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An Engineering and Operational Review of Modern Aluminum Sliding Systems for Large-Format Glazing

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Abstract

The article presents an engineering and operational analysis of modern aluminum sliding systems used for large-format glazing. The relevance of the topic is dictated by the architectural trend toward creating panoramic and transformable spaces, which makes these systems a key element of modern buildings. Meanwhile, the rapid technological evolution of these structures creates a contradiction: on one hand, architects strive for maximum transparency and barrier-free access, while on the other, they face strict engineering requirements for energy efficiency, hermeticity, and durability. The goal of the article is to resolve this discrepancy by systematizing knowledge about various types (lift-and-slide, folding-sliding, etc.) and developing practical recommendations for their selection. It is concluded that the industry is moving toward specialization: lift-and-slide systems are being established as the standard for energy-efficient solutions in demanding climatic conditions, while folding-sliding systems occupy a niche where the priority is the maximum opening of the aperture, often at the expense of thermal insulation characteristics. The contribution of this work lies in formulating an original approach to system selection based on preventive engineering and consideration of the climatic context and long-term operational risks. The presented materials will be useful for practicing architects, structural engineers, and façade consultants.

Keywords: *Aluminum Profiles, Barrier-Free Access, Large-Format Glazing, Lift-And-Slide Systems, Sliding Systems, Folding-Sliding Systems ("Accordion"), Thermal Characteristics, Energy Efficiency.*

INTRODUCTION

Modern architecture is steadily moving toward blurring the boundaries between internal space and the surrounding environment, forming new standards of comfort and aesthetics. Large-format glazing has become the key tool for realizing this concept, allowing for the creation of panoramic views, filling rooms with natural light, and visually expanding them.

In this context, aluminum sliding systems have ceased to be a purely utilitarian element; they have transformed into complex engineering complexes upon which the building's external appearance, energy efficiency, safety, and operational characteristics depend. The choice of aluminum as the primary material for such structures is not accidental; its unique combination of strength, lightness, and corrosion resistance makes it possible to manufacture profiles of minimal visible width capable of bearing the weight of massive insulating glass units reaching tens of square meters. Unlike steel, aluminum does not require such complex anti-corrosion treatments, and compared to PVC profiles, it is characterized by incomparably higher rigidity and durability, which is crucial for large-scale structures [13].

Innovations in materials, mechanics, and automation are leading to the emergence of systems with fundamentally new capabilities, requiring architects and engineers to have a deep understanding of their technical specifications and operational potential. This article will examine the key typologies of systems and conduct their comparative analysis based on fundamental criteria. Special attention is paid to advanced technological solutions that define the industry's development vector, including systems with concealed frames, structural designs, and intelligent control. The study aims to systematize current knowledge and formulate scientifically-grounded recommendations for specialists facing the task of selecting and integrating these systems into architectural projects.

MATERIALS AND METHODS

The sources studied during the preparation of this article can be divided into three thematic blocks. The first includes overview and reference materials from manufacturers and specialized resources [1, 2, 4-7, 10-12], which describe

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system types (sliding, lift-and-slide, folding), design features, operational characteristics, energy efficiency, design, and market trends. The emphasis is on comparing solutions based on functionality and aesthetics. The second category is devoted to engineering studies and modeling of the thermal characteristics of sliding systems [3, 9, 13]—using modeling of heat, air, and moisture interaction to predict condensation on the internal surface of lift-and-slide profiles. The third block concerns the application of mechanical and control technologies in the operation of sliding structures, including automation and control systems [8, 14].

Issues concerning the long-term operation of large-format systems in various climatic conditions, the integration of digital control systems, and the assessment of resistance to loads and wind impacts remain insufficiently studied.

Methods of systematic and comparative analysis, a review of engineering and industry literature, technical analysis of design solutions and operational mechanisms, and generalization were used in writing this article.

RESULTS AND DISCUSSION

The market offers several fundamental design solutions for aluminum sliding systems, each with its own set of advantages and limitations. The choice of a specific type is determined by a combination of architectural tasks, climatic conditions, and functional requirements.

For instance, the tilt-and-slide system (also known as a PSK portal), historically one of the first and most budget-friendly options for “warm” sliding glazing, is essentially a window structure equipped with special hardware (Fig. 1). Its operating principle is that to open, the sash first tilts inward (similar to the ventilation mode on a window) and then slides to the side along guides fixed to the frame [1, 4, 10].

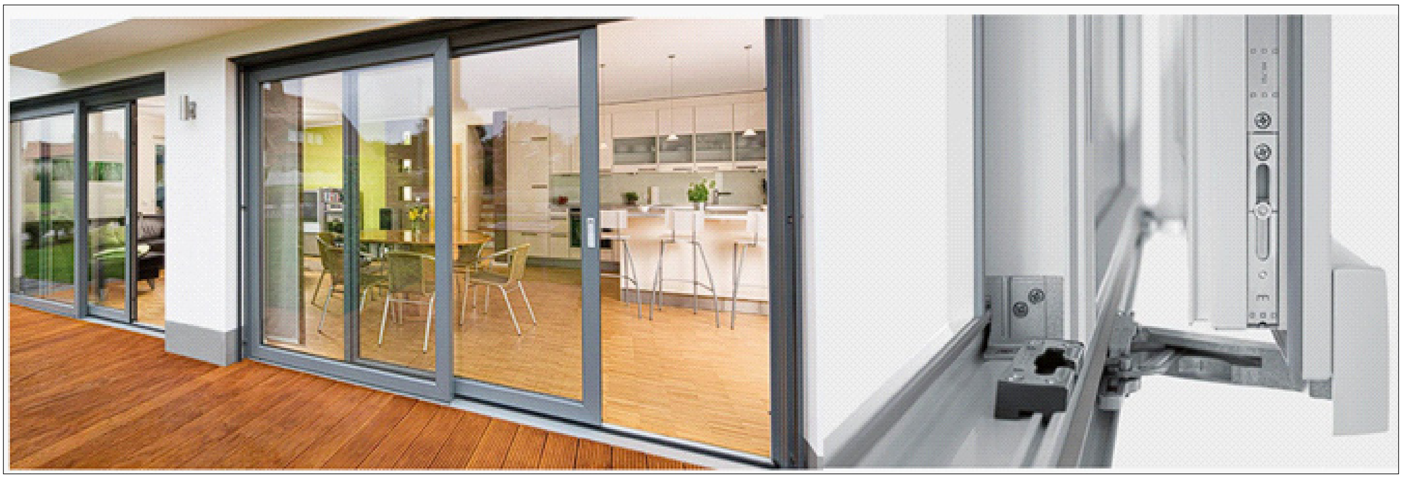

Fig. 1. Tilt-and-Slide System. Surface-Mounted Tilt-and-Slide Hardware [3]

Lift-and-slide systems (Fig. 2) are the option that is now the industry standard for large-scale glazing, thanks to their sophisticated mechanics and high operational characteristics. When the handle is turned, a special mechanism lifts the sash by a few millimeters, disengaging it from the seals and placing it on rollers. After this, the heavy sash moves along the guide rail with minimal effort. In the closed position, it is lowered, pressing tightly against the frame around the entire perimeter and ensuring a high level of hermeticity [2, 5, 7-9, 10].

Fig. 2. Lift-and-Slide System [3]

Folding-sliding systems of the "accordion" type (Fig. 3) offer a unique possibility—the almost complete opening of the aperture. The sashes, connected by hinges, fold up and slide to one of the walls when opened, freeing up to 90% of the passageway. This creates a maximum unification of internal and external space [4, 8, 14].

Fig. 3. Folding Glazing "Accordion" [3]

Table 1 presents a comparison of the main types characterized.

Table 1. Comparative Analysis of Types of Aluminum Sliding Systems (Compiled Based on [1, 7, 9])

Characteristic	Tilt-and-Slide	Lift-and-Slide	Folding-Sliding
Operating Principle	Sash tilts and slides on surface-mounted tracks	Sash lifts and rolls smoothly on a rail via rollers	Sashes fold into a "stack" and slide to the side
Max. Sash Weight	up to 200 kg	up to 600 kg (manual), up to 1200 kg (automatic)	up to 200 kg
Max. Height	~2.4 m	up to 4 m and higher (special solutions)	up to 4.5 m
Thermal Insulation (Uw)	Medium	High (from 0.85 W/m^{2}K and lower)	Medium (from 1.54 W/m^{2}K)
Hermeticity	Medium	High	Medium, risks of air infiltration
Flush Threshold	Not possible	Possible	Possible, but structurally complex
Aperture Opening Percentage	up to 50%	up to 66% (on three rails)	up to 90%
Advantages	Low cost, ventilation mode	Highest dimensions, thermal insulation, hermeticity, convenience	Maximum aperture opening, configuration flexibility
Disadvantages	Size limitations, high threshold, visible hardware	Higher cost, sashes do not clear the aperture completely	Lower hermeticity, demanding maintenance

Modern systems are evaluated by a complex set of parameters that determine their compliance with high architectural and operational requirements. In recent years, it is in these areas that the greatest technological progress has been observed.

The drive to reduce thermal losses is the main vector of development. This is achieved through: improved thermal breaks (polyamide inserts separating the outer and inner parts of the aluminum profile are becoming wider and have a more complex, multi-chamber geometry), multi-chamber profiles, and multi-layer glazing [6, 12].

Regarding aesthetics and minimalism, modern design demands maximum transparency and the least possible visibility of structural elements. Manufacturers are responding to this request with the following solutions: reducing the width of profiles, and concealed frames (designs allow the frame to be completely hidden in the structure of the walls, floor, and ceiling—as a result, only the narrow strip of the sash profile itself remains visible, creating the effect of a "glass wall") [11].

Integration with "smart home" systems turns sliding doors into an active element of the building. Modern automation provides:

- Control of heavy sashes (electric drives allow for effortless control of sashes weighing over 1000 kg);
- Integration with BMS (the ability to control via smartphone, voice commands, or according to predefined scenarios—for example, automatic closing when the air conditioner is turned on);
- Safety (systems are equipped with obstacle sensors, which prevents pinching; they can be integrated with biometric access systems—fingerprint scanners).

Table 2 below provides characteristics of flagship systems.

Table 2. Flagship Systems of Leading International Manufacturers (Compiled Based on [3, 11])

Manufacturer	Model	Key Features	Max. Sash Weight	Max. Height	Min.Interlock Width
Aluprof (Poland)	MB-Skyline Type R	Lift-and-slide, concealed frame, automation possible	1200 kg	4 m	25 mm
Schüco (Germany)	ASE 80.HI	Lift-and-slide, high thermal insulation (Passive House), Smart Close soft-closing system	500-600 kg	3.5 m	~40 mm
Sepalumic (France)	4300	Lift-and-slide system for large-scale apertures	300 kg	3 m	106 mm
Yawal (Poland)	Moreview	Lift-and-slide, concealed frame, extra-large custom sizes	1200 kg	4 m (up to 6 m)	27 mm
Airclos (Spain)	S220 RPT	Folding-sliding (“accordion”) with thermal break, minimalist design	200 kg	4.5 m	74 mm

The complexity and variety of modern aluminum systems require a structured approach to their selection, one that goes beyond a simple comparison of catalog data. Based on the analysis conducted, it is advisable to formulate recommendations for architects and engineers.

Thus, the problem of selecting the optimal system often comes down to finding a compromise between the desired percentage of aperture opening and the requirements for hermeticity. The novelty of the proposed approach lies in strictly tying the system type to the operating conditions. For objects located in regions with severe winters, as well as for glazing in residential premises (bedrooms, living rooms), it is advisable to prioritize lift-and-slide systems with high thermal resistance ratings. Their superior hermeticity minimizes heat loss and eliminates air infiltration.

Folding-sliding solutions (“accordions”), despite their ability to completely open the aperture, are appropriately used in milder climates or for unheated and seasonally used spaces (such as terraces, verandas, restaurants) where thermal insulation requirements are not as critical, and the ability to transform the space is key.

The next recommendation concerns the integration of barrier-free access in the early stages of design. Creating a flush threshold is a standard for modern architecture, but its implementation requires careful coordination. When choosing a lift-and-slide system, it is necessary to incorporate structural recesses for recessing the bottom frame during the design phase of foundations and floors. This solves the problem both aesthetically and functionally, ensuring compliance with accessibility standards for people with limited mobility. Neglecting this stage makes the subsequent integration of a flush threshold practically impossible without costly modifications.

Another suggestion is related to viewing automation as a standard for large-scale structures. As the mass of sashes increases, manual operation becomes uncomfortable—it sometimes leads to premature wear of the hardware. For sashes weighing over 250-300 kg, an automatic drive should be considered not as an option, but as a necessary component of the system. This impacts the comfort of operation, ensures the correct and safe functioning of the mechanics, and extends the service life of the entire structure. Systems with automation concealed in the frame (as in premium solutions like Yawal Moreview or Schüco) are seen as preferable from an aesthetic standpoint.

The justification for the recommendations provided above lies in the plane of preventive engineering—they are aimed at preventing common operational problems and achieving a long-term balance between the architectural expression, functionality, and energy efficiency of the building.

CONCLUSION

The analysis conducted has shown that modern aluminum sliding systems represent a science-intensive product existing at the intersection of materials science, precision mechanics, and digital technologies. Their evolution reflects fundamental shifts in the architectural paradigm, where transparency, energy efficiency, and human comfort are prioritized. There is a move away from simple and compromising solutions in favor of high-tech lift-and-slide and highly specialized folding-sliding systems. The dominant trends defining the appearance of advanced products from leading global manufacturers are the striving for "invisibility" of the structures by minimizing profiles and their concealed installation, as well as the achievement of outstanding thermal insulation indicators comparable to passive building standards. The possibility of integrating sashes weighing over a ton and spanning several stories, controlled via a smartphone, has ceased to be a futuristic concept—it is an engineering reality.

The recommendations formulated in the article possess practical significance, as specialists are offered a clear decision-making algorithm based on the analysis of climatic conditions, functional purpose, and durability requirements, which allows for the optimization of the system choice for a specific project.

Prospects for subsequent research in this field lie in several directions. First, the study and implementation of new materials (for example, carbon-fiber-reinforced composites, which can offer even higher strength at a lower mass). Second, the development of frameless systems based on structural glazing with sliding elements, including those using innovative principles similar to magnetic levitation. Third, a deeper integration of sliding systems into the overall building management system (BMS), which helps to adapt their position and degree of opening in real-time depending on weather conditions, time of day, etc. Solving these tasks will allow the next step to be taken in creating the adaptive, sustainable architectural environment of the future.

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