

INSTITUTION OF MECHANICAL ENGINEERS HONG KONG BRANCH  
EVENING LECTURE “SIM-TO-REAL” FOR CARS’ ON 20/10/2017



*Fellow Member of Institution of Mechanical Engineers cum Convener of Automotive Engineering Specialist Group of Mechanical, Marine, Naval Architecture and Chemical Division of The Hong Kong Institution of Engineers, Ir. Alexander T.S. Wong, presented souvenir to the speaker, Mr. Jeff Ho, Application Development of Covestro (Hong Kong) Limited*

The discovery of polycarbonates (PC brand name Makrolon by Covestro AG) by Hermann Schnell of Covestro AG in 1953 opened an era of new material for a wide range of applications. Formed from monomer under chemical processes, PC is break-resistant, light-weight, transparent, robust, dimensionally stable and high heat-resistant in the form of granules, sheets or film. This enables the material to be applied in the screens of computers, smart-phones and flat-screen displays, DVD or CDs, windows, building structures such as stadium transparent roofs and road noise barriers, automotive glazing and bodywork parts, and medical devices. Especially, merited by extreme robustness, light-weight with glass-like transparency, impact resistance at extremely low temperatures, high dimensional stability and excellently high-resistance with the glass transition temperature up to 148 °C, PC has won favour by the automotive and transportation industry and its applications are becoming more extensive.

A PC-made panoramic roof cuts weight by up to 50 % compared to glass roofs, resulting in a marked decrease in green-house gas emissions. The high impact resistance of PC also offers a vital safety benefit. There is great potential for functional integration, and the design freedom allows new forming possibilities. Utilising a high-gloss PC bezel allows manufacturers to

maximise the glass-like surface area of a panoramic roof. The strength and transparency of Makrolon makes this unique design possible.

For decades, car headlamps were made of glass. From the 1980s the transparent high-performance plastic Makrolon has become the material of choice – being lightweighted, tough and easy to shape. Then in 1998, Makrolon was first applied to automotive glazing for Smart rear window. Now the panoramic roof of Bugatti, solar-powered vehicle roof developed by Webasto AG, the spoiler on Audi A7, the panoramic tilt roof for Volkswagen, the roof of smart fortwo and the multi-functional auto trim strips for Gerhardt are made of a range of PC products. To achieve high resistance to abrasion, scratching and ultra violet exposure/weathering, a coating is an effective way of protecting PC in automotive glazing application. PC's fire resistant can be improved by the addition of fire-retarding additives into the material.

The application of PC can extend to automotive lighting, featuring high heat resistant, low specific gravity, excellent transmission and good impact strength of the material. Moreover, its good flow property enables the lighting parts with thin wall design. Another possibility is using injection moulded thermal conductive PC as heat sink for LED lighting. Not only can it offer thermal conductivity as high as 22 W/m-K, it also features light weight, high degree of mouldability and competitive production cost. The high thermal conductivity of PC could also be found valuable to cooling batteries on electric cars.

PC components are commonly made by the injection moulding, which can be simulated by Computer-Aid Engineering (CAE). Moldflow is one of the standard CAE software packages for simulating the behaviour of PC in the whole process of injection moulding, starting from filling (inject melted PC into the mould cavity to form the component shape), cooling (from the melt temperature as high as 300 °C to around 80°C before eject the part from the mould) and warpage (deformation after part ejection). Moldflow can achieve high accuracy which can help to avoid injection moulding related problems such as excessive warpage, sink mark, short shot and high internal stress inside the component across the production process right in the design stage. Moldflow can also simulate thin wall, two component, gas-assist, sequential, injection-compression and film-insert moulding.

At the design phase, it is possible to evaluate the part performance under static, thermal and linear/non-linear loading conditions with the aid of mechanical CAE analysis. For automotive applications, analysis can be extended to crash, noise and vibration hardness and creep. CAE thermal analysis can help to shorten the lead time in production for thick lens used in automotive lighting.

In summary, endowed with excellent mechanical properties, transparency and mouldability, PC is a promising material for automotive components such as PC window, interior and exterior component. Not only can it reduce the weight of vehicles, but it can also help cut fuel consumption and green-house gas emissions, while keeping strength, safety and style. CAE simulation can evaluate the performance of PC-made automotive components in the manufacturing and application stages, minimising defects and design errors. More extensive applications of PC on vehicles are on the horizon.

IMechE Hong Kong Branch thanks Mr. Jeff Ho, Senior Engineering Specialist, Polycarbonates, Application Development of Covestro (Hong Kong) Limited and his Covestro colleagues for their generous delivery of the lecture.

\*\*\* END \*\*\*

Encl.  
WHT



# IMechE Event – Covestro Leatures

Application of CAE Simulation in  
Developing Automotive  
Polycarbonate Parts  
October 20<sup>th</sup>, 2017  
Jeff Ho

covestro.com

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# Company Introduction

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## Main production sites

Key data 2016



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## Employees

Key data 2016



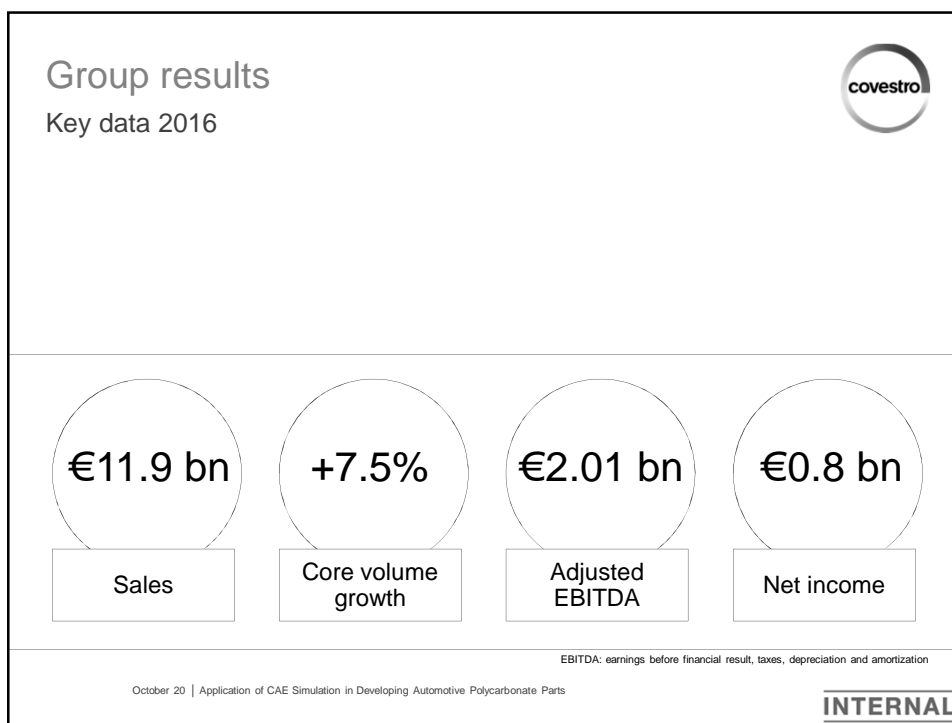
**Covestro has a workforce of around 15,600\* employees worldwide.**

Employees are primarily in production, marketing, sales and administration, in research and development.

\* Converted into full-time equivalent

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## Key element of the strategy

### Innovation



Teams of inventors at Covestro constantly work on new materials, production and finishing processes as well as solutions for applications.

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## Solid basis

### Innovation



Around **1000** employees in research and development worldwide

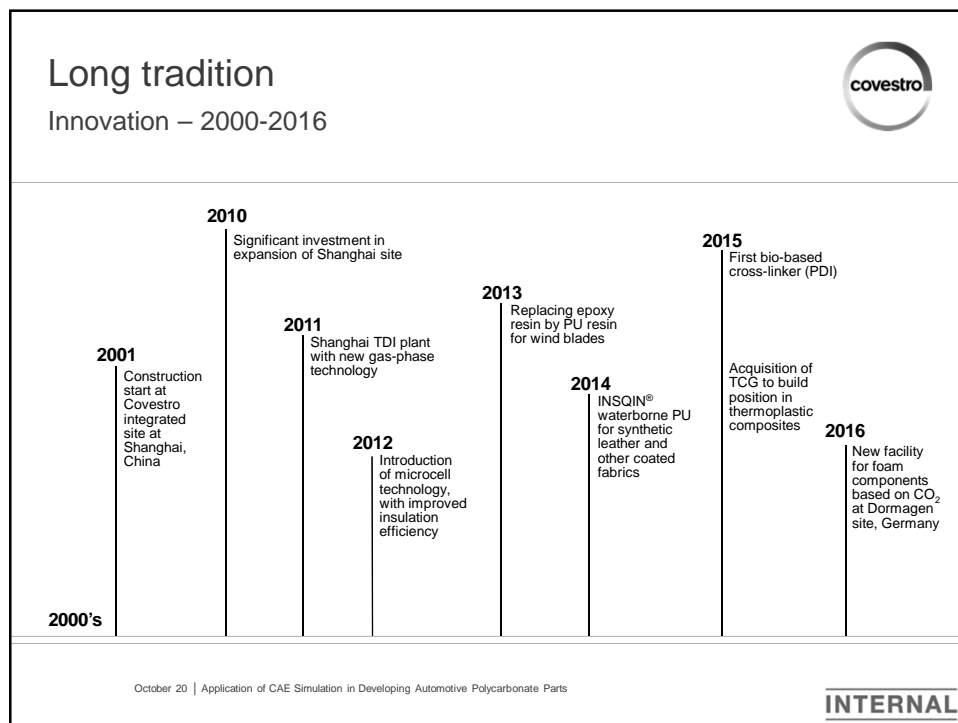
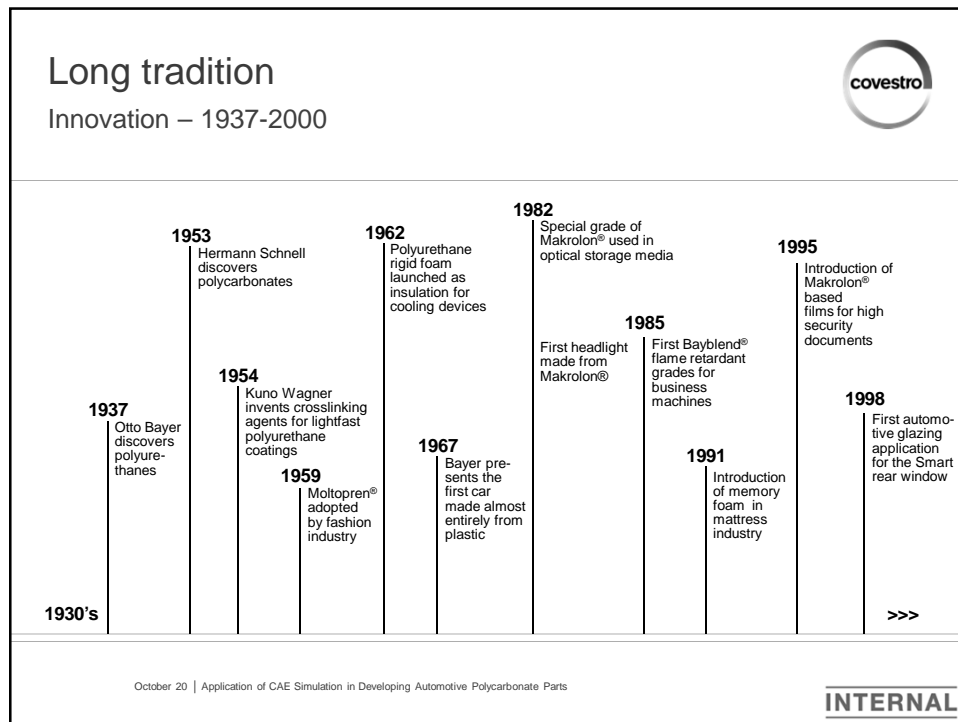
Large **innovation centers** in Europe, North America and Asia

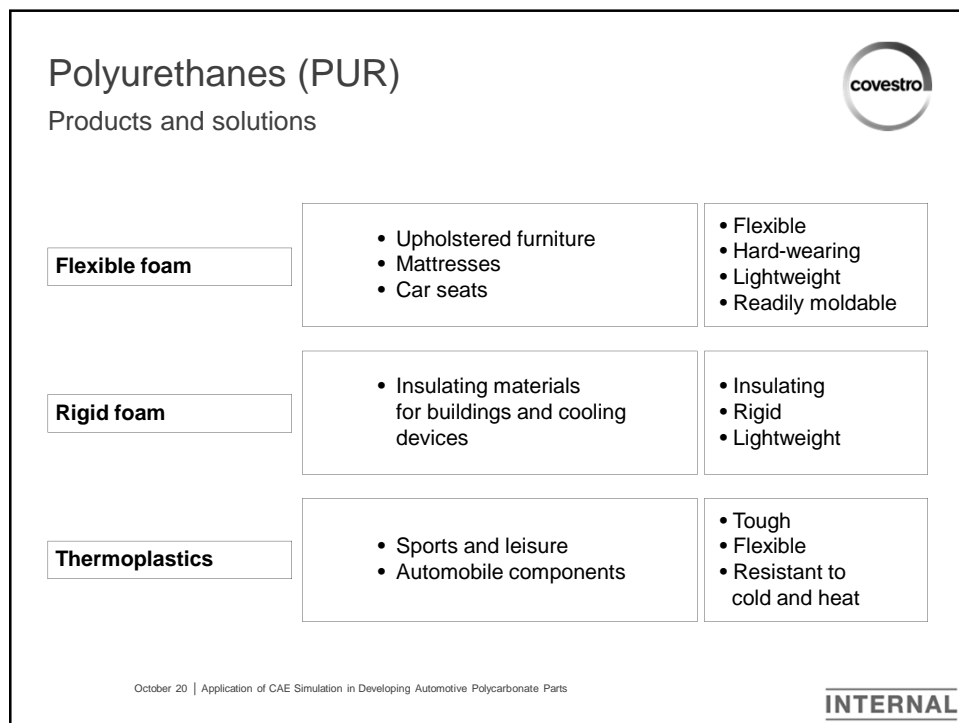
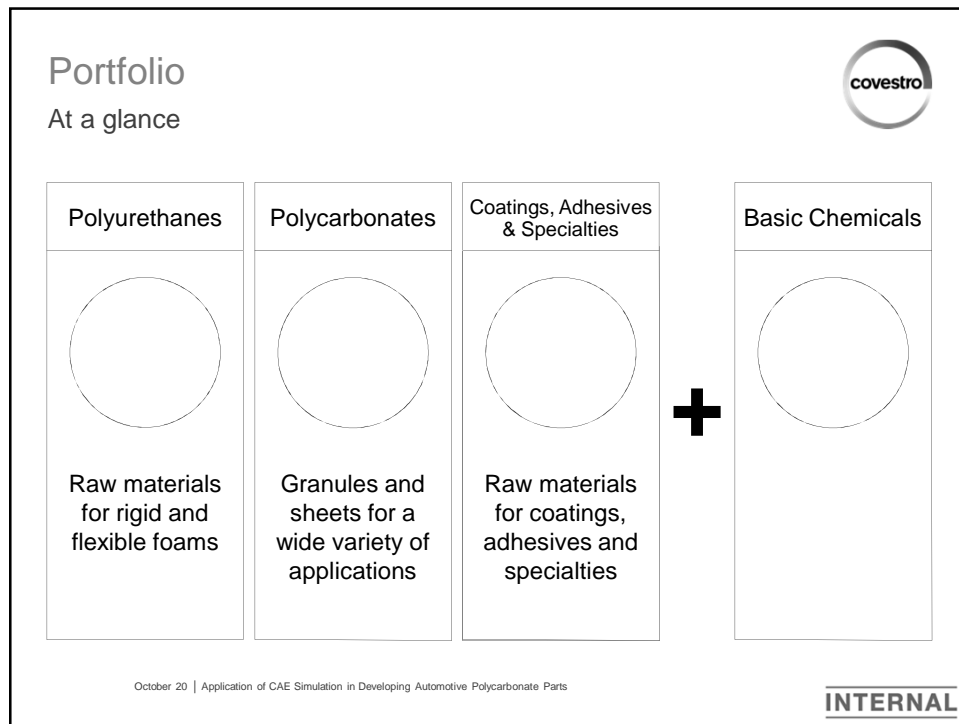
Approx. **260 million EUR** spending for research and development

**Cooperation** with universities, incubators, customers and suppliers around the world

Needs-based **project pipeline** through systematic innovation process and consistent industrial marketing

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## Coatings, Adhesives, Specialties (CAS)

Products and solutions



### Raw materials for surface coatings

- Automotive/transportation,
- Flooring
- Furniture
- Infrastructure

- Durable
- Protective
- High-gloss/matte

### Raw materials for adhesives and sealants

- Shoes, textiles
- Furniture
- Automotive/transportation
- Construction

- Easy to process
- Low emissions
- Widely adjustable

### Raw materials for specialties

- Cosmetics
- Medical devices
- Textiles
- Sports and leisure

- Gentle on the skin
- Flexible
- Functional

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## Polycarbonates (PCS)

Products and solutions



### Granules Sheets Films

- Computers
- Smartphones
- Flat-panel displays
- DVD/CD

- Roof structures
- Windows
- Conservatories
- Partition walls


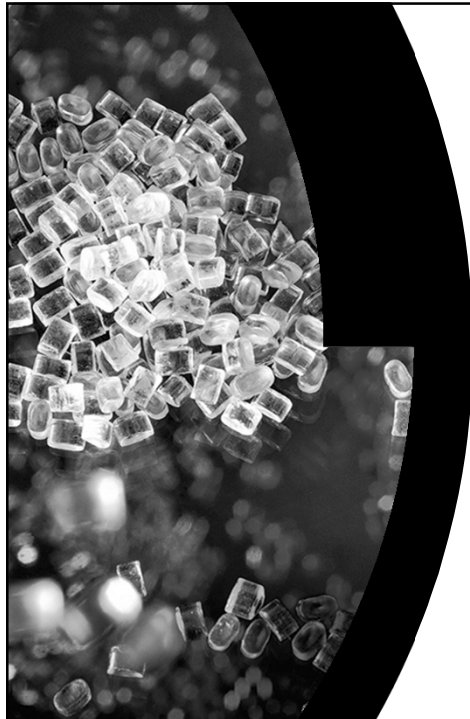
- Automotive glazing
- Bodywork parts

- Medical devices

- Break-resistant
- Lightweight
- Transparent
- Dimensionally tough
- Heat-resistant

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# Polycarbonate Used in Automotive

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## Polycarbonate



It is extremely **robust**, **lightweight** with **glass-like transparency** and is **impact resistant** – even at extremely low temperatures. It has a **high dimensional stability** and is easily molded, yet has **excellent heat resistance** with a glass transition temperature of up to 148°C.

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## Modified Polycarbonate or Blend



### Apec®

Apec® the high heat polycarbonate is most suitable for applications that must withstand high temperatures and exhibit toughness, impact resistance and high transparency.

### Bayblend®

Bayblend® (PC+ABS; PC+ASA blend) offers an ideal combination of mechanical and thermal properties for automotive, electrical/electronic, household, sports and IT applications.



### Makrolon®

Makrolon® polycarbonate comprises a broad portfolio of lighting, optical, medical and food contact, flame-retardant, impact-modified and glass-fiber reinforced grades which generate high-performance and sustainable properties.

### Makroblend®

Makroblend® (PC+PET; PC+PBT blend) is ideal for applications requiring the toughness of polycarbonate coupled with improved chemical resistance.

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## Applications

### Panoramic roof benefits from polycarbonate glazing



OEM: Bugatti

Industry: Automotive & Transportation

Application: panoramic roof of a car

Product: Makrolon®AG2677 polycarbonate

Technology: Automotive Glazing

- ✓ High toughness
- ✓ Good heat resistance
- ✓ Glass-like transparency, optical quality
- ✓ High dimensional accuracy and stability

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## Applications

### Lightweight polycarbonate glazing roof



OEM: Webasto AG

Application: Webasto AG solar-powered vehicle roof

Product: Makrolon® AG2677

Technology: Automotive Glazing

- ✓ Weight reductions up to 50 percent compare to glass.
- ✓ Better insulation, reduce energy consumption for heating.
- ✓ Boost the travel range of electric vehicles

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## Applications

### Premium material for premium cars



OEM: Audi

Application: Spoiler

Product: Makroblend® UT235 M (PC+ PET blend)

Technology: Two component molding

- ✓ Strength, UV protection and chemical resistance to gasoline and cleaning agents.
- ✓ Paintable, high-quality, Class A surface with uniform surface quality to match adjacent metal parts, and a low-gap design.
- ✓ Very low coefficient of linear thermal expansion (CLTE), high heat resistance, improved flow and an excellent surface.

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## Applications

### Single-part tailgate with integrated backlight



Supplier: Covestro

Application: One-part tailgate with backlight

Product: Makrolon® polycarbonate

Technology: Injection molding

- ✓ Complete, one-part tailgate design with backlight module.
- ✓ Seamless outer skin.
- ✓ Potentials for cost reduction by simplifying assembly and logistics.

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## Applications

### Large roof bezel uses polycarbonate



OEM: Audi, Volkswagen

Application: Panoramic tilt roof

Product: Makrolon® 2605 polycarbonate

Technology: Injection compression molding

- ✓ Glass surface twice as large as a traditional sunroof.
- ✓ One-piece, U-shaped panel.
- ✓ Deep, black gloss effect and a glass-like, scratch-proof surface.
- ✓ Three-dimensional glazing components.

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## Applications

Auto interiors with a personal touch



Supplier: Gerhardt

Industry: Automotive

Application: Multi-functional auto trim strips

Product: Makrolon® polycarbonate,  
Bayblend® (PC+ABS; PC+ASA blend),  
Makrofol® polycarbonate film

- ✓ Matte and high-gloss structures
- ✓ Attractive colors with gloss effect
- ✓ Outstanding coatability
- ✓ Excellent metallization
- ✓ Scratch resistance
- ✓ Production efficiency with film insert molding

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## Applications

Automotive lighting



Product: Apec® (high heat polycarbonate)

- ✓ High heat resistance
- ✓ Lower specific gravity
- ✓ Excellent transmission
- ✓ Good flow properties
- ✓ Good impact strength

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## Applications

### Heat sinks



To meet the need for efficient cooling, Covestro supplies a high-performance Makrolon® polycarbonate for injection-molded heat sinks. This Makrolon® based grade offers a thermal conductivity up to 22W/m·K

- ✓ Reduced weight of LED light engine
- ✓ Strong heat-transferring capability
- ✓ High level of design freedom
- ✓ Cost-effective production

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## Applications


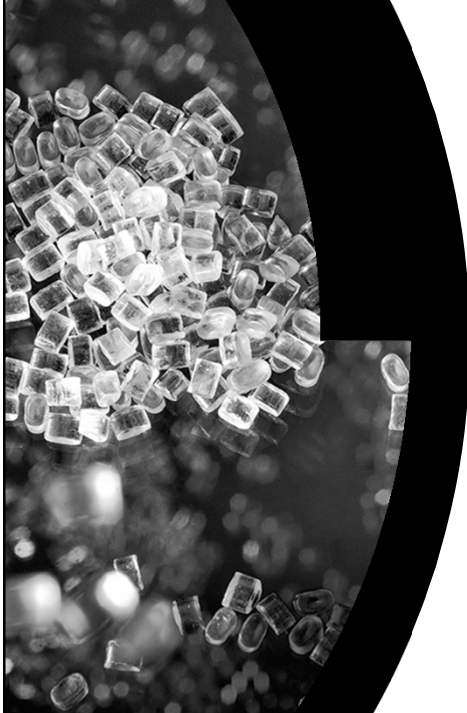
### Other possibilities



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# CAE Analysis Used in Automotive

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## CAE Analysis Used in Automotive

### Injection Molding Process CAE Simulation



Standard injection molding process

- Filling
- Cooling
- Warpage

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## CAE Analysis Used in Automotive

### Injection Molding Process CAE Simulation



Molding defects...

- Warpage
- Sink mark
- Short shot
- High internal stress

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## CAE Analysis Used in Automotive

### Injection Molding Process CAE Simulation



Special molding process

- Thin wall molding
- Two component molding
- Gas assist molding

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## CAE Analysis Used in Automotive

### Injection Molding Process CAE Simulation



Special molding process

- Sequential molding
- Injection compression molding
- Film insert molding

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## CAE Analysis Used in Automotive

### Structural CAE Simulation



- Static analysis
- Thermal expansion
- Linear/non-linear

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## CAE Analysis Used in Automotive

### Structural CAE Simulation



- Crash simulation
- Noise & vibration harshness (NVH)
- Creep

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## CAE Analysis Used in Automotive

### Thermal CAE Simulation



- Thickness optimization for Lens
- Heat transfer analysis

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**BY 2050 THE FLEET OF  
PASSENGER CARS MIGHT  
INCREASE FROM AROUND  
900 MILLION TODAY TO  
OVER 2 BILLION.**

Source: Shell Passenger Car Scenarios until 2040, 2014  
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Mobility

Global trends



Our answer:

Products from Covestro help to construct lightweight vehicles, reducing fuel consumption.

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## Renewable energies – Solar Impulse

Sustainability



### SUN IN THE TANK

**Covestro is among the sponsors of the Solar Impulse project – flying without fuel.**

- Ultra-lightweight polyurethane foams for the cockpit and batteries
- Extremely thin polycarbonate sheets for cockpit window
- Specialty adhesives for composite material

Copyright: Solar Impulse

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## Purpose

At a glance



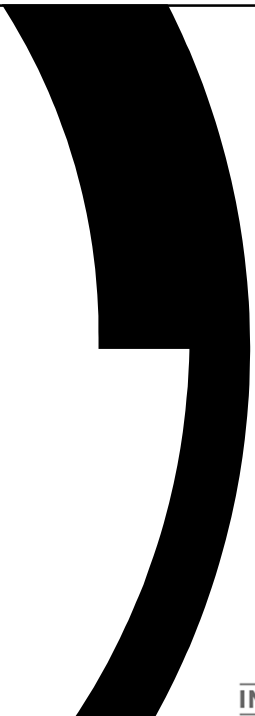

To make the world a brighter place.

We develop state-of-the-art polymer materials, that can do more.

We help push boundaries by supplying innovative and sustainable products, technologies and solutions for key industries and modern life.

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Thank you for  
your attention

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Forward-looking statements

This presentation may contain forward-looking statements based on current assumptions and forecasts made by Covestro AG.

Various known and unknown risks, uncertainties and other factors could lead to material differences between the actual future results, financial situation, development or performance of the company and the estimates given here. These factors include those discussed in Covestro's public reports, which are available on the Covestro website at [www.covestro.com](http://www.covestro.com).

The company assumes no liability whatsoever to update these forward-looking statements or to adjust them to future events or developments.

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**Date:** 20 October 2017  
**Time:** 19:00 to 20:30  
**Venue:** N001, The Hong Kong Polytechnic University

Computer Aided Engineering (CAE) permit both time and cost savings in process and product development. With the outstanding properties of polycarbonate together with CAE simulation, vehicle components like this one have reduced weight by up to 50 %, contributing CO<sub>2</sub> emission reduction and the stylish appearance.

Please come and join our technical lecture to learn more about CAE analysis for polycarbonate in the automotive industry.

The image is provided by and permitted by Covestro to use



For registration, please scan the above QR code or visit IMechE webpage:  
<http://nearyou.imeche.org/near-you/north-east-asia/hong-kong/events>

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**Institution of  
MECHANICAL  
ENGINEERS**

**Evening Lecture**

**"SIM-TO-REAL" FOR CARS**

**Supporting Organisation**

**HKME** THE HONG KONG  
INSTITUTION OF ENGINEERS  
香港工程師學會

Mechanical, Marine, Naval Architecture & Chemical Division  
機械、輪機、造船及化工分部