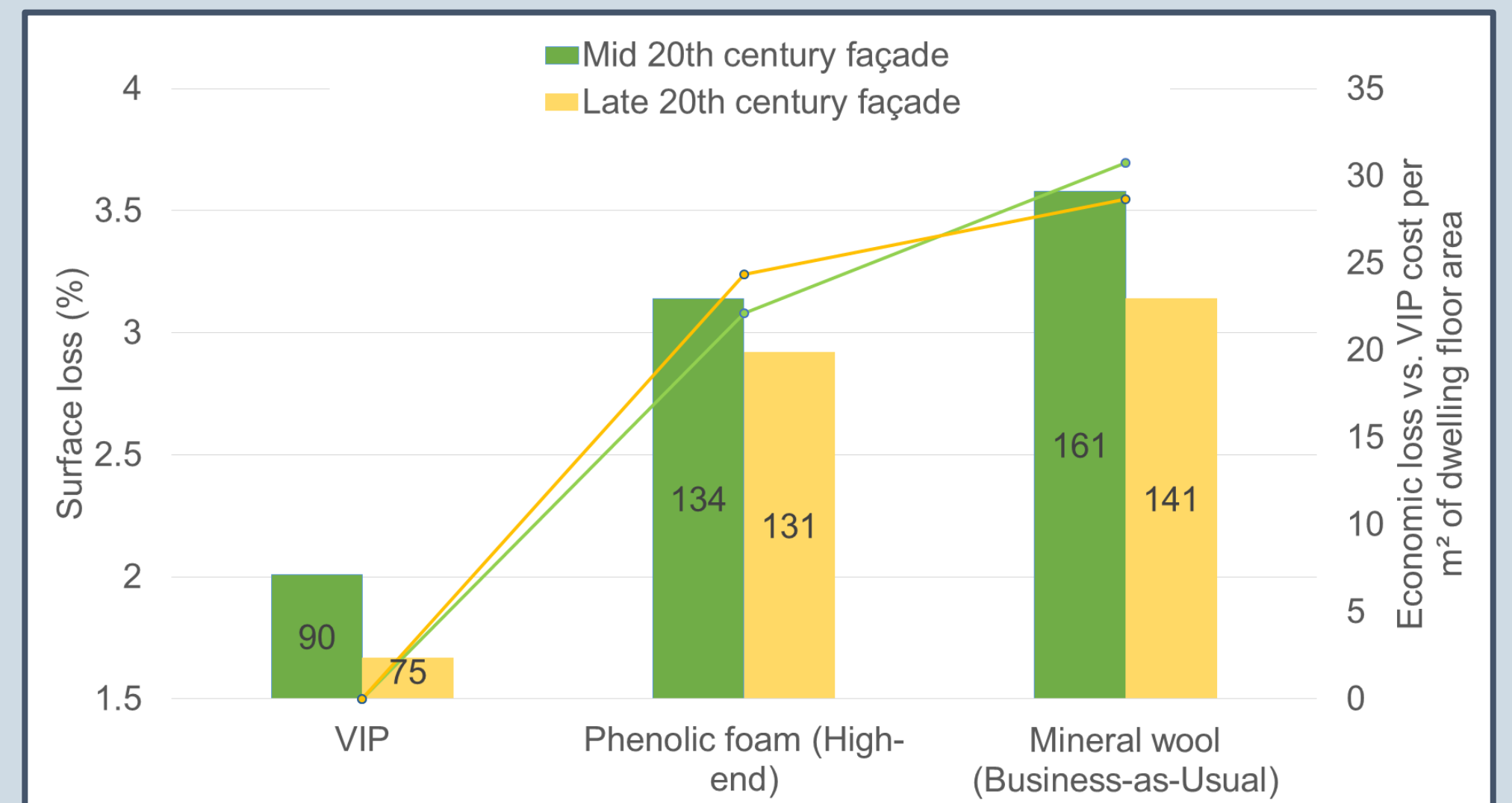


Enabling deep energy renovation in existing social housing through ultra-thin interior insulation and digital prefabrication

- **Deep renovation with minimal thickness:**
VIP-based interior façade achieves regulatory thermal performance with only 75–90 mm total build-up.
- **Space preservation:**
Usable floor-area loss is reduced by 43.9% compared to business-as-usual interior insulation.
- **Habitability ensured:**
The VIP solution is the only option that complies with room-size regulations in constrained dwellings.
- **Process efficiency:**
A scan-to-fabrication digital workflow reduces on-site installation time by 31%.

Figure 1. Space–thickness–cost trade-off of interior renovation solutions meeting the same energy-performance target.



Introduction

Deep energy renovation of existing housing is a key pathway towards the decarbonisation of the building sector, yet spatial and architectural constraints often limit feasible solutions. Exterior insulation can alter façade identity, while conventional interior insulation reduces usable floor area and may compromise habitability, particularly in social housing. High-performance materials such as Vacuum Insulation Panels (VIPs) enable **high thermal resistance with minimal thickness**, but require alternative construction approaches to ensure safe handling and buildability.

Methodology

This study develops and validates a **prefabricated interior façade system** integrating VIPs within a lightweight timber frame and a dedicated service cavity. The solution is implemented in a real **social-housing** case study in Pamplona (Spain). A digital workflow links **laser scanning, BIM modelling and panel optimisation to fabrication-ready outputs**, enabling accurate adaptation to existing geometries. Performance is **benchmarked** against mineral wool (business as usual) and phenolic foam (high-end) solutions designed to meet the same thermal target.

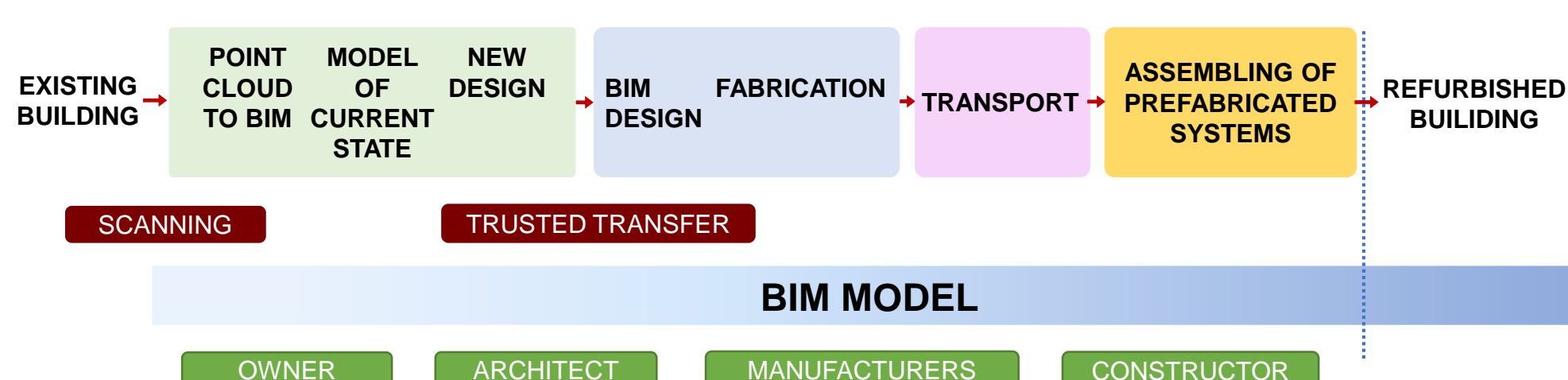


Figure 2. Specific flowchart of an integrated construction process.

Results

The VIP-based system achieves deep-renovation thermal performance with **total thicknesses of 75–90 mm**. In the case study, usable floor-area loss is limited to 2.01%, compared to 3.58% for mineral wool and 3.14% for phenolic insulation, representing **reductions of 43.9% and 36.0%**, respectively. Only the VIP solution preserves habitability room-size thresholds.

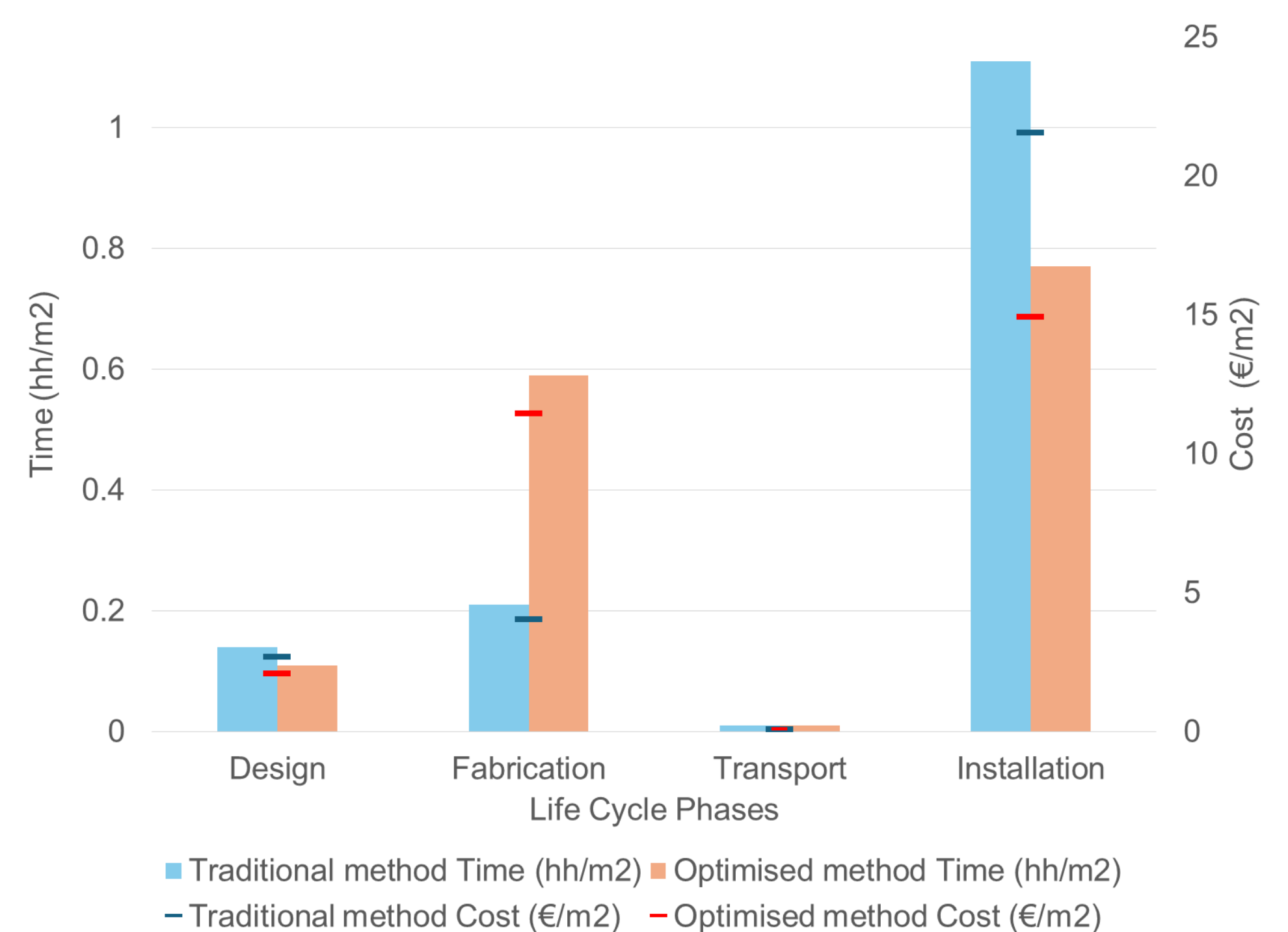


Figure 3. Comparative cost and time analysis of interior wall cladding.

From a process perspective, the digitalised workflow redistributes time and cost from on-site installation to off-site fabrication, reducing site labour, risks and indirect impacts. While **total cost and time remain comparable at pilot scale**, results indicate strong potential gains when scaled to serial renovation.

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