Barbican Feasibility Study

Hamish McMichael RIBA

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AMBUE

Barbican: Feasibility Study for Empirical Building Performance Modelling.

The Brief:

Ambue were approached by Emma Bushell, Energy and Carbon Manager at City of London Corporation, to discuss the challenge of developing a strategy to improve the comfort and building performance of the residential dwellings on the Barbican Estate.

About Ambue:

Ambue was founded by Hamish McMichael, an Architect, Conservation Architect and Retrofit Coordinator, to focus on the design and technical challenges of Retrofitting existing housing properties. The company employs a wide range of specialist designers, engineers, surveyors, software engineers and more recently Building Regulations Principal Designers, to support its work on High Risk Buildings.

Ambue have engaged with Atamate to support this project. Atamate is a technology company who are developing hardware and software to monitor and control building systems in existing buildings. Atamate's core team are Building Services Engineers who provide technical support in the design, implementation and configuration of their building monitoring and control systems.

Summary of the challenge:

Further to initial conversations and a high level review of available documentation, our summary of the issues to be addressed are as follows:

Comfort:

We have been advised that comfort levels are a frequent concern of residents. We understand that the original design philosophy was for the Landlord to provide an ambient background level of space heating, and for residents to supplement this with individual space heating systems (i.e. plug in electric heaters) to boost the temperature to a level that suits their preference.

A consequence of the system set up, is there is a one size fits all approach, with dwellings either feeling too cold or overheating, with few means to customise this to suit the individual resident's preferences.

Control:

We have been advised that all of the residential buildings in the Barbican Estate are controlled as a whole, by a programme that switches all underfloor heating either on or off, following a set programme. This is a graph which plots external temperature (based on a single thermometer) against time of day, and when the temperature falls below the trigger temperature at that point in time, everything is turned on.

There is no control depending on building type, dwelling location (such as being sheltered or highly exposed), dwelling size, aspect and orientation etc.

There is also no override control for the residents, such as the ability to pre-programme the heating to suit their preferences for a background temperature, occupancy, time of day or different rooms or zones within the dwelling, apart from reducing the total load in the flat, or by entirely eliminating the heating in a room. Both of these interventions can only be carried out for a whole heating season, not on a day by day basis.

This gives very little agency and control to the occupants, and we have heard anecdotally of residents resorting to removing fuses to stop the heating and opening windows to cool the building down.

The data we have reviewed to date is anecdotal rather than measured evidence based.

Efficiency:

The implication of this lack of control is that it is extremely wasteful in costs and emissions.

The costs of the energy are charged back to the residents on a pro-rata basis, providing no agency based on actual desired consumption, and inadvertently discouraging good energy management principles.

The current energy consumption of the Barbican estate comprises a significant part of the City of London Corporation's Scope 2 CO2 emissions (based on current energy grid emissions data).

Building Fabric:

Due to the nature of the materials and details of the construction, there is a high thermal mass to the dwellings which influences the demand response, particularly with the electric heating elements being embedded in the screed.

How long does it actually take for the internal temperatures to respond to the external trigger temperature and reach a perceptibly comfortable level? We have heard anecdotally that the demand response time can be from 1 to 2 hours?

What is the implication of different floor coverings and finishes?

Once external temperature has reached an acceptable level and the heating is switched off, how long does the fabric continue to radiate heat?

If a resident opens a door or window letting in fresh air and releasing heat, how responsive is the heating to stabilise the temperature?

The above factors will need to be understood, before modelling any proposals for fabric upgrades to the building.

Heritage

The Grade II Listed brutalist buildings designed by Chamberlain Powell and Bonn, are iconic and have great heritage significance. To establish the context and demonstrate a rigorous methodology, a Statement of Significance will need to be prepared before any Listed Building consultations for alterations are begun, (however there is already extensive documentation regarding the importance of these buildings, so there is ample source data).

During their development, any proposals will need to be considered with regards to the impact each intervention could have on the significance, to inform the development of a Heritage Impact Assessment.

If such proposals are based on detailed, methodical and empirical data collection, it is easier to justifiably demonstrate the need for an intervention and to form the basis for dialogue with the local Conservation Officers. Due to the significance of the estate, early dialogue with both the 20th Century Society and English Heritage would be advised, although this is currently out with the scope of this study.

User engagement:

It is critical to the development of successful strategies for the improvement of the performance of these buildings, that the impact on the occupants is fully understood. It would therefore be prudent to align the measurement and data collection, with user briefing, so that the data can be interpreted alongside individual human responses, including insights into occupancy, comfort levels and any user actions (such as turning on supplementary heating or opening windows).

To fully understand the buildings, we also need to understand the perception of their performance from the occupants.

This data can then be used to inform suggested interventions, including with regards to the landlords obligations contained within the lease agreements.

Studies undertaken to date:

We have received copies of various studies which have previously been undertaken into the buildings of the Barbican Estate.

These studies are helpful to look at the wider technical context and there has in the past also been some useful energy modelling, to provide a theoretical baseline of how the dwellings should perform.

These previous energy models of specific dwellings create a theoretical appraisal of the building, however the data inputs (such as the U-value performance of the concrete walls and floors) will be based on assumptions.

All modelling is hypothetical, therefore our recommendation is that to develop a better understanding of the buildings challenges (including the implications of any proposed alterations), it is essential to base the modelling on actual measured data.

This empirical data can then be used to calibrate detailed energy models, to provide a more accurate model of the actual building performance.

Proposal:

The proposed study, would be to measure actual data, to then build detailed calibrated energy models of sample dwellings, to asses measured performance (energy demand, operational cost, carbon emissions and comfort). These can then be extrapolated to provide analysis at a building level, enable us to consider the following strategies:

a) Modifications to the baseline operation of the building. What would happen if the existing operational controls are adjusted, for example changing the trigger temperatures, or the daily time profile (periods when the heating is switched on)? What changes could this have on the performance and actual comfort in the measured sample dwellings?

b) What would the implications be, if the controls were adjusted and calibrated on a building or zone basis? What are the implications for different dwelling archetypes, based on size, location, orientation, aspect and exposure?

c) What would the implications be, if the heating could be controlled on an individual dwelling basis. This could be full control of the background heating, or adjustments to lower the background heating to an acceptable level and the reintroduction of localised space heating as part of the solution.

d) What are the options for other upgrades, for example to ventilation, domestic hot water provision and user controlled local space heating? What would the implications be for other localised fabric interventions (subject to heritage approval), such as window upgrades, soffit or roof insulation, internal wall insulation etc.

e) What would the implications be if fabric improvements are targeted to the worst performing dwellings (energy efficiency and comfort), so that the performance gap between the best and least efficient dwellings is reduced. This could then result in overall adjustments to the background heating provision being made, with fewer concerns from the occupants of the worst performing dwellings.

The Scope of the Study:

Our proposal is to measure the buildings performance over the next heating season (to include a shoulder month when the heating is switched off) and then use this data to undertake detailed actual modelling of the building.

1) Measurement:
    - Install Atamate data sensors in each room of sample dwellings- collect data on existing performance (temperature (air and surface), CO2, occupancy, relative humidity).
    - Install Data loggers on the incoming electrical supply to each dwelling.
    - Survey Geometry (Lidar – internal with Matterport Camera, external with Drone), U-value surveys (Heat Flux), Cold Bridges (Thermographic imagery by Drone), Air Tightness tests (Fan Door Blower/ Pulse Air Test)
2) Modelling:
    - Building Information Model (BIM) and building physics models to calculate the fabric performance (Heat Transfer Coefficient).
    - Thermal Bridges (Psi values)
    - Thermal mass: Overheating : Solar Gain
    - Condensation Risk / Hygrothermal Modelling (WUFI: Warme Und Feuchte Instationar).
        i. Orientation
        ii. Exposure (height above ground)

Use the measurement data to calibrate the modelling for the baseline condition, and then the implications of various upgrades.

Drone surveys:

We have approached Vantage UAV Ltd to provide a quote for undertaking drone surveys to support the analysis. The drone surveys will primarily enable us to undertake external Thermal Imaging with an Infra-Red camera. This survey (flown at night when heating is on and no solar warming on the surfaces) will help identify the areas of heat loss through the façade, around windows, openings, services. It will also identify the relative rate of heat loss transmission between different areas of the thermal bridges, with the exposed concrete structure. This information can be used to help target upgrade interventions.

The drone survey can also show areas of saturated material which can help identify building defects. To enable thorough analysis, the drone survey also needs to capture a daytime comparison flight, with normal photographic imagery. The combination of the

Thermal and photographic image files, can also provide very useful data for stock condition inspections.

The survey company have also quoted for undertaking a 3D LiDAR (Light Dimension and Ranging) laser survey of the building, which can be used to create more accurate 3D models and record data. This is particularly useful if the available record data is not in a digital format, as it can be used to create a more accurate 3D model of the as built condition, including any post completion alterations.

Initial options to consider for upgrades:

Systems and Services:

- Heating controls Improve the existing services control and performance
  - Atamate propose systems controls (both individual dwelling and "landlord" background data.
  - Individual metering and consumption
  - Individual controls
  - Dynamic controls (time of use)
  - Systems integration (with ventilation, domestic hot water)
  - Integration with smart technology- Occupancy sensors – access/ concierge/ remote apps
  - Controls for use, time patterns, weekly occupancy: Machine Learning to learn and adapt to occupant use.
- Supplementary space heating
  - E.g. Air to Air Heat Pumps (A2AHP) – Direct electric – Infra Red Heating
- Ventilation upgrades (coordinated with Building Regulation Principal Designer services and fire-stopping requirements)
- Domestic Hot water

Fabric: Impact on fabric/ thermal mass calculations.

- Window upgrades (U-values, G-values – overshading – air tightness – purge ventilation) (Also – safety, security, fire evac)
- Doors. U-value, security, fire compartmentation.
- Roofs, Soffits. Ceilings (to cold bridge areas?)
- Walls: Shared spaces – external walls – cold bridges (e.g. to balconies).
  - Internal Wall Insulation solutions – to shared walls, external walls, party wall returns.
    - Materials, finishes, fixing.
    - Insulation specifications, thickness, performance, fixings, maintenance.

Heritage Impact Assessment of interventions

Methodology:

- Identify Pilot dwellings: undertake sample surveys/ Measure data over heating season.
- Model the archetypes within it – to undertake technical analysis.
- Develop options for upgrades.
- Analyse impact on building performance and heritage impact assessment of each option.
- Consultation with leaseholders.
- Initial consultation with Conservation Officers and Heritage Stakeholders (Historic England, 20th Century Society) – who will want full technical analysis and risk assessment, details and specifications, to understand impact.

Future works (outside scope of the study).

- Select potential pilot dwellings- apply for Planning Permission/ Listed Building consent. Apply for Grants?
- Deliver pilot properties.
- Negotiate with Conservation Officers, to establish a planning performance agreement, for a pre-approved package of "solutions" to each archetype.
- Expand the study and appraisal for each other building/ block.

Selecting a representative sample:

The proposal is to undertake the study on buildings which can provide a good representation of a significant proportion of the estate, and to select a number of dwellings to measure and model within those blocks, to enable us to understand the different physical characteristics (dwelling size, aspect and form factor) to provide data for comparative analysis.

It is therefore proposed to analyse the following sample archetype dwellings in these representative buildings:

Defoe House: (8 sample dwellings)

- First Floor End Block
- First Floor Mid Block
- Mid Floor End Block
- Mid Floor Mid Block
- Top Floor End Block
- Top Floor Mid Block
- Sub-podium – End Block
- Sub-podium – Mid Block

Shakespeare Tower: (6 sample dwellings)

- Higher Floor – Any orientation
- Mid Floor – Orientation A
- Mid Floor – Orientation B
- Mid Floor – Orientation C
- First Floor – Any Orientation
- Penthouse - Any Orientation

Seddon House: (7 sample dwellings)

- Lower Floor (exposed soffit)- End
- Lower Floor (exposed soffit)- Mid
- Middle Floor - Mid – East Orientation
- Middle Floor – Mid- West Orientation
- Middle Floor – End- any Orientation
- Top Floor – Mid
- Top Floor – End

Workflow methodology and outline programme:

- It is proposed that the Data loggers are installed in December 2024, and data is collected through to April/ early May 2025.
- Geometric surveys and modelling – January – March 2025.
- Data analysis and report generation April – June 2025.
- Presentations, Stakeholder Engagement and Final Report – June/ July 2025.

Pricing Options:

The table below summarises the unit costs per building study, based on the number of archetypes to survey and model. We have scheduled the costs of the Drone surveys as an option, if the budget allows.

	Daily rate £600 Days	Unit cost	**Defoe House** 8 sample dwellings	**Shakespeare Tower** 6 sample dwellings	**Seddon House** 7 sample dwellings	
Measurement						
Atamate Data Collection (inc site visits)		£2,500	£20,000	£15,000	£17,500	
Air pressure test (fan door blower)		£250	£2,000	£1,500	£1,750	
Heat flux measurements (U-value)		£300	£2,400	£1,800	£2,100	
Sub total		**£3,050**	**£24,400**	**£18,300**	**£21,350**	
Modelling						
EPC/EPR		£120	£960	£720	£840	
Ambue Retrofit Assessment		£180	£1,440	£1,080	£1,260	
Internal Lidar Scan (Matterport)		£150	£1,200	£900	£1,050	
3D BIM model	0.5	£300	£2,400	£1,800	£2,100	
Retrofit Coordination: Strategy options	0.5	£300	£2,400	£1,800	£2,100	
Desing/ spec options	0.75	£450	£3,600	£2,700	£3,150	
WUFI / IES modelling	3	£1,800	£14,400	£10,800	£12,600	
Sub total		**£3,300**	**£26,400**	**£19,800**	**£23,100**	
Drone Surveys -by building						
RGB Drone Condition Survey			£3,000	£3,000	£3,000	
Drone Thermal Imaging			£7,000	£7,000	£7,000	
Drone 3D point Cloud Scan			£8,850	£8,850	£8,850	
Sub total			**£18,850**	**£18,850**	**£18,850**	
Analysis and Report/ Presentation						
Coordination and Resident Engagement	1	£600	£4,800	£3,600	£4,200	
Extrapolate for whole building 3D model	2		£1,200	£1,200	£1,200	
Analysis of measurement data	4		£2,400	£2,400	£2,400	
Re-calibrate model with measured data	3		£1,800	£1,800	£1,800	
Prepare written report and conclusions	5		£3,000	£3,000	£3,000	
Draft Statement of Significance and Heritage Impact Assessment	2		£1,200	£1,200	£1,200	
Stakeholder/ Community Engagement/ presentation	2		£1,200	£1,200	£1,200	
Sub total			**£15,600**	**£14,400**	**£15,000**	
Total			**£85,250**	**£71,350**	**£78,300**	**£234,900**
All figures exclude VAT						
Total without drone surveys			***£66,400***	***£52,500***	***£59,450***	***£178,350***

Added Value:

The survey data (including the Drone Surveys) can provide valuable insights into the stock condition and inform wider strategies for repairs and planned maintenance works.

The 3D Digital models will provide a valuable resource, which can be developed into a "Golden Thread" of data for the existing buildings. This is an important requirement for duty holders to provide for High Risk Buildings, under the Building Safety Act.