Keeping the Built Environment Virtuous at UWL

As the world grapples with the challenges of climate change and the need to transition to a low-carbon economy, one of the pressing issues is reducing the carbon footprint of existing buildings. Older buildings in particular pose a unique challenge due to their, often, restrictive structures, inefficient envelopes, and outdated energy systems.

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Nasrin Khanom and Claire Willitts from the University of West London (UWL) discuss the process of decarbonising old and ageing buildings by implementing new renewable and clean energy technologies at UWL. The transformation serves as a beacon of hope, demonstrating that sustainable practices can be integrated into our whole built environment.

The Buildings: A Glimpse into the Past

Our case study centres on decarbonising four historical sites located in an urban part of west London. The buildings include the St. Mary's Road (SMR) campus, Paragon House (PH), Vestry Hall (VH) and Drama Studio London (DSL) – see Box 1 for more information about each building. These buildings were constructed between the 1879s and 2006 and present a mix of construction types and building conditions. The mission was to enhance these buildings with new and modern renewable and energy-efficient technologies to make them flagships for sustainable energy in the post-modern era.

Assessment of the Old Systems

The initial step in decarbonising the buildings involved a thorough assessment of existing energy systems. The buildings relied heavily on fossil fuels for heating and electricity, producing significant carbon emissions. In many areas the windows and building fabric insulation were inadequate by sustainable standards, causing energy leaks, and most of the lighting systems used fluorescent fittings. The energy consumption and carbon emissions of these buildings prior to commencement of the decarbonisation project (and before the Covid-19 pandemic) stood at 10,205,398 kWh and 2,522 tCO_2e for the academic year 2018/19 (1st August 2018 to 31st July 2019). See Box 2 for more information about the building's previous energy systems.

Renewable Energy Integration

In 2020, UWL made a bid for £5.1m of grant funding from the UK government's Public Sector Decarbonisation Scheme (Phase 1) having scoped a significant opportunity to improve building performance and reduce carbon emissions. The grant was awarded in January 2021 and the funding was used to install a range of renewable energy and energy efficiency technologies to decarbonise these buildings in west London by the end of 2021.

To deliver the transformation, a mix of renewable and clean energy technologies was introduced. 584 solar photovoltaic thermal (PVT) panels, each rated at

340Wp, were installed on the roof at SMR. This solar array not only generates electricity that is used to heat the building's hot water but also generates power for lighting and small power systems. The solar PVT was combined with a 900kW Ground Source Heat Pump (GSHP) that was installed in a restricted and challenging site to harness the constant temperature of the Earth, providing efficient heating all year-round. This allowed for the retirement of the old, fossil-fuel-based heating system.

A 432kW Air Source Heat Pump (ASHP) was installed at PH, which supplies a 5,000 litre thermal store. A 59kW GSHP was installed at the smaller DSL site and a 31kW ASHP was installed at VH.

Box 1: Buildings' Profiles

St. Mary's Road (image on the left):

The St. Mary's Road (SMR) Campus is in Ealing, west London. It combines numerous buildings containing classrooms, staff office areas, a library as well as several specific use rooms (specialist wet and dry lab facilities, teaching kitchens, dance and performance studios, film and photography studios, and computer suites, etc.). The campus spans circa 30,612m². Approximately 50% of that area is open 24/7 to support student access and the remainder typically operates between 06:00-22:00hrs on Monday-Friday and from 08:00-18:00hrs on Saturday and Sunday. The site operates approximately 52 weeks per year. The buildings are of differing construction but are predominantly mid-late 20th Century construction, with concrete and steel frame and flat roof.

Paragon House:

Paragon House (PH) was built in 2006 and is a 13-storey concrete frame, flat roof and glazed curtain wall structure in Hounslow, west London. It accommodates a reception, café and restaurant as well as two main lecture theatres located on the ground floor, dry labs and computer suites, staff office accommodation and classrooms throughout all levels, with a function suite on the 11th floor. The site spans approximately 11,702m² and typically operates between 06:00-22:00hrs on Monday-Friday. The building is open on Saturday from 08:00-18:00hrs and closed on Sunday.

Drama Studio London:

The Drama Studio London (DSL) building is in Ealing, west London. The Studio was established in the 1960s but the building itself is more than 100 years old, with a long history and of local interest. It is open only during term times and operates between 09:00-17:00hrs on Monday to Friday. The four-storey building houses eight studio rooms and a theatre room, plus a library, costume and workshop areas and staff office accommodation. The building is of traditional Edwardian residential construction with cavity walls and timber frame roof.

Vestry Hall:

Built in 1879, Vestry Hall (VH) is a heritage red brick and sandstone single-storey building with a mix of pitched and flat roof, in Ealing, west London. It is a large acoustic studio where students can develop their skills; equipped with two performance rooms, a live recording room and the main hall suited to concert performances. The building is one of the few remaining facilities of its type in London. The site spans approximately 221m² and typically operates between 09:00-21:00hrs on Monday-Friday. The building is open at weekends from 09:00-17:00hrs.

Box 2: Energy Systems Pre-Decarbonisation Project

St. Mary's Road (SMR)

SMR was supplied by three main gas meters and one main electric meter with multiple electrical distribution boards. Some of these are equipped with sub-meters, approximately 30 across the site, and most are connected to the old Building Management System (BMS). The campus had two boiler houses in the basement of the building. These provided heating and hot water across the campus. Heating was provided by three No. Remeha Gas 610 Eco Pro gas fired modular boilers rated at 610kWth each. Boilers are composed of two modules each. The site has both constant temperature (CT) and variable temperature (VT) systems. Heating is provided by a wet radiator system and/or underfloor heating. There are also several twin pipe Fan Coil Units (FCUs) for heating, with no provision for cooling. There are also some small point of use electric water heaters throughout the building. The main cooling is provided by Variable Refrigerant Flow units (VRF) and various split units. Ventilation is passive or provided by Air Handling Units (AHUs) serving the various areas of the building. All AHUs are inverter controlled and mainly located on the roof. The site also has several kitchen extracts and toilet extracts. Heating and ventilation plant is controlled through a BMS TREND IQVIEW 8 system. The site has a mixture of LED lights and some conventional lights such as T5 lights. In 2014, the University installed 800m2 of solar PV on the flat roof above the Library area of the building.

Paragon House (PH):

PH is supplied by one day and one half-hourly (HH) gas meters and two HH electric meters with three incomers. Submeters have been added to the non-landlord distribution boards on all floors. Those meters cover lighting, and small power loads. Heating was provided by three Hoval condensing gas fired boilers rated at 200kW each. Boilers provided Low Temperature Hot Water (LTHW) serving the Air Handling Unit (AHU), around 270 FCUs, various radiators throughout the building and the trench heating system at the building perimeter. Hot Water System (HWS) was provided by one direct gas fired boiler rated at 100 kW linked to a Domestic Hot Water (DHW) storage vessel. There are also several small electric ZIP and Hydroboil water heaters across the building for DHW point of use. The main cooling is provided by three McQuay chillers located on the roof, with one chiller currently out of use. They provide cooling to all four AHUs and all FCUs. The equipment was controlled through a Johnson Controls BMS. The site has a mixture of LED, compact fluorescent downlight and plug-in lamps which are mostly controlled via Passive Infrared Sensors (PIRs).

Drama Studio London (DSL):

The heating at DSL ran through the storage heaters throughout the building. There are a total of 16 storage heaters spread throughout the floors across multiple rooms.

Vestry Hall (VH):

The heating at VH was generated by two gas fired boilers. These boilers only provided heating to the main hall, front office, toilets and the lobby. The remaining heating in the building was provided by individual air-conditioning units in each of the rooms. Temperature in the Hall and in all rooms with pianos are kept at around 21°C all year to maintain the condition of the pianos and prevent the instruments from damage. In Studio 1, there are four Vent-Axia fans which are kept on 24/7.

"Each technology required a bespoke design to suit the building construction and configuration. None of the systems were off-the-shelf solutions and that meant a broad collection of skilled designers, engineers and installation teams were required to develop dynamic and progressive systems. The nature of that challenge required superlative collaboration, not just within the design and installation team but also following handover, when the technologies became the most prominent operational system within the University, and therefore the most exposed", says Claire.

The solar PVT, GSHP and ASHP installations combine for an estimated saving of 2,430,518 kWh of energy and 511 tCO2e per year that has since been evidenced. A full list of renewable energy and energy-efficiency measures for each site can be found in Box 3 below.

Box 3: Renewable Energy and Energy Efficiency Measures Implemented

Measure	SMR	PH	VH	DSL
LED Lighting Replacement	✓	✓		
BMS Upgrade / Optimisation	✓		✓	
DHW Upgrade				✓
Solar PVT	✓			
Insulation			✓	
ASHP		✓	✓	
GSHP	✓			✓
Chiller Optimisation		✓		

Improving Energy Efficiency

In addition to renewable energy integration, improving energy efficiency played a crucial role in decarbonising the buildings. Insulation was added to the roof void at VH to further reduce energy waste. The lighting system at SMR and PH was overhauled, replacing the majority of the fluorescent bulbs with LED lights with automated controls, which are not only more energy-efficient but also have a longer life. The outdated hot water calorifier at DSL was replaced with the latest energy-efficient type to reduce heat losses through improved insulation. Split system air conditioning units were installed to provide dedicated cooling to the IT data rooms at PH, and this led to noticeable energy savings associated with preventing the central chillers from being in constant operation when the site is not running 24/7.

The secondary glazing, insulation, LED lighting, energy-efficient hot water system and split air conditioning units are estimated to save 144,123 kWh of energy and 13 tCO2e per year and contribute to better environmental conditions for occupiers.

Building Energy Management System

To maximise the benefits of renewable energy and energy efficiency, a Building Management System (BMS) was installed at SMR and VH. The system allowed for real-time monitoring and control of energy usage within the building. It automated various processes, such as adjusting the Heating, Ventilation, and Air-Conditioning (HVAC) systems based on occupancy and external weather conditions. Smart electricity and heat meters were also implemented to provide detailed energy consumption data on the solar PVT, GSHP and ASHP. "The BMS is estimated to save 53,596 kWh of energy and 6 tCO_2e per year but importantly gives us the data we need to make informed choices about our energy use and maintain integrity when we are evaluating our impact" says Nasrin.

Challenges Faced

While the project delivered a sustainable operation, it was not without its share of challenges, other than those of design integration already discussed. The installations required planning permission and compliance with local listing restrictions for some buildings, which made the project more complex. Three of the four sites are located in residential areas and within Conservation Areas, making the logistics of delivery highly emotive and demanding, especially during a period when the majority of the population was working from their home. The timeline for delivery from grant award was extremely aggressive and made further challenges by the Covid-19 pandemic and the continuing impact of Brexit on supply chains.

Results and Benefits

The project was delivered in line with the Public Sector Decarbonisation Scheme programme and around the University operation with minimal disruption, which was a huge success in its own right, preserving student and staff experience. After the implementation of renewable energy and energy efficiency measures, the buildings' performance improved dramatically. The project delivered several key technical benefits:

• Carbon Reduction

Carbon emissions were significantly reduced by 560 tCO_2e per year; 6% higher than estimated. This made substantial progress towards UWL's net zero carbon target. Scopes 1 and 2 carbon emissions were reduced by 34% in academic year 2022/23 (1st August 2022 to 31st July 2023) compared to academic year 2018/19 (pre-Covid level). 87% of the University's total commercial gross internal floor areas are now heated by renewable technology.

• Energy Efficiency

Energy consumption decreased substantially, leading to significant electricity and gas savings of 2,838,816 kWh; 8% higher than estimated.

• Comfort

Occupants of the buildings experienced an improvement in comfort due to the renewable energy technologies, improved insulation, and the automated lighting and HVAC control through the BMS. This in turn, contributed to a positive student and staff experience.

• Community Impact

The project is estimated to deliver a social return on investment of £15m over the lifetime of the equipments. This is in relation to environmental, education and skills, employment and volunteering and economic. The project commenced during Covid-19 and UWL was able to create 60 new job opportunities despite the majority of the UK's workforce being furloughed.

• Reputation
The reach of the project has reinforced UWL's commitment to its sustainability agenda and its role as an anchor institution in west London, further showcasing its dramatic trajectory to become one of the best Modern Universities in London.

Conclusion

With the right mix of skills and mindset the challenge of decarbonising old and ageing buildings is not insurmountable. By integrating a mix of renewable energy sources, implementing energy efficiency measures, and embracing smart energy management, it is possible to give the older stock of urban landscape a new longevity and avoid the carbon associated with demolishing outdated buildings. "It exemplifies that the past and future can coexist, preserving the legacy of historic architecture while embracing the imperative of sustainable, clean energy technologies in keeping the built environment virtuous as it continues to age" says Claire.

"We face a stark reality that old and ageing buildings are carbon intensive, and relying on fossil fuels as the primary energy source makes the people, environment and the economy more vulnerable to the effects of climate change. Increasing energy resilience by transitioning to low-carbon technologies is critical for mitigating and adapting to climate change. While decarbonising existing buildings presents its own set of challenges, it is not impossible to achieve, and given the urgency of the climate emergency, patience may not be a virtue" says Nasrin.

Authors' Profiles:

Nasrin Khanom has worked in sustainability for over ten years and is the Head of Environmental Sustainability at the University of West London. She was featured in the ENDS Power List 2023 recognising the top 100 UK environmental professionals who have made the greatest impact in the past two years. In 2020, Nasrin was named one of edie's '30 under 30 next generation of sustainability leaders', and the Energy Managers Association commended her for the 'Energy Manager of the Year' award.

Claire Willitts is the Director of Property Services at the University of West London and has over eighteen years of experience in estate and project management. She is a chartered surveyor and a member of the Royal Institution of Chartered Surveyors.