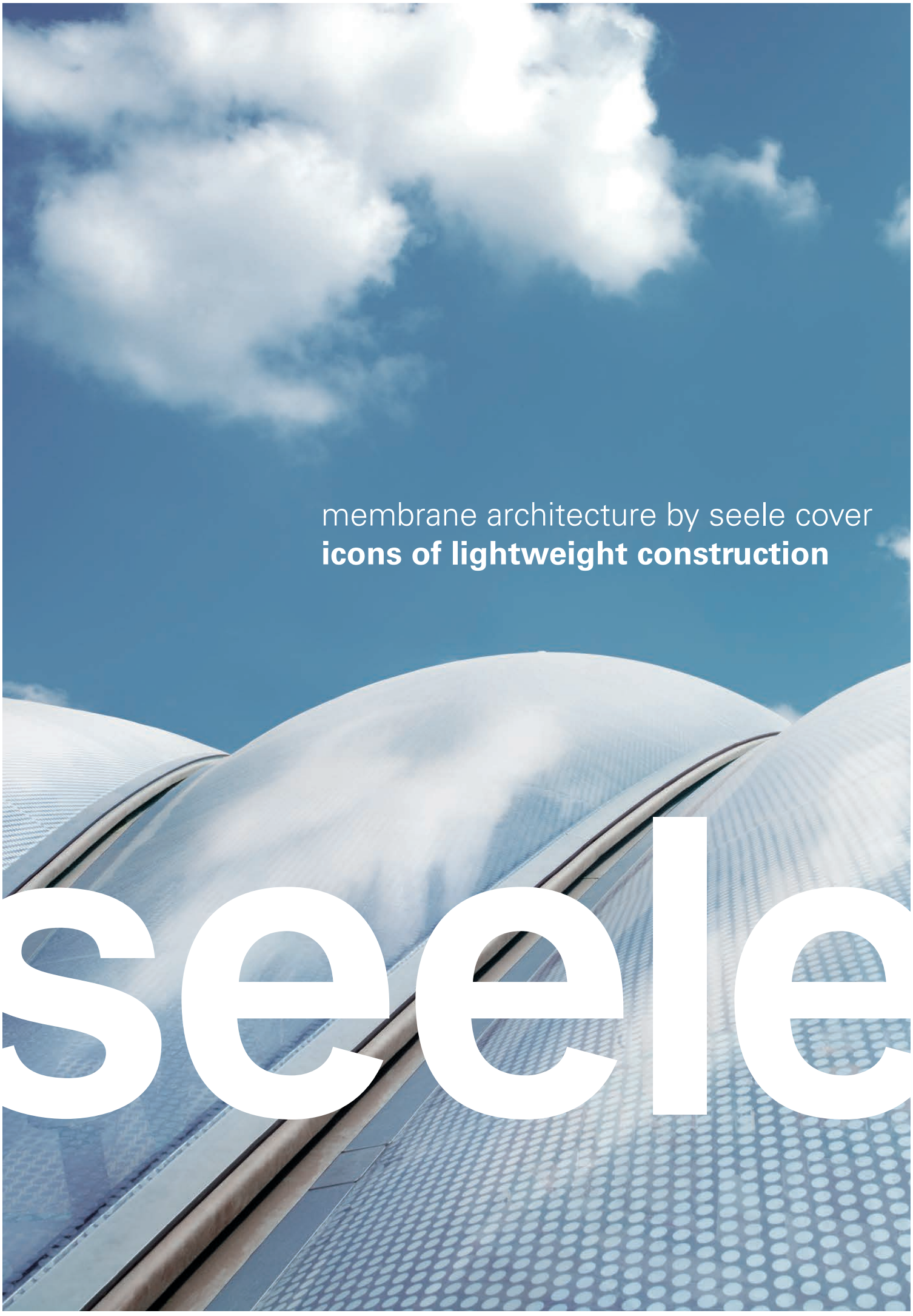

membrane architecture by seele cover
icons of lightweight construction
seele

your expert for membrane structures.

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.

seele cover is based in Germany and 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. Besides carrying out R&D, structural analysis and design, seele cover is also responsible for membrane fabrication. Moreover, seele cover can provide the entire range of services for membrane architecture – from consultancy to logistics to erection.

→ **1,000 sqm** production department
→ **70,000 sqm** annual production capacity
→ **more than 630** membrane structure projects completed

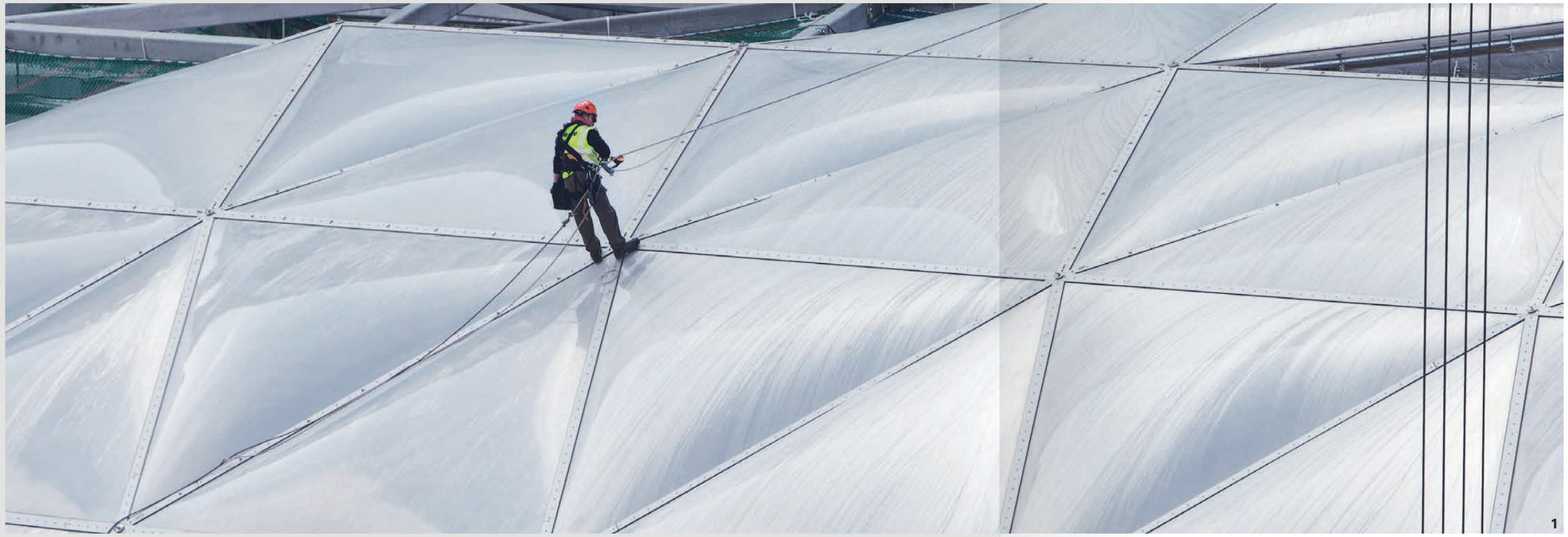
content

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

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.



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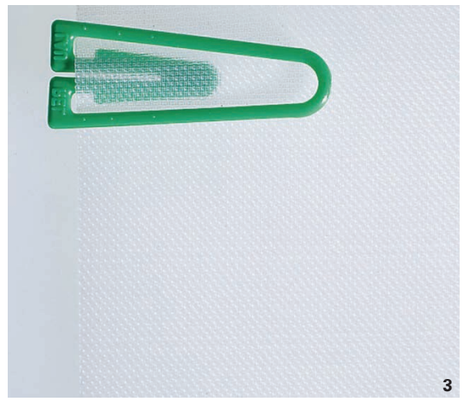

3

Lightweight structures by seele cover are based on light materials, efficient loadbearing structures and intelligent systems. The results are fascinating single-layer plate and shell structures and multi-layer modular forms of construction. 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. Light is therefore specifically used as a controllable design element.

ETFE (ethylene tetrafluoroethylene) is a fluorine-based polymer and belongs to the same family as PTFE (commonly called Teflon®). ETFE films are very thin (100 µm – 400 µm), can be highly transparent (from 88 to 95 %) and allow the passage of the UV radiation responsible for promoting photosynthesis in plants. Owing to the non-adhesive surface properties of ETFE, dirt, dust and debris do not stick to the surface, instead are washed away by the rain, thus resulting in a "self-cleaning" effect. ETFE is therefore ideal for lightness and transparency.

Membranes are woven materials with a protective coating. The most common membrane materials are PVC-coated polyester and PTFE- or silicon-coated glass. 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.

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 membrane 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 double-layer ETFE cushions must fit exactly. Depending on the g value required, the membrane cushions are printed with three different patterns of dots and transparent or matt film chosen for the inner layer to suit the internal usage.

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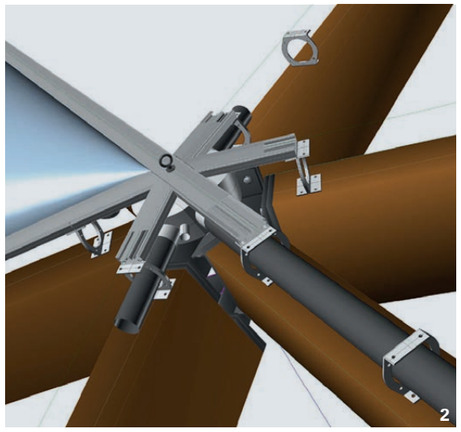
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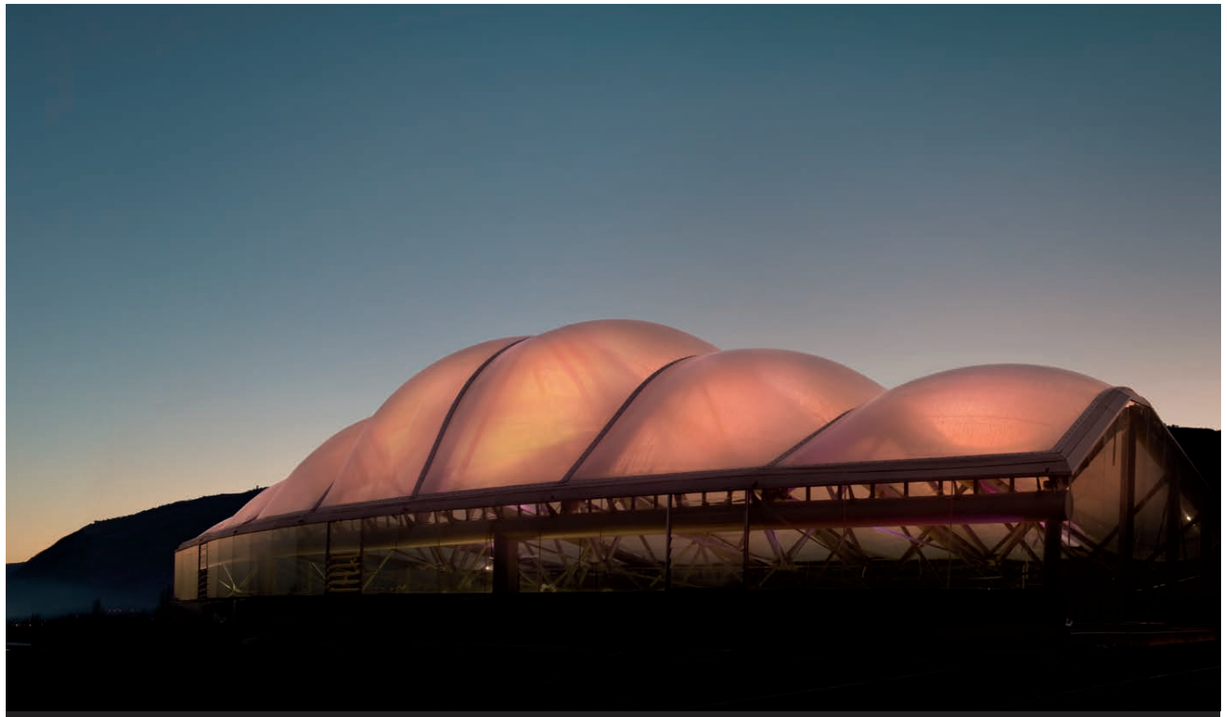
1 In the middle of the building the beams are vertical, but on both sides they tip over more and more towards the gable ends, finally cantilevering up to 30 m out over the water.

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 devised 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



Vitam' Parc, Neydens (FR)
Architects L35 Arquitectos

→ **4,500 sqm** three-layer ETFE roof
→ **63 cushions** up to 26 m long
→ **500 sqm** three-layer ETFE roof with seven air-filled cushions over the climbing arena

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.

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.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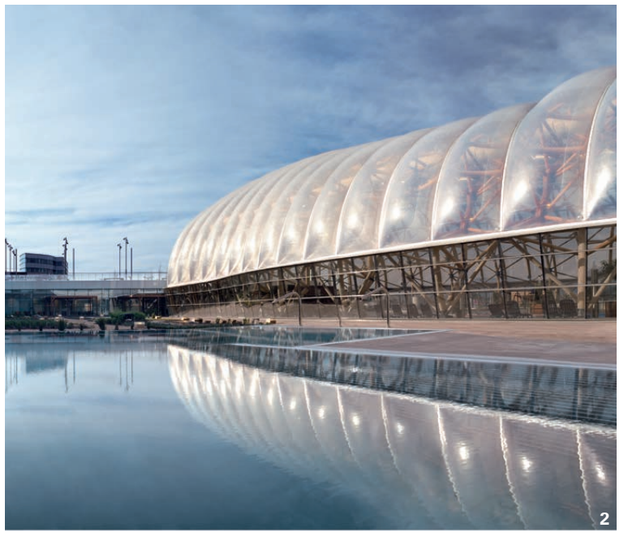
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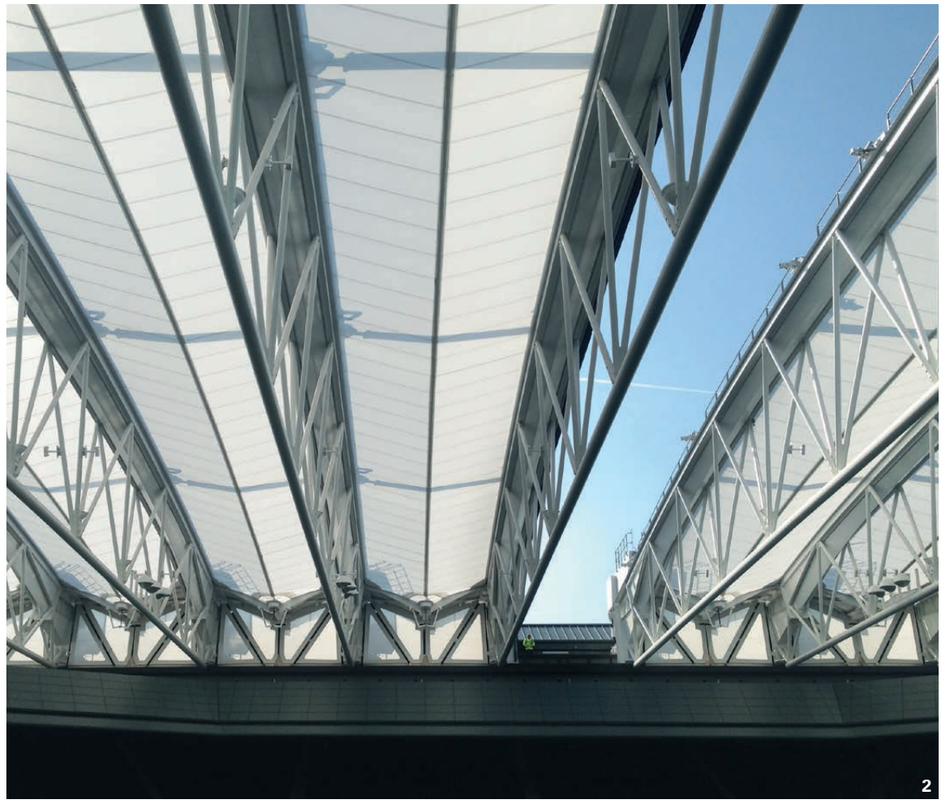
Membranes are ideal for sports arenas. They are very light in weight and protect against outside elements such as rain and solar radiation, yet still let in enough light to create a pleasant atmosphere. Their very low weights and long spans enable very cost-effective, energy-efficient systems. The primary 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 spectators. 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.

1



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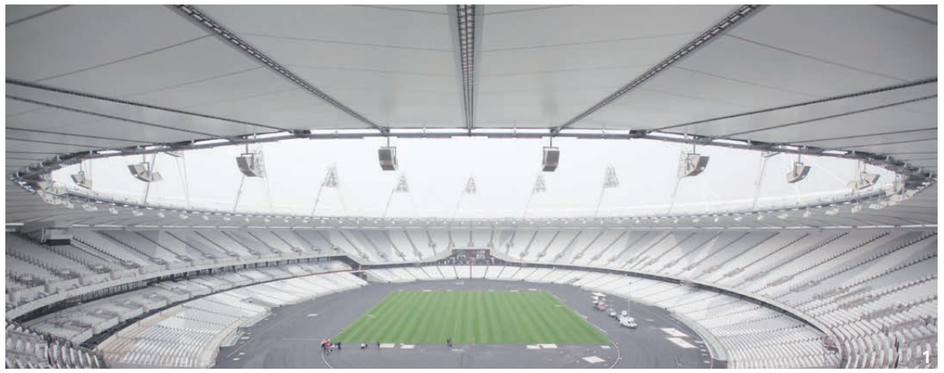
The No.1 Court in Wimbledon was enlarged as part of a general refurbishement. A new retractable roof was realized, so that matches can take place in any wheather condition.

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 6,000 sqm 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 65 m, the membranes are fixed to the 11 steel trusses that span across the stadium. The membranes are tensioned by steel cables (33 t preload) so that they always remain free from creases and folds at any position of the roof.

2 The roof required a total of 10 main membranes, 11 so-called drainage membranes, 80 batwing membranes for waterproofing the sides of the roof and a vertical membrane for the southern end of the roof.



Olympic Stadium, London (GB)

Architects Populous

2

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

4

5

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.

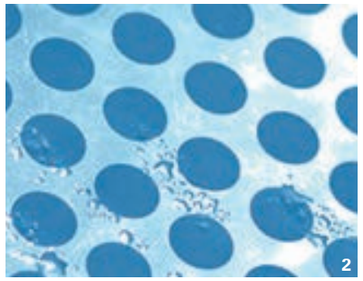
5 The single-ply ETFE film with a thickness of 250 µm is printed with a pattern of silver-grey dots to reduce the amount of incoming daylight. The total membrane area of 38,000 sqm is made up of 880 individual panels in sizes of up to 216 sqm.

Confluence Shopping & Leisure Complex, Lyon (FR)

Architect Jean Paul Viguier

1 The LED lighting in the roof – in all the colours of the rainbow – is a spectacular additional feature of the 22,000 sqm 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 top layer of the film.



modern shopping malls mean 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, Lille

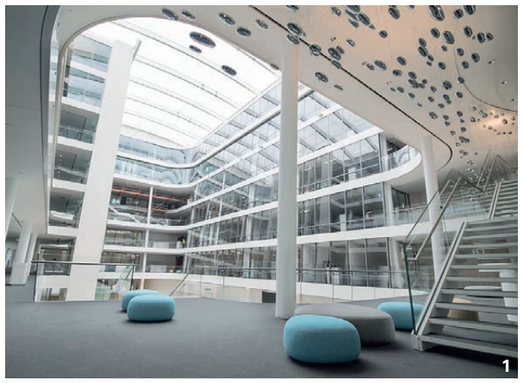
3 The dome consists of 122 air-filled ETFE cushions supported by a framework of curved steel circular hollow sections. The 28 × 38 m structure weighs about 26 t and was delivered to site in separate parts that were welded together on site and given a final coating before the whole dome was lifted into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

high energy efficiency for expressive architecture.

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 can be just thrown in the oven again to create other ETFE products. 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, as the atmosphere inside such an atrium is as close as you can get to that of the open air! This is minimalist design: low energy during manufacture, less material, open-air feeling and recyclability.

corporate headquarters with an atrium roof of ETFE cushions. 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.

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 cushion roof improves the energy efficiency of the building and at the same time integrates perfectly with the expressive architecture. Despite the demanding thermal specification, the membrane solution achieves a brilliant spatial experience for the staff.



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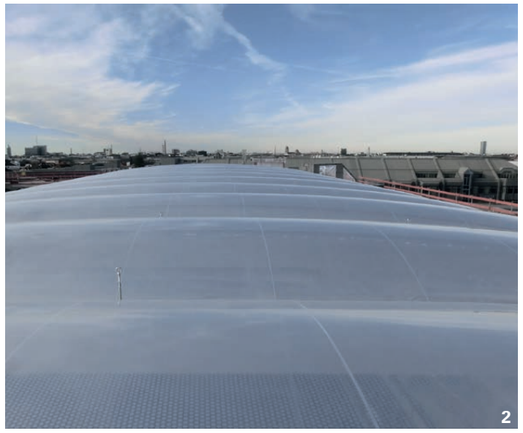

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1 Combined with the printing, the result is an efficient, energy-conscious solution. The reflective property of the membrane roof also reduces the build-up of heat in the atrium.

2 The membrane roof by seele covers an area of about 892 sqm. It consists of four-layer ETFE film cushions, the inner surface of the uppermost layer of which is printed with silver dots covering 50 % of the area. This four-layer ETFE film design means several insulating layers that ensure an optimum U value.

Siemens Corporate Headquarters, Munich (DE)
Architects Henning Larsen GmbH

printed dots ensure an agreeable, diffuse scattering of the incoming light and thus a pleasant interior atmosphere during any type of weather.

Aida Cruises, Hamburg (DE)
Architects Partner Ship Design GmbH, Hamburg

→ **4.000 sqm** ETFE film roof
→ **3-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.

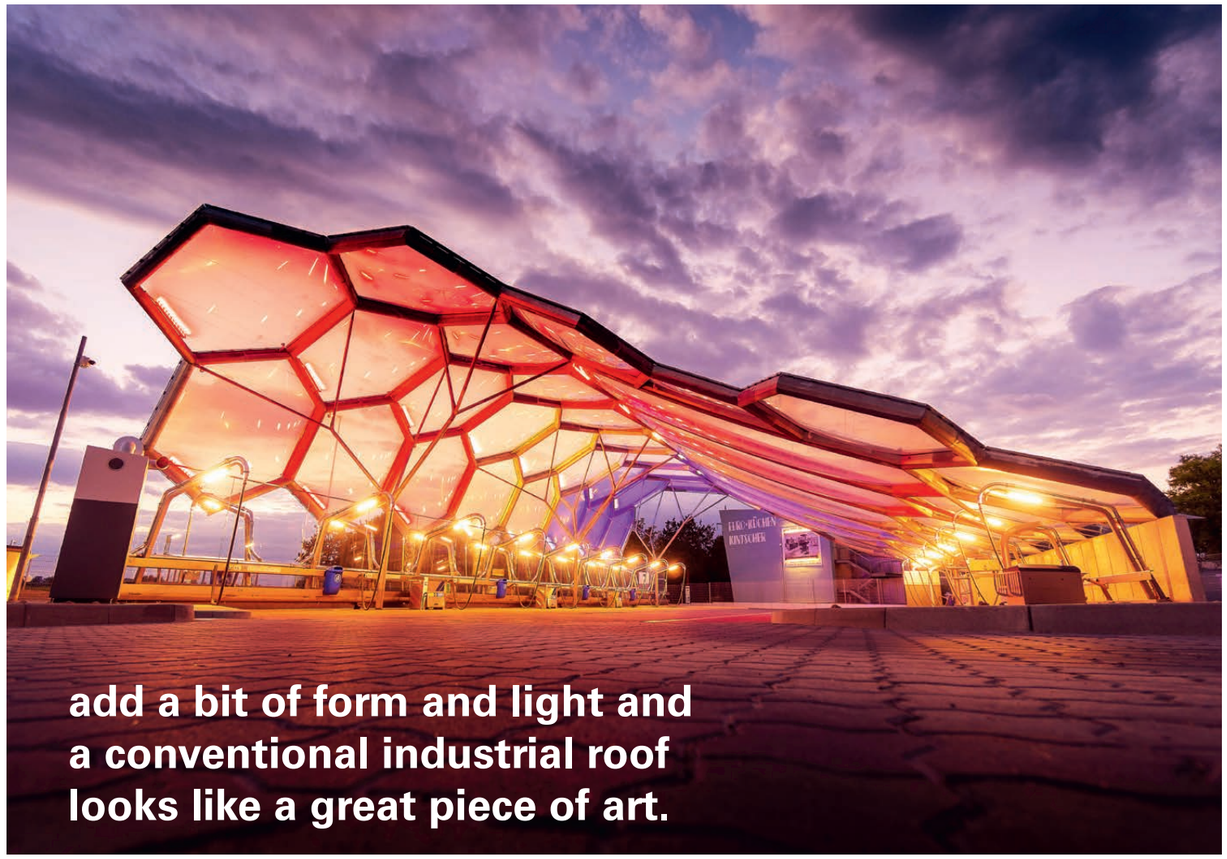
2 Once again, this unique project has enabled seele to live up to its role as a pioneer in the field of innovative membrane construction.

1

2

Using ETFE as the roof covering offers a number of advantages. The weight per unit area of the three-layer ETFE film cushions (with thicknesses of 250, 200 and 250 µm) is less than 1.5 kg/m². 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 also ensures that lighting and media installations are perfectly integrated into the ETFE film skin.

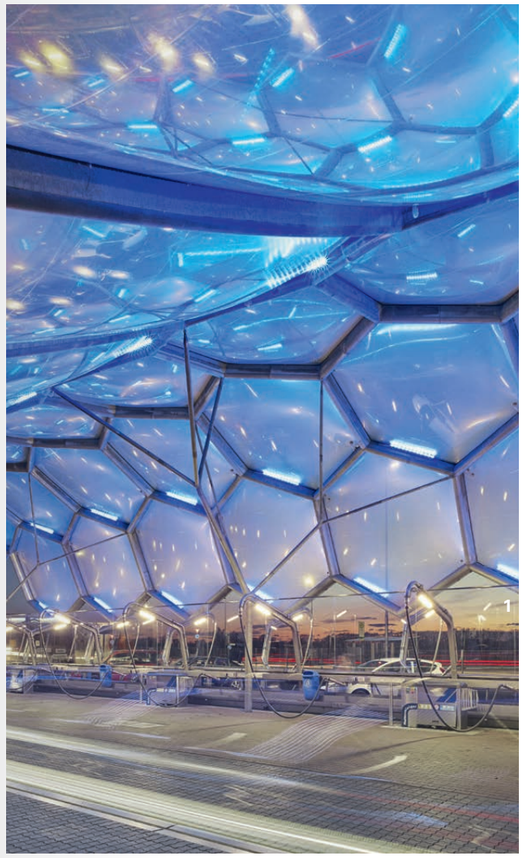


add a bit of form and light and a conventional industrial roof looks like a great piece of art.

Membranes and ETFE films can also 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.

Sundheimer Fort, Kehl (DE)
Engineers wilhelm + partner

This car wash in Kehl near the French border now has a membrane 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 710 sqm. The lighting possibilities of the ETFE film cushions lend an everyday structure a completely new aesthetic.



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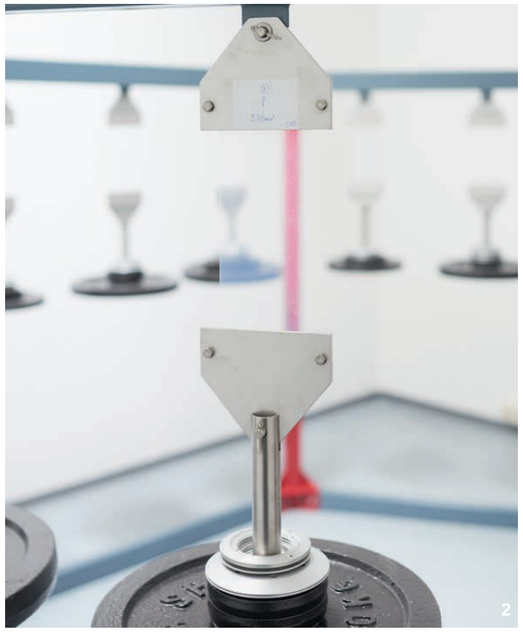
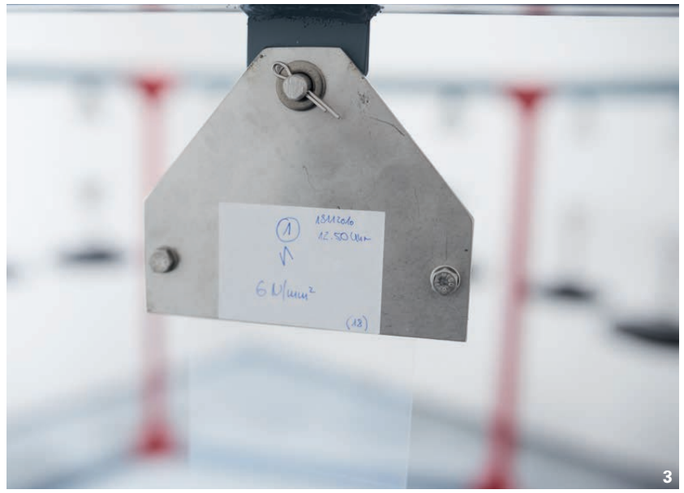
Nuremberg Trade Fair, entrance zone, Nuremberg (DE)
Architects kadawittfeldarchitektur GmbH

The entrance hall and forecourt at one of the entrances to Nuremberg's trade fair grounds now benefit from the shelter of a roof of steel louvres with transparent ETFE cushions. The principal design element here is an approx. 10,000 sqm roof of steel louvres supported 16 m above the ground on steel columns. On plan the roof is an elongated rectangle with an extra triangle at one end. Transparent ETFE cushions span between the steel louvres. Two-ply cushions are used above open areas, but a three-ply design over the air-conditioned entrance hall for better thermal insulation in the winter. Parts of the cushions are printed with patterns of dots to prevent excessive levels of heat and light in the interior in the summer.





the degree of innovation essential for membrane structures and ETFE films is supplied by our own R&D department with its test centre, facilities and laboratories – plus outdoor testing grounds for performing long-term weathering tests on full-size mock-ups.

1 Outstanding ETFE expertise is one of seele's strengths. Welding machines optimised by seele engineers produce weld seams in excellent quality which are tested in seele's own test centre.

2 Static, cyclic and dynamic short- and long-term tests are carried out to establish mechanical properties and material parameters.

3 Long-term tests for the expansion behaviour of ETFE films in different grades.

4 The R&D department tests materials for QA purposes. The monoaxial tensile testing machine tests the stress, strain, stiffness and strength of membranes and ETFE films. Various edge members, temperatures (-40 to +100° C) and types of fixing can be simulated.

5 Computers evaluate the results of the tensile tests.

newest development

ETFE with aerogel filling by seele cover achieves U value of 0.165 W / (m² 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 cover 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 cover 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/(m²K) 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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