Measured baseline and calculated retrofit potential for energy and indoor environmental quality (IEQ) in a reconstructed historic municipal office building in Riga

Guna Bebre[1], Aleksejs Prozuments[1], Anatolijs Borodinecs[1], Arturs Palcikovskis[1] and Nika Kotovica[2]

[1] Institute of Sustainable Building Materials and Engineering Systems, Faculty of Civil and Mechanical Engineering, Riga Technical University, Riga, Latvia
[2] Riga Municipal Agency "Riga Energy Agency", City of Riga, Riga, Latvia

guna.bebre@rtu.lv

RIGA TECHNICAL UNIVERSITY

D → C
Energy class: from Class D to upper Class C

−35%
Total final energy (≈580 MWh per year)

−75–80 t
CO_2 per year (≈212 → 135 t/year)

~90%
of occupied hours within EN 16798 Category II

12–15 pp
of the saving from HVAC optimisation alone – no visible change

Post-retrofit values are calculated with a model calibrated against metered data; the measures are not yet implemented.

1 Context and aim

Reconstructed historic buildings are a distinct, little-studied heritage category: a modern structure behind façades that reproduce a lost historical building. The protected value is the **historical image and townscape**, not original fabric.

The Riga City Hall complex (UNESCO Historic Centre of Riga) was completed in 2003 behind a reconstruction of the 18th–19th-century town hall façade, destroyed in 1941. **Aim:** quantify baseline deficiencies and calculate a retrofit package compatible with preservation requirements.

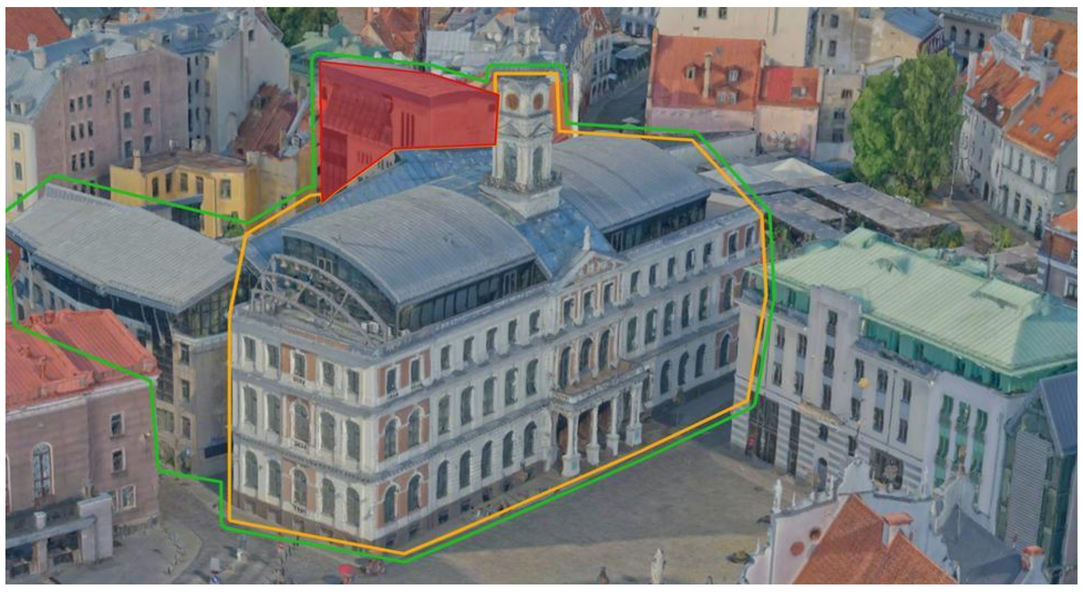


Figure 1. Riga City Hall complex (green), reconstructed historic façade on Town Hall Square (yellow) and the investigated building (red). Source: GEO RIGA [9].

2 Building and methodology



- **Contemporary rear block** of the protected complex, 2003
- **8 floors** · 11,800 m² heated · >39,000 m³
- **~200 occupants** daily
- **U_{avg} 0.80 W/m²K** vs 0.48 limit [14]
- **Glazed south elevation** without shading
- **5 AHUs**, 677 kW nominal, district heating

Figure 2. Courtyard elevations of the investigated building.

Metered data
2019–2024 heating invoices and electricity sub-meters

❯

HVAC audit
Feb 2024: air handling units, pumps, valves, controls

❯

IEQ monitoring
Feb & Jul 2025, five floors, vs EN 16798 Cat. II [7]

❯

Calibrated PHPP
EN ISO 52016-1 [8]; deviation <10% heat, <12% electricity

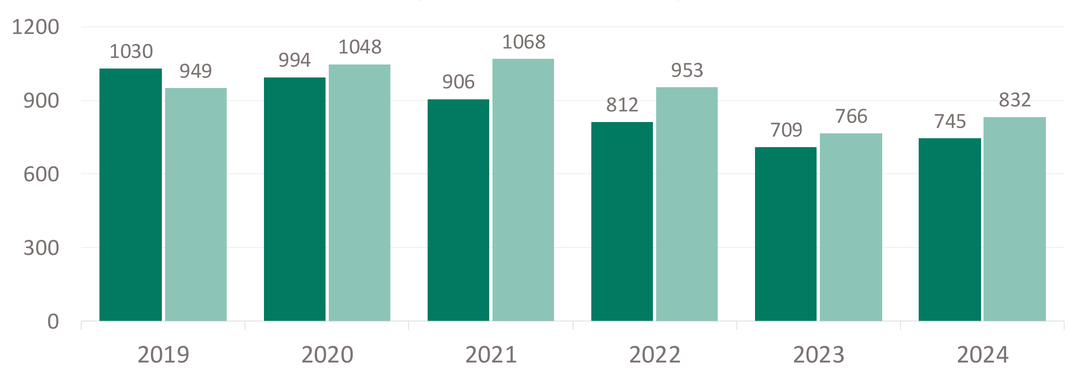


Figure 3. Annual metered heating and electricity, 2019–2024. The heating decline reflects milder winters and reduced COVID-19 occupancy, not upgrades.

3 Measured baseline

2024 energy audit: Class D – 93 kWh/m² space heating (limit 90 [14]), 141 kWh/m² total final energy, 22 kWh/m² cooling, ≈212 t CO_2/year.

Parameter	Winter (Feb 2025)	Summer (Jul 2025)
Globe temperature	23–24 °C; gradient 2–3 °C	28–31 °C near south façade
Relative humidity	14–19%	45–55%
CO_2	480–660 ppm (low occupancy)	>1200 ppm (enclosed offices)
Air temperature	22–24 °C	27–30 °C
Window-frame surface	13–16 °C	39–42 °C
Illuminance	200–450 lx	>2000 lx

Compliant Marginal Non-compliant

Table 1. Measured IEQ vs EN 16798-1 Cat. II [7]

HVAC audit findings

- **Heating coils:** 677 kW design, 548 kW datasheet; only 38 kW delivered in zones designed for 69–95 kW
- **All balancing valves fully open** – uncontrolled flow distribution
- **Oversized two-speed pumps** permanently at high speed
- **Fixed setpoints**, no outdoor compensation – simultaneous heating and cooling
- **Heat recovery 28.8%** vs 65–70% benchmark [15]

4 Heritage-compatible retrofit

Envelope
Appearance preserved
- 200 mm insulation; triple glazing U = 1.1 W/m²K
- Airtightness n50 5.0 → 2.0 h^{-1}
- −25–30% transmission heat losses

HVAC optimization
Internal – no visible change
- Hydronic balancing: +15% heat distribution efficiency
- Variable-speed pumps: −8–10% pump electricity
- CO_2/occupancy-controlled ventilation: −12% fan energy

Solar-control glazing
South units, g = 0.35
- −18–22% cooling demand
- Peak illuminance >2000 → <800 lx
- Glare exceedances removed at perimeter desks

Indicator	Baseline	Post-retrofit	Change
Space heating (kWh/m²·yr)	93	**60**	**−35%**
Space cooling (kWh/m²·yr)	22	**17–18**	**−18–22%**
Electricity (MWh/yr)	709–1068	**650–700**	**−12–15%**
Total final energy (kWh/m²·yr)	141 (D)	**92 (C)**	**−37%**
Primary non-renewable (kWh/m²·yr)	121 (B)	**95–100 (B)**	**−20%**
CO_2 emissions (kg/m²·yr)	19.7	**12.5–13**	**−35%**
Envelope U_{avg} (W/m²K)	0.80	**0.48–0.50**	**−40%**
Heat-loss coefficient H_T (W/m²K)	1.07	**0.65**	**−39%**
Ventilation heat recovery	28.8%	**65–70%**	**+35–40 pp**

Table 2. Baseline vs calculated post-retrofit performance (combined package).

Estimated IEQ: operative temperature in Cat. II for >90% of occupied hours (vs 20–25% overheating); CO_2 <1000 ppm in all zones; winter RH 30–35%; glare exceedances removed.

5 Lessons for heritage buildings

1. **Know what is protected.** Original fabric, historical image or townscape setting defines the acceptable measures; contemporary parts of a protected complex share its appearance requirements.
2. **Building services first.** HVAC measures deliver 12–15 pp of the ~35% saving without affecting protected values.
3. **Measure before modelling.** On-site audit and IEQ monitoring reveal faults – unbalanced hydronics, low heat recovery – that a normative calculation alone would miss.

Next steps: post-renovation monitoring to verify savings and IEQ, hourly overheating assessment of the south façade, heritage-acceptable solar shading, and cost-benefit analysis.

Co-funded by the European Union

SMARTeeSTORY

Acknowledgements. Co-funded by the European Union under Horizon Europe grant 101103956 (SMARTeeSTORY). Views and opinions expressed are those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.

[7] EN 16798-1:2019 Energy performance of buildings – Ventilation for buildings – Part 1. CEN.
[8] EN ISO 52016-1:2017 Energy needs for heating and cooling, internal temperatures and heat loads. ISO.
[9] Riga City Council. GEO RIGA geospatial portal, 3D reality model of Riga. georiga.lv
[14] Cabinet Regulation No. 280 (2019) LBN 002-19 Thermotechnics of Building Envelopes. Republic of Latvia.
[15] EN 13053:2006+A1:2011 Ventilation for buildings – Air handling units. CEN.

EEHB 2026
The 6th International Conference on Energy Efficiency in Historic Buildings
13-14 October 2026, Strasbourg, France



RÉPUBLIQUE FRANÇAISE
Liberté
Égalité
Fraternité

Cerema
CLIMAT & TERRITOIRES DE DEMAIN