EuroPHit

D3.9_Overall Refurbishment Plan

DRAFT

CS14 Wilmcote House

Portsmouth, UK

INTELLIGENT ENERGY – EUROPE II

Energy efficiency and renewable energy in buildings

IEE/12/070

EuroPHit

[Improving the energy performance of step-by-step refurbishment and integration of renewable energies]

Contract N°: SI2.645928

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Abstract

This overall refurbishment plan provides an overview of the retrofit steps of a step-by-step refurbishment to EnerPHit standard to be undertaken for the Wilmcote House project in Portsmouth, UK.

Firstly, the existing building will be described, including the building components and component conditions. In addition, the existing energy efficiency performance of the building will be described.

In a second step, the overall refurbishment plan will describe the retrofit steps to be undertaken until the refurbishment will finally be completed.

The intention is to achieve the EnerPHit standard through a thorough upgrading of the thermal envelope, improved airtightness and reduced thermal bridging. In order to achieve these characteristics, a steel exoskeleton will be introduced on one façade of the building, enclosing existing external walkways. MVHR systems will be introduced into each dwelling in order to provide efficient ventilation.

Project Location

Wilmcote House, Tyseley Rd, Southsea, Portsmouth, UK. PO5 4NA.

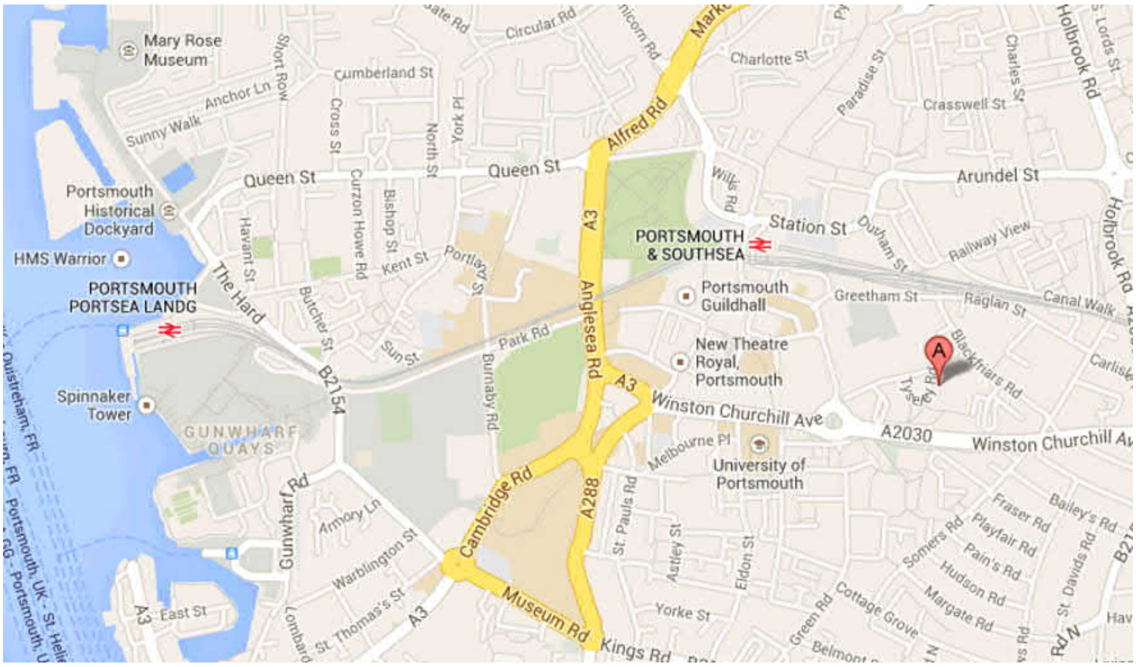

Figure 1 Location Map [Google maps, 2013]

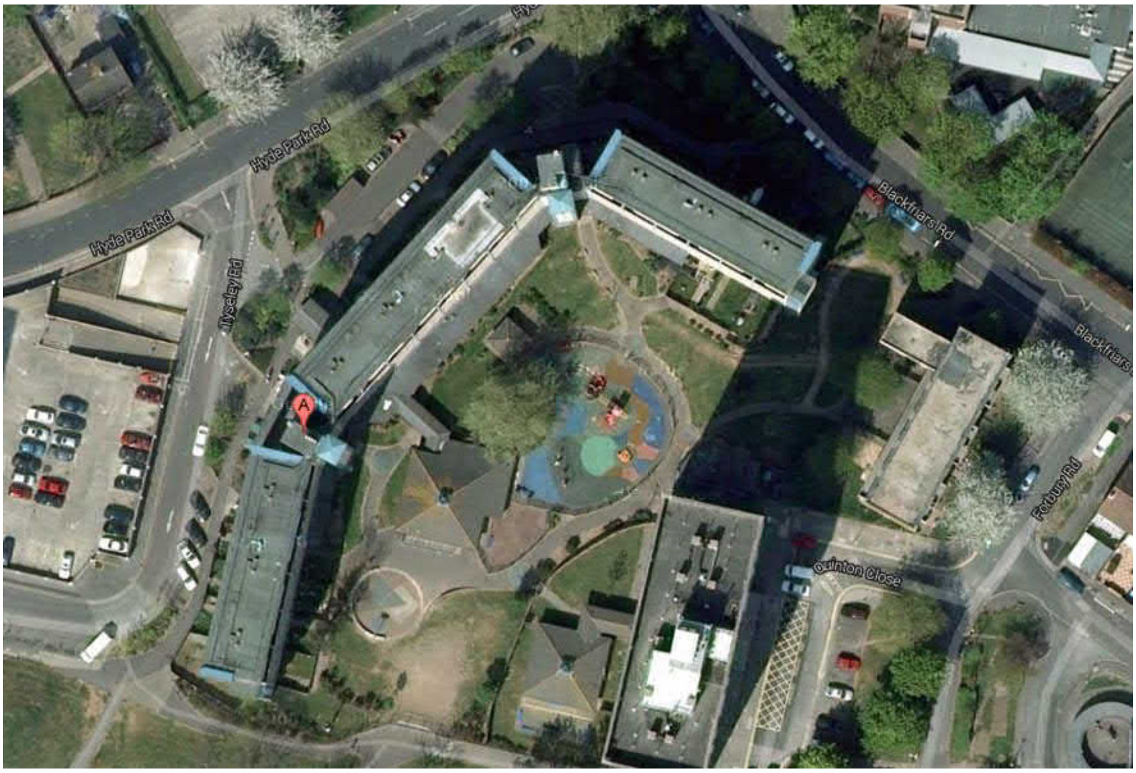

Figure 2 Aerial view of Wilmcote House [Google maps, 2013]

1 General Project description

This section of the document outlines key information about the building and the refurbishment works planned.

1.1 Motivation

The following factors were all motivations of the client to undertake a deep retrofit:

- Excessive electric heating costs for residents. Many residents living in fuel poverty and heating homes improperly.
- Significant maintenance costs
    - Condensation reported by a third of residents
    - Window repairs requested by 80% of residents in the last two years
    - Water ingress issues due to properties and communal stairways
- Windows and roof at the end of their serviceable lives
- Concrete repairs required to maintain the life of the structure
- Internal and external decoration failing
- Ineffective security in communal areas
- Financial cost appraisal supported refurbishment
- Factors against demolition
    - Cost (direct demolition/construction costs, loss of rent, etc.)
    - Disturbance to community
    - Site constraints and planning requirements
    - Impact on already stretched council housing stock

1.2 Existing Building

Wilmcote house provides over 100 homes largely in the form of 3 bedroom maisonettes. The homes are arranged in 5 levels (10 stories) across 3 blocks linked via two main stair cores. It is located in the central Portsea Island area of Portsmouth. The building is owned and managed by Portsmouth City Council. Wilmcote House was built in 1968 using a prefabricated reinforced concrete sandwich panel system; it is in need of significant repairs, including some structural work, without which the remaining life of the building is likely to be around 30 years. The concrete sandwich panels incorporate only around 25mm of insulation, which combined with all electric heating means staying warm in the building is expensive; many residents experience fuel poverty. The existing floor area is 10,233m^2.

1.3 Refurbishment steps

1.3.1 Retrofit steps within EuroPHit

The retrofit works that will be undertaken include the external insulation for the exposed facades of the building, replacement of all windows and external doors, and the provision of MVHR systems for each dwelling.

1.3.2 Further retrofit steps

The building is being refurbished with all residents in-situ due to the lack of availability of suitable alternative accommodation into which the Client could move its tenants. This is also seen as less disruptive for the residents and an issue that the Client has consulted residents on. The situation is eased slightly because the client has not moved any new residents into the block as homes have naturally been vacated thus around 20% of the building is not currently occupied.

Work will be phased so as to minimise resident disruption rather than each necessary activity of the refurbishment work being carried out in one go. To enable the major works to the extension of living room floors and the enclosure of the balconies, which involves the cutting of reinforced concrete, living rooms will be temporarily partitioned off to enable life to continue in each dwelling. Future works to be considered:

1.4 EnerPHit standard

The project intends to meet the EnerPHit standard as part of the initial phase of works.

1.5 Images

Below is an image of the existing building

Figure 3 External view of existing building (1)

2 Existing building

2.1 General description

Wilmcote house provides over 100 homes largely in the form of 3 bedroom maisonettes. The homes are arranged in 5 levels (10 stories) across 3 blocks linked via two main stair cores. It is located in the central Portsea Island area of Portsmouth. The building is owned and managed by Portsmouth City Council. Wilmcote House was built in 1968 using a prefabricated reinforced concrete sandwich panel system; it is in need of significant repairs, including some structural work, without which the remaining life of the building is likely to be around 30 years. The concrete sandwich panels incorporate only around 25mm of insulation, which combined with all electric heating means staying warm in the building is expensive; many residents experience fuel poverty. The existing floor area is 10,233m^2.

Improving the building to the demanding EnerPHit standard involves a number of challenges; how to insulate the rear façade which features integral but exposed walkways without introduction thermal bridges, how to provide appropriate and effective ventilation and how to provide cost effective heating in a building with limited space for communal services and whose structural characteristics proscribe the use of gas.

Wilmcote House will be split into three thermal envelopes with the two unheated stair cores remaining outside the thermal envelopes in order to simplify the detailing required. External walk ways will be enclosed within the thermal envelopes of the blocks in order to improve the area / volume ratio and make the detailing simpler and thus more cost effective. Internal balconies that exist on alternate stories, those between the walkways, will also be enclosed, increasing the size of the maisonettes and again and simplify detailing. The three blocks will be made airtight using an external system before external insulation is applied to each block.

External insulation will be applied to the exposed façades of the building, excluding the stair cores which will fall outside the thermal envelopes created. A steel frame, resting on new foundations at ground level, will be fixed to the rear elevation, enclosing the existing walkways and balconies and providing a suitable structural plane into which the windows enclosing the walkways can be installed, and the new insulated façade can be fixed to. On the front façade, insulation will be fixed to the existing structure; the proposed wall build up following refurbishment is shown in the following sketch.

Existing windows and doors are to be replaced with Passive House certified windows and doors, including insulated doors from the stair cores into each of the newly enclosed walkways that provide access to each dwelling. Front doors to dwellings will open into communal space that has been enclose within the thermal envelope thus these doors need not be certified or insulated.

Passivhaus principles will be followed regarding continuity of insulation and alignment of windows and doors in the insulation layer. For structural reasons related to the prefabricated concrete panel system used to construct Wilmcote house, the existing reinforced concrete ground floor cannot be broken up to allow insulation to be installed beneath a new slab – such a course of action could destabilise the building. The finished floor to ceiling height is insufficient to insulate over the slab thus ground floors will not be insulated. This could be a future refurbishment step following any potential reduction in the cost of very thin, high performance insulation.

Pre refurbishment testing has shown that Wilmcote House is reasonably airtight for an existing structure built without regard to a particular airtightness standard. The refurbishment strategy is to install an air tight layer around the building before the application of the external wall insulation system. Details will be developed by the design team from April 2014 onwards.

Each dwelling will be provided with individual MVHR systems. Existing individual space heating systems in the form of electric storage and panel heaters will be retained for the time being due to resident familiarity and budgetary constraints. Surveys of residents suggest that they are keen to ensure sufficient provision of heating. Heating system improvements could be addressed as and when the current systems reach the end of their lives, (however there is little to go wrong with them), in accordance with the step-by-step approach taken by EuroPHit. The ventilation of the enclosed communal spaces is currently being considered by the design team.

2.1.1 Building data

Construction Time	:	1968
Last retrofit	:	Early 1990s
Building use	:	Residential
General condition	:	Significant maintenance issues
Occupancy	:	Council housing
Treated floor Area	:	10,233m^2

2.1.2 Client

Name / Company	:	Portsmouth City Council
Address	:	Housing & Property Services
		12 Chaucer House (First Floor)
		Isambard Brunel Road
		Portsmouth
		UK
		PO1 2DR
Email	:	Steve.Groves@portsmouthcc.gov.uk
		Meredydd.Hughes@portsmouthcc.gov.uk

2.2 Envelope of the existing Building

2.2.1 Floor slab

Description	:	Concrete
U-Value [W/(m²K)]	:	>2
Installation date	:	1968
Condition	:	Average
Next replacement	:	Unknown

2.2.2 External walls

Description	:	Large Bison REEMA concrete panels
U-Value [W/(m²K)]	:	>2
Installation date	:	1968
Condition	:	Poor
Next replacement	:	As part of current refurbishment project

2.2.3 External walls to ground

Description	:	Large Bison REEMA concrete panels
U-Value [W/(m²K)]	:	>2
Installation date	:	1968
Condition	:	Poor
Next replacement	:	As part of current refurbishment project

2.2.4 Windows

Description	:	uPVC double glazing
U-Value [W/(m²K)]	:	~2
Installation date	:	1988
Condition	:	Poor
Next replacement	:	As part of current refurbishment project

2.2.5 Roof / Top floor ceiling

Description	:	Concrete
U-Value [W/(m²K)]	:	>2
Installation date	:	1968
Condition	:	Poor
Next replacement	:	As part of current refurbishment project

2.3 Technical equipment of the existing building

2.3.1 Heating

Description	:	Electric storage heating
Performance ratio of heat generation [%]	:	Unknown
Installation date	:	Unknown
Condition	:	Average
Next replacement	:	Unknown

2.3.2 Domestic hot water

Description	:	Hot water cylinder with electric immersion
Performance ratio of heat generation [%]	:	Unknown
Installation date	:	Unknown
Condition	:	Poor
Next replacement	:	As part of current refurbishment project

2.3.3 Ventilation

Description	:	Natural ventilation
HR Efficiency [%]	:	N/a
El.Efficiency [Wh/m³]	:	N/a
Installation date	:	N/a
Condition	:	N/a
Next replacement	:	N/a

2.4 Energy efficiency of the existing building

The current building has minimal energy efficiency features. The concrete sandwich panels incorporate only around 25mm of insulation, which combined with all electric heating means staying warm in the building is expensive; many residents experience fuel poverty. The current windows were installed in 1988, so are in need of being thermally upgraded.

2.4.1 Modelled efficiency parameters

PHPP: specific heating demand [kWh/(m²K)]	:	178
PHPP: specific cooling demand | Overheating frequency [kWh/(m²K) | %]	:	0
PHPP: specific primary energy demand [kWh/(m²K)]	:	N/a

2.4.2 Available consumption parameters

Annual Gas/Oil consumption | bills [kWh/a | €]	:	N/a
Annual Electricity consumption | bills [kWh/a | €]	:	Data unavailable due to multiple occupants
Other	:	N/a

For an overview of the energy efficiency of the existing building, see the verification spreadsheet of the PHPP below.

EnerPHit verification

Building:	Wilmcote House Block B
Street:	Tyseley Road
Postcode/City:	Portsmouth
Country:	England
Building Type:	Residential Refurbishment
Climate:	South England
Home Owner(s) / Client(s):	PCC
Street:	Isambard Brunel Road
Postcode/City:	Portsmouth
Architect:	ECD Architects
Street:	Blue Lion Place, Long Lane
Postcode/City:	London SE1 4PU
Mechanical System:	
Street:	
Postcode/City:	

Year of Construction:		Interior Temperature:	20.0	°C
Number of Dwelling Units:		Internal Heat Gains:	2.1	W/m²
Enclosed Volume V_e:				
Number of Occupants:	87.6			

Specific building demands with reference to the treated floor area — use: Monthly method

				Requirements	Fulfilled?*
	Treated floor area	3064.3	m²		
Space heating	Annual heating demand	**178**	**kWh/(m²a)**	25 kWh/(m²a)	**no**
	Heating load	**75**	**W/m²**	-	**-**
Space cooling	Overall specific space cooling demand		**kWh/(m²a)**	-	**-**
	Cooling load		**W/m²**	-	**-**
	Frequency of overheating (> 25 °C)	0.0	%	-	**-**
Primary Energy	Space heating and cooling, dehumidification, household electricity.		**kWh/(m²a)**	316 kWh/(m²a)	
	DHW, space heating and auxiliary electricity		kWh/(m²a)	-	**-**
	Specific primary energy reduction through solar electricity		kWh/(m²a)	-	**-**
Airtightness	Pressurization test result n_{50}	**8.0**	**1/h**	1 1/h	**no**

* empty field: data missing; '-': no requirement

Figure 4 Specific energy efficiency values of the existing building modelled with PHPP

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2.5 Images

Below are a number of images of the existing building.

Figure 5 External view of existing building (1)

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Figure 6 External view of existing building (2)

Figure 7 External view of existing building (3)

3 Retrofit steps

3.1 Overall refurbishment Plan

3.1.1 Retrofit steps:

The retrofit works that will be undertaken include the external insulation for the exposed facades of the building, replacement of all windows and external doors, and the provision of MVHR systems for each dwelling. Further steps will be considered in future.

Step	Year	Measure	Specific Heating Demand	Specific Heating Load
0	2013	Existing Building	178 kWh/m^2/yr	75 W/m^2
1	2014/15	Walls, Windows, Doors, Roof, Ventilation	17 kWh/m^2/yr	12 W/m^2
2	2020	Heating?*	17 kWh/m^2/yr	12 W/m^2
3	2025	Ground floor insulation?	14 kWh/m^2/yr	11 W/m^2
4	2025	PV?	n/a	n/a

*Changing the current electric heating system will not improve the energy efficiency of the building however it will improve controllability and comfort of residents

Table 1 Overview refurbishment steps

3.1.2 Efficiency Improvements

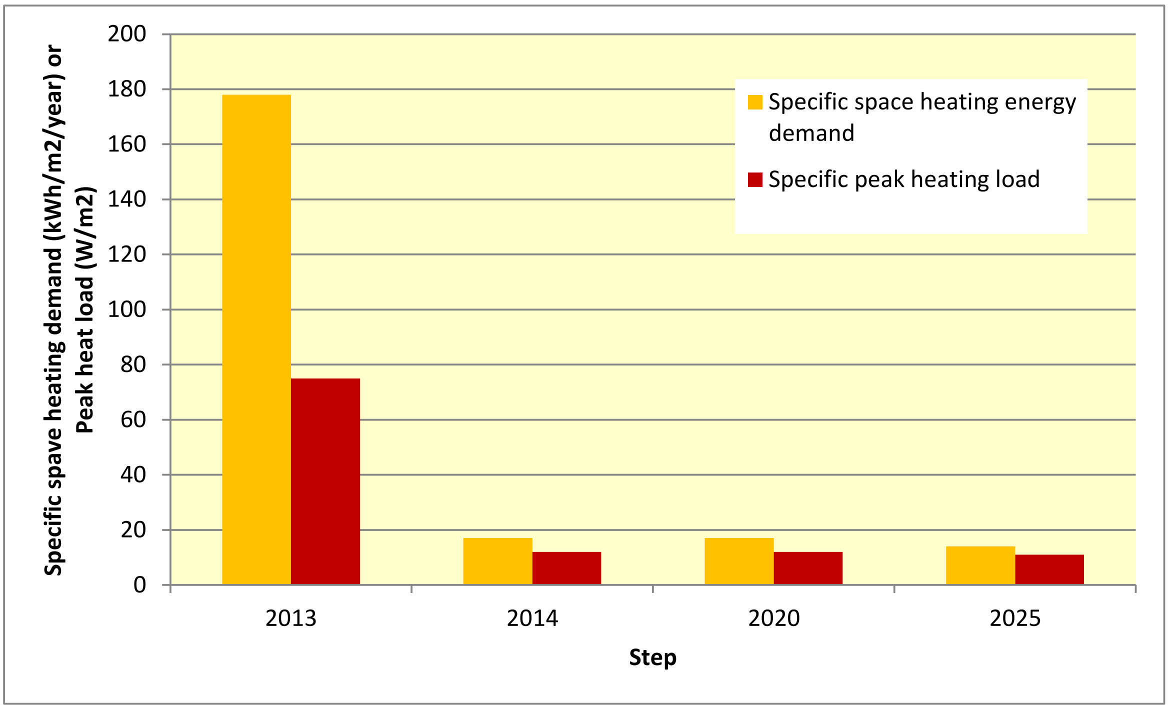

Figure 8 Overview energy efficiency improvement according to the overall refurbishment plan

3.2 Retrofit steps within EuroPHit

3.2.1 Retrofit step 1:

The retrofit works that will be undertaken include the external insulation for the exposed facades of the building, replacement of all windows and external doors, and the provision of MVHR systems for each dwelling.

Start date	:	Summer 2014
Completion date	:	Autumn 2016
Budget	:	£13million
PHPP: specific heating demand [kWh/(m²K)]	:	18
PHPP: specific cooling demand | Overheating frequency [kWh/(m²K) | %]	:	0 (0% overheating with summer window opening)
PHPP: specific primary energy demand [kWh/(m²K)]	:	177

3.2.1.1 New wall insulation

Description	:	External wall insulation
U-Value [W/(m²K)]	:	0.140
Installation date	:	Summer 2014 – Autumn 2016
Lifespan	:	50yrs+

3.2.1.2 New roof insulation

Description	:	Roof insulation
U-Value [W/(m²K)]	:	0.13
Installation date	:	Summer 2014 – Autumn 2016
Lifespan	:	50yrs+

3.2.1.3 New windows

Description	:	Rehau Geneo triple-glazing
U-Value [W/(m²K)]	:	0.84 (average installed)
Installation date	:	Summer 2014 – Autumn 2016
Lifespan	:	20yrs+

3.2.1.4 New ventilation component

Description	:	Zehnder Mechanical Ventilation with Heat Recovery (MVHR) system
HR Efficiency[%]	:	92
El.Efficiency [Wh/m³]		0.42
Installation date	:	Summer 2014 – Autumn 2016
Lifespan	:	25yrs+

EnerPHit verification

Building:	Wilmcote House Block B
Street:	Tyseley Road
Postcode/City:	Portsmouth
Country:	England
Building Type:	Residential Refurbishment
Climate:	South England
Home Owner(s) / Client(s):	PCC
Street:	Isambard Brunel Road
Postcode/City:	Portsmouth
Architect:	ECD Architects
Street:	Blue Lion Place, Long Lane
Postcode/City:	London SE1 4PU
Mechanical System:	
Street:	
Postcode/City:	

Year of Construction:		Interior Temperature:	20.0	°C
Number of Dwelling Units:		Internal Heat Gains:	2.1	W/m²
Enclosed Volume V_e:				
Number of Occupants:	87.6			

Specific building demands with reference to the treated floor area — use: Monthly method

				Requirements	Fulfilled?*
	Treated floor area	3064.3	m²		
Space heating	Annual heating demand	**17**	**kWh/(m²a)**	25 kWh/(m²a)	**yes**
	Heating load	**12**	**W/m²**	-	**-**
Space cooling	Overall specific space cooling demand		**kWh/(m²a)**	-	**-**
	Cooling load		**W/m²**	-	**-**
	Frequency of overheating (> 25 °C)	1.3	%	-	-
Primary Energy	Space heating and cooling, dehumidification, household electricity.		**kWh/(m²a)**	122 kWh/(m²a)	
	DHW, space heating and auxiliary electricity		kWh/(m²a)	-	-
	Specific primary energy reduction through solar electricity		kWh/(m²a)	-	-
Airtightness	Pressurization test result n_{50}	**1.0**	**1/h**	1 1/h	**yes**

* empty field: data missing; '-': no requirement

Figure 9 Specific energy efficiency values after measures within EuroPHit

3.2.2 Future retrofit steps

Further retrofit steps are being considered but exact details are yet to be finalised. Section is to be completed when information is available. Options being considered include the heating system, ground floor insulation, and renewable energy systems.

3.2.2.1 Retrofit step 2:

To be inserted

Start date	:
Completion date	:
Budget	:
PHPP: specific heating demand [kWh/(m²K)]	:
PHPP: specific cooling demand | Overheating frequency [kWh/(m²K) | %]	:
PHPP: specific primary energy demand [kWh/(m²K)]	:

3.2.2.1.1. New envelope component

Description	:
U-Value [W/(m²K)]	:
Installation date	:
Condition	:
Next replacement	:
Other	:

3.2.2.1.2. New heating component

Description	:
Performance ratio of heat generation [%]	:
Installation date	:
Condition	:
Next replacement	:
Other	:

3.2.2.2 Retrofit step 3:

To be inserted

Start date	:
Completion date	:

Budget	:
PHPP: specific heating demand [kWh/(m²K)]	:
PHPP: specific cooling demand | Overheating frequency [kWh/(m²K) | %]	:
PHPP: specific primary energy demand [kWh/(m²K)]	:

3.2.2.2.1. New envelope component

Description	:
U-Value [W/(m²K)]	:
Installation date	:
Condition	:
Next replacement	:
Other	:

3.2.2.2.2. New heating component

Description	:
Performance ratio of heat generation [%]	:
Installation date	:
Condition	:
Next replacement	:
Other	:

3.2.2.3 Retrofit step 4:

To be inserted

Start date	:
Completion date	:
Budget	:
PHPP: specific heating demand [kWh/(m²K)]	:
PHPP: specific cooling demand | Overheating frequency [kWh/(m²K) | %]	:
PHPP: specific primary energy demand [kWh/(m²K)]	:

3.2.2.3.1. New envelope component

Description	:
U-Value [W/(m²K)]	:
Installation date	:
Condition	:

Next replacement	:
Other	:

3.2.2.3.2. New heating component

Description	:
Performance ratio of heat generation [%]	:
Installation date	:
Condition	:
Next replacement	:
Other	:

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3.3 Images

These pictures or drawings illustrate the retrofit process.

Further images to be inserted during/following refurbishment

Figure 10 Render of Wilmcote House post-refurbishment (1) (ECD Architects)

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Figure 11 Render of Wilmcote House post-refurbishment (2) (ECD Architects)

Figure 12 Render of Wilmcote House post-refurbishment (3) (ECD Architects)

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4 Completion of step-by-step refurbishment to EnerPHit standard including RES

To be inserted upon completion

4.1 General description

To be inserted upon completion

4.2 Retrofit steps carried out

To be inserted upon completion

Figure 13: PHPP9 beta [PHI 2013] Variant sheet with the retrofit steps carried out

4.2.1 Building data

Construction Time :
Last retrofit :
Building use :
General condition :
Occupancy :
Treated floor Area :
Other :

4.2.2 Client

Name / Company :
Address :
Email :
Other :

4.3 Envelope of the refurbished Building

4.3.1 Floor slab

Description :
U-Value [W/(m²K)] :
Installation date :
Condition :

Next replacement :

Other :

4.3.2 External walls

Description :

U-Value [W/(m²K)] :

Installation date :

Condition :

Next replacement :

Other :

4.3.3 External walls to ground

Description :

U-Value [W/(m²K)] :

Installation date :

Condition :

Next replacement :

Other :

4.3.4 Windows

Description :

U-Value [W/(m²K)] :

Installation date :

Condition :

Next replacement :

Other :

4.3.5 Roof / Top floor ceiling

Description :

U-Value [W/(m²K)] :

Installation date :

Condition :

Next replacement :

Other :

4.4 Technical equipment of the refurbished building

4.4.1 Heating

Description	:
Performance ratio of heat generation [%]	:
Installation date	:
Condition	:
Next replacement	:
Other	:

4.4.2 Domestic hot water

Description	:
Performance ratio of heat generation [%]	:
Installation date	:
Condition	:
Next replacement	:
Other	:

4.4.3 Ventilation

Description	:
HR Efficiency[%]	:
El.Efficiency [Wh/m³]	
Installation date	:
Condition	:
Next replacement	:
Other	:

4.5 Energy efficiency of the refurbished building

To be inserted

4.5.1 Modelled efficiency parameters

PHPP: specific heating demand [kWh/(m²K)]	:
PHPP: specific cooling demand | Overheating frequency [kWh/(m²K) | %]	:
PHPP: specific primary energy demand [kWh/(m²K)]	:

For an overview of the energy efficiency of the completed step-by-step refurbishment, see the verification spreadsheet of the PHPP 9 beta version [PHI 2013] on the next page.

Figure 12: Specific energy efficiency values of the completed project modelled with PHPP 9 Beta

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4.6 Pictures / Drawings

To be inserted upon completion

5 RES Strategy / PV potential Evaluation

To be completed

5.1 Inhabitant's comfort and location concept

Onyx Solar will study in the following pages, the integration of photovoltaic technology on the Wilmcote House Refurbishment project located in Portsmouth (United Kingdom).

BIPV integration will be analyzed as a multifunctional added value where, in addition to the electrical generation, the system could provide passive bioclimatic properties as thermal inner comfort -since most of the UV and infrared radiation from the sun will be harvested by the silicon-based material (solar filter effect)-, natural sunscreen and the highly modern appearance.

The location is a key issue in order to consider the best solutions for this intervention. Into these parameters, there are critical factors that must be taken into account to move ahead. These critical factors include climate and microclimate features, geographical conditions (latitude, longitude, altitude above sea level, orientation) and building orientation.

Location	
Country	
Region	
Latitude	
Longitude	
Altitude	
Time Zone	

Table 2 Location parameters

	Global Irradiation	***Diffuse Irradiation***	***Average temperature***
	kWh/m²	***kWh/m²***	***°C***
January			
February			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			
Year			

Table 3 Microclimate conditions

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Portsmouth shows annual irradiation of -------- kWh/m^2. The average annual temperature is -------- °C. The elevation above sea level is --------- m. These climatic and geographic parameters, and the specific location of the building –latitude, longitude, altitude above sea level, orientation- were critical facts when selecting the technology to be implemented.

It is mandatory to point out that it has not been considered the effects of shadows or components of diffuse radiation and albedo in this approach. Therefore, a detailed analysis of production taking into account these critical factors should be done in subsequent stages of the analysis.

5.2 Evaluation of potential BIPV systems

5.2.1 PV Ventilated façade

This is an alternative solution for external walls that is composed by an insulation material in the inner part, an air gap and PV modules in the outer layer. This system could be implemented to reduce thermal exchanges and to avoid thermal bridges, producing at the same time clean electricity. Thanks to the ventilated air chamber and to the application of insulating material, this system increases the acoustic absorption and reduces the amount of heat that buildings absorb in hot weather conditions. In the air gap, the density difference between a hot and cold air creates a natural flow removing the air through a chimney effect that helps to eliminate heat and moisture increasing inner comfort.

Block A and stair core B: The ventilated façade would be located in the garden facade, covering the opaque walls. The scheme of the PV integration is shown below:

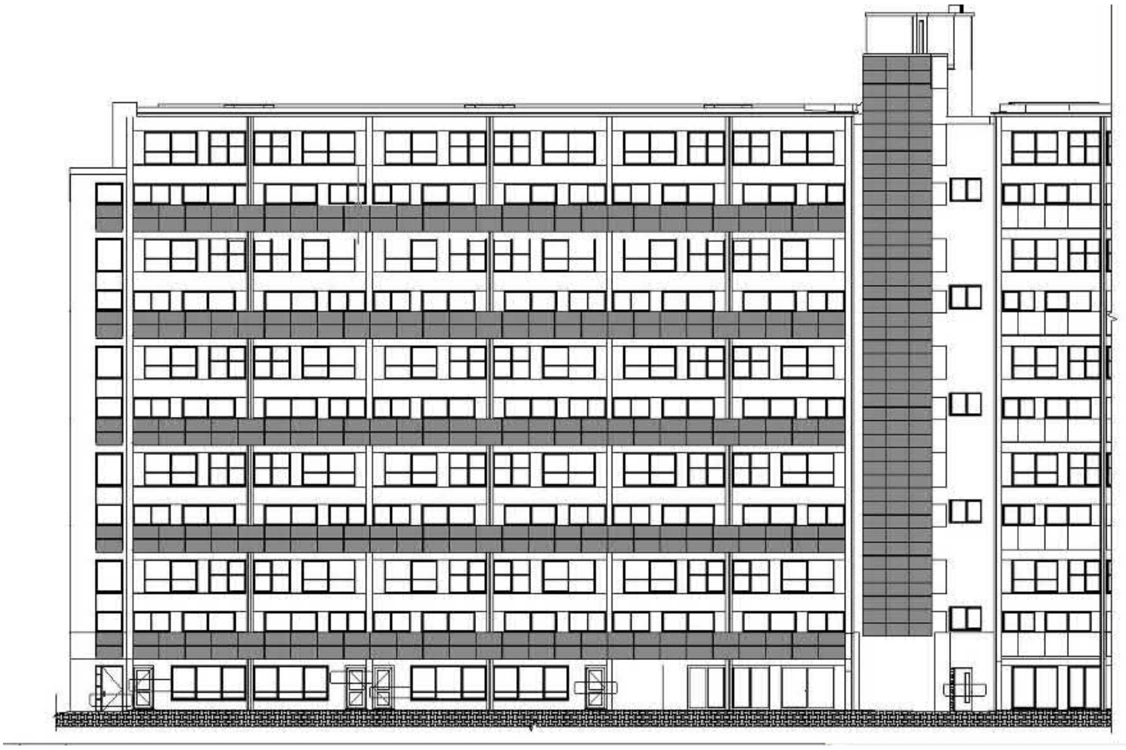

Figure 14 Block A garden façade view

Block B Garden façade: *to be inserted*

Stair core C façade: *to be inserted*

Block C Garden façade: *to be inserted*

The description of the components composing the PV ventilated system is included below:

5.2.1.1 PV glass

Amorphous silicon technology

The technology selected for this proposal will be amorphous silicon technology (a-si) due to the following reasons:

- Due to the location, orientation and surroundings, direct exposure of glass to solar radiation rarely would be achieved in an optimal way, being mandatory the harvesting of diffuse radiation. Then, amorphous silicon technology is the one that offers the best result in terms of kWh/kWp installed under these irradiation conditions.
- Furthermore, this technology offers the best aesthetic solutions when combining with other claddings/construction materials due to its plain characteristics and opaque color.

Glass dimensions and configuration

The glass selected for the integration is an opaque glass with a nominal power of 49 Wp/unit. The initial dimensions proposed for the PV glass are 1245x635 mm.

Block A Garden façade: The installation consists of 280 glasses, with an active surface of 221,36 sqm and a total power installed of 13,72 kWp.

Stair core B façade: The installation consists of 129 glasses, with an active surface of 101,98 sqm and a total power installed of 6,32kWp.

Block B Garden façade: *to be inserted*

Stair core C façade: *to be inserted*

Block C Garden façade: *to be inserted*

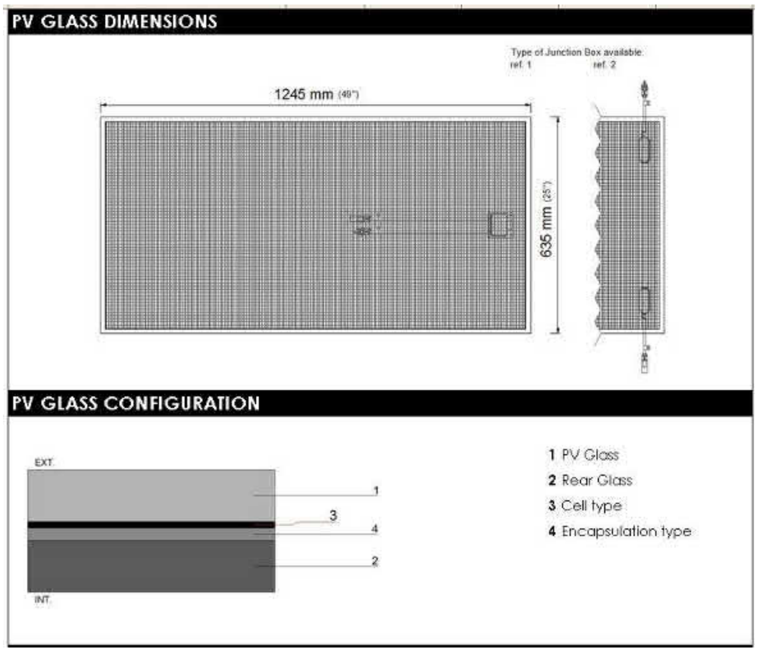

Figure 15: PV opaque a-si glass. Dimensions and configuration

A-SI OPAQUE		
Electrical data test conditions (STC)		
Nominal peak power	49,00	P_{mpp} (Wp)
Open-circuit voltage	64,50	V_{oc} (V)
Short-circuit current	1,05	I_{sc} (A)
Voltage at nominal power	51,70	V_{mpp} (V)
Current at nominal power	0,95	I_{mpp} (A)
Power tolerance not to exceed	±5	%
STC: 1000 w/m², AM 1.5 and a cell temperature of 25°C, stabilized module state.		
Mechanical description		
Length	1245	mm
Width	635	mm
Thickness	6,85	mm
Surface area	0,79	m²
Weight	12,65	Kg
Cell type	a-Si Thin Film Solar Cells	
Transparency degree	Dark	
First layer	3,2 mm Float Glass	
Second layer	3,2 mm Float Glass	
Thickness encapsulation	0,45 mm EVA	
Color code / thickness	--	
Junction Box		
Protection	IP65	
Conectors	MC4 or compatible	
Wiring Section	2,5 mm²	
Limits		
Maximum system voltage	1000	V_{sys} (V)
Operating module temperature	-40...+85	°C
Temperature Coefficients		
Temperature Coefficient of P_{mpp}	-0,19	%/°C
Temperature Coefficient of V_{oc}	-0,28	%/°C
Temperature Coefficient of I_{sc}	+0,09	%/°C

Table 4 PV opaque a-si glass. Technical data sheet

5.2.1.2 Insulation

To be inserted

5.2.1.3 Fixing system

BiPV photovoltaic glazing structurally does not defer from other type of glazing, and therefore, it is integrated in a ventilated façade system as any other cladding material.

The structure system is responsible for ensuring proper anchorage of the photovoltaic glass, facilitating the installation and maintenance of the modules and providing the orientation and inclination of the area integrated with the PV glasses. In the present case, as the PV system will be located on the building's facade, a secure anchorage to the original facade must be ensured, allowing at the same time, proper ventilation so the building can take advantage of the thermal benefits of ventilated facades.

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For the projected solution, the use of aluminium angles attached to the building façade is proposed, achieving a ventilated chamber of about 100 mm. At the opposite end of the angles, a vertical aluminium upright is placed, to which the staples are bolted. The PV glasses are fastened with these staples, allowing placing the glasses without metallic frame and achieving a separation between the glasses and the original façade of 100 mm. The contact between the staples and the photovoltaic glass will be fixed with an EPDM joints.

Adding the significant stability of the system, thanks to EPDM joints between glass and structure, we assure that the façade is correctly sealed. This fixing system is an easy way of installation and, at the same time, will allow carrying out the maintenance work, in case it would be necessary to remove some of the units.

This solution provide an important aesthetical value to the structure, from inside and outside view, combining with a significant resistant to wind action.

5.2.2 PV Roof superposition

Another option is the integration on the roof, taking advantage of this area directly exposed to the sun.

The description of the components composing the PV ventilated system is included below:

5.2.2.1 PV glass

Crystalline technology

The technology selected is the mono-crystalline (m-c) silicon, with a black back sheet, for the following reason:

Due to the location, orientation and planned placement, photovoltaic traditional panels can provide the best exposure to solar radiation (understood as such direct solar radiation in optimum angle) so it becomes critical exploit the available area to install most power as possible. Technology of mono-crystalline silicon is which provides the best results in terms of kWp/m2 radiation for these conditions.

Glass dimensions and configuration

The glass selected for the integration is an opaque glass with a nominal power of 240 Wp/unit. The initial dimensions proposed for the PV glass are 1641x989 mm.

We will expound an approximation assuming 50% of the rooftop´s area as PV integration area. In this way, we would leave aside space for maintenance works and possible devices located on the roof as heating/cooling system, lift´s facilities, etc.

The total area is approximately 380 sqm, so we can consider an integration area of 190 sqm. Mentionated area allows tu integrate 117 PV units with the dimensions mentioned above, with an active surface of 189,88 sqm and a total power installed of 28,09 kWp.

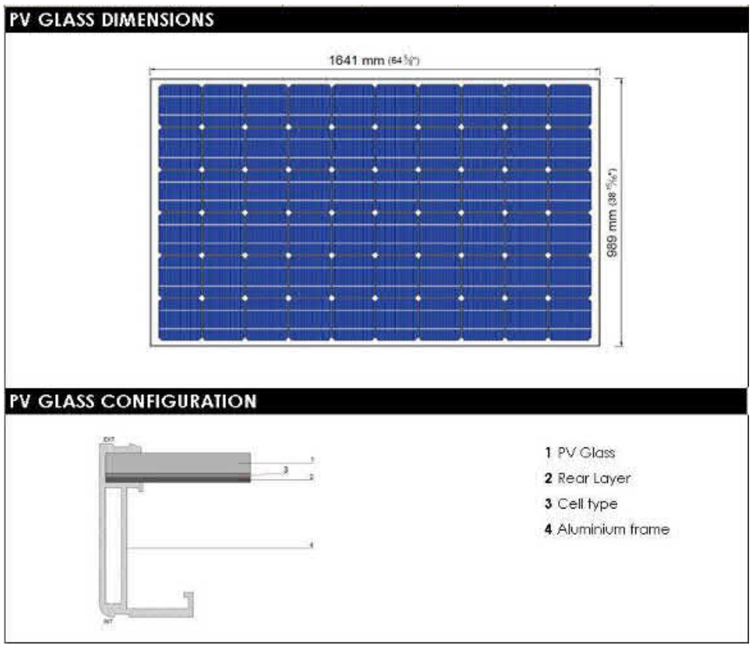

Figure 16 PV m-c glass Dimensions and configuration

M-C		
Electrical data test conditions (STC)		
Nominal peak power	240	P_{mpp} (Wp)
Open-circuit voltage	37,1	V_{oc} (V)
Short-circuit current	8,5	I_{sc} (A)
Voltage at nominal power	30,3	V_{mpp} (V)
Current at nominal power	7,94	I_{mpp} (A)
Power tolerance not to exceed	±3	%
STC: 1000 w/m², AM 1.5 and a cell temperature of 25°C, stabilized module state.		
Mechanical description		
Length	1641	mm
Width	989	mm
Thickness	46	mm
Surface area	1,62	m²
Weight density	23,50	Kg
Cell type	6" Mono -	Crystalline
Transparency degree	60	cells
First layer	4 mm	Float glass
Second layer	1 mm	TEDLAR / PYE
Thickness encapsulation	0,90 mm	EVA Foil
Junction Box		
Protection	IP65	
Conectors	MC4 or	compatible
Wiring Section	2,5	mm^2
Limits		
Maximum system voltage	1000	V_{sys} (V)
Operating module temperature	-40...+85	°C

Table 5 PV m-c glass Technical data sheet

5.2.2.2 Insulation

To be inserted

5.2.2.3 Fixing system

To be inserted

5.3 Production estimation

A preliminary estimation of PV energy generation can be determined for the proposed solutions by means of implementing simulation tools, where key site location factors as climatic parameters (latitude, longitude, altitude above sea level, orientation) and BIPV system characteristics (tilted angle, azimuth etc.) are considered to establish the final solution energy performance.

The graphic draws a comparison between Peak Power and Energy yield for the different options of PV integration.

Considering the data of energy mixing in ------ (country name) according to the International Energy Agency, where a ratio of ---- Kg CO2 / KWh is found, it can be extracted the following emissions of CO2 per year that would be prevented for each option proposed:[1]

PV type	opaque a-si	opaque a-si	Opaque m-c
Location	Block A garden facade	Stair core B facade	Block B garden facade
Installed PV area [m²]	221,36	101,98	pending
Installed peak power [kWp]	13,72	6,32	pending
Annual RES gains [kWh]	9588	4788	pending
CO2 emissions prevented	pending	pending	pending

PV type	opaque a-si	opaque a-si	m-c
Location	Stair core C facade	Block C garden facade	Block A Roof top
Installed PV area [m²]	pending	pending	189,88
Installed peak power [kWp]	pending	pending	28,09
Annual RES gains [kWh]	pending	pending	27222
CO2 emissions prevented	pending	pending	pending

Table 6 Energy production summary

[1] CO_2 emissions from fossil fuels consumed for electricity generation, in both electricity-only and combined heat and power plants, divided by output of electricity generated from all fossil and non-fossil sources. Both main activity producers and auto producers have been included in the calculation.

Source: CO2 EMISSIONS FROM FUEL COMBUSTION Highlights (2013 Edition), INTERNATIONAL ENERGY AGENCY

6 Refurbishment to the current National Standards

To be inserted upon completion

6.1 General Description

Add a more detailed description of the main differences between the building retrofitted according to national regulations and EnerPHit standard.

6.2 Efficiency results comparison table

	Existing building	National regulations	EnerPHit standard	Differences [%]
Space heat demand [kWh/(m²/a)]				
Primary energy demand [kWh/(m²/a)]				
Heat Load [W/m²]				

Figure 17: Comparison of efficiency results

6.3 Building envelope comparison table

	Existing building	National regulations	EnerPHit standard	Differences [%]
Airtightness Pressure test n50 [1/h]				
Building envelope				
Floor Slab [W/(m²K)]				
Walls to ground [W/(m²K)]				
Walls [W/(m²K)]				
Roof / Attic ceilings [W/(m²K)]				
Windows [W/(m²K)]				
Doors [W/(m²K)]				
Thermal bridging ΔU[W/(m²K)]				

Figure 18: Comparison of building envelope components

6.4 Building equipment comparison table

	Existing building	National regulations	EnerPHit standard	Differences [%]
Ventilation	**Natural**	**Natural**		
HR Efficiency [%]				
Electric efficiency [Wh/m³]				
Ducting				
Heating	**Boiler**		**Heat pump**	
Energy source	Gas		Electricity	
Performance ratio of heat generation [%]				
Thermal output kW				
Insulation of pipes				
Domestic hot water	**Gas**		**Heat pump**	
Energy source	Gas		Electricity	
Performance ratio of heat generation [%]				
Thermal output kW				
Insulation of pipes				
Cooling	**Gas**		**Heat pump**	
Energy source	Gas		Electricity	
Performance ratio of cooling generation [%]				
Thermal output kW				
Insulation of pipes				

Figure 19: Comparison of building envelope components

6.5 RES implementation comparison table

	Existing building	National regulations	EnerPHit standard	Differences [%]
Renewables	None			

Figure 20: Comparison of building envelope components

6.6 Conclusions

To be inserted

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