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

Deliverable 4.2 – Energy Performance Report – Warsaw I demo

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

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ENERGY REPORT – WARSAW I

Deliverable 4.2 – Energy Performance Report

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1. General information

1.1 Building description

Warsaw I democase consists of three large buildings connected into one bigger, with 294 apartments in total, located in a high-density area of Warsaw. Buildings are connected to the district heating system, which is covering space heating needs and delivers heat for domestic hot water production. Below the bird's eye view of the demo.

Figure 1: Aerial view of the Warsaw I demo

Following a brief summary of the demo general data

Table 1: General information

General information	
Location	Warsaw, Poland
Use category	Residential
Building type	Multi-family block
Construction year	1976
Renovation year	-
Number of floors	13
Number of apartments/units	294

1.2 GIS and environmental data

In order to apply proper environmental conditions to BEM, EnergyPlus weather file for nearest available location was included, which is POL_Warsaw.123750_IWEC. The external temperatures imported into the BEM model are showed in the following graph.

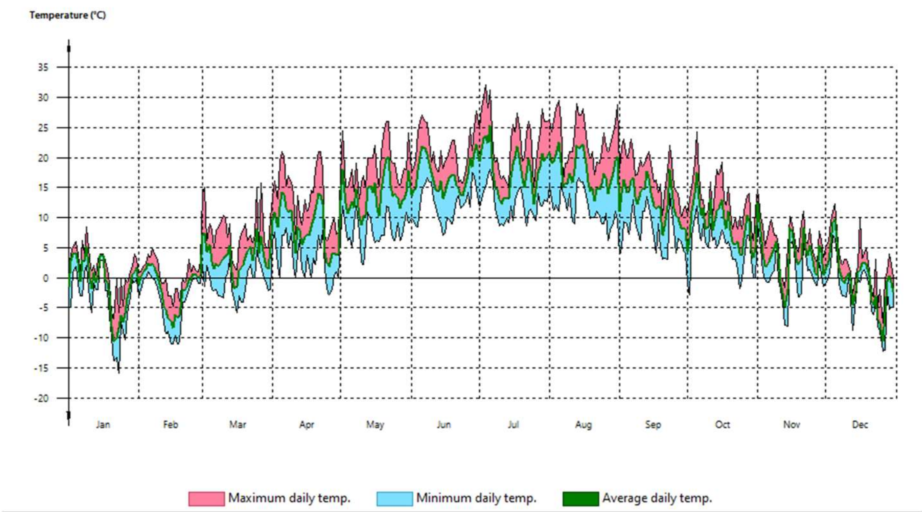


Figure 2: Minimum, maximum and average air temperature distribution

Error! Reference source not found. contains summary of general environmental data.

Table 2: General environmental data

General environmental data	
Location	Warsaw, Poland
Weather file	POL_Warsaw.123750_IWEC
Altitude [m]	100
Latitude [degrees]	52.1
Longitude [degrees]	21.1
Undistributed temp. of the soil [°C]	10.0
Network water temperature [°C]	15.0

2. Energy modelling

2.1 BIM-to-BEM procedure and software tools used

To complete the BIM-to-BEM process of Warsaw I demo case, the CYPETHERM-based procedure has been applied and the following tools have been used:

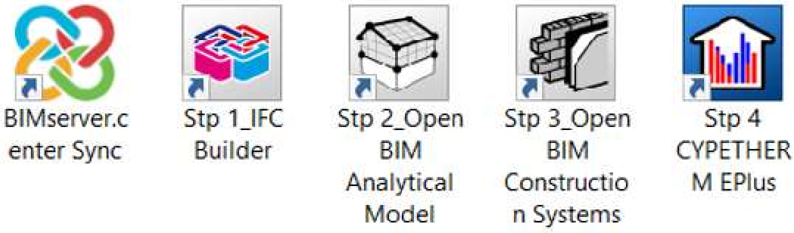


Figure 3: Software tools used to complete the BIM-to-BEM procedure

The BIM model was developed with Archicad software and a proper .idf file was exported directly with the tool's utilities. Following the BimSpeed guidelines, the .idf file was uploaded to BIMserver.center platform using the Ifc Uploader provided by CYPE. Then the Open BIM Analytical Model was used to generate the analytical model of the building. A few adjustments have been required:

- a slight geometry simplification of main entrance of the building
- the adjacencies identification for those surfaces which are not in contact with surrounding air, such as walls shared with the adjacent building next.

Last step in Open BIM Analytical Model was to create thermal spaces and assign them into groups differentiating by the room purpose and usage profile. The analytical model, once generated, has been exported once again in BIMserver.center and the project has been synchronized to be open within the Open BIM Construction Systems for the characterization of the building elements under the thermal point of view, defining all types of external and internal partitions, layer by layer, providing specific physical properties for each of them.

Model updated with construction data was uploaded once again to platform and fetched into Cypetherm Eplus, in order to complete the BEM with all thermal boundary conditions (e.g. rooms temperature profiles, lighting, ventilation, occupancy) and the HVAC systems.

2.2 Auditing procedures and data collection

Draft Building Information Model for the building was available before the project has started. The gathering of the data was performed through the on-site visit and discussion with the building owner.

2.3 Description of BEM's technical features

2.3.1 Envelope components and materials

This paragraph summarises the construction systems implemented within the Warsaw I BEM to characterise the thermal behaviour of the building. Envelope and internal partitions data were collected from buildings documentation, checked by on-site assessment and aggregated into Energy data collection spreadsheet. Gathering partitions data needed for BEM creation made the process faster and more reliable. Table 3 summarises all the materials implemented within the BEM.

Table 3: Materials

Layers					
Material	e	ρ	λ	RT	Cp
Concrete. Reinforced (with 1% of steel)	6.00	2300.00	2.30	0.03	1000.00
EPS 5	5.00	8.50	0.08	0.63	1450.00
Concrete. Reinforced (with 1% of steel)	14.00	2300.00	2.30	0.06	1000.00
Gypsum (density 1200)	1.00	1200.00	0.43	0.02	1000.00
Concrete. Reinforced (with 1% of steel)	25.00	2300.00	2.30	0.11	1000.00
Plywood (density 500)	1.00	500.00	0.13	0.08	1600.00
Concrete. Medium density (density 1800)	3.00	1800.00	1.15	0.03	1000.00
EPS 3	3.00	8.50	0.06	0.54	1450.00
Concrete. Medium density (density 1800)	2.00	1800.00	1.15	0.02	1000.00

Used abbreviations			
e	*Thickness cm*	RT	*Thermal resistance (m²·K)/W*
ρ	*Density kg/m³*	Cp	*Specific heat J/(kg·K)*
λ	*Thermal conductivity W/(m·K)*		

Within Table 4 all the construction systems created for the Warsaw I BEM using the Open BIM Construction Systems tool and stored within a dedicated library linked to the workflow on BIMserver.center have been reported.

Table 4: Construction systems

External Walls_Reference name	Layers	Thickness [cm]	Total Thickness [cm]
Data accuracy	every material present	± 1 cm	± 1 cm
Facade	Concrete. Reinforced 6	6	25
	EPS 5	5	
	Concrete. Reinforced 14	14	
Internal Walls_Reference name	**Layers**	**Thickness [cm]**	**Total Thickness [cm]**
Partition wall	Gypsum (density 1200)	1	27
	Concrete. Reinforced 25	25	
	Gypsum (density 1200)	1	
Slab on Grounf Floor_Ref. name	**Layers**	**Thickness [cm]**	**Total Thickness [cm]**
Floor 0	Plywood (density 500)	1	32.00
	Concrete. Medium density 3	14	
	EPS 3	3	
	Concrete. Reinforced 14	14	
Floor Slabs_Reference name	**Layers**	**Thickness [cm]**	**Total Thickness [cm]**
Floor 1	Plywood (density 500)	1	15.00
	Concrete. Reinforced 14	14	
Roofs_Reference name	**Layers**	**Thickness [cm]**	**Total Thickness [cm]**
Roof	Concrete. Reinforced 14	14	43.00
	Air cavity	15	
	Concrete. Reinforced 14	14	
Doors_Reference name	**Door type**	**Thermal transmittance [W/m2K]**	
Data accuracy	**-**	**± 0,01**	
M_single-flush_ext	wood external	2.61	

2.3.2 HVAC systems

Regarding the HVAC systems, the building is characterised by a district heating connection. No cooling systems or mechanical ventilation systems are installed. There are three types of thermal zones defined as following.

Thermal zone	Space classification	Min comfort temperature [°C]	Ventialation demand	DHW demand [l/day]
Thermal Zone 01	Occupied	20	8,3	35 per person
Thermal Zone 02	Occupied	24	13,9	35 per person
Thermal Zone 03	Not occupied	n.r.	n.r.	n.r.

2.3.3 Occupancy, lighting, equipment and operating patterns

Warsaw I BEM has been characterised also under the point of view of the internal gains as summarised in following table 5.

Table 5: Internal gains features

Thermal zone	Space classification	Installed light power [W/m2]	Internal equipment [W/m2]	Occupancy activity level [W/person]
Thermal Zone 01	Occupied	1,9	8,3	126
Thermal Zone 02	Occupied	9,5	13,9	-
Thermal Zone 03	Not occupied	-	-	-

Relevant operating schedules and occupational patterns have been assumed based on standard residential uses and on a few information collected from the users. Following figures show a few of the patterns set for the Warsaw I BEM.

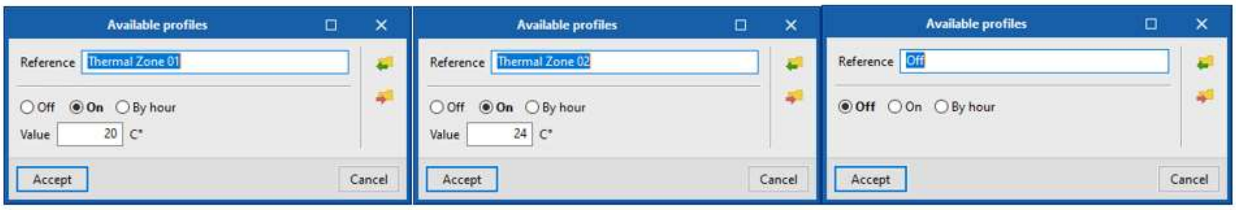
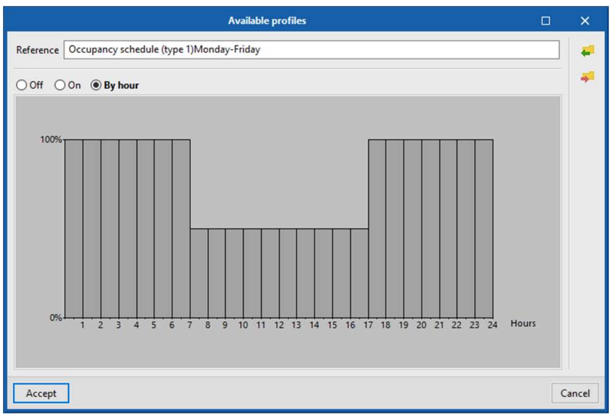


Figure 4: Heating schedule



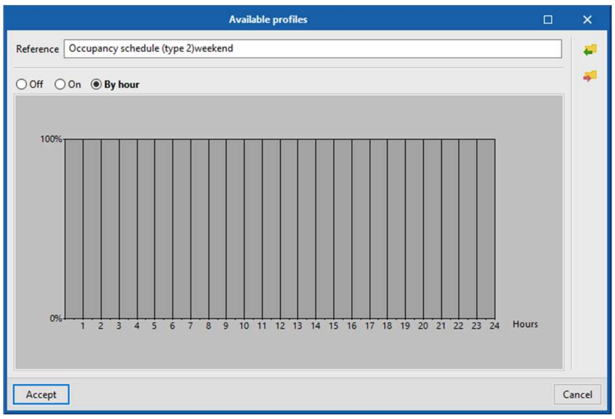


Figure 5: Occupancy, lighting and equipment schedule

3. BEM calibration

Owner of simulated building was not able to provide annual thermal energy utilization data. Due to the fact that calibration methodology and energy calculations with the use of CypeTherm+ were performed within P2ENDURE research project (https://www.p2endure-project.eu/en), and the demonstration building in Warsaw (from BIM-SPEED project) and demonstration buildings from P2ENDURE project have been constructed with similar construction technology, the calibration approach from P2ENDURE project was repeated for Warsaw demonstration project. In P2Endure project in Polish demonstration buildings (in Gdynia and Warsaw) were successfully calibrated basing on real annual thermal energy utilization data. Because of many similarities of both buildings, we decided to repeat calibration steps from P2Endure building energy model in current BEM case. Calibration methodology basically assumes that ventilation performance is decreased by 15% in all building's thermal spaces.

4. Building energy performance simulation results

4.1 General considerations

All openings of the simulated building have very poor thermal insulation properties with factors 3.1 W/m2K for windows and 2.6 W/m2k for entrance doors.

The highest heat consumption exists in thermal zones with highest minimum air temperature and ventilation requirements, such as bathrooms and kitchens.

4.2 Energy KPIs

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

BS.OPED: Operational Primary Energy Demand

The primary energy demand has been calculated from the final energy consumption at consumption point and multiplied by the conversion factor (specific for Poland) for final energy to primary energy. The table below summarises the primary energy demand related to natural gas and network electricity.

Table 6: BS.OPED Operational Primary Energy Demand

BS.OPED: Operational Primary Energy Demand	
Ep [kWh/m^2]	234.64

Energy vector	C_{ef} (kWh/year)	C_{ef} (kWh/m²·year)	f_{cep}	C_{ep} (kWh/year)	C_{ep} (kWh/m²·year)	$f_{cep,nr}$
Coal	3411352.65	193.26	1.084	3697906.27	209.50	1.082
Electricity obtained from the network	52652.26	2.98	2.368	124680.54	7.06	1.954
Natural gas	266995.86	15.13	1.195	319060.06	18.08	1.189

C_{ef}: *Energy consumption at consumption point (final energy), kWh/m²·year.*
f_{cep}: *Conversion factor for final energy to primary energy.*
C_{ep}: *Primary energy consumption, kWh/m²·year.*

BS.TED: Total Energy Demand

The energy demand of the building is the total amount of energy the technical systems of the building (heating and cooling) have to provide to maintain its indoor environment in comfortable conditions. The table below summarises the results obtained from the calculation of the heating energy demand (there is no cooling for the Warsaw II demo)

Table 7: BS.TED Total Energy Demand

BS.TED: Total Energy Demand	
$Q_{HEATING}$ [kWh/m²year]	184.6
Q_{DHW} [kWh/m²year]	11.3
Q_{TOT} [kWh/m²year]	**195.9**

		Jan (kWh)	Feb (kWh)	Mar (kWh)	Apr (kWh)	May (kWh)	Jun (kWh)	Jul (kWh)	Aug (kWh)	Sep (kWh)	Oct (kWh)	Nov (kWh)	Dec (kWh)	Year (kWh/year)	Year (kWh/m²·year)
BUILDING (S_u = 17651.33 m²; V = 44714.10 m³)															
Energy demand	**Heating**	**562616.1**	**519044.6**	**417231.3**	**245059.1**	**113746.0**	**42346.1**	**31110.4**	**30373.7**	**116248.7**	**251685.9**	**399773.2**	**528606.6**	**3257841.8**	**184.6**
	DHW	**17007.3**	**15361.4**	**17007.3**	**16458.6**	**17007.3**	**16458.6**	**17007.3**	**17007.3**	**16458.6**	**17007.3**	**16458.6**	**17007.3**	**200246.9**	**11.3**
	TOTAL	**579623.4**	**534406.0**	**434238.6**	**261517.7**	**130753.3**	**58804.7**	**48117.6**	**47381.0**	**132707.3**	**268693.2**	**416231.9**	**545613.9**	**3458088.7**	**195.9**

BS.TEC: Total Energy Consumption

Total Energy Consumption has been calculated directly using the simulation engine of CYPETHERM EPlus. Following table summarises Primary energy consumption for heating and domestic hot water production.

		Jan (kWh)	Feb (kWh)	Mar (kWh)	Apr (kWh)	May (kWh)	Jun (kWh)	Jul (kWh)	Aug (kWh)	Sep (kWh)	Oct (kWh)	Nov (kWh)	Dec (kWh)	Year (kWh/year)	Year (kWh/m²·year)
BUILDING (S_u = 17651.33 m²; V = 44714.10 m³)															
Energy demand	**Heating**	**562616.1**	**519044.6**	**417231.3**	**245059.1**	**113746.0**	**42346.1**	**31110.4**	**30373.7**	**116248.7**	**251685.9**	**399773.2**	**528606.6**	**3257841.8**	**184.6**
	DHW	**17007.3**	**15361.4**	**17007.3**	**16458.6**	**17007.3**	**16458.6**	**17007.3**	**17007.3**	**16458.6**	**17007.3**	**16458.6**	**17007.3**	**200246.9**	**11.3**
	TOTAL	**579623.4**	**534406.0**	**434238.6**	**261517.7**	**130753.3**	**58804.7**	**48117.6**	**47381.0**	**132707.3**	**268693.2**	**416231.9**	**545613.9**	**3458088.7**	**195.9**
Coal (f_{cep} = 1.082)	EF_{heat}	589126.8	543502.2	436891.4	256606.4	119105.8	44341.5	32576.3	31804.9	121726.4	263545.5	418610.7	553514.8	3411352.6	193.3
	EP_{heat}	638613.4	589156.4	473590.3	278161.3	129110.7	48066.1	35312.7	34476.5	131951.4	285683.3	453774.0	600010.0	3697906.3	209.5
	$EP_{nr,heat}$	**637400.1**	**588037.0**	**472690.5**	**277632.8**	**128865.4**	**47974.8**	**35245.6**	**34411.0**	**131700.7**	**285140.5**	**452911.9**	**598870.0**	**3690880.2**	**209.1**
	EF_{light}	7325.2	6616.3	3662.6	3544.4	861.8	834.0	861.8	3662.6	3544.4	7325.2	7088.9	7325.2	52652.3	3.0
	EP_{light}	17346.0	15667.4	8673.0	8393.2	2040.7	1974.9	2040.7	8673.0	8393.2	17346.0	16786.5	17346.0	124680.5	7.1
	$EP_{nr,light}$	**14313.9**	**12928.7**	**7157.0**	**6926.1**	**1684.0**	**1629.7**	**1684.0**	**7157.0**	**6926.1**	**14313.9**	**13852.2**	**14313.9**	**102886.4**	**5.8**
	EF_{dhw}	22676.4	20481.9	22676.4	21944.9	22676.4	21944.9	22676.4	22676.4	21944.9	22676.4	21944.9	22676.4	266995.9	15.1
	EP_{dhw}	27098.3	24475.8	27098.3	26224.1	27098.3	26224.1	27098.3	27098.3	26224.1	27098.3	26224.1	27098.3	319060.1	18.1
	$EP_{nr,dhw}$	**26962.8**	**24353.5**	**26962.8**	**26093.0**	**26962.8**	**26093.0**	**26962.8**	**26962.8**	**26093.0**	**26962.8**	**26093.0**	**26962.8**	**317464.8**	**18.0**
	$C_{ef,total}$	**619128.3**	**570600.4**	**463230.4**	**282095.7**	**142644.0**	**67120.3**	**56114.4**	**58143.9**	**147215.7**	**293547.0**	**447644.5**	**583516.3**	**3731000.8**	**211.4**
	C_{ep}	**683057.7**	**629299.6**	**509361.6**	**312778.6**	**158249.7**	**76265.1**	**64451.7**	**70247.8**	**166568.7**	**330127.5**	**496784.6**	**644454.2**	**4141646.9**	**234.6**
	$C_{ep,nr}$	**678676.8**	**625319.2**	**506810.2**	**310651.9**	**157512.1**	**75697.5**	**63892.4**	**68530.8**	**164719.8**	**326417.2**	**492857.0**	**640146.7**	**4111231.4**	**232.9**

Table 8: BS.TEC Total Energy Consumption

BS.TEC: Total Energy Consumption	
EP_{heat}[kWh/m²]	209.6
EP_{cool}[kWh/m²]	Cooling not present
EP_{light}[kWh/m²]	7.1
EP_{dhw}[kWh/m²]	18.1
EP_{TOT}[kWh/m²]	**234.6**

5. Building renovation scenarios

To perform and assess multiple energy simulations for building renovation scenarios, the CYPETHERM EPlus has been used taking the BEM baseline as a reference and changing the relevant parameters within the already developed BEM.

5.1 Renovation scenarios proposed

For the Warsaw I democase, the following building renovation scenarios have been assessed according to Task 7.1 premises. The following table summarises the configuration of each scenario.

Table 9: Overview of the Warsaw I Renovation Scenarios

	ETICS	Ventilated	Rooftop module	Windows	Second window	Indoor insualtion	PV
Scenario 01	X		X	X		X	X
Scenario 02	X		X		X		
Scenario 03		X	X			X	

Here below the technical details of the interventions proposed..

Table 10: Technical features of the interventions

External Walls_Reference name	Layers	Thickness [cm]	Total Thickness [cm]
Facade (ventilated)	Facing	8	51
	Airgap	3	
	Rockwool	15	
	Concrete. Reinforced 6	6	
	EPS 5	5	
	Concrete. Reinforced 14	14	
External Walls_Reference name	Layers	Thickness [cm]	Total Thickness [cm]
Facade	Plaster	1	41
	EPS 0032	15	
	Concrete. Reinforced 6	6	
	EPS 5	5	
	Concrete. Reinforced 14	14	
Floor Slabs_Reference name	Layers	Thickness [cm]	Total Thickness [cm]
Floor 1	Concrete. Medium density	8	37

	EPS	15	
	Concrete. Reinforced 14	14	
Roofs_Reference name	Layers	Thickness [cm]	Total Thickness [cm]
Roof	Bitumen membrane	1	65
	EPS 0032	20	
	Bitumen membrane	1	
	Concrete. Reinforced 14	14	
	Air cavity	15	
	Concrete. Reinforced 14	14	
Doors_Reference name	Door type	Thermal transmittance [W/m2K]	
M_single-flush_ext	wood external	2.61	
Windows_Reference name	Window Type	Thermal transmittance [W/m2K]	
1-Flügelfenster	plastic external	0.9	
2-Flügelfenster	plastic external	0.9	

5.2 Scenario 1: description and results

In scenario 1, the following interventions has been analysed:

- ETICS have been added to the external walls;
- Insulation has been added to the roof of the building;
- Type 1 windows have been changed with better thermal properties;
- Indoor floor insulation has been added to all of the slabs;
- PV system has been installed on the roof with a yield of 43000kWh (84kWp).

The following KPIs have been calculated:

BS.OPED: Operational Primary Energy Demand

Table 11: BS.OPED Operational Primary Energy Demand

BS.OPED: Operational Primary Energy Demand	
Ep [kWh/m²]	98.3

BS.TED: Total Energy Demand

Table 12: BS.TED Total Energy Demand

BS.TED: Total Energy Demand	
$Q_{HEATING}$ [kWh/m²year]	93.3
Q_{DHW} [kWh/m²year]	11.3
Q_{TOT} [kWh/m²year]	**104.6**

BS.TEC: Total Energy Consumption (and sub KPIs; Energy consumption for heating, cooling, lighting, DHW)

Table 13: BS.TEC Total Energy Consumption

BS.TEC: Total Energy Consumption	
EP_{heat}[kWh/m^2]	79.5
EP_{cool}[kWh/m^2]	Cooling not present
EP_{light}[kWh/m^2]	6.5
EP_{dhw}[kWh/m^2]	18
EP_{TOT}[kWh/m^2]	**98.3**

BS.TES: Total Energy savings

Table 14: BS.TES Total Energy Savings

BS.TES: Total Energy Savings			
	Baseline	Scenario 01	SAVING
EP_{heat}[kWh/m^2]	209.6	79.5	62 %
EP_{cool}[kWh/m^2]	Cooling not present		
EP_{light}[kWh/m^2]	7.1	6.5	8 %
EP_{dhw}[kWh/m^2]	18.1	18	0 %
EP_{TOT}[kWh/m^2]	234.6	**98.3**	**58 %**

5.3 Scenario 2: description and results

In scenario 2, the following interventions has been analysed:

- ETICS has been added to the exterior walls;
- insulation has been added to the roof.

The following KPIs have been calculated:

BS.OPED: Operational Primary Energy Demand

Table 15: BS.OPED Operational Primary Energy Demand

BS.OPED: Operational Primary Energy Demand	
Ep [kWh/m^2]	108.1

BS.TED: Total Energy Demand

Table 16: BS.TED Total Energy Demand

BS.TED: Total Energy Demand	
$Q_{HEATING}$ [kWh/m^{2}year]	99.2
Q_{DHW} [kWh/m^{2}year]	11.3
Q_{TOT} [kWh/m^{2}year]	**110.5**

BS.TEC: Total Energy Consumption (and sub KPIs; Energy consumption for heating, cooling, lighting, DHW)

Table 17: BS.TEC Total Energy Consumption

BS.TEC: Total Energy Consumption	
EP_{heat}[kWh/m^2]	83.6

EP_{cool}[kWh/m²]	Cooling not present
EP_{light}[kWh/m²]	6.5
EP_{dhw}[kWh/m²]	18
EP_{TOT}[kWh/m²]	**108.1**

BS.TES: Total Energy savings

Table 18: BS.TES Total Energy Savings

BS.TES: Total Energy Savings			
	Baseline	Scenario 02	SAVING
EP_{heat}[kWh/m²]	209.6	83.6	60 %
EP_{cool}[kWh/m²]	Cooling not present		
EP_{light}[kWh/m²]	7.1	6.5	8 %
EP_{dhw}[kWh/m²]	18.1	18	0
EP_{TOT}[kWh/m²]	**234.6**	**108.1**	**53 %**

5.4 Scenario 3: description and results

In scenario 3, the following interventions has been analysed:

- A ventilated facade with insulation has been added to the exterior walls;
- roof insulation and indoor floor insulation have been added;
- windows type 2 have been exchanged with triple glass;
- On top of the building thermal solar has been added with a yield of 80000kWh per year (84kWp).

The following KPIs have been calculated:

BS.OPED: Operational Primary Energy Demand

Table 19: BS.OPED Operational Primary Energy Demand

BS.OPED: Operational Primary Energy Demand	
Ep [kWh/m²]	92.4

BS.TED: Total Energy Demand

Table 20: BS.TED Total Energy Demand

BS.TED: Total Energy Demand	
$Q_{HEATING}$ [kWh/m²year]	92
Q_{DHW} [kWh/m²year]	11.3
Q_{TOT} [kWh/m²year]	**103.3**

BS.TEC: Total Energy Consumption (and sub KPIs; Energy consumption for heating, cooling, lighting, DHW)

Table 21: BS.TEC Total Energy Consumption

BS.TEC: Total Energy Consumption	
EP_{heat}[kWh/m²]	78.6
EP_{cool}[kWh/m²]	Cooling not present
EP_{light}[kWh/m²]	6.5

EP_{dhw}[kWh/m^2]	18
EP_{TOT}[kWh/m^2]	**92.4**

BS.TES: Total Energy savings

Table 22: BS.TES Total Energy Savings

BS.TES: Total Energy Savings			
	Baseline	Scenario 03	SAVING
EP_{heat}[kWh/m^2]	209.6	78.6	62 %
EP_{cool}[kWh/m^2]	Cooling not present		
EP_{light}[kWh/m^2]	7.1	6.5	8 %
EP_{dhw}[kWh/m^2]	18.1	18	0 %
EP_{TOT}[kWh/m^2]	**234.6**	**92.4**	**60 %**

6. Time reduction evaluation

Following table shows the results of the time reduction for the Warsaw I democase. The BIM SPEED process completed as previously described has been compared to the creation of a BEM using a traditional process, based on the expertise of the Mostostal's energy modeler on similar buildings.

Table 23: Time reduction analysis for the BIM-to-BEM process compared to traditional BEM creation process

	Workflow required for the BEM creation	Traditional process		BIM SPEED PROCESS	
		activity description	time required (working days)	activity description	time required (working days)
1	**BUILDING DATA COLLECTION (site inspection, document/drawing analysis,..), specific data for the thermal characterization are needed**				
	a) direct geometrical measurements (needed if detailed and reliable technical drawings are not available)		3	Information extracted directly from BIM	0,5
	b) collection and detection of the thermal characteristics of building components (mapping of windows type, wall type…)		1,5	Information extracted/partially extracted from BIM	0,5
	c) collection and identification of relevant HVAC characteristics (installed power, type of terminals, …)		0,5	Not included in BIM (same for traditional process)	0,5
	d) data on building operational uses		1	Not included in BIM (same for traditional process)	1
2	**Building geometry creation**				
	a) 2D floorplans reconstruction from on site measurements (needed if detailed and reliable technical drawings are not available)		3	Not needed - geometrical information extracted directly from BIM	0
	b) creation of the 3D geometry of the building directly with specific Building Energy Simulation tools		5	creation of the Analytical model using BIM (just minor adjustments may be needed)	3
3	**Building thermal characterisation**				
	a) creation of the building components and related libraries (e.g. materials, stratigraphies..)		3	the same as traditional process	2,5
	b) definition of the thermal zones (uses, internal gains - occupancy, lighting, equipment schedules - temperatures..)		3	the same as traditional process	2,5
4	**HVAC characterisation**				
	a) creation of the HVAC components (and related libraries)		1	the same as traditional process	1
	b) definition of the systems		1	the same as traditional process	2
	TOTAL TIME REQUIRED		22		12,5
	BIM-to-BEM time reduction compared to current practice: 43%				