environment.





Auchan Pôle Europe Shopping Centre,  
Mont-Saint-Martin (FR)

**Architects** VDDT Architectes

**3+4** The dome consists of 122 air-filled ETFE cushions supported by a framework of curved steel circular hollow sections. The 28×38m structure weighs about 26t and was delivered in separate parts. These were welded together on site and given a final coating before the whole dome was lifted into position in one piece.

office buildings, educational institutions, culture and art

## high energy efficiency for expressive architecture.

ETFE is very light, thus allowing the creation of an atrium roof with the minimum amount of material, which is not only very sustainable but also very enjoyable. The atmosphere inside such an atrium is as close as you can get to that of the open air. The supplementary materials such as aluminum profiles, rubber seals, PVC flexible hoses and steel connections can also be disassembled into their components and be part of a circle economy. And all this with a minimal energy input for disassembling. This is minimalist design: low energy during manufacture, less material, open-air feeling and recyclability.

### **corporate headquarters with an atrium roof of ETFE cushions.**

An office atrium roof can create enormous added value in office buildings. The “sustainability” goal has been especially supported by seele in the form of a forward-looking solution for the roof over the offices atrium. The printed membrane envelope improves the U-value in winter, but also reduces the build-up of heat in summer. Despite the demanding thermal specification, the membrane solution achieves a brilliant spatial experience for the staff.

### **vertical solutions for high-end light transmission into the building**

Lifted roofs, light-flooded atriums or movable façade structures can be realised almost without limits based on an ETFE-cushion structure. Looking from the inside out, the expanse of the sky can be enjoyed without further structural enclosures.



**1** The many fields of expertise of leading global technology player **Siemens** are concentrated in its **headquarters building** in Munich. Both internally and externally, the design by Henning Larsen Architects boasts spectacular qualities and so quite obviously reflects the image of this company.

**2 Auchan Pôle Europe Shopping Centre, Mont St.Martin (FR)** Due to a vertical application and the reduced loads, light and filigree solutions can be implemented in the façade.

**3** In the immediate vicinity of the Paris airport, in Gonesse, the new **headquarters of JJA**, was designed by the architectural office L35 with two large atriums (2,530 sqm combined), covered by light-flooded ETFE cushions. The longest cushion has a span of about 30m.



Headquarters of JJA, Gonesse (FR)

**Architects** L35

- **2,530 sqm** membrane construction for 2 atriums
- **41** two-layer, air-filled ETFE cushions
- up to **31 m** long cushions

office, education, culture, art

**create added values – pleasant interior atmosphere during any type of weather.**



# a cloud filled with air

Moravian Gallery/Wolke Brno, Brno (CZ)



Six filigree columns and tie rods connected to the nearby buildings support the art installation »The Cloud« in the courtyard of the arts-and-crafts museum in Brno.

The outer, almost chaotic net consists of 1,080m stainless steel ropes with 444 crossing points.

## How do you ensure, that a cloud doesn't fly away?

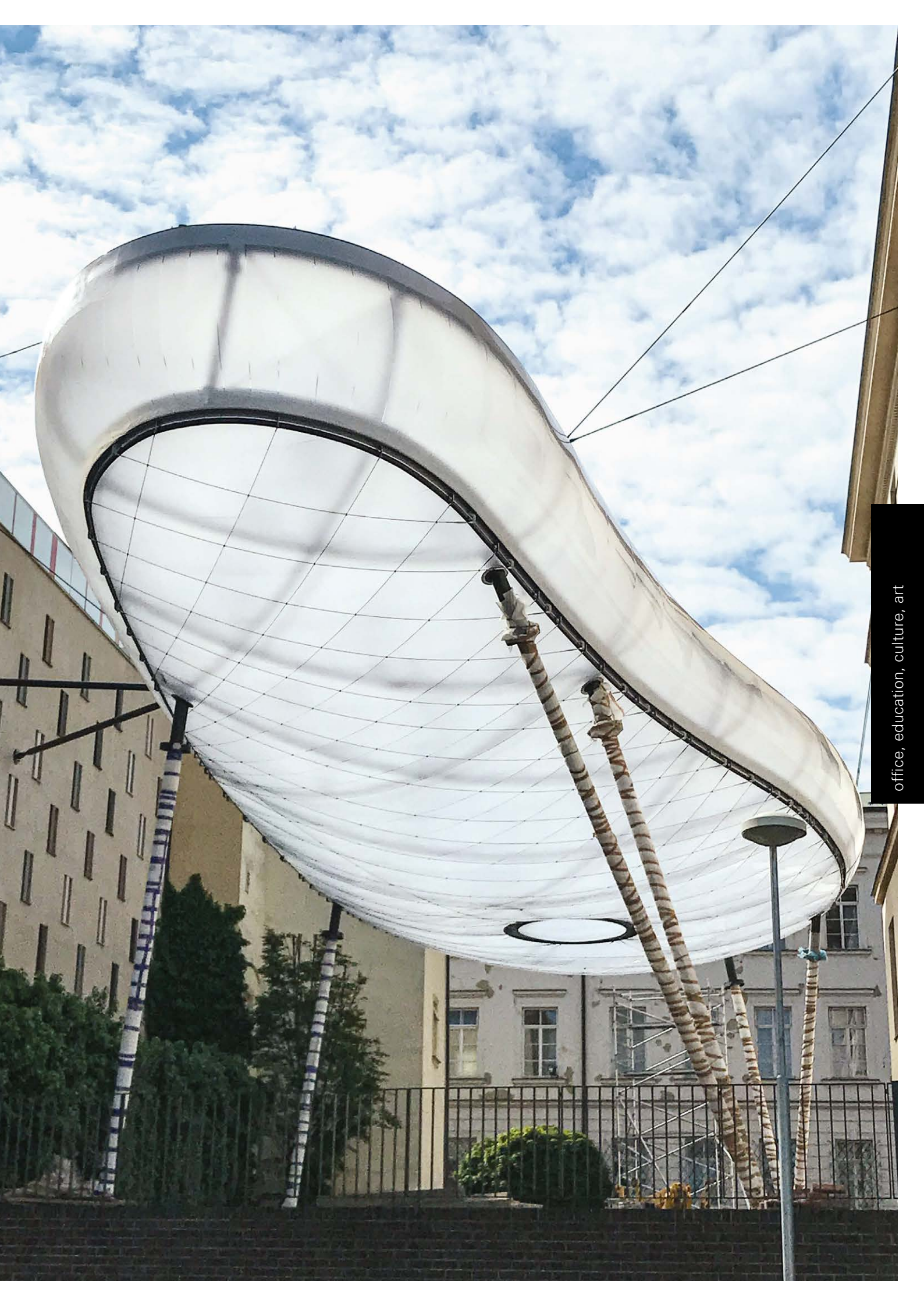
The demand of the artist and architect Marek Jan Štěpán could only be achieved with an oversized cloud consisting of ETFE, which stands on 6 filigree columns and is connected to the nearby buildings. For this art object, the definition »air chamber designed in a three-dimensional amorphous shape« would actually suit better. Thus the challenge for seele was to coat the inner frame on site with 3 ETFE layers (top/bottom/boarder layer). An exciting new task for the team. Even the manufacture had to break new grounds regarding the welding technique for such film-sizes.

Together with the architect, an irregular net made of stainless steel ropes including nodes on and below the cloud, was developed. Furthermore, the design considered the collocation of the ropes, in order to make it appear as irregular as possible, almost

chaotic, but still meet the static requirements. 1,080m of ropes with a thickness of 6mm were tightened. For fixation, a punctual connection was installed at the approx. 444 crossing points of the ropes. The sixfold penetration of the ETFE film, caused by the columns for the support structure, was solved perfectly.

For maintenance reasons as well as the additional installation of a sound system and a LED lighting inside, an opening with a diameter of approx. 2.8m was installed in the ETFE cloud. In this way it is possible to stage the cloud with music and enlighten the construction in colour for upcoming events. This magnificent work will certainly captivate all visitors.





office, education, culture, art





Aida Cruises, Hamburg (DE)

**Architects** Partner Ship Design GmbH, Hamburg

→ **4,000sqm** ETFE film roof

→ **three-layer** ETFE film cushion

**vibrations from the ship's engines, acceleration forces due to the motion of the ship, high wind loads 50 m above sea level, the marine climate with its salt concentrations plus the different climate zones place tough demands on materials, structural design and details.**



## shipbuilding

**A new material on cruise liners.** Besides the design and construction of façades for buildings, seele is also involved in providing exceptional membrane structures for ships. The use of ETFE film roofs on ships is a new development, which is why the technical solutions pose great challenges. seele's involvement in unique projects underpins its pioneering role in innovative membrane structures. The engineering must take account of corrosion protection, vibrations, noise, temperature and humidity fluctuations, loading assumptions, dead, wind and snow loads, acceleration and restraint forces.

**1** Three-layer, transparent ETFE film cushions span over the pool and leisure areas of the activity decks with their "4 Elements" and "Beach Club" centrepieces.

**2** Once again, this unique project has enabled seele to live up to its role as a pioneer in the field of innovative membrane construction.



**Using ETFE as the roof covering offers a number of advantages.** The weight per unit area of the three-layer ETFE film roof (with thicknesses of 250, 200 and 250  $\mu\text{m}$ ) is less than 1.5 kg/qm. A corresponding laminated safety glass roof would weigh at least 20 times this figure. Design benefits are larger support spacings and a lower system stiffness. The higher UV transmittance and transparency is transforming the interior more and more into an outdoor experience.

**Movable structures with media technology.** When the sliding ETFE roof over the pool opens on the upper deck of the AIDAprima, it's thanks to seele. Designs with the high corrosion resistance necessary for cruise liners, for example, include energy chains with flexible air lines, drive systems with electric geared motors, belt drives, pneumatic seals, locking mechanisms, control systems with inductive sensors and remote operation, for instance. seele additionally ensures that lighting and media installations are perfectly integrated into the ETFE film roof.

canopies



**add a bit of form and light, and a conventional industrial roof looks like a great piece of art.**

Membranes and ETFE films can be used for more industrial, more robust applications such as the car wash facility shown above. As always, their main characteristics of low weight and long spans make them a very cost-effective choice. Nevertheless, they can be used in harsh environments, too, from cold to hot. They can resist snow loads and high winds and they remain safe, as any debris is harmless.

Vacuum Station, Kehl (DE)

**Engineers** Wilhelm + Partner

This car wash in Kehl near the French border now has an ETFE cushion canopy. The brief called for the construction of a canopy of hexagonal frames over the car vacuum area. There are 41 panels of two-layer, transparent, pneumatic film cushions covering an area of 710sqm. The lighting possibilities of the ETFE film cushions lend an everyday structure a completely new aesthetic.



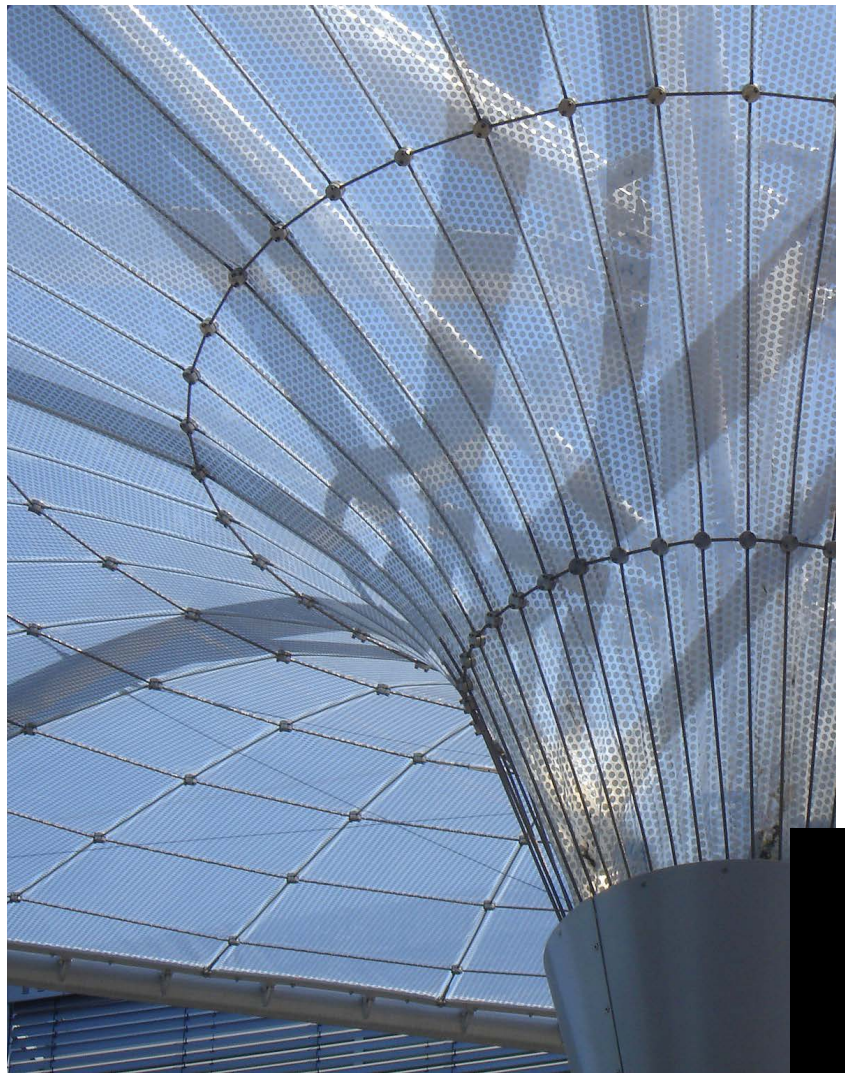


Westendgate, Frankfurt (DE)

**Architects** Just Burgeff

**Engineers** Wilhelm + Partner

Renamed “WestendGate,” the building welcomes its users with an “organic” tree structure. Five columns, each consisting of four steel circular hollow sections, support the canopy. They rise vertically 2 m to 3 m out of the pavement before they branch out like a tree. The canopy consists of 79 different polygons. Each of these panels requires a different two-layer ETFE cushion supplied by seele. To prevent overheating below the canopy, the upper layer of ETFE has been printed with a pattern of dots (50% coverage).



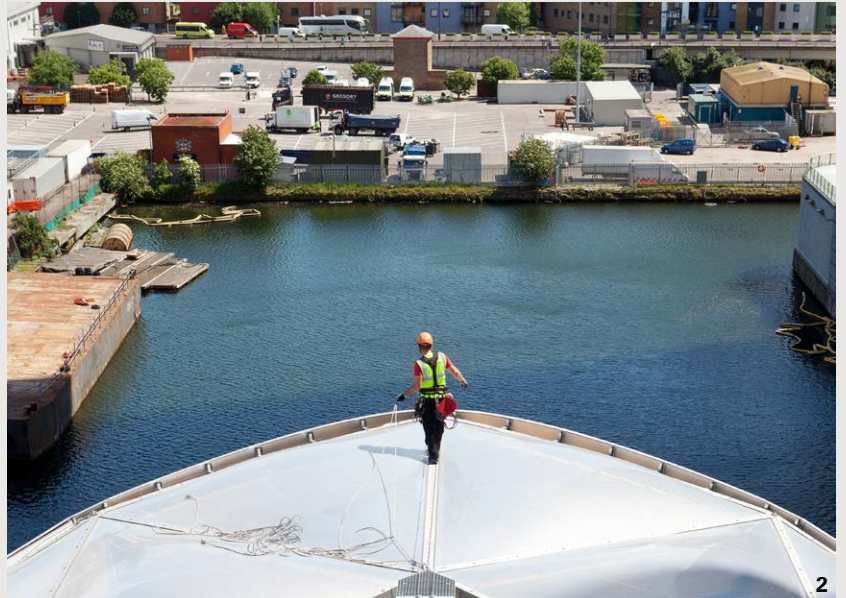
IHK, Würzburg (DE)

**Architects** Göger/Redelbach

Transparency and light were the basic design elements in the concept of the architects for the expansion of the headquarters of the Würzburg Chamber of Commerce and Industry. Accordingly, they covered the newly created courtyard of the annex with three light funnel-shaped (tulip shape) membrane screens (umbrellas), which are made of a single layer ETFE fabric. Numerous events could be held in the courtyard regardless of weather. The three screens set at different levels, with side lengths of 11 m, 12.5 m and 14 m, cover a total area of 480 sqm, while maintaining a light and filigree appearance.

assembly & maintenance

**unique design, special shapes, lightweight material, high engineering creativity, powerful with volume of air, finally implemented and maintained with a lot of craftsmanship.**







**1 Shopping City Târgu Mureş, Romania** The construction was implemented very close to the design specifications of the architect and the client. Structural changes were also considered during the planning phase.

**2 Canary Wharf, London, UK** Trained assemblers and industrial climbers installed the ETFE cushions without interrupting other construction works.

**3 – 5 Atrium IABG Ottobrunn, Germany** Especially roof openings must be inspected precisely during maintenance. The pressurisation system ensures even pressure in the cushions and a clean air supply.

research & development

## ETFE with aerogel filling by seele achieves U-value of 0.165 W / (qm K).

DFAB House is a modular research and innovation building at Empa (Swiss Federal Laboratories for Materials Testing and Research). It was the first house built largely with robots and 3D printers. seele designed and built a world innovation here: a translucent ETFE façade with aerogel filling.

The project was implemented by ETH Zurich and industrial partners from various sectors. seele supported the project with

ETFE cushions for the upper part of the building. With its aerogel filling, the ETFE façade achieves a U-value of 0.165W/(qmK) and g value of 0.12. In terms of sustainability, this innovation is an important step for the future – without sacrificing design freedoms.





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