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Performance Assessment and Post Occupancy Evaluation of Low-Energy Retrofit of Public Buildings: Case Study of Coventry University Living Lab

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1.0 Introduction

REtrofitting Solutions and Services for the enhancement of Energy Efficiency in Public Buildings (RESSEEPE) is an EU funded project that focuses on the refurbishment of existing public buildings in three European cities: Coventry (UK), Barcelona (SP) and Skelleftea (SW).

Aims of the project:

- Bring together design and decision making tools and innovative building fabric manufacturers to collaborate and improve building performance through low energy retrofitting
- Set up a diagnosis methodology for an integrated renovation of public buildings at building and district level (Replicability of the solutions)
- Development of a systemic view for selection of the most empowering retrofitting mix: low energy renovation of existing public districts.
- Adapt, demonstrate and validate the technologies in different demo-sites

In figures:

- Around 50% energy savings will be achieved on different types of sites;
- Energy consumption reduction of 66 kWh / m^2 year
- CO_2 emissions reduced to 48,15 kg / m^2 year
- A rehabilitation cost under 19% of investment costs associated with new construction of an equivalent building

2.0 Decision Making and Technology Selection Process

The presentation describes the methodology followed for decision-making, building selection and process of selection and installation of prototype low-energy technologies for building retrofit of Coventry University buildings demo-site (Figure 1).

The process is designed to ensure that the technologies selected will meet the objectives of the project in terms of achieving 50% of energy reduction within a specified budget. The core idea is to select and test some advanced technologies already in the market and others developed specifically within the RESSEEPE project, in order to evaluate the potential benefits of these technologies.

The technology selection for application in demo-site buildings is dependent on the specific need of the demo-site, both in terms of its climate, building performance challenges, cost, response to user comfort and potential replicability.

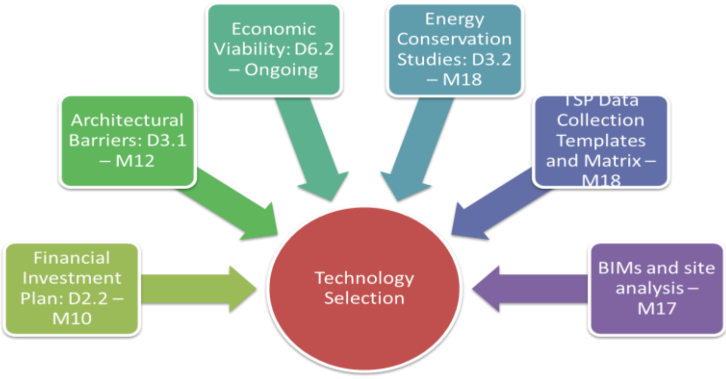

Figure 1 – Technology selection process

3.0 Technologies selected and installation process

After going through this selection procedure a mix of technologies were selected for each demo-site (Table 1). Coventry University demo-site developed a dual strategy, with John Laing Building used as a living lab to test new innovative technologies on some parts of the building (Figure 2), but being extrapolated to the entire building; and Richard Crossman Building as a whole building retrofit, with innovative technologies that are already available in the market.

Demo-site / Technology (m^2)	John Laing Building, Coventry (m^2)	Richard Crossman Building, Coventry (m^2)
EPS-G Panels	57	X
Aerogel Based Insulating Mortar	57	X
Vacuum Insulated Panels	56	X
Solar PV	X	9,395
Seasonal Thermal Energy Storage (Water and PCM)	301	X
EC Windows	56	X
Ventilated Façade	28	X
LED Lighting	X	2,600
High Efficiency Windows	28	9,395
BIPV	57	X
Solar Thermal Collectors - UPC	X	X
Solar Thermal Collectors	X	X
Building Fabric Improvements**	X	934
Total Area of Site Affected	**3,660**	**9,395**

Table 2 – Technologies Implemented in UK Pilot Buildings

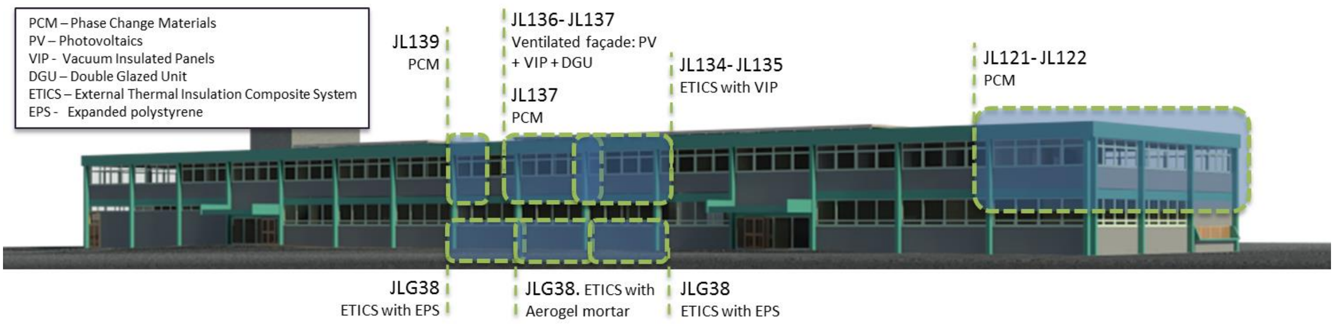

Figure 2: Location of the interventions in John Laing Building

The installation of the different low carbon technologies in Richard Crossman building lasted for nine months and it was developed according to plan and without any setbacks. Regarding the technology installation in John Laing living lab case study (Figure 3), due to the state-of-the-art status of the technologies implemented, some challenges were faced during the coordination of retrofitting activities.

Figure 3: Technologies implemented in John Laing Building

The barriers found for achieving real life integration/performance were the following:

- International project: complicated to manage, non awareness of local regulations or systems such as Health and safety, lack of accurate existing building data.
- Lack of knowledge of how the technologies interact with the whole constructive systems – technologies can perform in isolation whereas the whole system interaction is unknown.
- Aesthetics: matching the aesthetic of existing design when using innovative technology

The learning throughout the process is important in order to obtain conclusions from the barriers and engagement issues faced during the selection process, procurement, and installation and user satisfaction evaluation when retrofitting a public building.

4.0 Monitoring, simulation and performance evaluation

In order to ensure the expected designed performance criteria is achieved, a monitoring campaign of the energy and environmental performance of the retrofitted spaces before and after the installation has been undertaken. The performance monitoring such as indoor environmental sensors, heat flux sensors, electricity and gas meters have been installed to monitor individual technologies.

The process also includes detailed stakeholder engagement and assessment of user satisfaction (Figure 4). An initial stakeholder engagement provided a platform to highlight critical factors such as user comfort, consideration on local planning constraints and disruption. The engagement of users of the buildings is vital for achieving the socio-economic and environmental benefit of low energy retrofit.

One important component of the selection process includes the building performance modelling using IES virtual Environment. Current and post retrofit conditions of John Laing and Richard Crossman Buildings have been developed giving us indicative potential savings that will be derived from the retrofit action. Figure 5 shows the IES-VE 3D Model for both buildings with an indication of retrofit action.

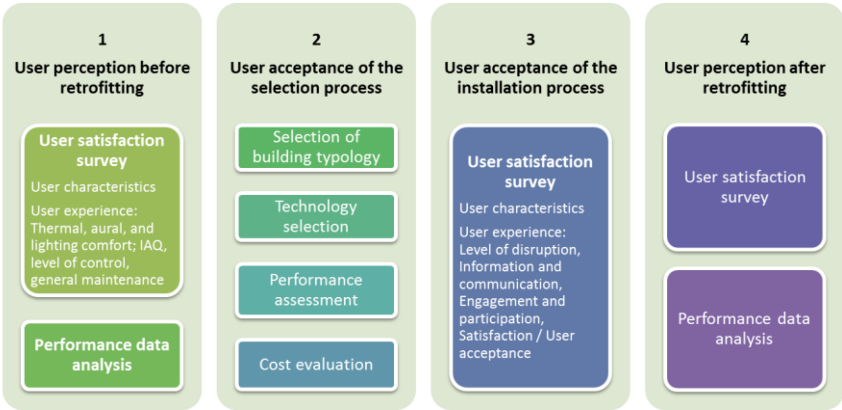

Figure 4. Assessment of user satisfaction

Figure 5. IES-VE 3D Model for Richard Crossman and John Laing Buildings

The results of the modelling of Richard Crossman show significant reduction in total energy consumption for the entire building in the region of 49% which meets the initial project objective of 50% post retrofit energy reduction (Table 2). Even though there is slight increase in electric consumption this will be offset by the 75kWp Solar PV system that has been integrated in the building. Regarding John Laing, because the strategy on this building is to test the technologies on some sections of the building, the modelling focusses on the performance of individual spaces that have technology intervention.

	Richard Crossman Building			John Laing Building		
	Pre	Post Full	Change	Pre	Post Full	Change
Boilers energy (MWh)	2593.3398	749.8302	71.09%	418.7628	371.2533	**11.35%**
Total system energy (MWh)	3180.573	1097.0815	65.51%	448.8424	401.3487	**10.58%**
Total nat. gas (MWh)	2593.3398	749.8304	71.09%	418.7628	371.2533	**11.35%**
Total electricity (MWh)	1103.2562	1168.4075	-5.91%	30.0797	30.0954	**-0.05%**
Total Carbon Emissions (Kgco2)	1132751	632847	44.13%	106064	95810	**9.67%**
Total energy (MWh)	3696.5952	1885.3925	**49.00%**	448.8424	401.3487	**10.58%**
Total energy (MWh/m2)	0.393464098	0.200680415	**49.00%**	0.122634536	0.109658115	**10.58%**
Total energy (KWh/m2)	393.4640979	200.6804151	**49.00%**	122.6345355	109.6581148	**10.58%**
Total grid disp. Elec (Mwh)	0	-32.8447				

Table 2. IES-VE Simulation Results – Richard Crossman and John Laing Buildings

Data from the monitoring will be used to calibrate the simulation and use it to extrapolate the benefit of these technologies to the entire building. The calibrated models will also be used to extrapolate results to other buildings within the urban district.