

Internal and External Environmental Conditions (element 4)

The measurement and monitoring of internal and external environmental conditions enables the researcher to understand the thermal and other environmental conditions in a building. When analysed in relation to occupancy and energy use, these parameters can assist in understanding the relationship between comfort levels, energy use and environmental conditions.

Level 2: Data loggers

Cost: ₹₹₹	Time: ⌚⌚	Skills: 🙌🙌
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Light-touch environmental monitoring is a relatively simple and accessible method of providing temperature, relative humidity and even CO₂ data on a continuous and regular basis. This information is useful when building an overall profile of a building.

As with spot measurements, there are needed data parameters and 'nice to have' parameters, the selection of parameters to log depends on the objectives of the study.

Potential tools needed:

- Internal temperature / RH loggers
- External temperature / RH logger

How: The data loggers, such as hobos and i-buttons, can log at a variety of rates; from one minute to daily and weekly. The rate of logging is dependent on the level of detail required for the study as well as the length of study. A 30 minute / 1 hour interval is a sufficient recommended frequency for long-term data logging.

ANSI/ASHRAE Standard 55 provides standard methods for measurements which can be applied to logger placement; however, limitations apply. As examples:

- loggers must generally be fixed to walls and not 1 meter in from walls;
- loggers may need to be placed higher than recommended heights in standards to avoid occupant tampering;
- loggers should never be placed where direct sunlight falls or where any other extreme conditions may exist, with the exception that those extreme conditions are also being measured with purpose.

It is crucial to record exact date, time and data logger references in order to ensure that the data can later be 'stitched' together and avoid inaccurate data being included in the overall analysis. It is also helpful to print plans of the building to label location of data loggers (or any other tools used for BPE). The table below lists recommended minimum resolution and accuracy for logging and monitoring devices.

Measurement	Resolution	Accuracy
Temperature	0.1°C	±0.5
Relative humidity	1%	±10%

Timing: Data loggers should be installed at the earliest opportunity possible. To save time and visits plan to install data loggers during the same visit to the building when performing other tasks such as walkthrough with stakeholders/occupants. Additionally, though it is ideal to plan where to place data loggers before visiting the building, the walkthrough may provide more insight into ideal places to put data loggers.



Potential barriers: It is not always possible to install the data loggers in 'standardised' locations due to occupant preference and use of the rooms. It became obvious that it was important that the locations needed to be out of the way, and fixed to immovable objects; as there were examples of furniture being re-arranged and the data loggers going missing. However, some occupants (and researchers) were hesitant to fix the loggers to the walls in case of damage to the finishes. It is recommended that data logger location and installation and removal protocols are to be put in place prior to the installation of any data loggers to ensure consistency across a set of case study dwellings.

Level 2.5: Remote monitoring of environmental conditions

Cost: ££££	Time: ⌚⌚⌚	Skills: 🙌🙌🙌🙌
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The remote monitoring of environmental conditions allows the researcher access to continuous data from anywhere. Generally, the types of data to be collected at a minimum are:

- Internal temperature and RH
- External temperature and RH

As with spot measurements, there are needed data parameters and 'nice to have' parameters (e.g. CO₂ and VOCs, the selection of parameters to monitor depends on the objectives of the study.

How: Generally monitoring equipment should be installed by trained professionals with a guarantee to fix data transmission issues if they arise. The data collection, storage and processing systems should be considered carefully.

Potential barriers: Whilst the actual data collection units are not always vastly expensive, the remote monitoring hub increases costs substantially. In addition, some sensors require an electrical socket and this should be considered when installing the systems for a long period of time.

Missing data can be a common occurrence if all possibilities are not considered:

- As with energy monitoring, where WiFi stability may be an issue, an Ethernet connection would be recommended for uninterrupted data transmission.
- occupants switching sensors off to use the sockets for other purposes,
- occupants switching off sensors due to the irritation caused by the flashing light (particularly in bedrooms),
- hub signalling failures

