Preserving the Past, Modeling the Future: A Retrofit Framework for the Sava Center in Belgrade

Suncica Milosevic[1], Ajla Aksamija[2]
[1] University of Kansas, School of Architecture and Design, Lawrence, United States
[2] University of Utah, School of Architecture, College of Architecture and Planning, Salt Lake City, United States
suncica.milosevic@ku.edu, ORCID: https://orcid.org/0000-0003-2251-6545
ajla.aksamija@utah.edu

Abstract: The Sava Center in Belgrade is one of the most iconic architectural and cultural landmarks of *Yugoslav Modernism*. Built between 1976 and 1979, it functioned as a major congress and cultural venue, embodying ideals of civic ambition, technological innovation, and public accessibility. With its monumental Brutalist aesthetic and an all-encompassing spatial program, it remains a uniquely significant example of the region's architectural innovation and technological advancement.

This research presents a performance-based retrofit framework for historically significant buildings of this scale and typology, using the Sava Center as a hypothetical case study. Developed through a multi-method approach - bridging architectural history, building science, and digital performance modeling - the study demonstrates how design, technology, and heritage values can be aligned to improve energy performance without compromising architectural and cultural integrity. Methods include archival research, BIM modeling, hygrothermal and thermal envelope simulations (Revit, WINDOW, THERM, WUFI), and whole-building energy analysis (IES VE). Results suggest that the proposed design strategies could reduce energy use by over 50% while preserving the building's original character, programmatic intent, and civic function.

Initiated in 2021, the study coincided with actual renovations to the Sava Center's Congress Hall building following its simultaneous privatization and designation as a cultural heritage site. These interventions, though aimed at energy efficiency, were completed rapidly, with minimal transparency and significant programmatic changes. Although the renovations concluded before the study's completion, the presented case study remains a critical reference for more systematic and preservation-sensitive retrofits.

In a region where too many significant buildings built between 1945 and 1991 are being rapidly privatized and, unfortunately, demolished, this framework helps illuminate the substantial potential for their protection - both through cultural heritage designation and sensitive, energy-efficient renewal. This research introduces the overarching framework, key findings, and policy implication, with future work to expand on detailed analysis.

Keywords: Brutalist architecture; energy-efficient retrofitting; cultural heritage preservation; building performance modeling; adaptive reuse; Western Balkans

1 Introduction and Background

The Sava Center, originally named *Dom Prijateljstva* (Hall of Friendship), stands as one of the most significant architectural and cultural landmarks of Yugoslav Modernism (Sobajic et al. 2011). Designed by Serbian architect Stojan Maksimović (1934-2024) and constructed between 1976 and 1979, it was conceived as a bold, multipurpose complex to host the 1977 Conference on Security and Cooperation in Europe (CSCE) in Belgrade - a diplomatic summit of global importance during the Cold War (Cultural Monument Protection Institute of Belgrade 2021; Sobajic et al. 2011). This ambitious project marked a critical moment for Yugoslavia, aimed at positioning its capital among major Western European cities and reinforcing its leadership in the Non-Aligned Movement.

The complex consists of four interlinked structures: *Building A* (Main Administrative and Congress Center), *Building B* (Congress-Concert Hall), *Building C* (Crowne Plaza Hotel), and *Building D* (Pasarela – the connecting passageway). Formally, the Sava Center exemplifies late Yugoslav Brutalism, realized through reinforced concrete and steel, with glazed pyramidal forms, sloped curtain walls, concrete brise-soleils, cascading terraces, and planted roof gardens. Yet, it also subtly anticipates emerging High-Tech and Postmodernist influences, seen in its color-coded mechanical systems, lush interior gardens, exposed piping, and user-focused design features reminiscent of Stirling, Roche, Piano, and Rogers (Mrenovic 2016). **Figure 1** illustrates the Sava Center's complex exterior at the time of its realization and diagrams its four interconnected buildings. **Figure 2** shows the complex's colorful interior spaces, with intentionally exposed and color-coded mechanical systems, and its integration of interior green spaces.

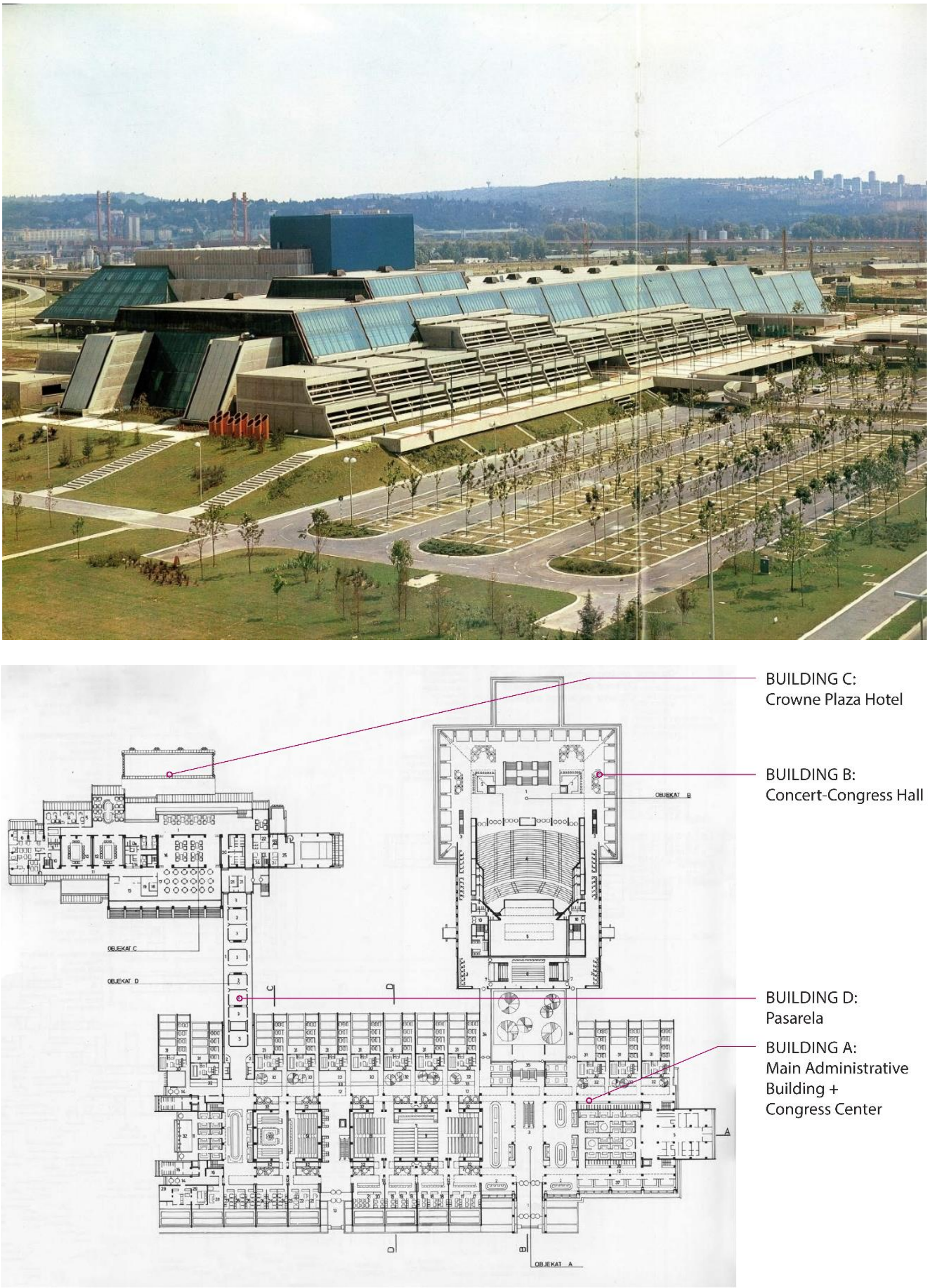


Figure 1: Historical photograph of Sava Center (Draskovic and Bogunovic 1977) and a plan diagram of its interlinked building components (Mrenovic 2016).

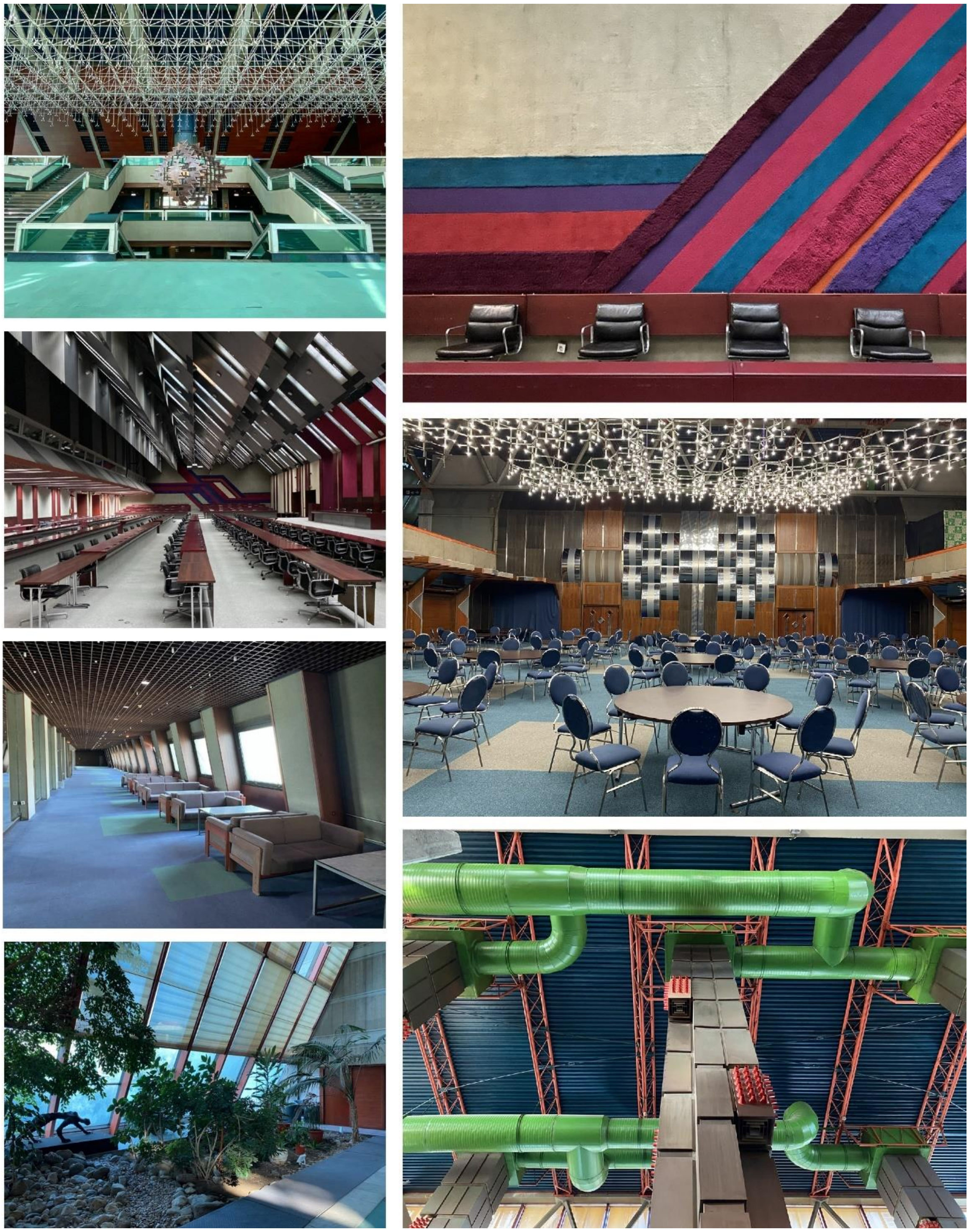


Figure 2: Pre-renovation photos of the colorful interior finishes at Sava Center's *Building A* – Main Administrative Building and Congress Center and *Building B* – Congress-Concert Hall (personal archive 2021).

Beyond its architectural language, the building's programmatic design was remarkably expansive. *Building A* alone includes three plenary halls, numerous delegation suites, office spaces, retail boutiques, restaurants, cafés, exhibition galleries, and informal lounges—functioning as a civic and commercial "*city within a city*" (Draskovic and Bogunovic 1977). This is detailed in **Figures 3 and 4** which are derived from original construction drawings at the Historical Archive of Belgrade, as *Building A* analysis is the primary focus for this study. Plans delineate a typical building module that was selected for detailed analysis. From inception, the Sava Center was intended to serve both formal functions and the everyday urban life of Belgrade residents. Its indoor greenery, multi-level circulation routes, and transparent atrium-like layout were not merely aesthetic features but symbols of public access, visibility, and transparency.

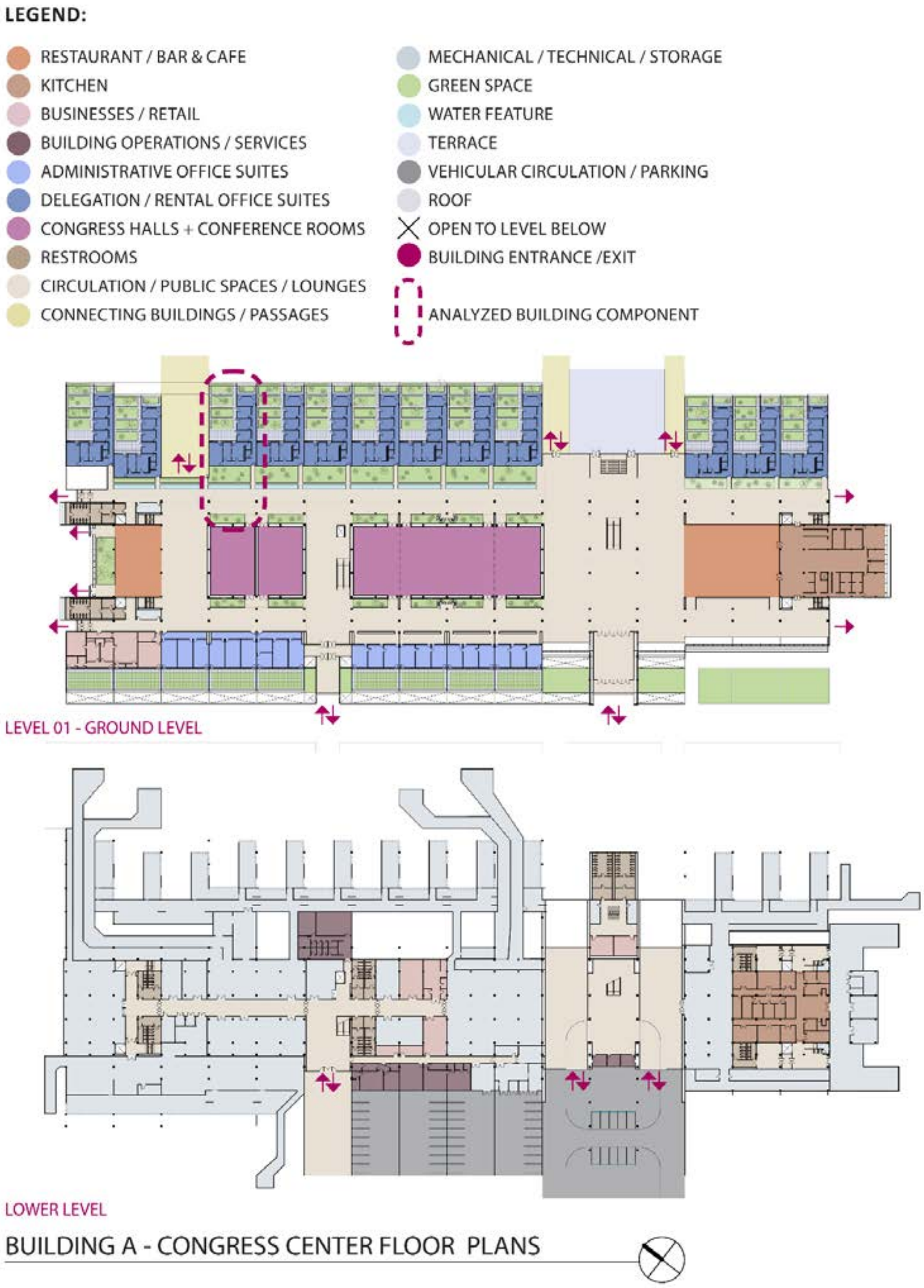


Figure 3: Detailed lower and ground level floor plans of Sava Center’s *Building A* – Main Administrative Building and Congress Center (personal archive).

Figure 4: Detailed floor plans of the upper gallery levels of Sava Center's *Building A* – Main Administrative Building and Congress Center (personal archive).

The selection of New Belgrade as its site was equally intentional (Mrenovic, 2016; Perovic, 2020). This post-war expansion of the city, first planned by the renowned Serbian architect and urban planner Nikola Dobrović (1897-1967) in the late 1940s, was imagined as a modernist counterpoint to the historic core across the Sava River. Initially criticized for being a "*dormitory city*" lacking cultural life, New Belgrade was redefined by the Sava Center's completion, which brought a new magnetism to the area (Vujosevic et al., 2023). From hosting global political events to serving as a hub of local social life, the complex offered both monumental symbolism and everyday functionality.

Each phase of the project reflected both its design ambition and political urgency. The first phase, *Building A*, was designed and constructed in under a year, providing more than 50,000 m² of adaptable space just in time for the CSCE; subsequent phases added the 3,700-seat concert hall in 1978 and the 500-room hotel in 1979, further solidifying the complex's capacity to host high-profile international events and visitors (Mrenovic 2016; Perovic 2020). Maksimovic's work earned national and international acclaim, with the Sava Center receiving the prestigious October Award (1977), Borba Award (1978), and a nomination for the inaugural Pritzker Architecture

Prize in 1979. Later, after the collapse of Yugoslavia in 1991, Sava Center was awarded the Grand Award ("*Velika nagrada"*) by the Serbian Society of Architects (Brakocevic and Mucibabic 2015; Mrenovic 2015; Politika 2021).

Politically, the Sava Center encapsulated the ambitions and contradictions of Yugoslav socialism. It was both a showcase of national technological prowess and a highly symbolic site. The collapse of the federation began here with Slovenia's withdrawal from the League of Communists during the 1990 congress; it later hosted events marking the fall of Slobodan Milošević in 2000, cementing its status as a stage for pivotal political transformations (Vujosevic et al. 2023).

Building A's spatial flexibility was key to its enduring relevance. As shown in **Figure 3**, the ground floor includes three large, reconfigurable plenary halls and extensive administrative and commercial facilities that are surrounded by internal "streets", green spaces, and water features – representing a "*city within a city*" concept (Draskovic and Bogunovic 1977) that was meant to be a prime location for citizens and tourists alike and be an inclusive public hub (Vujosevic et al. 2023). The upper gallery levels contain modular office suites, exhibition spaces, and a press center – all with intentional visibility of activities below, while the basement served to primarily house complex mechanical systems and support services. The building's characteristic administrative suite cells, totaling 33 across the building, were designed as modular, self-contained, and adaptable spaces; each including private terraces, individualized environmental controls, and moveable partitions (see **Figures 3 and 4**).

The architectural design emphasized clarity and accessibility. Circulation routes were arranged as transparent pedestrian "*streets*," with generous communal zones, visual connectivity across levels, and carefully designed separation of vehicular and pedestrian access (Draskovic and Bogunovic 1977). Outdoor green areas and tiered parking zones (shown in Figure 1) were carefully integrated into the urban fabric, emphasizing ecological sensitivity and user comfort. In total, approximately 3,000 m² of interior green space was incorporated, including planted terraces and an indoor artificial creek, reinforcing the complex's identity as a human-scaled, livable environment.

Despite its historic and cultural significance, the Sava Center faced periods of neglect and financial strain following the Yugoslav wars. By the early 2000s, its operations had declined sharply. In 2020, the City of Belgrade sold Buildings A and B to a private developer—already owner of the hotel component—triggering widespread public concern. In response, the Serbian government designated the complex as a cultural heritage site, marking the first time a socialist era building in Serbia received such status (Cultural Monument Protection Institute of Belgrade 2021).

By late 2023, *Building A* had undergone extensive retrofitting, reportedly improved energy efficiency while preserving the original aesthetic. Triple glazing, HVAC system upgrades, and rooftop PV panels were among the improvements implemented (Kecmanovic et al. 2024) and although performance data is limited, the building received LEED Gold certification, suggesting substantial sustainable strategies. *Building B* is expected to follow suit.

Despite lack of transparency and public engagement in the process, Sava Center's transformation into a preserved, retrofitted cultural monument offers a promising model for similar post-war modernist structures across the region. This was the very first building constructed during the former Yugoslavia's socialist period that achieved cultural heritage recognition in Serbia (Cultural Monument Protection Institute of Belgrade 2021). Its historical significance, formal adaptability, and new energy-efficient upgrades position it as a prime case study for heritage-sensitive retrofitting. This paper focuses on case-study analysis of Sava Center's *Building A*, applying performance modeling and retrofit simulation to demonstrate how architectural integrity, cultural values, and sustainability goals can be reconciled in future renovations of Yugoslav-era buildings.

2 Research Methods and Analytical Framework Overview

The overarching goal of this research was to develop and propose a qualitative and quantitative framework through which existing buildings, including buildings of cultural heritage value, can be carefully retrofitted into high-performing, sustainable buildings that retain their original design qualities and emphasize the importance of protection of both formal and spatial features that are unique to their specific context and culture. While presenting a detailed, case-by-case approach – the goal of this framework is that once completed for several similar case studies (of similar typology, construction type, and in similar cultural and geographic context), it may be scalable and applied more broadly to systematically address a larger number of similar buildings.

This study employed a combination of archival and observational research to investigate the Sava Center's *Building A* original design intent and current performance. Primary sources included original architectural documentation, construction drawings, and published literature. These materials were used to analyze key architectural features, assess the building's present condition and function, and inform the development of a full Building Information Model (BIM) in Revit software. **Table 1** summarizes the extensive archival and empirical data collection and **Figure 5** diagrams the overarching analysis framework and workflow, structured into four main research phases: (1) archival and empirical research; (2) BIM modeling and environmental analysis; (3) building envelope performance analysis; and (4) whole-building energy simulation – which result in quantitative benchmarking of existing and retrofit energy-use against current policy requirements.

Table 1: Archival and empirical data collection summary for Sava Center complex in Belgrade, Serbia.

***Sava Center*, Belgrade, Serbia**				
Date	***Data Type***	***Source***	***Citation***	***Comments***
August 30 - September 2, 2021.	Exterior and interior photographs of all *Sava Center* buildings and the general site.	Personal Archive	/	Extensive photographing of the exterior and interior building conditions in the Sava Center's three buildings (the Administrative Congress Center, Congress Hall, and Hotel). At the time data was collected on all three buildings before determining the scope of detailed analysis for this complex. The hotel building was already renovated, while the two main, originally public buildings were closed for initiated full-scope renovations.
September 3, 2021	Historical literature and postcards on *Sava Center.*	National Archive of Serbia	Popovic et al. 1980; Draskovic and Bogunovic 1977; Tomasevic et al. 1999.	Three detailed textbooks and historical postcards were located during this visit. Special permission was granted to digitize these publications for my ongoing reference and detailed analysis.
September 3-8, 2021.	Technical drawings and archival documentation on *Sava Center*'s *Building A – Main Administrative Building and Congress Center.*	Historical Archives of Belgrade	Directorate for Construction and Reconstruction of Belgrade. 1976a; Directorate for Construction and Reconstruction of Belgrade. 1976b.	Scanned files include construction drawings of floorplans, sections, elevations, and miscellaneous details, as well as supporting textual documents - particularly the project manual. Technical documents also included mechanical, electrical, plumbing, and ventilation drawings and diagrammed systems. Files included archival folders labeled 4, 5, 7(1), 7(2), 20, 4 and 6.
September 3-8, 2021	Technical drawings and archival documentation on *Sava Center*'s *Building B - Congress Hall.*	Historical Archives of Belgrade	/	Scanned files on this archival folder were not used in this research due to scope. Files included archival folders labeled 1, 2, 4, and 6.
September 3-8, 2021	Technical drawings and archival documentation on *Sava Center*'s *Building C - Hotel Intercontinental.*	Historical Archives of Belgrade	/	Scanned files on this archival folder were not used in this research due to scope. Files included archival folders labeled 1A, 1B, 2, 3, and 4.
September 3-8, 2021	Technical drawings and archival documentation on *Sava Center*'s *Building D – Pasarele.*	Historical Archives of Belgrade	/	Scanned files on this archival folder were not used in this research due to scope. Files included archival folders labeled 3 and 7.

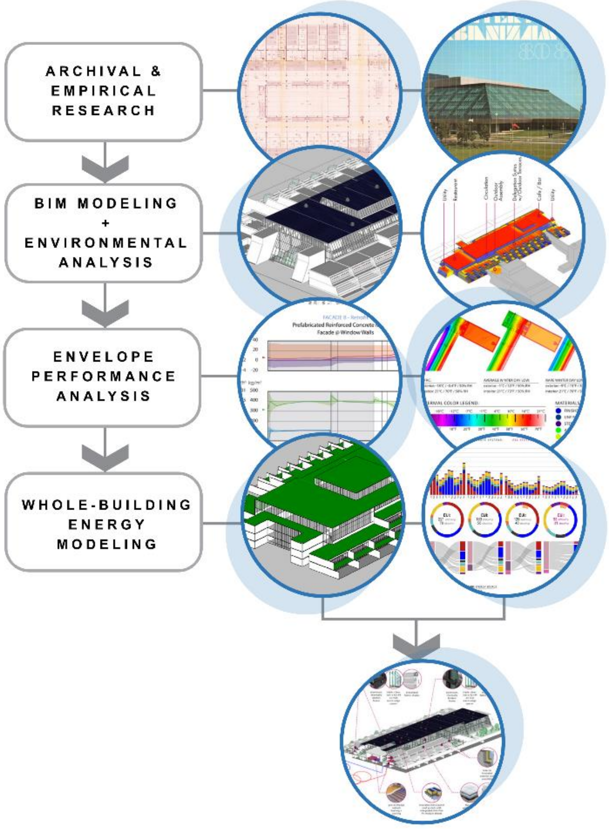


Figure 5: Framework diagram of the four general research methods.

This study began with extensive archival research and site observations to investigate the building's original design intent and current conditions. Primary sources included original construction drawings, project manuals, and published literature. These materials informed the development of a comprehensive Building Information Model (BIM) of Building A, created using Autodesk Revit.

The BIM model served as the basis for creating typical building enclosure sections, which were evaluated for thermal and moisture performance. Opaque facade systems were assessed using manual R-value calculations, while glazed systems were analyzed using the standard U.S. National Fenestration Rating Council (NFRC) WINDOW and THERM software procedures (NFRC 2017) to determine their overall U-factor values. These analyses produced a complete assessment of the building enclosure's thermal performance, which was compared to the current 2022 edition of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) *Standard 90.1* (ASHRAE, 2022). This U.S. standard provides a widely adopted performance benchmarks for building enclosures suited to global climate zones.

For whole-building energy performance, the BIM was simplified and imported into IESVE energy modeling software to create an energy model. The model incorporated enclosure performance data together with zoning and mechanical system specifications. Simulations yielded Energy Use Intensity (EUI) values that were benchmarked against the EU Energy Performance of Buildings Directive (EPBD) and the 2021 recast proposal (European Parliament and Council of the European Union 2018; European Commission 2021). The EPBD requires that, when buildings undergo major renovation, energy performance be upgraded to minimum standards. It promotes deep renovation and a transition away from fossil-fuel energy sources, and it recognizes heritage constraints by allowing adapted or exempt requirements for buildings of special architectural or historic merit (European Parliament and Council of the European Union 2018; European Commission 2021). In parallel, the EU Taxonomy—establishing sustainability criteria to support the European Green Deal—defines "renovation of existing buildings" as either meeting the EPBD definition of major renovation or achieving a ≥30% reduction in primary energy demand (PED), validated by Energy Performance Certificates (EPCs) and excluding on-site renewables from the 30% calculation (European Commission 2021a; European Parliament and Council of the European Union 2020). As a practical design target, deep renovations should therefore aim to meet or exceed the ≥30% energy use reduction threshold (European Commission 2021a).

Regarding national regulation in Serbia, responsibilities are split between two ministries. The Law on Efficient Use of Energy (Ministry of Mining and Energy) provides the general legal framework, while the Rules on Energy Efficiency of Buildings (Ministry of Construction, Transport and Infrastructure) set specific performance benchmarks and methodologies (Official Gazette of the Republic of Serbia 2013; Official Gazette of the Republic of Serbia 2011). Revisions are underway, supported by a 2021 Serbia–UNDP agreement to improve energy efficiency in public-sector buildings (UNDP 2022). Although Serbia enforces its own regulations, they closely follow EU directives, align with relevant EN and ISO standards, and are typically applied in post-design compliance checks.

In contrast, this research adopts ASHRAE 90.1-2022 for envelope benchmarks and the EPBD recast's overarching goals at the design phase, to provide a globally transferable, user-friendly reference for early decision-making and cross-case comparison (ASHRAE 2022; European Commission 2021). Once optimized at this stage, proposed retrofit strategies can be aligned with national and local regulations for final validation and implementation.

The overarching long-term goal of this research is to develop a scalable, performance-based retrofit framework for existing buildings, particularly those with cultural heritage value, that balances improved energy performance with preservation of architectural character. The aim is to support the systematic renewal of under-protected, historically significant buildings across post-socialist regions and help influence policy decisions that align with protecting and renewing the many examples of similarly exemplary buildings.

3 Case Study Analysis and Results

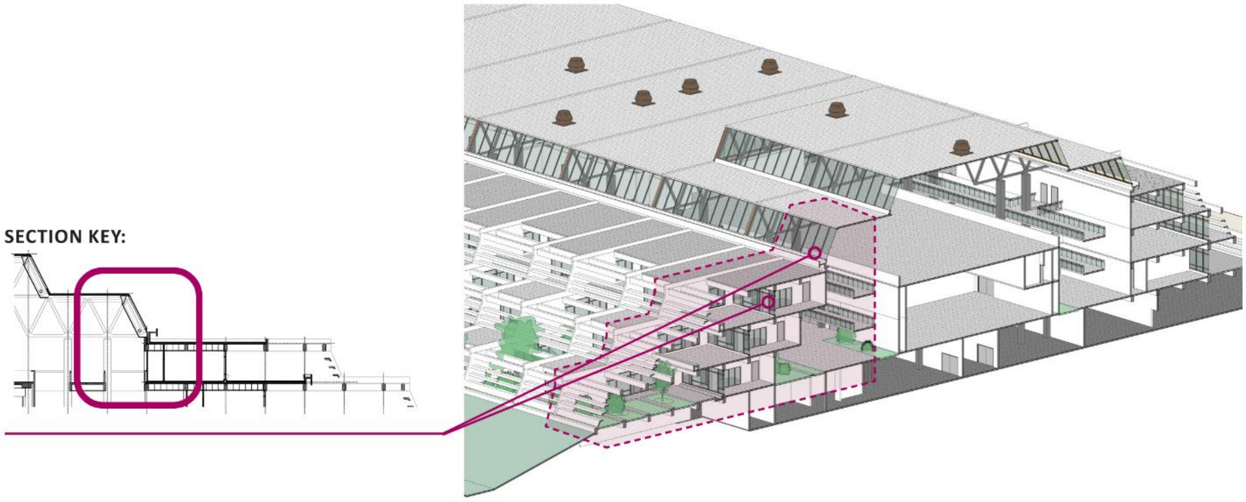


Figure 6: Illustration and key section of the Sava Center's *Building A* – Main Administrative Building and Congress Center's typical facade system (personal archive).

Building A of the Sava Center complex was selected for detailed analysis as the focal point of this study. Known as the Main Administrative and Congress Center, this building served as the original phase of the Sava Center development (Brakocevic and Mucibabic 2015). Based on the architectural and programmatic analysis of *Building A*, a typical modular office suite—representing one of the most frequently repeated spatial units within the building—was selected for detailed envelope analysis, as it was representative of the building's most implemented glazed and opaque building facade systems. This area includes private terraces and different types of roof systems, making it a representative test unit for broader envelope-level interventions. These areas of analysis are illustrated in **Figure 6**. In addition to the envelope, the study considered the implications of active system upgrades, including HVAC zoning, lighting efficiency, and potential integration of renewable systems such as rooftop PVs, while preserving the aesthetic character of the original architectural elements.

3.1 Existing Opaque Enclosure Systems

Building A combines prefabricated and cast-in-place reinforced-concrete wall assemblies, all augmented with interior thermal, acoustic, and moisture-control layers that contradict Brutalist stereotypes of uninsulated concrete. Typical prefabricated exterior walls were comprised of reinforced concrete, "*Thoroseal"* waterproofing, rigid insulation, and an interior brick masonry leaf. Cast-in-place variants combined reinforced concrete, "*Thoroseal*" waterproofing, perlite-insulated masonry, and various interior finishes such as plaster, wood paneling, ceramic tile, or gypsum board (Directorate for Construction and Reconstruction of Belgrade 1976a). Below-grade concrete masonry unit (CMU) walls integrated continuous waterproofing layers with protective masonry. Meanwhile, roof systems included insulated metal panels (IMPs) above the sloped glazed volumes and flat reinforced-concrete roofs over modular office "*cells*," all specified with vapor barriers, polyurethane insulation, bituminous sloping layers such as bitumoperlite, and a light-colored "*Repanol*" waterproofing chosen for visible stepped terraces (Directorate for Construction and Reconstruction of Belgrade 1976b). Occupied terraces added concrete pavers and acoustic ceilings beneath the slab. Noise control was prioritized through elastic pads at mounted equipment, multi-stage attenuation in ductwork, and robust partition insulation, enabling performance to NR30 (~35 dB) (Directorate for Construction and Reconstruction of Belgrade 1976b). Archival documentation demonstrates that careful attention was paid to implementing thermal, moisture-resistant, and sound insulation as passive methods.

3.2 Existing Glazed Enclosure Systems

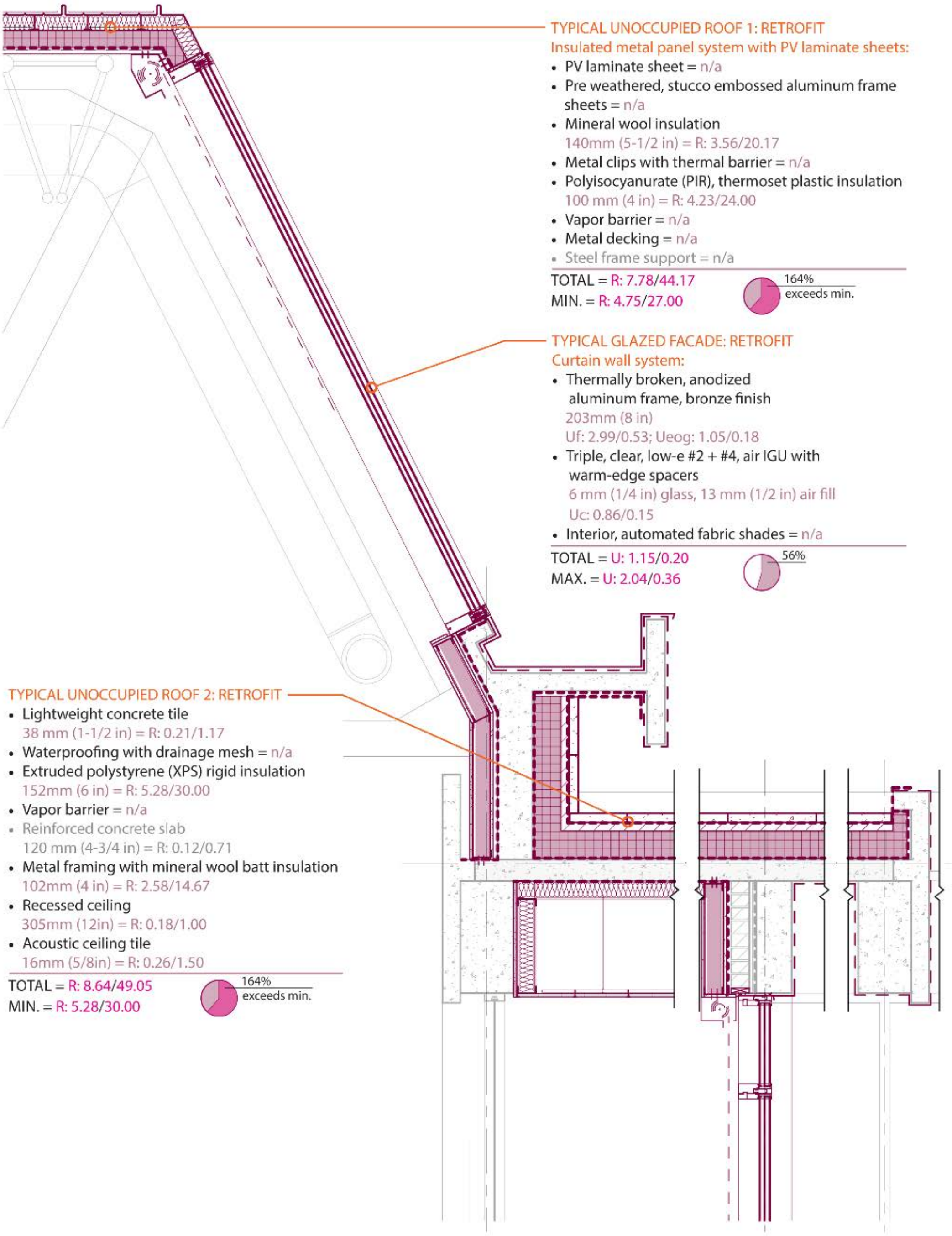
Two primary glazed facade systems characterized the enclosure of Building A: (a) the expansive surfaces of sloped curtain walls, characterized by their green-tinted, double air insulating glazing unit (IGU) glazing and bronze-finish aluminum frames supported by an interior frame matrix of structural steel tubes which were painted in bright red, and (b) the vertical, floor-to-ceiling window walls that are characterized by clear, double air-IGU glazing and matching bronze-finish aluminum frames (Directorate for Construction and Reconstruction of Belgrade 1976a and 1976b). The tinted glass was a novel passive measure estimated to deflect about 40% of solar heat gain (Draskovic and Bogunovic 1977), supplemented by remotely controlled "*Griesser Soloscreen*" blinds of steel-wool, PVC coated textile to reduce glare while maintaining daylight and views. Administrative office suites were additionally shaded by stepped roof overhangs and distinctive concrete brise-soleil walls which further reduced direct solar exposure and provided visual privacy for the office spaces and their terraces (Directorate for Construction and Reconstruction of Belgrade, 1976a, 1976b). The implementation of tint, overhangs, interior blinds, and brise-soleil walls reflected the designers' and engineers' high awareness of the need for passive reduction of energy use for this enormous, glass-jewel-box building, and their awareness that such a vastly glazed atrium would require significant energy in summer and winter conditions (Draskovic and Bogunovic 1977).

3.3 Existing Mechanical Systems

Sava Center's mechanical design exemplified early High-Tech architecture, with exposed, color-coded installations reflecting the "*urban machine*" aesthetic of contemporaries like the Pompidou Center (Tomasevic et al., 1999). Systems were supplied via Belgrade's district hot-water network for heating and on-site chillers for central air distribution (Draskovic and Bogunovic 1977). The building was divided into four zones: (1) plenary halls isolated within double walls, served by single-zone, low-pressure constant air volume (CAV) systems; (2) modular administrative suites, each conditioned on demand with variable air volume (VAV) systems concealed above recessed ceilings; (3) the vast glazed atrium requiring own VAV conditioning through both basement mechanical rooms and rooftop AHUs, with intentionally exposed, brightly colored ductwork incorporating integrated vacuum and sound distribution systems; and (4) basements, which used steam radiators and natural or mechanical ventilation, with no cooling (Draskovic and Bogunovic 1977). Outdoor air was supplied through below-grade concrete plenums to mechanical rooms, with orange-painted, tall intake stacks marking the system in the landscape (Draskovic and Bogunovic 1977). Together, these technologies demonstrated remarkable environmental awareness for the 1970s and a commitment to user comfort, contradicting later generalizations that Brutalist structures neglected energy efficiency or acoustic performance (Vujosevic et al. 2023).

3.4 Proposed Building Enclosure Systems

Passive retrofit strategies, illustrated and detailed in **Figures 7 and 8**, focused on improving envelope performance while minimizing visual and material disruption. Thermal resistance R-values of solid assembly systems were manually calculated, referencing Aksamija (2013) and Stein et al. (2006), while the U-factor values of the glazed assembly were calculated using WINDOW and THERM software. Detailed tables and figures that illustrate full scope of tested glazing systems will be included in more technical future publication. **Table 2** provides the ASHRAE 90.1–2022 benchmarks for this climate zone and building type.



TYPICAL UNOCCUPIED ROOF 1: RETROFIT

Insulated metal panel system with PV laminate sheets:

- PV laminate sheet = n/a
- Pre weathered, stucco embossed aluminum frame sheets = n/a
- Mineral wool insulation
  140mm (5-1/2 in) = R: 3.56/20.17
- Metal clips with thermal barrier = n/a
- Polyisocyanurate (PIR), thermoset plastic insulation
  100 mm (4 in) = R: 4.23/24.00
- Vapor barrier = n/a
- Metal decking = n/a
- Steel frame support = n/a

TOTAL = R: 7.78/44.17
MIN. = R: 4.75/27.00

164% exceeds min.

TYPICAL GLAZED FACADE: RETROFIT

Curtain wall system:

- Thermally broken, anodized aluminum frame, bronze finish
  203mm (8 in)
  Uf: 2.99/0.53; Ueog: 1.05/0.18
- Triple, clear, low-e #2 + #4, air IGU with warm-edge spacers
  6 mm (1/4 in) glass, 13 mm (1/2 in) air fill
  Uc: 0.86/0.15
- Interior, automated fabric shades = n/a

TOTAL = U: 1.15/0.20
MAX. = U: 2.04/0.36

56%

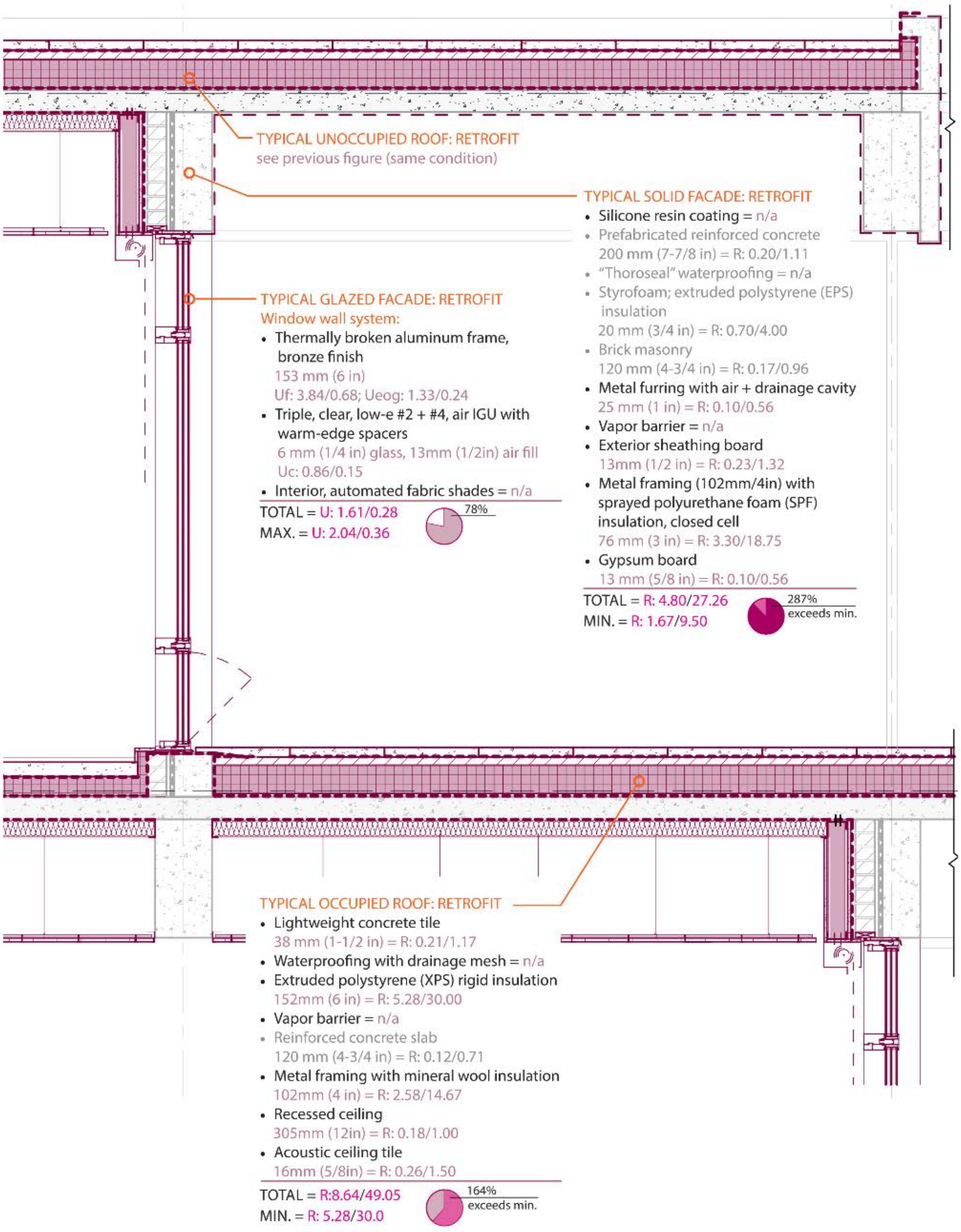
TYPICAL UNOCCUPIED ROOF 2: RETROFIT

- Lightweight concrete tile
  38 mm (1-1/2 in) = R: 0.21/1.17
- Waterproofing with drainage mesh = n/a
- Extruded polystyrene (XPS) rigid insulation
  152mm (6 in) = R: 5.28/30.00
- Vapor barrier = n/a
- Reinforced concrete slab
  120 mm (4-3/4 in) = R: 0.12/0.71
- Metal framing with mineral wool batt insulation
  102mm (4 in) = R: 2.58/14.67
- Recessed ceiling
  305mm (12in) = R: 0.18/1.00
- Acoustic ceiling tile
  16mm (5/8in) = R: 0.26/1.50

TOTAL = R: 8.64/49.05
MIN. = R: 5.28/30.00

164% exceeds min.

Figure 7: Detailed illustration and thermal performance summary of the proposed retrofit building enclosure at the Sava Center's *Building A* typical glazed atrium condition (personal archive).



TYPICAL UNOCCUPIED ROOF: RETROFIT
see previous figure (same condition)

TYPICAL GLAZED FACADE: RETROFIT
Window wall system:

- Thermally broken aluminum frame, bronze finish
  153 mm (6 in)
  Uf: 3.84/0.68; Ueog: 1.33/0.24
- Triple, clear, low-e #2 + #4, air IGU with warm-edge spacers
  6 mm (1/4 in) glass, 13mm (1/2in) air fill
  Uc: 0.86/0.15
- Interior, automated fabric shades = n/a

TOTAL = U: 1.61/0.28
MAX. = U: 2.04/0.36
78%

TYPICAL SOLID FACADE: RETROFIT

- Silicone resin coating = n/a
- Prefabricated reinforced concrete
  200 mm (7-7/8 in) = R: 0.20/1.11
- “Thoroseal” waterproofing = n/a
- Styrofoam; extruded polystyrene (EPS) insulation
  20 mm (3/4 in) = R: 0.70/4.00
- Brick masonry
  120 mm (4-3/4 in) = R: 0.17/0.96
- Metal furring with air + drainage cavity
  25 mm (1 in) = R: 0.10/0.56
- Vapor barrier = n/a
- Exterior sheathing board
  13mm (1/2 in) = R: 0.23/1.32
- Metal framing (102mm/4in) with sprayed polyurethane foam (SPF) insulation, closed cell
  76 mm (3 in) = R: 3.30/18.75
- Gypsum board
  13 mm (5/8 in) = R: 0.10/0.56

TOTAL = R: 4.80/27.26
MIN. = R: 1.67/9.50
287% exceeds min.

TYPICAL OCCUPIED ROOF: RETROFIT

- Lightweight concrete tile
  38 mm (1-1/2 in) = R: 0.21/1.17
- Waterproofing with drainage mesh = n/a
- Extruded polystyrene (XPS) rigid insulation
  152mm (6 in) = R: 5.28/30.00
- Vapor barrier = n/a
- Reinforced concrete slab
  120 mm (4-3/4 in) = R: 0.12/0.71
- Metal framing with mineral wool insulation
  102mm (4 in) = R: 2.58/14.67
- Recessed ceiling
  305mm (12in) = R: 0.18/1.00
- Acoustic ceiling tile
  16mm (5/8in) = R: 0.26/1.50

TOTAL = R:8.64/49.05
MIN. = R: 5.28/30.0
164% exceeds min.

Figure 8: Detailed illustration and thermal performance summary of the proposed retrofit building enclosure at the Sava Center’s *Building A* typical office suite condition (personal archive).

Table 2: Building enclosure thermal performance requirements for nonresidential buildings located in ASHRAE Climate Zone 4A (ASHRAE 2022).

Building Type	**ASHRAE** ***Standard 90.1 (2022)***
Non-residential	*Energy Standard for Sites and Buildings Except Low-Rise Residential Buildings.*
Opaque Enclosure Elements	***Min R-Value with continuous insulation*** *(m^2-°K/W / h-ft^2-°F/Btu)*
Roofs	
With insulation entirely above deck:	5.28 / 30.0
Metal building:	4.75 / 27.0
Walls	
Mass, above grade:	1.67 / 9.5
Mass, below grade:	1.32 / 7.5
Floors	
Mass, interlevel:	2.57 / 14.6
Slab-on-grade:	2.64 / 15.0
Transparent Enclosure Elements	***Max. U-Factor for all frame types + all orientations*** *(W/m^{2}K / Btu/h-ft^2°F / % SHGC)*
Fenestration	
Fixed:	2.04 / 0.36 / 36%
Operable:	2.55 / 0.45 / 33%
Door:	3.58 / 0.63 / 33%

These overarching, passive building enclosure strategies included the following strategies:

a) **Opaque wall system upgrades:** For the opaque facade upgrades, the proposed retrofit strategies include additional internal insulation with own light-framing system and waterproofing layers that provide for a well-insulated and ventilated assembly that enhances both thermal and moisture performance. An interior facing approach was necessary for this building to preserve its exposed concrete character. A 25 mm (1 in) air and drainage cavity with metal furring channels is first added, with small perforations in the existing concrete to promote evaporation and ventilation. This is followed by a conventional metal-framing system filled with closed-cell spray polyurethane (SPF) insulation, sheathing, and protected with a more porous vapor barrier to avoid moisture entrapment, since waterproofing already exists within the original wall assembly. The assembly is finished with interior gypsum board, while the exposed concrete surfaces receive a silicone resin coating to improve moisture resistance. Applied to prefabricated solid facades, this strategy yields an R-value exceeding ASHRAE 90.1–2022 minimums by **187%** and **116%** for its two types of opaque building facades (ASHRAE 2022).

b) **Roof and terrace system upgrades:** Roof gardens and exterior terraces were upgraded with additional thermal insulation below and above the substrate. For the flat roofs of the administrative office suites, the retrofit strategy removes the existing insulation and replaces it with high-performance extruded polystyrene (XPS) rigid insulation. In cases where office space is located below, the roof assembly is further enhanced with mineral wool insulation beneath the structural concrete slab and finished with recessed acoustic tile ceilings to improve interior comfort. Both unoccupied and occupied roofs are topped with lightweight concrete tiles to provide a cohesive exterior appearance. This upgrade achieves an R-value that exceeds ASHRAE 90.1–2022 minimum requirements by **64%** (ASHRAE 2022). For the atrium volumes, the existing IMP roofs are proposed to be replaced with advanced IMP systems with integrated thin-film solar technology. This approach allows for substantial energy savings and on-site renewable generation while maintaining the building's low-profile silhouette and avoiding visually intrusive photovoltaic panels that could compromise its protected architectural character. With integrated polyisocyanurate (PIR) and mineral wool insulation, the upgraded panels achieve an R-value that exceeds ASHRAE 90.1–2022 roof requirements also by **64%** (ASHRAE 2022).

c) **Glazed facade system upgrades:** For the glazed facades, the retrofit strategy proposes replacing all systems with high-performance, thermally broken aluminum frames fitted with clear, triple glazed, low-e coated glass types and warm-edge spacers. Since the original green tint served only a performance function, present-day low-e coatings can achieve superior solar control without altering transparency or color. This allows the building to regain its intended conceptual character as a luminous "*glass-enclosed city*" while also unifying its aesthetic and reducing costs through standardized glazing specifications. With this upgrade, the curtain wall achieves an overall U-factor that meets **78%** of the ASHRAE 90.1–2022 maximum requirement, while the window wall overall U-factor meets **56%** of the maximum requirement (ASHRAE 2022). Proposing entirely new glazing systems that integrate high-performing, thermally broken aluminum frames, high-performing glass, and warm-edge glass spacers was necessary as previous studies by authors determined that glazed system performance is only ensured and best optimized when all three of these major components are considered together (Aksamija and Milosevic 2023).

d) **Shading devices:** The building's original concrete brise-soleils were preserved with proposed replacement of interior roller shades. Due to the historic significance of this building, exterior shading devices at the sloped curtain wall systems were not considered and not necessary at the already shaded glazed window walls.

3.5 Proposed Mechanical Systems

Together with the results of building enclosure analysis, different mechanical systems were simulated using IESVE to assess potential energy use reductions and complement envelope improvements. A total of five energy models were simulated, including the following existing and retrofit scenarios, with their results summarized in **Figure 9**:

- **Model 1 (Existing – Central HVAC)** represents the as-built condition with district-supplied hot water for heating and hot water consumption, steam radiators, centralized air-distributed HVAC for plenary, office, and atrium zones, and electrically powered chillers for cooling, while basement spaces relied on radiators, limited ventilation, and no cooling.
- **Model 2 (Retrofit – Enclosure Systems)** implements all proposed enclosure upgrades but retains the original mechanical systems to measure performance gains from envelope improvements alone.
- **Model 3 (Retrofit – Enclosure + Mechanical Systems)** combines enclosure upgrades with high-efficiency versions of the original zoned mechanical systems, including centralized HVAC, steam radiators, and mechanical ventilation in basements, with the critical difference that district hot water is assumed to be supplied by natural gas, reflecting Belgrade's recent transition to natural gas. It includes allowable lighting savings per ASHRAE 90.1–2022 minimums for each space type and thin-film PV technology renewable energy source.
- **Model 4 (Retrofit – Enclosure + Advanced Mechanical Systems)** incorporates the same enclosure, lighting, and PV upgrades but replaces the centralized HVAC system with a geo-exchange system paired with active chilled beams and electric heat pumps for heating, cooling, and ventilation.

Although the natural-gas-based high-efficiency HVAC of Model 3 represents a practical and environmentally improved option that capitalizes on existing infrastructure, the most optimal results were achieved in **Model 4**, where the geo-exchange and chilled beam system delivered the lowest energy use, greatest efficiency, and highest environmental benefit. In addition, this scenario best aligns with the building's original conceptual intent of showcasing the most advanced technologies available while ensuring long-term sustainability, comfort, and quiet operation. Energy use intensity (EUI) and energy distribution by source for all scenarios are summarized in **Figure 9**.

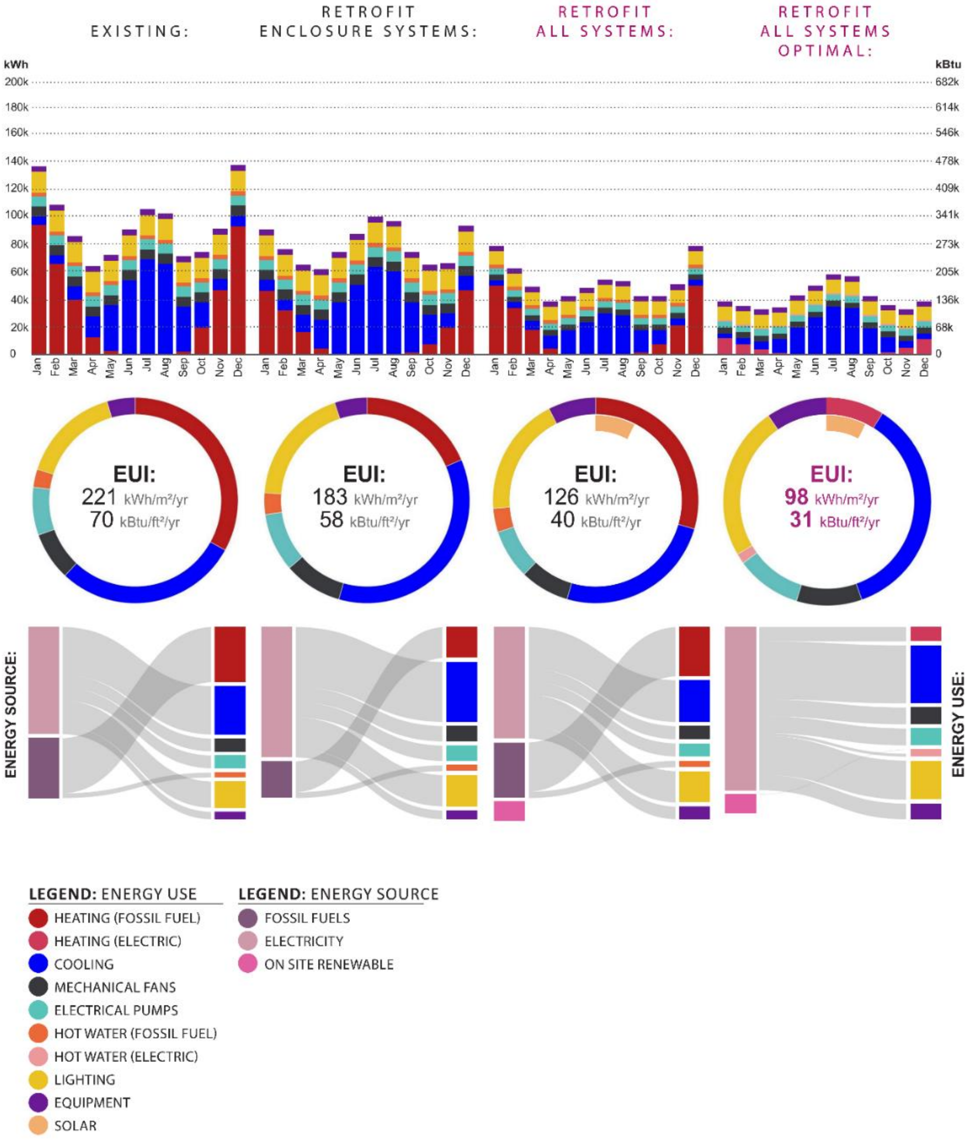


Figure 9: IES VE full-building energy-use simulation results for existing and retrofit scenarios.

4 Study Results and Policy Implications

Results show that the proposed retrofit strategies for Building A of the Sava Center can substantially reduce operational energy use while preserving key architectural features. By combining robust envelope upgrades with high-efficiency mechanical systems and minimal-impact interventions, the building's simulated Energy Use Intensity (EUI) falls by over 50% relative to baseline—surpassing the EU Taxonomy criterion for renovation of existing buildings (≥30% primary energy demand reduction) and aligning with the EPBD deep-renovation objectives (European Commission 2021a; European Parliament and Council of the European Union 2018, 2020). These results demonstrate that heritage-status buildings can undergo deep renovation to achieve both preservation quality and performance levels typically associated with new construction, while avoiding demolition and reaffirming the building's historic value.

The retrofit of the Sava Center's Building A presents valuable insights into how energy efficiency goals and cultural heritage preservation can be reconciled in large-scale, late-modernist buildings. This case study illustrates not only the technical feasibility of performance-based retrofitting but also the critical need for supportive policy frameworks, transparent planning processes, and heritage-sensitive design approaches, particularly in post-socialist contexts where such buildings are often politically contested and vulnerable.

4.1 Heritage Protection and Policy Gaps

Until recently, buildings from the Yugoslav socialist period (1945–1991) have remained largely absent from formal heritage protection frameworks across the Western Balkans. Despite their monumental architectural significance and cultural symbolism, many have been subjected to neglect, ad hoc renovations, or demolition—often following privatization. The Sava Center's designation as a cultural monument in 2021 marked a major precedent. This decision, which followed widespread public concern after its sale to a private investor, reflects a growing awareness of the need to preserve late-20th-century architectural heritage before it disappears. However, the designation only provides partial protection and was implemented after privatization had already occurred. This sequence of privatization followed by emergency heritage intervention illustrates a broader policy gap - the absence of preventive planning instruments that proactively evaluate, designate, and guide the renewal of architecturally significant buildings before they are put at risk.

4.2 Retrofit as a Tool for Cultural Continuity

The Sava Center example highlights how energy-efficient retrofitting can serve as a vehicle not just for environmental performance, but for the cultural continuity of buildings that embody national, political, and social histories. Rather than treating these buildings as outdated relics, the overarching retrofit analysis framework presented here recognizes them as adaptive urban assets that can continue their originally envisioned civic function while meeting current sustainability and performance goals. In this context, retrofitting complements restoration rather than being a fully divergent process. This approach also challenges the assumption that heritage protection must freeze a building in time. Instead, it promotes a model of dynamic stewardship where performance upgrades are carefully layered into the existing structure to support its long-term function.

4.3 Applicability to Regional and Global Contexts

The framework developed in this study, particularly its hybrid use of ASHRAE and EPBD performance benchmarks, is designed to be transferable beyond the specific regulatory context of Serbia. Many countries in Southeastern and Eastern Europe share similar typologies of state-built, large-scale public infrastructure projects from the socialist era. These buildings often share concrete and steel hybrid structures, modular and repetitive plan geometries, deep floor plates and complex HVAC systems, and poor glazing system performance with high energy demand. Moreover, many share similar ownership where they have become a burden to actively maintain and upgrade by their inheriting local and national governing bodies, where they are in dire need of renovation. By anchoring retrofit performance benchmarks in international standards while tailoring design interventions to building-specific needs, the framework can be replicated across other regions and provide a uniform comparative baseline.

5 Policy Recommendations and Conclusion

This case study demonstrates the urgent need for an integrated policy approach that bridges energy efficiency, cultural heritage, and post-socialist urban development. Based on the findings, four key policy directions are recommended:

- Early identification of high-value heritage assets: Many post-war modernist buildings are now approaching their fifth decade and soon will meet criteria for heritage eligibility. Establishing a registry of these buildings, coupled with policies that limit major alterations prior to potential privatization or sale, can safeguard them from premature or inappropriate interventions.
- Guidelines for retrofitting socialist-era modern heritage: As this case study illustrates, buildings from this period rarely require "freezing" preservation in the traditional sense. However, unregulated retrofitting risks erasing their authentic architectural character, functions, and programs. A clear set of retrofit guidelines is needed to balance cultural integrity with necessary upgrades, ensuring that interventions enhance rather than diminish architectural value.
- Economic incentives for retrofitting: Deep energy-efficient renovation is often dismissed as prohibitively costly, particularly for already privatized buildings where unforeseen technical challenges deter investment. This financial disincentive has led to the demolition of exemplary works of modernist architecture—an irreversible loss of cultural heritage. To counteract this, national and municipal governments must provide targeted funding, tax incentives, and technical assistance to support retrofitting of significant public buildings, particularly those in active use or under threat.
- Public inclusion and data transparency: Public access to post-retrofit performance data should be prioritized to enable broader learning, replication, and accountability. In the case of the Sava Center, the retrofit ultimately achieved LEED Gold certification and substantial energy improvements, yet the process was marked by limited transparency. This raises pressing questions about the balance between private investment, public oversight, and cultural protection. Future policy must proactively address these tensions with instruments that ensure openness and accountability.

This paper has presented a performance-based retrofit framework for culturally significant buildings, using the Sava Center's Building A in Belgrade as a detailed case study. = Through archival research, BIM modeling, thermal simulations, and whole-building energy analysis, this study has shown that deep retrofitting of historically significant structures is both technically feasible and culturally responsible. Simulation results suggest that proposed envelope and systems upgrades could reduce energy use by more than 50%, far surpassing current EU renovation targets. Importantly, these gains were achieved while retaining the building's defining architectural elements and spatial logic—demonstrating that preservation and performance need not be mutually exclusive. The framework developed here is intentionally scalable and transferable. It offers a replicable methodology for evaluating and retrofitting other post-war modernist buildings across Southeastern Europe and comparable contexts, where architectural heritage is often undervalued yet holds significant potential for adaptive reuse. Beyond technical outcomes, this research contributes to the wider discourse on aligning energy policy and heritage protection in regions where public policy is fragmented and narratives of the socialist past remain politically contested.

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