We are in the year 2030. After a day in the office, the autopilot of my electric car navigates me safely and without any stress through the commuter traffic. Having arrived home, the garage opens automatically, the central locking of the house is deactivated simply and securely via my smartphone, and the front door swings open silently. The electronic “butler” asks me at the time of entry for my choice of design for the large multimedia wall, and I opt for the “Mediterranean” module. While entering the living room, my favourite scene has already appeared on the large panoramic glazing with the blue sea and small dream bays, punctuated by a gentle breeze inviting you to set sail. I have a clear conscience since I know that this comfort in my plus energy house does not affect the climate and is sustainable.
mechanical break-in, but the entire building shell is impermeable to electromagnetic waves, so that all attempts at eavesdropping fail, and I feel autonomous and secure in my home. Thanks to modern nanotechnology, the maintenance effort for cleaning the windows and facades is almost zero and inside the rooms, active climate wall surfaces provide natural humidity control as well as absorption of potentially harmful substances, which means that the air inside the house is almost as good as fresh mountain air.

The scenario in a plus energy house may appear like this or similar in 2030, if social development is not disturbed by wars, terrorist attacks and global climatic or natural disasters, but takes place peacefully and sustainably, power supply becomes regenerative and the technical options undergo advanced development and are utilised consistently. However, there would continue to be different life and living standards, which means that apart from the scenario for those enjoying well-being, for simple buildings there will also be a market for standardised building products and construction elements having industrial mass production. Low-cost windows with standardised frame materials, glazing, shading and simple fittings for opening them will be deployed in this segment, but technologies for efficient energy utilisation will be applied as well.

Overall, construction will be characterised by the advanced development of energy generation, improved energy efficiency, advancements in material sciences, nanotechnology, the demographic development in industrialised countries, global urbanisation as well as the entry of electronics, Internet and data mining in all walks of life. To support the construction industry with this development, the research initiative “Zukunft Bau” (Construction for the future) was started in Germany by the Federal Institute for Building, Urban and Spatial Research. The following report illustrates what is already being researched today and what may be possible tomorrow.
Energy efficiency

Power supply in the future will be determined completely by regenerative energy sources, whose costs of generation may be less than the levels of today, since the efficiency will keep improving and the issue of energy storage or backup would get resolved. The extremely low energy expenses for heating, climate control and hot water, as well as solar electricity generation in the building shell, in conjunction with decentralised electricity utilisation and storage provide security and autonomy for a building. The building engineering services will be mature and all components will network intelligently. The transmission of the control signals takes place via wireless technology [1] from the control centre or via smartphone.

The transparent window and glass surfaces will form the backbone of thermal power supply. New glass constructions with an intelligent combination of vacuum glass and coated glazing will achieve U values of 0.2 W/(m²K) with low g values at the same time. An ongoing research project for the development of pressure equalised multi-layer insulating glass units [2] opens up opportunities for better integration of solar shading and light control systems as well as improvement in thermal insulation and sound insulation with reduction in weight at the same time.

![Diagram of pressure equalised multi-layer insulating glass units](Picture: ift Rosenheim)

The solar gains are backed up in conjunction with thermal storage units. These may be physical systems (concrete core, water and ice tanks etc.), chemical or adsorptive tanks, which dissipate energy for heating and also absorb energy for cooling. At present, very powerful systems are being developed that utilise the enormous thermodynamic potential that lies in the phase transition from solid to liquid and from liquid to gas. These systems have storage density that is many times higher than simple water tanks, in which water is
only heated up [3]. This is why supplementary heating will be necessary only very rarely, which would then be of electric type and use even the energy from the environment with the help of highly efficient heat pumps.

![Diagram of thermal energy storage using the adsorption method](Picture: © Fraunhofer IGB, Stuttgart)

Even innovative “green” building materials will be deployed and plants, as well as living organic materials, as had been done once historically with the ivy facade. This causes improvement in the energy efficiency and the urban micro-climate (oxygen, temperature, humidity and quality) [4]. A concrete example in the form of a photo bio-reactor [5] was showcased and tested in the international building exhibition (IBA) in Hamburg in 2013.

Even the need for energy required for cooling or climate control in Europe will be almost zero with the help of highly efficient shadowing systems, thermal tanks, ventilation systems for cooling off at night and the utilisation of cooling by evaporation. When the house has been heated up adequately, the photovoltaic modules get pushed in front of the windows in order to convert solar energy to electricity and to provide shadowing to the room simultaneously. The modules for improving thermal insulation are utilised during the cold hours at night. No solar energy gains can be achieved on the north side, which means that highly thermally insulating vacuum glazing are used here, and they provide insulation comparable with the solid walls of today, and are generally designed as fixed glazing. In 2030, the non-transparent house walls will well comprise high-performance insulating panels [6] with a lightweight load-bearing construction made of metallic, wooden or FRP sections or of plates in honeycomb design. These external walls will be only a few centimetres thick, providing more living area with the same external dimensions and will be produced by innovative manufacturers of windows and facades. The wall construction will be free from thermal bridges and there will be no formation of condensate on parts of the windows or the exterior walls. The power cables and sensors will be located in the prefabricated walls and facades, and they will also be used for the movement and control of windows, doors and solar shading elements with the help of electric motors.
The entire building shell will be a combination made of glass elements and surfaces, which are encased with organic PV film, whose photo-electric layer can be applied easily and cost-effectively. Organic PV modules (OPV) will be used frequently in the building shell despite the low level of efficiency, since the manufacture will be low-priced, it will be possible to apply the cells on different materials and geometries, and the efficiency even in weak light and at high temperature will be adequate. Even at present, efficiency levels of 12% are achieved and the development is moving in the direction of 15 to 18%, since the absorber materials used convert light of different wavelengths to electricity. Highly efficient PV modules on the rooftop will be installed in multi-layer technique [7], which, with an efficiency level of over 40% will ensure that the house produces far more energy than it consumes.

In office and administrative buildings, cleaning, air-conditioning and artificial light form the largest cost block, and cost reduction by new technologies will drive their development. However, the greatest lever will lie with personnel costs, which may well constitute more than 80% compared to the manufacturing or operating costs. The satisfaction of the employees and the sickness rate will also be affected by the room climate. It is, in fact, difficult to measure the correlation, but what is certain is that good quality of air, comfortable temperature levels and adequate daylight will improve the feeling of well-being. The control systems of today cannot provide any satisfactory solution and are often not accepted. Systems of the future will respond adaptively and, in conjunction with customised control via voice commands, they will improve the acceptance levels, and thus, the energy conservation.
Fig. 6  Simple control of windows, doors, solar shading and building engineering services via smartphone will be a matter of course. (Picture: Somfy)

Fig. 7  Even today, modern windows facilitate natural ventilation with the help of automatically and intelligently controlled fittings technology. (Picture: ift-Techn. Information UM-02engl/1 Universal Design, Aug. Winkhaus)

Safety and comfort

The energy efficiency is, in fact, absolutely necessary, but personal purchase decisions are also influenced by emotions. For buildings, this means more security, comfort, health and better presentation. Security for windows is one of the standard features and is
achieved at present by suitable fittings and glazing. In the near future, automatic closing systems and a centralised building locking system with sensors in windows, doors and glass will become standard, and these will promptly send a message to the smartphone and to the nearest police station in case of damage or break-in. Sensors and electrical systems will also fetch a substantial plus for health, by ensuring adequate ventilation in a decentralised and natural manner via windows, which, if needed, can be opened or closed automatically, if the target values for humidity and CO₂ content have been reached. Thus, condensation and poor quality of air become a thing of the past – even without fans at all. In summer, the automatic windows can be used for natural cooling at night, without you having to wake up in case of thunderstorms, since the rain sensor in the window will close the windows automatically. The levels of comfort by automatic windows and doors will then be taken for granted, particularly for older persons or handicapped human beings. The operation will then be user-friendly and intuitively via smartphone, so that it meets the human need, that is of controlling your own living environment independently and automatically.

Manufacturers must grapple very intensively with the development of simple and intuitive control elements so that the consumer is able to use these products of greater complexity with ease in the future. The developments in the field of entertainment electronics and smartphones are already setting standards today, and they will soon also include the construction and living room segments. What is still visual control at present will be superseded tomorrow by voice commands and subsequently, perhaps, even by thought transmission [8]. The design principle of the universal design offers a comprehensive approach for the development and utilisation of innovative products and construction elements [9]. The objective of universal design is that as many human beings as possible with different levels of knowledge and capabilities should be able to use products and services easily and safely.

The levels of comfort and visual well-being are also enhanced by innovative glazing units. Glass surfaces in the future will be capable of being darkened or used as multimedia screens, which work like an LED monitor screen [10]. Even today, small and barely visible LED elements turn the glass into a screen, if needed, on which landscapes and moving pictures can conjure magic on the screen. Multimedia facades, which still comprise individually controllable LED strips today, will soon be replaced by flexible organic LED films (OLED) [11], which can be applied easily on any shapes and materials. Organic LED cells make this possible, for which cost-effective print methods are presently being developed [12], with the help of which the costs can be reduced and customized products can be produced in small quantities. OLED (Organic LEDs) are a few nanometres thin, self-emitting thin, flexible light sources, which consist of organic semiconductors and form the basis for thin, flexible displays with shining colours and high level of contrast. Organic LEDs are already being used at present in MP3 players, cameras and mobile telephones and they will find their way into the multimedia facade. Their high level of colour rendering index, their natural white light and the good degree of energy efficiency are beneficial.
Electronics and the Internet

The opportunities of the Internet and mobile terminal devices are still in the initial stages, and we just cannot foresee today how intensively this technology will yet penetrate into our lives. The initial approaches are being manifested in the automotive industry, which is already working on autonomous and self-rolling vehicles [13]. Since recent times, suppliers from the automotive industry [14] are also providing electromagnetic components for the windows and fittings segment, and are bringing dynamism into the construction sector with their experience, competence and economical strength. This is why in a few years from now, electrically operated windows and doors with intelligent sensor technology will be the standard for sophisticated building control equipment. Particularly for older people or handicapped human beings, automatically opening doors and windows provide a big plus in the quality of living and are becoming bestsellers. Companies that use this technology and gather experience at an early stage will then be one of the gainers. The basis for standardised electrical interfaces have already been worked out [15] and are being discovered as a mass market and undergoing advanced development by providers from other industries (automotive and electronics).

Fig. 8 OLED films shall will become large multimedia surfaces in windows and facades. (Picture: Philips Lumiblade)
The enormous performance capability of electronic control systems in the future will be based on the principles of data mining [16]. Data mining means that comprehensive data is collected from users and evaluated with the help of algorithms regarding potential patterns. In the process, methods of different disciplines such as computer-aided learning, artificial intelligence and statistics are used. This is how self-learning control mechanisms are created that identify the specific habits of the users quickly and certainly, and provide comfortable temperature, lighting conditions and fresh air accurately. They also lock all windows when the front door is closed. The Internet giant, Google, has acquired the building technology provider Nest Labs [17] at the beginning of 2014 and will promote the development and control via smartphone. The smartphone will then perhaps be called Personal Assistant (PA) and will enable the operation of all electronic devices of the working and leisure world via voice command or by thought transmission with the help of a Man-Machine-Interface [18]. Nobody can say with certainty whether artificial intelligence will enable machines to become autonomous then. Nonetheless, human beings will remain a notch above the technology and equipment, and will be able to switch it off completely if desired.
Demographic development and Universal Design

The low birth rates and the continuous rise in life expectancy lead to an increasing proportion of older human beings [19]. As a result of this demographic change, human beings aged 55+ with considerable purchasing power (Silver Agers), increasingly influence the social values as well as products and services. This target group attributes great importance to its own real estate property and comfort, security and freedom from barriers have the highest priority for construction – all of these being requirements that can be described and designed well with the design principles of Universal Design (UD). Today, UD is already being applied frequently for items of day-to-day need, mobile telephones, motor vehicles, health, transport as well as simple operation and control of electronic devices. In the living segment, kitchen and bathroom areas are being designed according to the criteria of UD. Soon, other segments of the construction industry will be covered by this trend – in particular, even the manufacturers of doors, gates, windows and construction fittings, since their products are essentially functional construction elements.

The design features of the universal design can be well described with the help of 7 principles:

1. **Wide usability**
   The design can be used and marketed for human beings with different levels of capabilities and skills.

2. **Flexibility in use**
   The design supports a wide range of customised preferences and options.
3. **Easy and intuitive use**
   The use of the design is easy to understand, independent of experience, knowledge, linguistic capabilities or instantaneous concentration of the user.

4. **Information that can be processed with sensory perception**
   The use of the design is easy to understand, independent of experience, knowledge, linguistic capabilities or instantaneous concentration of the user.

5. **Fault tolerance**
   The design minimises risks and the negative consequences of coincidental or inadvertent actions.

6. **Low level of physical effort**
   The design can be used efficiently and comfortably with minimum fatigue.

7. **Size and space for entry and use**
   Provide reasonable size and space for entry, reach, manipulation and use regardless of the size of the user, his/her posture or mobility.

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**Fig. 11** Kitchen in Universal Design (Picture: Küchen-Quelle GmbH)

This is why UD will need to be taken into consideration to a much larger extent in future for design and product development. In future, the demand will be for products that combine design with suitable functionality. A core issue in the process will be freedom from barriers. According to the study „Housing for the Elderly“ [20], there is a short-term need for additional 2.5 million homes suitable for senior citizens, which will rise to three million until 2020. There are doorsteps in 50% of all residential units, and these are perceived as barriers, particularly at the entry to the balcony or the terrace.
Fig. 12 ift Compass: Universal Design facilitates objective evaluation of construction elements based on an ift certification program. (Picture: ift Rosenheim)

This is why with the design features of Universal Design (UD), the simple and safe use of windows, doors and gates are coming increasingly into focus apart from the popular performance characteristics such as thermal insulation, sound insulation and fire safety or deformation stability. Buildings and building elements must be flexible and easy to change so that the building and living space continue to work even with changes in the user groups and the user behavioural patterns. This is the case, for example, if the occupants of a building become older, or other requirements come up with sickness or accident, if grandparents move in or small children get added to the family. This is why the flexible use of buildings and building elements is becoming increasingly more important and more accurate analysis of the user needs and product characteristics from the perspective of different users are necessary. Here, too, the holistic concept of the UD provides advantages with the solution of these tasks in the future.
Material sciences and nanotechnology

The material sciences are experiencing a phase of revival as a result of new manufacturing, production and analysing methods, nanotechnology as well as the specific impact of surface properties. This is applicable to a large extent particularly in the development of new composite materials, metallic alloys, fibre-reinforced polymers and thermoplastic elastomers. The first lot of products are already available in the market at present (interior doors and door handles), in which silver or copper ions [21] are incorporated in the surface texture using innovative coating methods and these have an antibacterial effect. In future, functional surfaces shall be developed that can be designed depending on the purpose of use. In the case of windows and facades this will simplify the work of maintenance and cleaning which means that cleaning windows and applying oil to fittings will become a thing of the past. However, even surfaces for improving the properties of physical buildings shall become possible, for example, the absorption of moisture in the air or the integration of harmful substances.
The development of new materials made of metal and plastics as well as composite constructions facilitates the production of filigree window and facade profiles of high strength with excellent thermal insulation properties that permit even more sunlight into the house. Different approaches have been followed in research projects of the research initiative “Zukunft Bau” (Construction for the Future). In the project “Development of light-weight profiles and building components made of fibre-reinforced plastics for applications in the textile building shell and window equipment” [22], construction guidelines for dimensioning as well as suitable and cost-effective manufacturing methods (pultrusion processes) have been worked out for FRP (Fibre-Reinforced Plastics) profiles.

The basics for using thermal methods to improve the wood-related properties as well as constructional basics for composite constructions were established for wooden windows in the project “Sustainable optimisation of wooden window profiles” [23]. This makes it possible to improve the properties of wooden window profiles with respect to the strength, thermal insulation and resistance to weathering. Thus, $U_f$ values of 0.6 W/(m² K) can be achieved for the frame, which then form the basis for windows having high levels of thermal insulation with $U_W$ values less than 0.4 W/(m²K). Even the use of decorative types of wood such as that of the cherry tree, mahogany or other precious timber is facilitated – this supports the trend towards unique designer windows made of wood.

Fig. 14 Copper ions incorporated in the surface (nano surface) have an antibacterial effect. (Picture: © Jezper, Fotolia)

In the metal segment, new metal alloys and surface coatings with high strength, better resistance against environmental influences as well as lower thermal conductivity are being developed. In this manner, more filigree window and facade profiles shall become possible, with which the solar energy can be utilised more efficiently, thermal bridges can be
decreased and the costs and effort for maintenance and cleaning can be reduced. The second development stimulus can be considered to be composite constructions using the frame materials wood and plastic. What is also of interest here is also the combination with composite fibre materials in which it depends on proper material-based composition and load transfer of composite fibre material profiles to metallic parts [24].

![Image: ULTRASLIM Innovative window profiles based on FRP profiles (Picture: FH Dortmund)](image1)

**Fig. 15** ULTRASLIM Innovative window profiles based on FRP profiles (Picture: FH Dortmund)

![Image: Wooden windows, too, change and become more high-performing (Picture: ift Rosenheim)](image2)

**Fig. 16** Wooden windows, too, change and become more high-performing (Picture: ift Rosenheim)
In conjunction with innovative bonding techniques, filigree window and facade constructions having high load-bearing capacity and long service life can be made using modular construction. Even in the fittings sector, the bonding technique will get established and the fittings shall be joined with the profiles using bonding. This yields better load introduction and distribution, which means that the constructions will have increased service life and will be capable of withstanding greater stress.

Fig. 17 Modular construction principles and window constructions (Picture: ift Rosenheim)

Sustainability

As a result of further scarcity and rise in prices of raw materials, sustainable production and use of products are becoming a necessity and the guidelines for successful economies and companies. The construction and real estate industry has a significant impact on the conservation of energy and resources, and hence, on the environment, since large amounts of energy and raw materials are consumed here. This is why you need to reckon with the situation that statutory requirements shall soon become more stringent. Moreover, the consumption of resources needs to be minimised across all phases of use, that is, for manufacturing the construction products, the construction phase and use until the dismantling. The building shell has a great impact, since for windows, facades and glazing units the consumption of resources during the 30 to 50 year period of use is considerably greater than that during the manufacturing process – completely in contrast to short-lived construction products such as carpet floorings or the interiors. This will drive the development of sustainable products.
The declaration of construction products by an EPD (Environmental Product Declaration) plays an important role in the overall evaluation process. The information in the EPD will serve as verification in the future and will be marked just as other characteristic values are already being specified at present in the performance declaration in accordance with the Construction Products Regulation (CPR). Moreover, an EPD also furnishes the data necessary for the building certification. An EPD contains information on the impact on the ozone layer, the climate (greenhouse effect) or the acidification of soil, water and air. This information forms the basis for various evaluation systems, for example, LEED, BREEAM as well as the BNB and DGNB systems, and soon, it will also be called for by mandatory verifications.

In the course of climate change, even the CO2 footprint [25] is gaining in significance, with this describing the CO2 consumption for products or services over a certain life cycle and will establish itself as a new unit for climate-friendly products. The concept of the ecological footprint assumes that we have only one planet with limited raw materials. The consumption of resources and energy is taken into consideration in the process that takes place in the course of manufacturing, using and disposing of a product or service. The unit is the so-called “Global Hectare” (gha) [26]. One advantage of the footprint is that it combines the global with the local. The footprint can be calculated both for the whole Earth and for regions or products. At present, the CO2 footprint of the human race exceeds the overall biological capacity of the Earth by about 20 percent. Many people are already basing their purchase decisions on the CO2 footprint, and in 2030 this would be a popular parameter.
Conclusion

The technologies for windows and facades in the future are already available today in principle. New materials and the integration of electromechanical building components will provide a great boost to development. However, these can get established only if the interfaces between the mechanical and electronic components can be designed easily and cost-effectively [27]. At present, there is still a dearth of building owners who would like to build such houses and architects who would design them, and more than these, companies that offer such technologies. As a research, inspection and testing, and certification body, ift Rosenheim has been supporting the construction industry worldwide for over 45 years with the development and introduction of new technologies and products as well as guidelines and directives in order to be able to evaluate and ensure the suitability of use and the products. In this way, ift Rosenheim would like to accelerate this technical development and make the world a healthier, more sustainable and safer place to live in. ift Rosenheim is working jointly with companies, architects and building owners for implementing the windows 2030 scenario.
Fig. 21  ift Rosenheim is also developing test procedures and instruments for innovative products (here, for example, calorimetric measurement for modern solar shading systems). (Picture: ift Rosenheim)

Literature and Sources


[6] Aerogel, German Aerospace Center (DLR), Institute of Material Physics in Space


[9] Technical information UM-02engl/1 Universal Design


(http://techcenter.mercedes-benz.com/en)

[14] Brose - Technik für Automobile, „Spindle drives for lift gates"
(http://www.brose.de/www/en/pub/products/vehicle_doors_and_lifigates/systems_for_lifgates.htm)

[15] ift Guideline EL-01engl/1 „Electronic systems in windows, doors and facades“; publisher: ift Rosenheim
(www.ift-rosenheim.de/web/portal/literaturshop)

[16] Research Center „Berlin Big Data Center (BBDC)“
(www.bmbf.de/press/3580.php)


[18] see position 8

[19] 12. Germany’s Population by 2060: Results of the 12th coordinated population projection
(https://www.destatis.de/EN/Publications/Specialized/Population/GermanyPopulation2060.pdf?__blob=publicationFile)

[20] Wohnen im Alter, (Housing for the Elderly), Study Forschungsheft (research journal) 147, Federal Institute for Building, Urban and Space Research, 2011

[21] Door knobs and interior doors with antiseptic coating (Häfele, online product catalogue, www.haefele.de), (Jeldwen brochure „Aseptic Door“)


[23] R & D project of the research initiative Zukunft Bau „Sustainable optimisation of wooden window profiles to achieve compliance with the requirements of EnEV 2012“, ift Rosenheim, ISBN: 8-3-86791-284-6

[24] R & D project of the research initiative Zukunft Bau „Entwicklung von materialgerechten Fügetecnologien für Faserverbundwerkstoffprofile durch Realisierung eines Übergangs des Matrixwerkstoffes von Polymerharzen zu Metallen im Knotenpunkt der Lasteinleitung“ (Development of joining technologies with appropriate materials for composite fibre material profiles through the realisation of a transition of the matrix material of polymer resin to metals in a node of load introduction), University of Stuttgart, Institute of Lightweight Structure and Conceptual Design– ILEK

[25] Guideline „CO₂ Footprint“ of the Federal Ministry for the Environment (BMU) and the Federation of German Industries (Bundesverband der Deutschen Industrie e.V., BDI)


[27] see position 15

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