Higher performance environments through sensor technologies and BIM
A proof of concept project to combine in-use performance data with BIM context data to produce actionable advice for landlords and tenants.
The Internet of Things (IoT), BIM and BMS are significant growth markets in the global built environment sector.
Whilst hardware, software and know-how exists for each of these markets, they face the challenge of consumer/supply chain hesitancy, poor integration and a need to build trust with their respective users.
Purpose and scope

To apply the 3D geometry and data produced within the BIM process combining this with
• smart metering and indoor environment monitoring
• the building physics model (SAP)
• control systems
• occupier feedback from an app
• creation of actionable advice through machine-learning
Value

This will provide not only essential contextual information but will also allow for the generation of meaningful actionable advice for

- householders (leading to better quality of life from reduced energy use and a healthy indoor climate)
- building and asset portfolio managers
- the wider supply chain
Advice required

- Are owners and landlords getting the building quality they paid for?
- How to achieve and maintain expected performance during occupied lifetime?
- What benefits is the Positive Input Ventilation (PIV) system giving to tenants and the environment? Improved well-being?
- How much energy is each property using? Per head? Per m²?
- How hard wearing are tenants on their property? Is there a correlation between repair calls and energy consumption?
- How to provide smooth building data following practical completion?
- Are the properties suitable for the tenants?
Information available

- Design performance spec (inc energy use)
- SAP calculations / models
- As-built property information: installed systems, wall constructions, building plans, surveyor reports
- Tenant information - demographic (number, age, gender)
- Costs of PIV system installation
- Modification requests in response to housing authority initiatives
- Maintenance records and resident complaints/requests
- CAD and BIM data (geometry, elements)
- Post-completion test results
Information needed

- Developed and QA checked BIMs (geometry and data)
- In-use energy consumption (metered loads and/or unmetered loads)
- In-use environmental condition monitoring
- Occupancy pattern (eg occupied all day, evening only)
- Lifestyle habits (eg smokers)
- Resident satisfaction - feedback on space, comfort, facilities
- Heat map of resident pathways and building space use (PIR triggers)
Actionable advice, reporting and alerting
Use cases

Energy performance

Well-being
- Overheating
- Indoor air quality
- Under-heating
- Lighting

Maintenance overspend
Energy performance
Does the regulated energy use exceed the DFEE by more than 10%?

Well-being
Under-heating: Can the property be readily heated (using primary heating system and costing less than 10% monthly income) to temperature (at least 18°C) when external temperature is 0°C or less and has been so for the past week?
Overheating: Does the internal temperature exceed 28°C for more than 2 days a year?
Indoor air quality: Does the concentration of CO2 exceed 1000ppm for more than 2 hours of occupied usage?
Lighting: Is there adequate lighting in the property? >400 lumens?

Maintenance overspend
Is more than £7.5k (£200M/26.5K) spent on the property per year?
## Types of advice which could be offered

<table>
<thead>
<tr>
<th>Industry</th>
<th>Landlord</th>
<th>Tenant</th>
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<tbody>
<tr>
<td>Adjust SAP figures in line with observed figures</td>
<td>Replace lights/appliances for energy efficient equivalents</td>
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<tr>
<td>Design buildings with greater lighting provision</td>
<td>Fit house auto ‘stand-by’ technology</td>
<td>Switch off lights/appliances when not used/needed</td>
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<tr>
<td>Update weather models</td>
<td>Fit ‘smart’ thermostats</td>
<td>Suggest comfort temperature and heating schedule</td>
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<tr>
<td>Design / build recommendations e.g. insulation, thermally unbridged junction details</td>
<td>Reduce hot water set-point temperature</td>
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<td></td>
<td>Avoid placement of vulnerable tenants in poorly ventilated homes</td>
<td>Suggest timely opening of windows, e.g. when returning home after summers day</td>
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Site of pilot project

Variety of 1 and 2 bed apartments, different floor levels and orientation
Sources of data

As designed data from housing authority BIM Model
As built data from housing authority at practical completion (SAP)
Measured / observed at sensor installation
Real-time monitored in-use performance
Customer satisfaction / survey
Data gathering

The solution will bring together

- BIM data (ongoing)
- Sensor data (ongoing)
- SAP report import to be input via web form (to commence after sensor data complete)
- Tenant details to be input via web form (to commence after sensor data complete)
Solution database

The solution’s SQL database will link the data inputs (BIM/SAP etc)

The minimum requirement for linking the information together is the importing and storing of basic building information (eg floors, spaces)

Floors, spaces and other key areas are now successfully imported and stored in an SQL Database

The main database structure is in place
We can now link sensor data to a building
Building Information Model
This was not a simple process, the model had a number of issues such as spaces incorrectly named, and doors incorrectly positioned causing export issues and delays.
Sensor types and set up

Majority of sensors have arrived and are in the process of being setup
A range test has been conducted to confirm total building coverage.

BuildAx, Tempcon, and Open Energy Monitor sensor technologies

Monitoring: Temperature, Light, Movement, Humidity, Window Open/Closed
Raspberry Pi

- Located on site and capable of transmitting reads to an API
- Handles loss of internet connection by storing locally (MySQL), transmits unsent data when connection resumed

```python
def function(self, unsendData, dbCon):
    saveCount = 0
    for row in unsendData:
        saveCount += 1
        rowId = row[0]
        statusCode = self.sendJsonData(row[1])
        if statusCode == 200:
            dbCon.updateAsSent(rowId)
    return saveCount
```
Logging test data

In order to test sending / receiving data through an API, we are currently logging test data to Open Energy Monitor.

The final dashboard interface is in development.
Project completion July 2018

Follow our progress
http://www.bimacademy.global/uk/smart-connected-buildings/