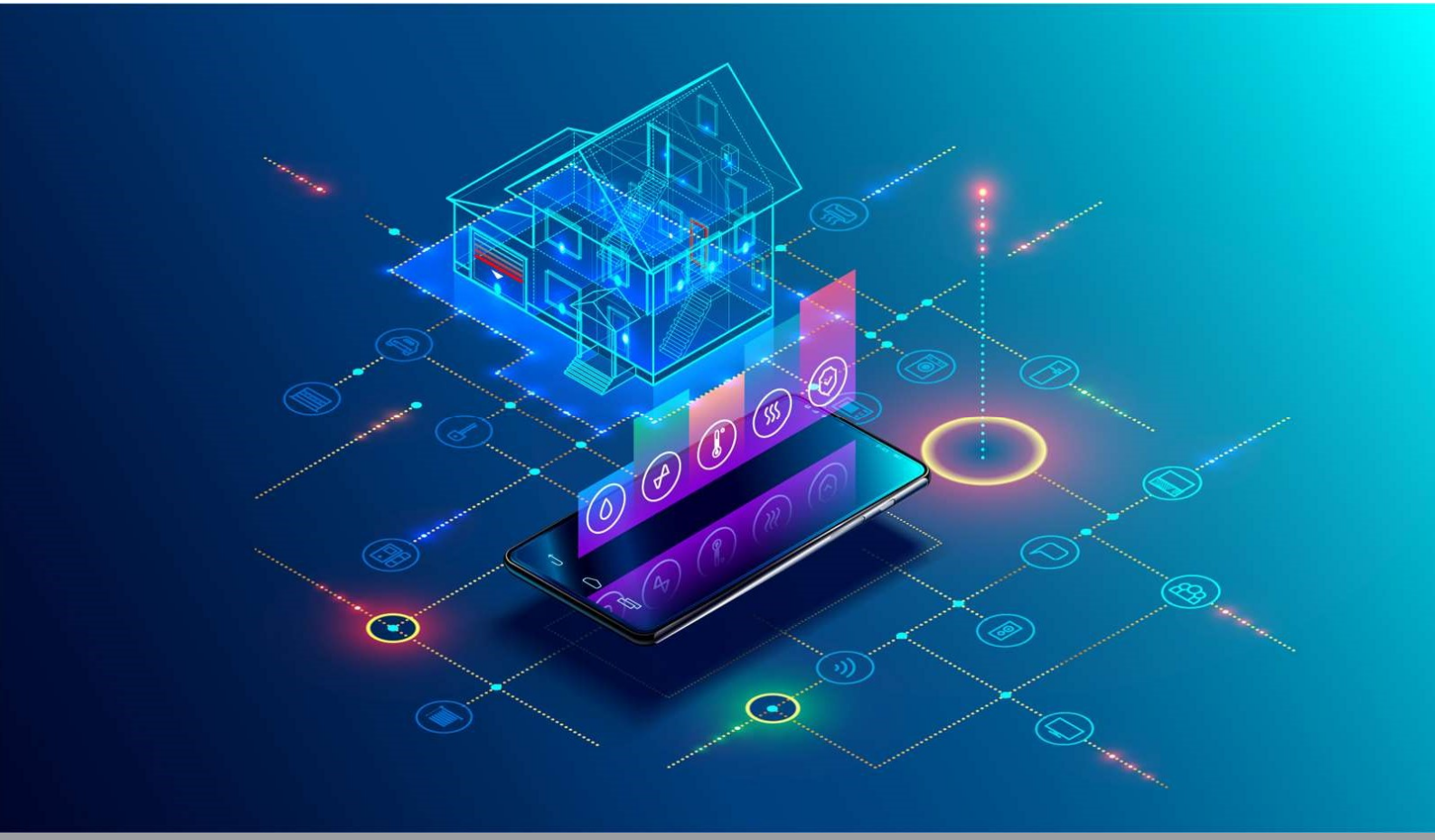
# Real demonstration results of BEM performance simulation using BIM-SPEED Toolset

## Deliverable 4.2 – Energy Performance Report – Lichtenrade demo



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BIM-SPEED
Harmonised Building Information Speedway for Energy-Efficient Renovation

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# ENERGY REPORT - LICTHTENRADE

## Deliverable 4.2 – Energy Performance Report – Lichtenrade demo

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| Produced by | TUB (Gallegos Garcia A. S.), RINA (Raggi E.) |
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## Colophon



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# 1. General information

## 1.1 Building description

"Lichtenrade" democase is a multi-story residential building located in Berlin, at Steinstrasse 42-43 in the neighborhood of Lichtenrade. Below the aerial photo of the site with an indicative view of the urban context.

Figure 1: Aerial view of the urban context and building location

The building consists of two separate structures (building 42 and 43), a basement, one ground floor and 6 upper floors with a total of 55 dwellings. The constructive characteristics of the building are consistent with the construction period and are characterized by not-insulated walls, reinforced concrete and brick mixed floors. Following photos shows the external view of the building.

Figure 2: External view of the building

Following a brief summary of the demo general data

Table 1: General information

| General information | |
|---|---|
| **Location** | Lichtenrade, Berlin (Germany) |
| **Use category** | Residential |
| **Building type** | Multi-story building |
| **Number of floors** | 7 |
| **Number of apartments/units** | 55 dwellings |

## 1.2 GIS and environmental data

Berlin is included in the available weather file list of EnergyPlus. Following a brief summary of the climate data.

Table 2: General environmental data

| General environmental data | |
|---|---|
| **Location** | Berlin (Germany) |
| **Weather file** | DEU_Berlin.103840_IEWC.epw |
| **Altitude [m]** | 50 |
| **Latitude [decimal]** | 52.397114 |
| **Longitude [decimal]** | 13.399792 |

# 2. Energy modelling

The building energy model of the demo was provided using directly the IDF Editor of Energy Plus. Therefore, the BIM-to-BEM process has not been applied. The BEM creation and the assessment of the renovation scenarios has been carried out in conjunction with 2 bachelor thesis and the demo has been used to assess different renovation scenarios and the decision-making-tool.

## 2.1 Description of BEM's technical features

Lichtenrade BEM consists of 55 dwellings. According to the structural inventory, building number 42 has a total of 1,389.47 m2/living-area while building number 43 has a living-area of 1,410.87 m2. There is a total of 2,800.34 m2/living-area, whereby half of the existing balcony areas were considered. At present, 9 of the apartments are empty and not occupied.

### 2.1.1 Envelope components and materials

This paragraph summarises the construction systems implemented within the Lichtenrade BEM to characterise the thermal behaviour of the building. Currently, the residential building complex consists of single- and double-glazed windows. The windowsills are mostly made of metal, whereas the frames of the windows are made of wood. The U-value of the different types of windows is altering between 2.490 W/(m2K) and 4.680

W/(m2K). Following table summarises the sizes of the existing single and double-glazed windows

Table 3: Area of the single- and double-glazed windows

| Name | Lenght (m) | Width (m) | Area ($m^2$) | Number of windows | Total Area ($m^2$) |
|---|---|---|---|---|---|
| Bath North (I) | 1.125 | 1.125 | 1.265625 | 4 | 5.0625 |
| Kitchen North (I) | 1.39 | 1.125 | 1.56375 | 4 | 6.255 |
| Kitchen South (I) | 1.15 | 1.02 | 1.173 | 4 | 4.692 |
| Room North | 2.025 | 1.505 | 3.047625 | 2 | 6.09525 |
| Room East | 1.885 | 1.51 | 2.84635 | 2 | 5.6927 |
| Room South | 1.71 | 1.48 | 2.5308 | 8 | 20.2464 |
| Balkony door | 0.74 | 2.35 | 1.739 | 56 | 97.384 |
| Room | 1.985 | 1.52 | 3.0172 | 24 | 72.4128 |
| Bath North (II) | 1.125 | 1.15 | 1.29375 | 24 | 31.05 |
| Kitchen North (II) | 1.39 | 1.15 | 1.5985 | 24 | 38.364 |
| Kitchen South (II) | 1.15 | 1.02 | 1.173 | 24 | 28.152 |
| Staircase (I) | 2.36 | 1.68 | 3.9648 | 12 | 47.5776 |
| Room South | 1.71 | 1.48 | 2.5308 | 48 | 121.4784 |
| Skylight | 1.41 | 0.46 | 0.6486 | 28 | 18.1608 |
| Staircase (II) | 2.36 | 0.84 | 1.9824 | 2 | 3.9648 |
| Summe | | | | 266 | **506.58825** |

The roof of the building complex is a flat roof with a slight slope. It is built in skeleton construction, whereby the rafters and square timber beams are made of wood. Oriented strand board (OSB) boards are fixed on top of the rafters. The bitumen membrane as the outermost layer seals the roof. Between the ceiling of the last floor and the roof is a large space in between filled with air.

### 2.1.2 HVAC systems

Regarding the HVAC systems, the building complex is conditioned by district heating. Each apartment is equipped by a single generator for the domestic hot water production. No cooling systems or mechanical ventilation systems are installed.

# 3. BEM calibration

The BEM has not been calibrated with the BIM SPEED new procedure (sufficiently detailed data were not available from both the energy bills side and the energy model side). The idf file provided by the development of a Master Degree's Thesis by a TUB student has been taken as a correct baseline on which different renovation scenarios were analysed within a further Bachelor Thesis (Lara Haidinger, Bachelor Thesis "Energy simulation supported Multi-Criteria Decision Making for building renovation design", Techniche Universitat Berlin, 11.02.2022).

# 4. Building energy performance simulation results

## 4.1 General considerations

The high energy consumption of the building is mainly due to the poor thermal properties of the building envelope. The building has therefore a great potential in terms of energy savings.

## 4.2 Energy KPIs

The following Energy KPI has been calculated according to D4.1 descriptions.

**BS.TEC: Total Energy Consumption**

Total Energy Consumption has been calculated directly using the simulation engine of Energy Plus. Following table summarises Primary energy consumption as documented within the Bachelor Thesis of Lara Haidinger (Techniche Universitat Berlin, 11.02.2022).

Table 4: BS.TEC Total Energy Consumption

| BS.TEC: Total Energy Consumption | |
|---|---|
| $EP_{TOT}$[kWh/m²] | **47.81** |

# 5. Building renovation scenarios

To perform and assess different building renovation scenarios EnergyPlus has been used taking the .idf file provided by the development of a Master Degree's Thesis by a TUB student has been as a reference for the baseline (actual state).

## 5.1 Renovation scenarios proposed

For the Lichtenrade democase, the windows and rooftop were deeply analysed to design the different renovation alternatives. The following scenarios have been assessed according to Task 7.1 premises.

- Scenario 01: windows replacement
- Scenario 02: rooftop insulation
- Scenario 03: windows replacement and rooftop insulation

To obtain the energy savings the annual energy consumption was first calculated. directly using the program 'EnergyPlus'. According to the U.S. Environmental Protection Agency (EPA), to have a convincing comparison of the different buildings, it is best to use the "Source Energy" provided by EnergyPlus as the unit of reference. It represents the total primary energy consumption plus all the delivery and production losses and consists of the total amount of raw fuel, which is necessary for the operation of the building (Energy Star, 2021).

## 5.2 Scenarios 1: description and results

For the first scenario all windows were replaced with triple-glazed windows. Since wooden windows entail high costs, the frames of the new windows are made of polyvinylchloride (PVC). The PVC frame is not only more cost-efficient but also more durable. To simulate the windows replacement and obtain the energy savings, the windows U-value has been changed directly in the idf file (EnergyPlus class: 'WindowMaterial: SimpleGlazingSystem'). In order to be compliant with the German Energy Saving Ordinance (EnEV), the existing window have been replaced with new windows characterised by a U-value of 1.30 W/(m²K).

The following KPIs have been taken directly from the Bachelor Thesis of Lara Haidinger (Techniche Universitat Berlin, 11.02.2022):

**BS.TEC: Total Energy Consumption**

Table 5: BS.TEC Total Energy Consumption

| BS.TEC: Total Energy Consumption | |
|---|---|
| $EP_{TOT}$[kWh/m²] | **43.94** |

**BS.TES: Total Energy savings**

Table 6: BS.TES Total Energy Savings

| BS.TES: Total Energy Savings | | | |
|---|---|---|---|
| | Baseline | Scenario 01 | SAVING |
| $EP_{TOT}$[kWh/m²] | 47.81 | 43.94 | 3.87 |

## 5.3 Scenarios 2: description and results

For the second scenario a mineral wool insulation was added between the rafters of the rooftop. For this purpose, a new object for the insulation was defined directly in the idf file (EnergyPlus class: 'Material:NoMass'). In order to be compliant with the German Energy Saving Ordinance (EnEV), that requires a $U_{max}$ of 0.24 W/(m²K), a R-value of 4.571 (m²K)/W was adopted.

The next step in EnergyPlus was to add insulation as an additional layer under the rooftop. Furthermore, another layer of OSB boards had to be applied to enclose and secure the insulation between the rafters. To prevent moisture from entering the roof and to seal the insulation, it is necessary to apply a layer of vapour barrier. This was not included in 'IDFEditor', as the layer is very thin, and the heat transfer can therefore be neglected.

The following KPIs have been taken directly from the Bachelor Thesis of Lara Haidinger (Techniche Universitat Berlin, 11.02.2022):

**BS.TEC: Total Energy Consumption**

Table 7: BS.TEC Total Energy Consumption

| BS.TEC: Total Energy Consumption | |
|---|---|
| $EP_{TOT}$[kWh/m²] | 47.10 |

**BS.TES: Total Energy savings**

Table 8: BS.TES Total Energy Savings

| BS.TES: Total Energy Savings | | | |
|---|---|---|---|
| | Baseline | Scenario 02 | SAVING |
| $EP_{TOT}$[kWh/m²] | 47.81 | 47.10 | 0.71 |

## 5.4 Scenarios 3: description and results

The third scenario consists in a combination of renovation scenario 01 and 02 with the replacement of triple-glazed windows and the insulation under the rooftop.

The following KPIs have been taken directly from the Bachelor Thesis of Lara Haidinger (Techniche Universitat Berlin, 11.02.2022):

**BS.TEC: Total Energy Consumption**

Table 9: BS.TEC Total Energy Consumption

| BS.TEC: Total Energy Consumption | |
|---|---|
| $EP_{TOT}$[kWh/m²] | 43.12 |

**BS.TES: Total Energy savings**

Table 10: BS.TES Total Energy Savings

| BS.TES: Total Energy Savings | | | |
|---|---|---|---|
| | Baseline | Scenario 03 | SAVING |
| $EP_{TOT}$[kWh/m²] | 47.81 | 43.12 | 4.69 |

# 6. Time reduction evaluation

The time reduction evaluation for the BIM-to-BEM process is not relevant from the Lichtenrade democase as the BEM was created with a traditional process using directly BEM software and not starting from a BIM model.