HEAT3D

BUILD
TEST
SOLUTIONS

Contents

1. Summary

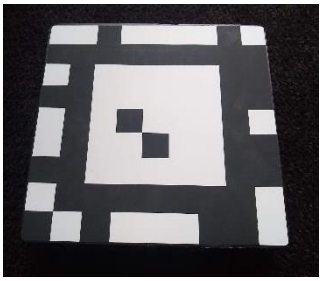
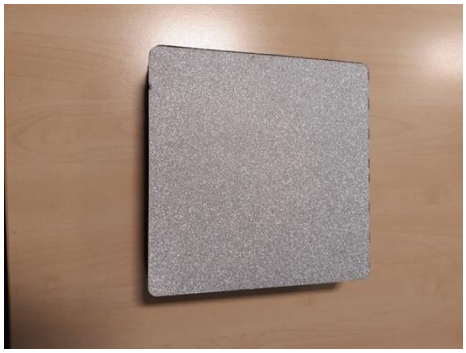
Heat3D is an innovative mobile app which allows you to precisely measure heat flow and U-values of building elements using a low-cost, quick and non-invasive method. Heat3D is designed to work on iPhones and iPads and uses a portable thermal camera to obtain results in a matter of hours as opposed to days or weeks using traditional techniques. The rapid nature of the measurement enables quantified U-values that are more accurate than manual calculation methods.

The Heat3D iOS app uses Apple ARKit to detect room features such as walls, floors and ceilings and construct a 3D model. When combined with a FLIR portable camera, infrared thermal images are projected on to the 3D model showing the heat signature through each surface. Quantitative infrared thermography enabled by the Heat3D hardware is used to calculate the heat loss through these surfaces and, using a minimum 45 minute long time-lapse survey, U-values are calculated and presented on the device.

2. Equipment

Heat3D requires the following equipment to carry out a survey:

	**Compatible iPad or iPhone** An iPad or iPhone with an A10X or better processor and lighting connector. **Please note:** Newer iPad Pro models (2nd gen and later) with a USB-C port are not compatible. See *Compatible iOS Devices* for more information.
	**FLIR ONE® Thermal Imaging Camera** A FLIR ONE infrared camera with a lightning connector. Compatible cameras include: • FLIR ONE Gen 3 • FLIR ONE Pro LT • FLIR ONE Pro (recommended) The top-level FLIR ONE Pro is recommended due to its higher resolution which will produce more accurate results.
	**Tripod for iPad or iPhone** A tripod for mounting the iPad or iPhone during time-lapse surveys. The adjustable mounting bracket can be used to clamp the iPad or iPhone in a landscape (horizontal) orientation. A wireless charger is provided for use with iPhones.

	**Air Target** An air target used to capture ambient air temperatures using the infrared thermal camera. The AprilTag on the front is used to automatically detect the position of the target in the Heat3D app.
	**Reflective Target** A reflective target used to capture radiative temperatures using the infrared thermal camera.
	**Target holder** A monopod which is used to mount the targets at the desired height close to a wall.
	**PID Temperature Control Unit** The temperature control unit is designed to regulate the ambient temperature within the room very accurately throughout the survey. It includes a PID controller, PT100 temperature sensor and 13A socket.

	**500W Convector Heater** The heater is plugged into the temperature control unit to ensure a stable temperature during the survey. **ONLY** convector heaters are supported, DO NOT use a fan-based heater instead as this will produce inaccurate results.

3. Compatible IOS Devices

Heat3D supports iOS devices with an A10X or better processor (2018/iPhone 8/3rd generation iPad or newer) and lighting connector. This is minimum chip required to make Apple ARKit work correctly. Newer iPad Pro models (2nd gen and later) are not compatible as they do not have a lightning connector which is required by the FLIR ONE camera.

If you already have a device and want to check it is compatible follow these steps to find out whether it has an A10X or better processor and a lightning connector:

1. Find the model number of your iPhone or iPad: https://support.apple.com/kb/HT208200
2. Identify your iPhone model: https://support.apple.com/HT201296

   OR

   Identify your iPad model: https://support.apple.com/HT201471

3. View the “tech specs” to find out the chip and connector type.

4. Requirements & Limitations

Heat3D can be used to measure the heat flow (Q) and U-value of suitable external walls subject to the following requirements and limitations:

- **Room Size**
  The room must be of a sufficient size to allow the camera and tripod to be mounted at least 2.5m away from the wall being measured. The room should also be closed as opposed to open plan.

- **No Obstructions**
  Heat3D must have a clear unobstructed line-of-sight to the wall being measured with no furniture (tables, chairs etc) in view.

- **Measurement Area**
  A suitable external wall of at least 1m width ideally away from windows, heat sources and any thermal bridging. Also make sure no solar radiation is incident on the inside wall surface through a window.

- **Wall Orientation**
  Avoid surveying a wall when it is being warmed by the sun. Either pick a cloudy day, a North facing or shaded wall or at night. Similarly heavy rain or strong winds on the outside wall will tend to increase the heat loss above normal and result in higher Q and U-values being measured.

- **Minimum 10°C Temperature Difference**
  A minimum of 10°C (50°F) difference between the internal and external temperatures is required to get a Q and U-value with less than 25% error. Pick a cold day when it is warm indoors, or vice-versa, a very hot day when it is cool indoors.

5. Preparation & Standard Operating Procedure (SOP)

To enable a valid Heat3D survey, the following standard operating procedure MUST be followed:

5.1. Ensure stable room temperature

In preparing for a survey, the room must be heated for at least twice the time constant of the external wall so that it is at a steady and stable temperature.

For instance, if the time constant of the wall is 6 hours (2-layer 25cm brick wall) then the room should be preheated for 12 hours beforehand.

Prior to starting the Heat3D survey, the room heating **MUST** be turned off or isolated using radiator valves. Additionally, make sure all doors and windows are closed so the only place for heat to flow is through the wall.

5.2. Check wall using thermal camera

Prior to starting a Heat3D survey, the external wall being surveyed should be checked using the infrared thermal camera to make sure there are no heating pipes buried in the wall or other sources of heat which will adversely affect the measurement.

5.3. Ensure sufficient lighting

Make sure there is good lighting in the room and that it remains on during the survey as Apple ARKit requires sufficient light to be able to recognise features in the room and lock on to them.

5.4. Mount the targets and enable Bluetooth temperature sensor

Affix the air and reflective targets to the magnet mounting brackets and lean the target holder against the wall. Make sure the Bluetooth temperature sensor is turned on. See Section 6 for more information.

5.5. Setup temperature control unit and convector heater

Plug the convector heater into the temperature control unit and turn on. **Adjust the setpoint temperature to match the current temperature within the room**. This will ensure the ambient temperature within the room is maintained at a stable temperature throughout the survey.

5.6. Do not obscure iPad/iPhone camera lens

Be careful not to obscure the iPad/iPhone camera lens at any point while performing a survey, e.g. by walking in front of it or inadvertently putting your finger/hand over it whilst positioning. The Apple ARKit and 3D model can drift very quickly if the camera is obscured for even a short time.

5.7. Vacate room

Once a Heat3D time-lapse survey has been started, vacate the room for the entire period and close all doors to ensure that the room temperature remains stable.

6. Equipment Setup

Equipment Positioning

Thermal Camera
The tripod containing the iPhone/iPad and FLIR thermal camera must be positioned approximately 2.5m away from the measurement wall.

Targets
Both targets should be positioned centrally within view of the Heat3D image capture.

Wired Temperature Sensor
The PT100 temperature sensor from the temperature control unit should be placed in the holder on the target bracket close to the air target so that both the sensor and the air target are at approximately the same height and temperature.

Convector Heater
The convector heater should be positioned approximately in the middle of the room. Insert the 3-pin plug from the heater into the 13A socket on the temperature control unit.

Air and Reflective Targets

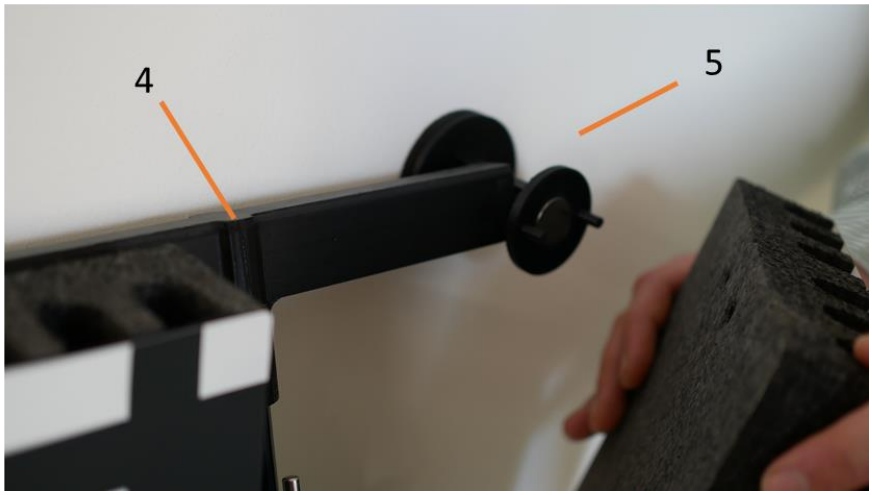
The targets are mounted to the target holder provided using the magnetic brackets. Attach a target to each bracket so that the cut-out notch is at the top, the air temperature target must go on the left with the reflective target on the right. The reflective target has holes in the back of it that slot onto the pegs on the holder so that it can only be mounted on the right hand side.

The air target incorporates a Bluetooth temperature sensor. Ensure that is set to the **ON** position so that it is active and Heat3D can read the temperature from the target. The batteries can be easily replaced and have a life of 2+ years, so it's good practise but not essential to turn the sensor off between tests.

Target Holder

The target holder made up of 6 components:

1. Telescopic pole top
2. Telescopic pole bottom
3. Joining bracket
4. T-shaped target holder bracket
5. Target holders
6. Air and Reflective Temperature Targets
7. PID temperature sensor bracket

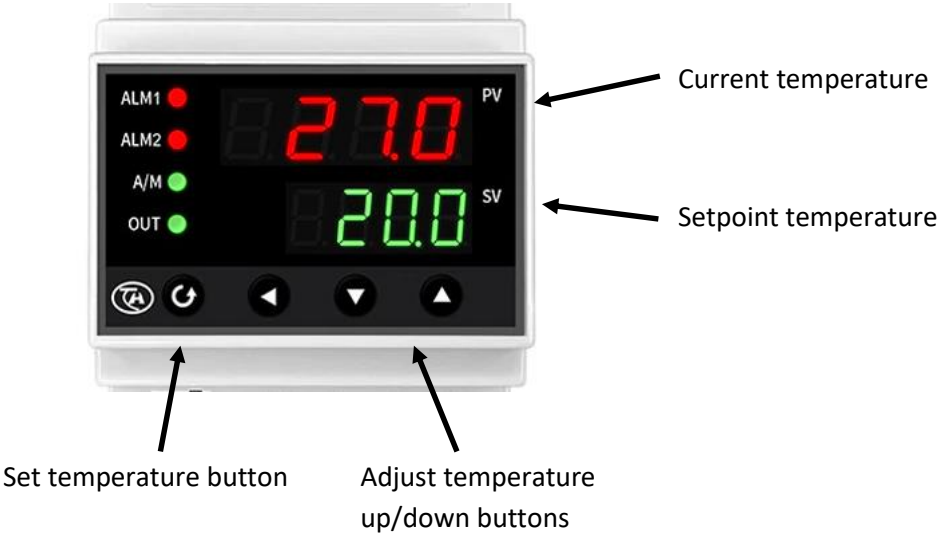


To assemble the target holder:

1. Screw in the two telescopic poles (components 1,2) into the joining bracket (3)
2. Slide the PID temperature sensor bracket (7) over the top of the telescopic pole top (1)
3. Slot in the T-shaped target holder bracket (4) to the top of the telescopic pole (1)
4. With the bottom pole resting against the floor, lean the assembled units against a flat wall with the 2 magnets facing away from the wall
5. Attach the 2 targets (6) magnetically, the reflective target goes on the right with the pegs on the reflective target holder (5) lining up with the slots on the reflective target (6)
6. The final assembled kit should look similar to the picture on the left above

PID Temperature Control Unit

Once the PT100 temperature sensor has been placed in the correct position next to the air target, the temperature setting on the PID controller must be adjusted to match the temperature in the room.

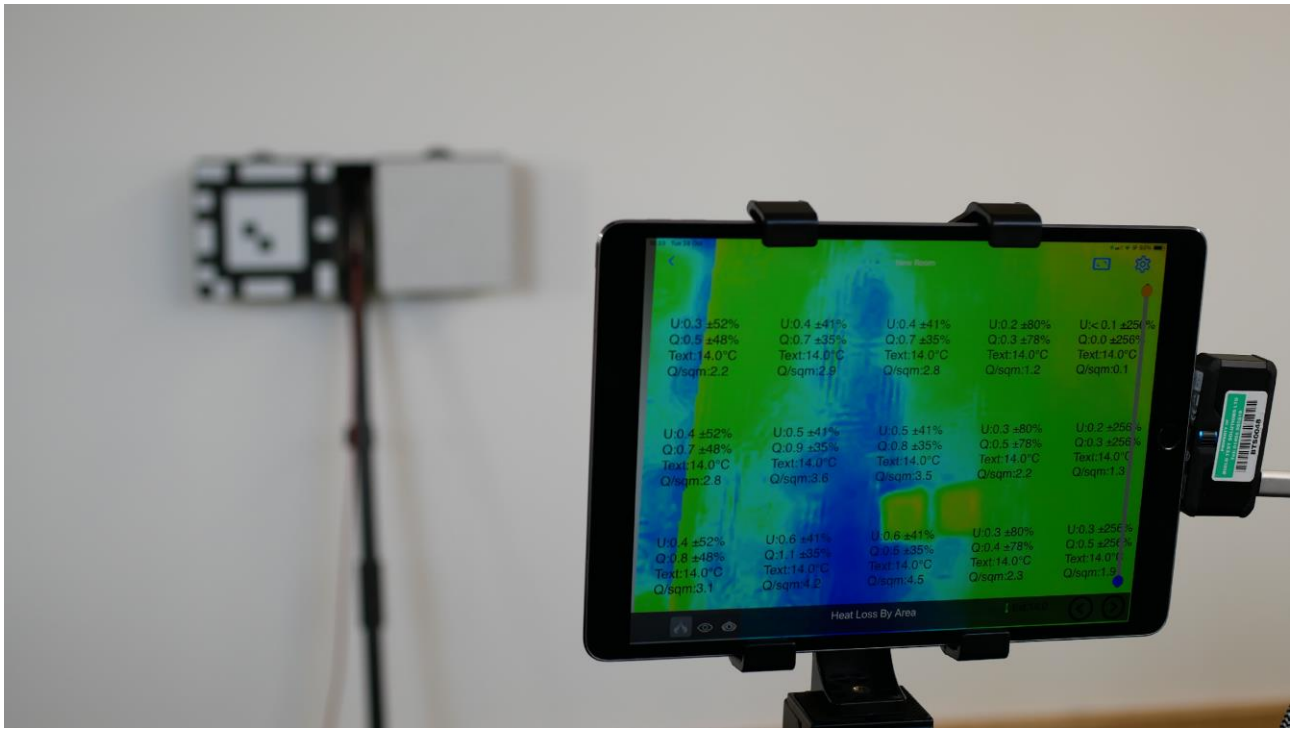


Press the “Set Temperature” button (indicated by a curling arrow) so that the decimal point flashes. Use the Up/Down arrows to adjust the setpoint value to match the current temperature within the room. The target holder monopod has a small bracket which can be used to mount the sensor from the temperature controller close to the target.

iPhone/iPad and FLIR Camera

Clamp the iPhone or iPad within the adjustable bracket so that it is mounted horizontally. Plug the FLIR camera into the Lightning port on the device so that the lens of the camera is facing the wall.

Turn the power on to FLIR camera by holding down the power button on the side for a few seconds. When it starts to flash green, it is ready for use.

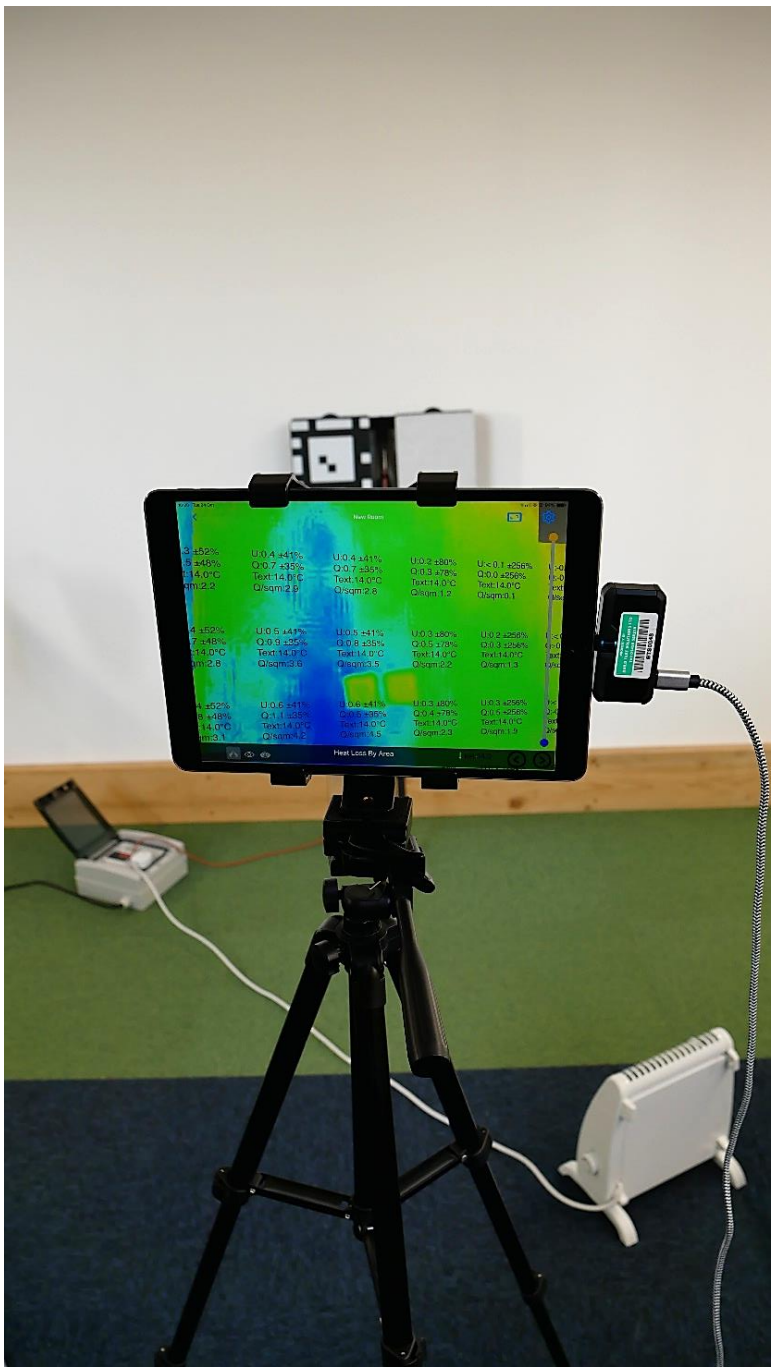


The FLIR camera **MUST** be connected to a power supply during a survey otherwise the battery will run out. The kit includes a USB power adapter and 5m USB-C power cable.

The battery in an iPad should be sufficient to complete around three timelapse surveys, but an iPhone battery may only sufficient for one survey. If using an iPhone use the provided wireless charger to maintain the battery charge during the survey.

Example Setup

Key points to consider when setting up equipment:



- The targets must be in clear line of sight from the IR camera
- The targets should be directly in front of the IR camera
- The tripod with the iPhone/iPad & IR camera should be approximately 2.5m from the wall being measured
- The wall which the measurement is being carried out on must be unobstructed
- There must be a clear line of sight between the heater and the reflective target
- The room should have been heated before the measurement takes place, if not the timelapse measurement is likely to take longer as the room will be heating up, which causes an imbalance in the thermal mass of the wall and invalidates the conditions for an accurate U-value measurement
- The aim is to achieve a stable temperature inside the room, the room should be vacated during the timelapse measurement
- Any other heating to the room other than the heater provided with the Heat3D kit should be turned off during the measurement
- There should be no direct sunlight on the external surface of the wall being measured during or for the 2 hours preceding the measurement
- The measurement zones should be at least 1m away from surfaces with significantly different temperatures, like windows or warm radiators

7. Using Heat3D

Open the Heat3D App

- Locate and open Heat3D using the icon on the app screen.
- The app is designed to work in landscape mode only. Hold the iPad or iPhone horizontally with the connector end to the right.

Connect the FLIR camera

- The Heat3D app must be open for it to detect the camera.
- Plug the FLIR ONE® camera into the lightning port on your iPad/iPhone, with its lenses facing away from you.
- Turn the camera ON by holding the power button on the underside for a second or two.
    - The button will turn red, and after a few seconds will start blinking green.
    - If it doesn't come on or turns itself off, it probably needs charging. Charge the camera using the included USB-C cable. You can charge it while using it.

Re-Aligning iPhone Compass

The 3D room models made by Heat3D use the device's Augmented Reality Kit (ARKit), this uses sensors within the device including the motion sensor to detect which way is down and the compass to define the x and y (effectively left and right) directions. The compass in an iPhone can be re-aligned to improve accuracy by moving the device in a large figure of 8 shape with the screen pointing upwards, this can help to improve the stability of the 3D model of the room.

Note: The Heat3D air target and Bluetooth sensor take time to reach room temperature if they are brought in from the cold. As a guide, if the air target or Bluetooth sensor were stored at 15°C and the room temperature is 20°C, then they should be left to acclimatise for at least 15 minutes otherwise they will under-report the true temperature.

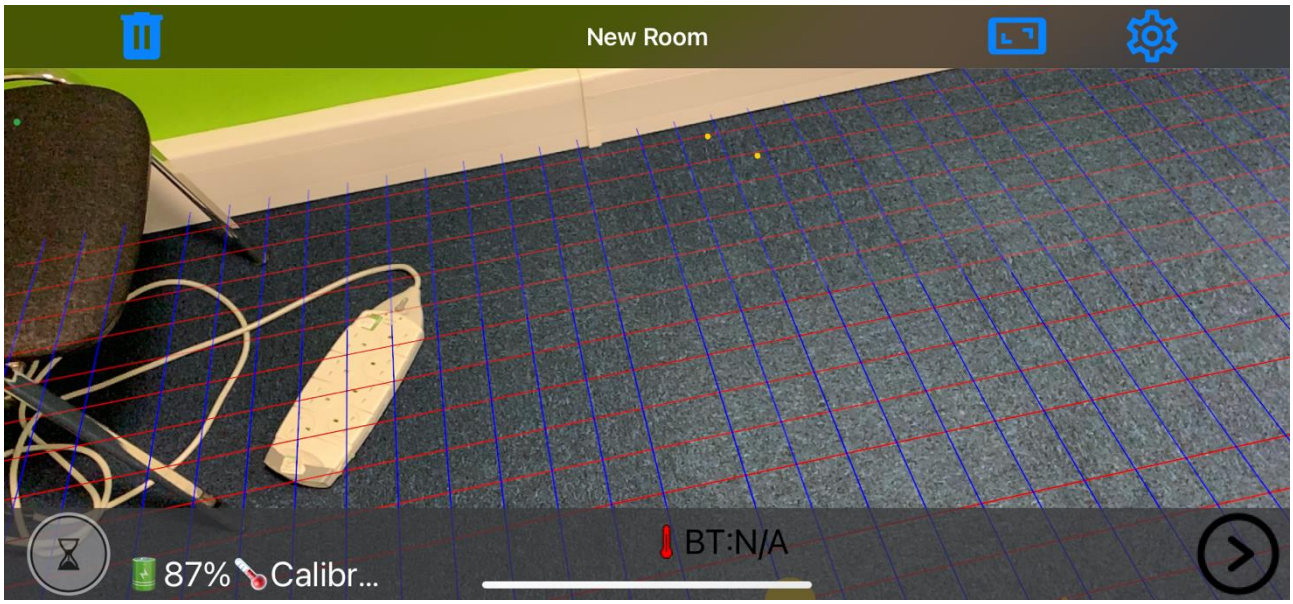
8. Starting a New Survey

The “New survey” mode should be used for **measuring heat flux only**. The U-values reported using this mode are for informational purposes only and are not designed to be representative of average U-value of the wall.

Use “New timelapse” to measure U-values accurately, see Section 7.

Establish the floor plane

Tap the ‘New Survey’ button in the top left. Heat3D needs to establish the floor plane, so point the camera at the floor and move it around until you see a blue and red grid appear showing the floor plan. If the grid does not appear it is worth pointing at a better lit section of the floor if one exists.

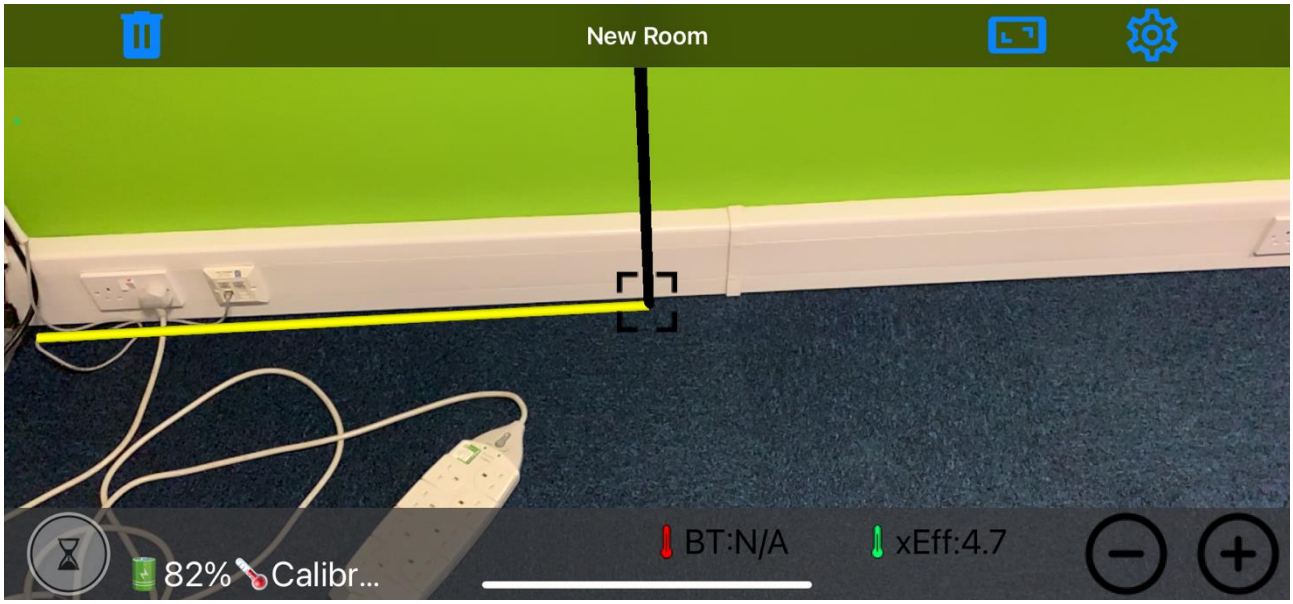


Tap the forward arrow button  bottom right to accept the floor plan and move to the next step.

Capture the room model

Now, you see a black cursor in the middle of the screen with a vertical guideline above it. Aim the cursor at one of the corners of your room where the walls meet the floor and tap the forward arrow button to continue.

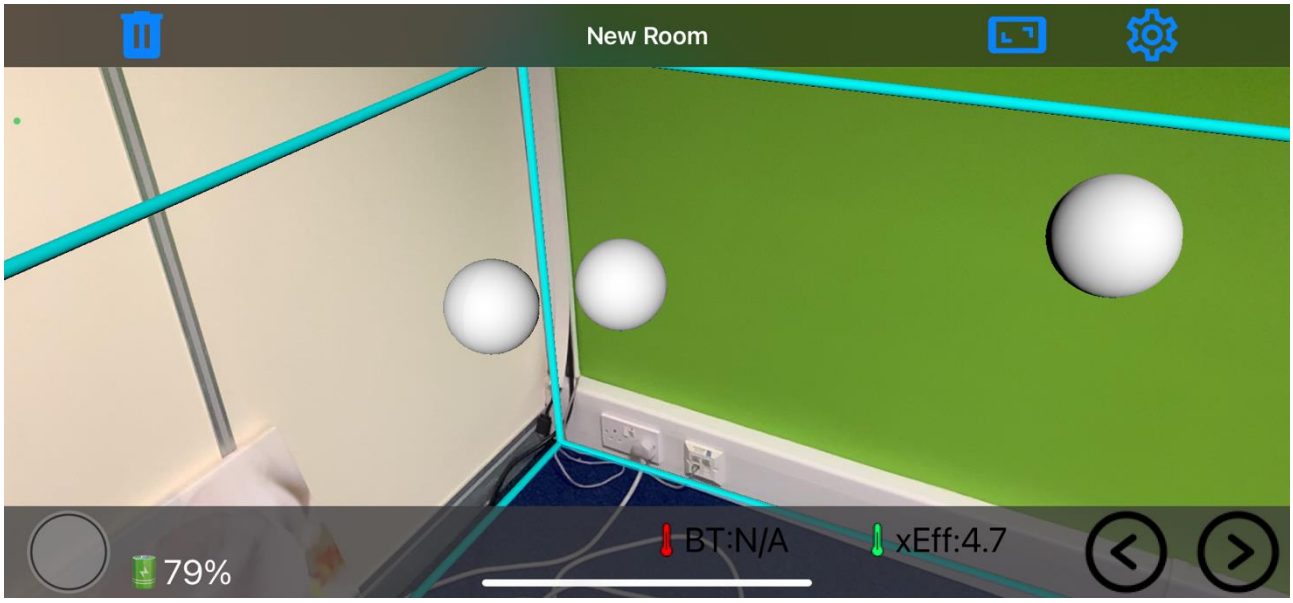
Move the yellow floor edge which appears rightwards to the next corner (it is important that you work clockwise round the room) and tap the forward arrow button again.



Continue round the room, marking all of the corners. The room can have as many corners as are required. You can undo each step by tapping the back arrow button.

If a floor corner is obscured, position the cursor at your best guess at the corner position. You will be able to drag the wall edge and thus the corner more accurately afterwards.

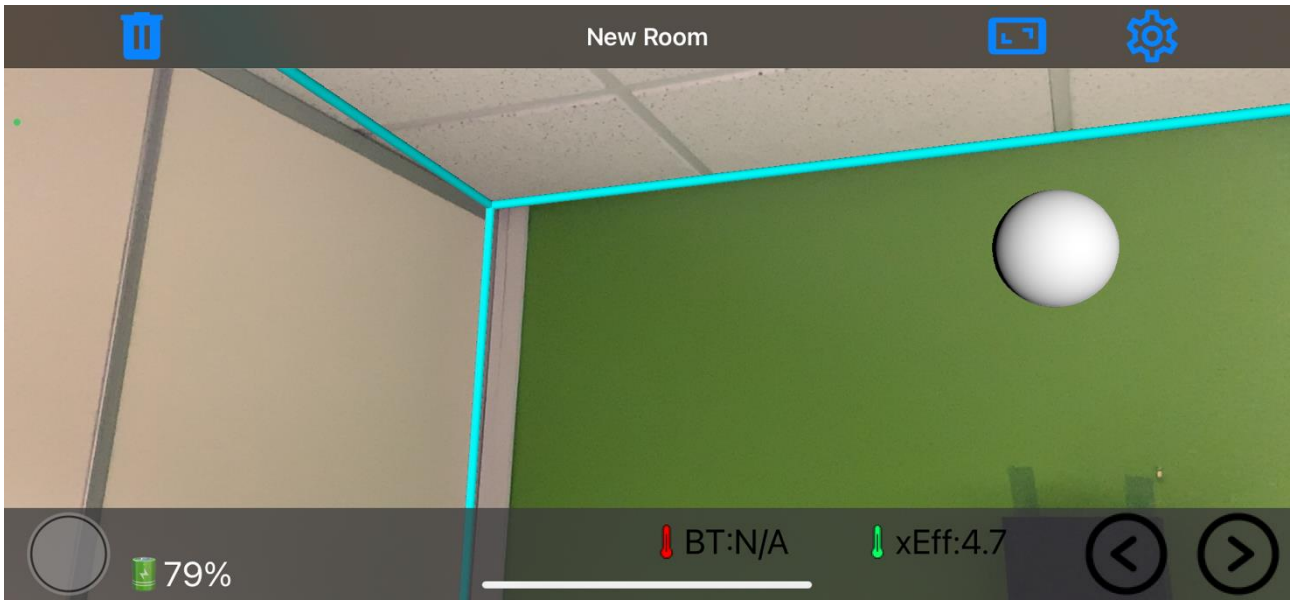
When you get back to the start, the room will be auto completed, and a 3D model will appear in light blue.



Adjust ceiling height and fine tune model

Now you'll see white spherical drag handles appear on all the edges. You can use these to adjust the ceiling height and the exact positions of the room corners. It often helps to walk around, so as to be close to the corner you are adjusting.

Fine tune your 3D model and room height by touch and drag on the 'handles' on the wall and ceiling edges.



Check temperatures are ready

The Bluetooth temperature and the external temperature (xEff) should have been automatically captured by this stage and the indicators at the bottom of the screen showing the current values in green. If not, they will be in red and you will need to wait until they turn green before you can move onto the next stage.

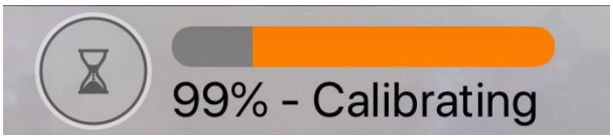
If the Bluetooth temperature doesn't appear after a few minutes, double check that you have turned ON the switch on the Bluetooth sensor.

If the external temperature (xEff) doesn't appear after a few minutes, ensure you have an Internet connection. The external temperature is downloaded from a Weather service based on your current location.

Wait for FLIR camera to calibrate

If the FLIR is not attached or HEAT3D has not detected it for some reason the FLIR camera indicator on the bottom left will show a cross in it. Detaching and re-attaching the FLIR can correct this.

To improve the accuracy of the U value measurements the FLIR ONE® needs to reach a stable calibration state. This can take up to 4 minutes the first time after turning it on. Heat3D shows an orange progress bar once at the bottom left when the FLIR ONE® is attached and turned on. The percentage shown indicates the charge level of the FLIR ONE®.



A loud "Bell" sounds when the FLIR ONE® is calibrated and stabilised and the progress bar changes to green and counts down for 4 minutes during which period you need to complete the survey before it has to re-calibrate. Another "Bell" sounds when you have 1 minute left.

Capture thermal data

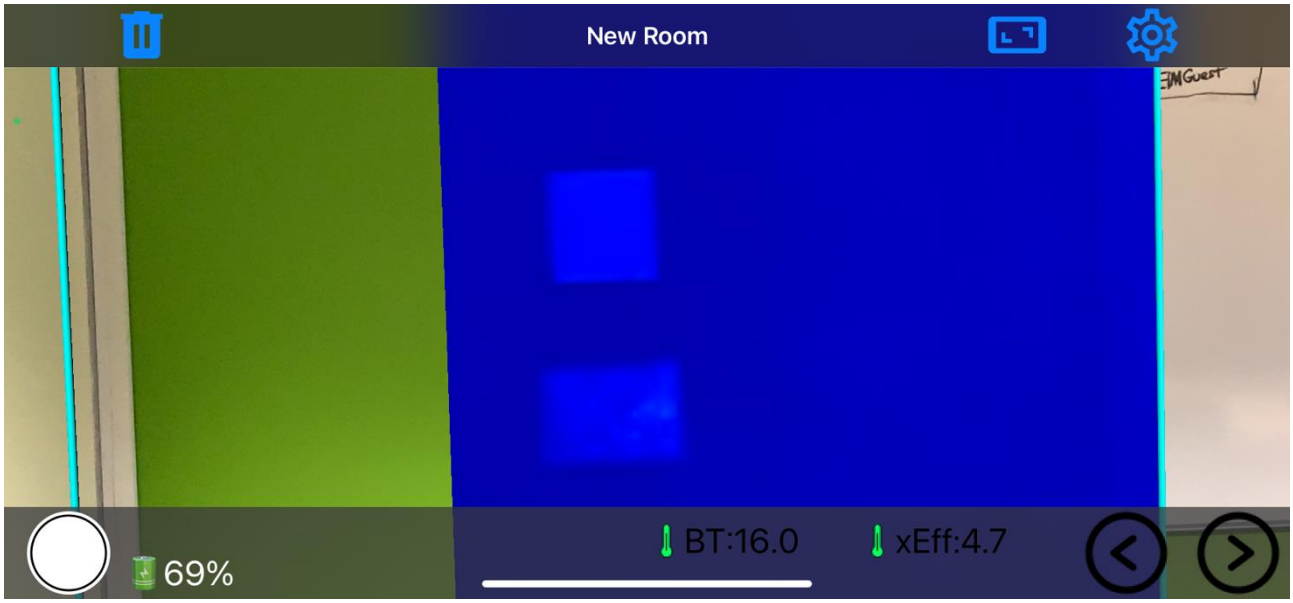
The camera button changes state to indicate:

	An X means the FLIR camera is disconnected, not detected or its battery is flat (there is a FLIR battery percentage remaining figure shown at the bottom right).
	The hourglass means the FLIR camera is still calibrating and not ready for use yet.
	The white button means the FLIR is ready to capture thermal images.

If it is not working for any reason, check the FLIR ONE® power button is ON (blinking green). You can unplug and re-plug it in perfectly safely if you want to and that sometimes clears the issue.

If the camera button bottom left is showing  you are ready to collect temperatures. Each press collects and shows thermal data for the visible part of a wall. Repeat until you have covered all the walls you want and then press the forward arrow to end the FLIR capture and move onto the next step.

As you tap the camera icon thermal images will appear on the wall. Move to a new spot, and repeat the process, till you have tiled the entire wall (or entire room). You need to maintain a certain amount of overlap between each FLIR frame so that Heat3D can re-calibrate the temperature drift between frames. If there is not enough overlap a “bong” sound will be heard and the new frame will not be captured. Just try again.



Don’t worry if you miss a spot, you can retake the FLIR images to fill in any missing tiles or leave them blank if you don’t want to include them in the measurement.

Exclude non-wall objects

Excluding non-wall objects will give a more accurate measurement of the average U-value across a wall surface, though it is not essential as it will not affect the output of the U-value measurement from the test or timelapse zones or across the rest of the wall.

Exclusions can be applied in two ways. The first is to draw a custom ‘Exclusion Zone’, this can be drawn to exclude things like windows, radiators or furniture. Secondly, the slider at the right of the screen can be used to set min & max temperature thresholds. Anything outside this band will be ignored. Adjust the two dots until you’ve excluded radiators or furniture which should not be included in the measurement.

Identify temperature targets

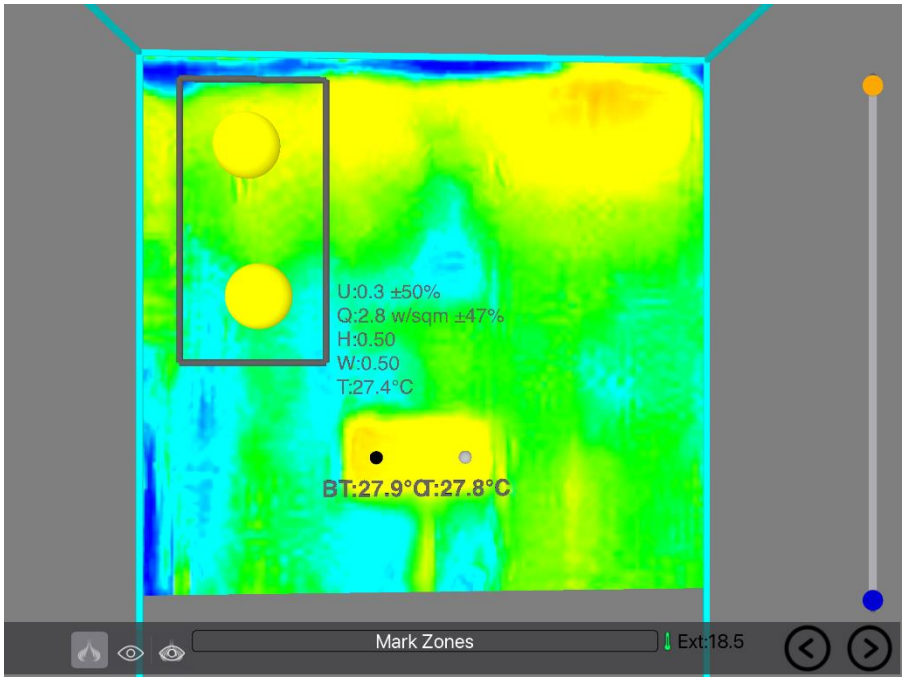
Once you have captured all of infrared images required, click the forward arrow button. The thermal image of the wall will adjust the colour range to match the temperature threshold. The position of the air and reflective targets will be automatically detected based on the AprilTag on the front of the air temperature target.

Add test and exclusion zones

Tap the forward arrow button again and you can then optionally select zones on the wall for specific measurements.

A test zone can be used to display the average performance for a custom area of particular interest, exclusions zones are areas you want to exclude and can be used for windows and radiators etc. as described above.

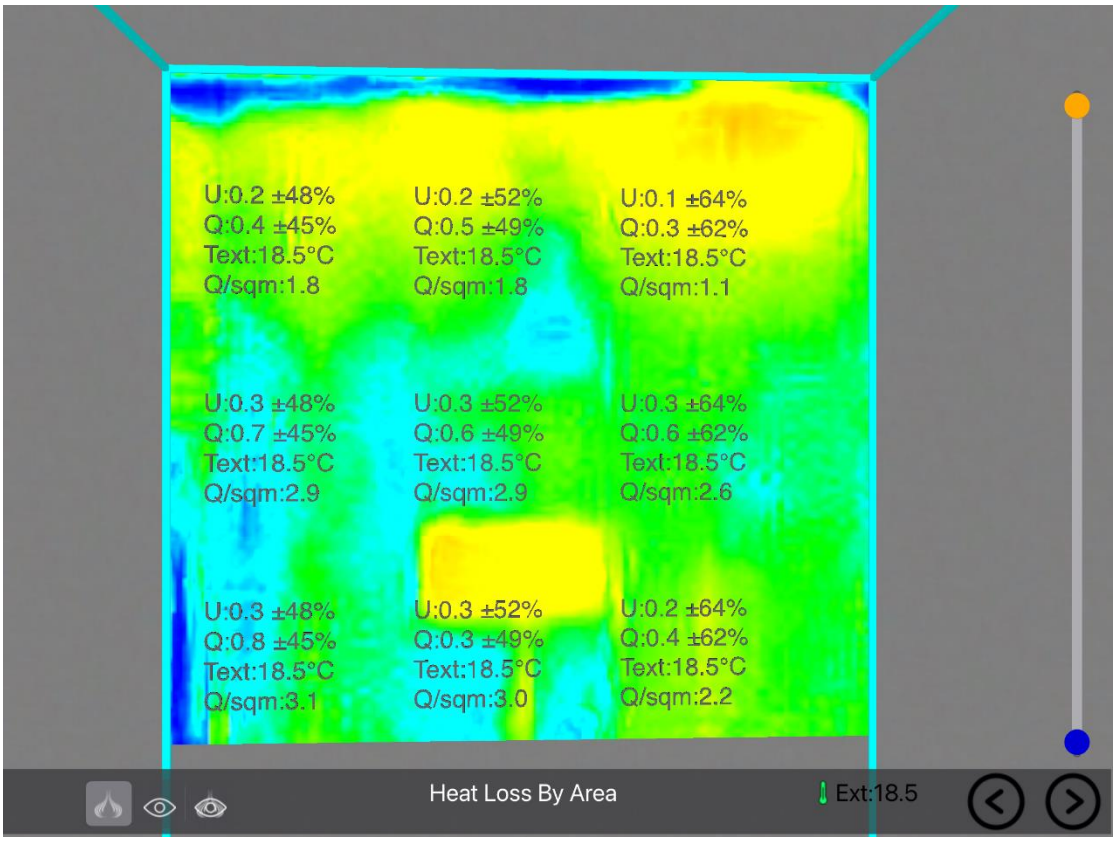
Tap “Mark Zones” and select “Test Zone”. Position the crosshair in the top left corner of where you want the test zone to be and tap the green tick when you are happy. You can adjust the size and position of the zone using the toggles.

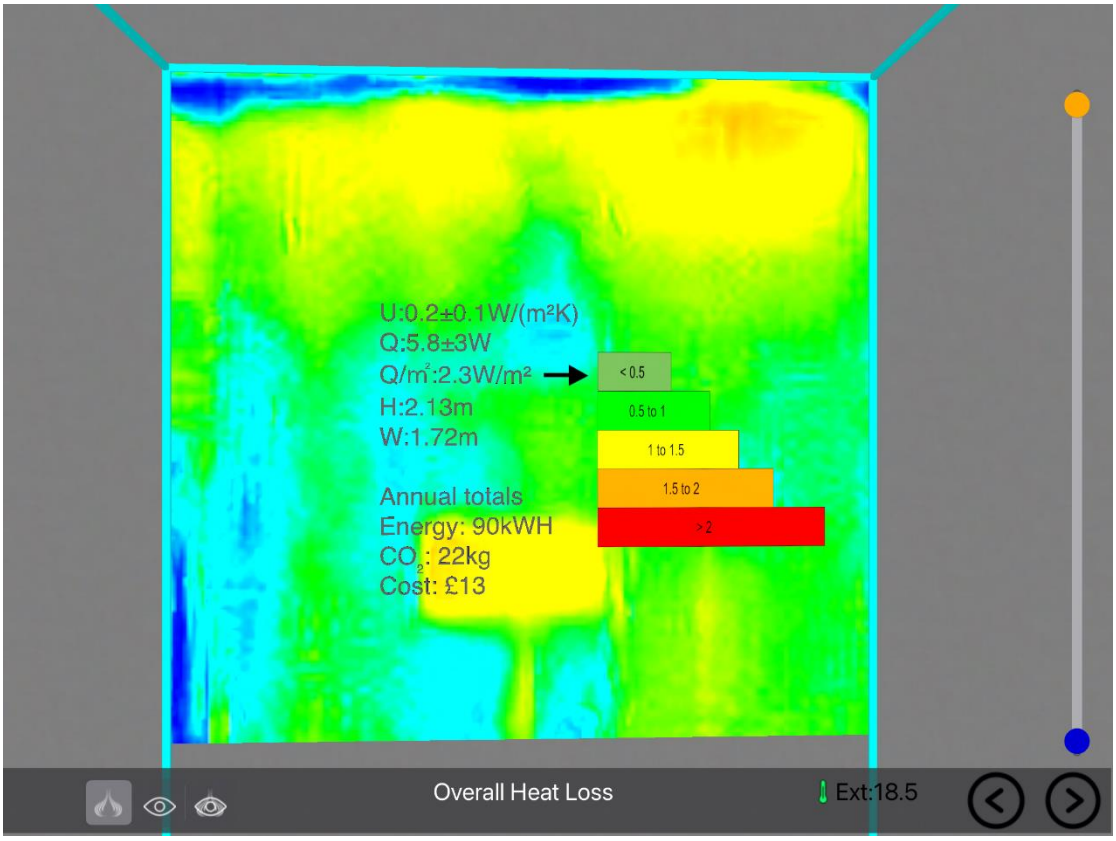


Cycle through the survey results

Clicking the forward arrow button will cycle through the results:

Average Temperature	This is the average surface temperatures across the wall.
Heat Loss by Area	This is the wall heat flow (Q) and U-values across the wall.
Overall Heat Loss	This is the overall heat flow (Q) and U-value for the entire wall excluding exclusion zones.
Test Zones	This is the heat flow (Q) and U-value for the test zone.





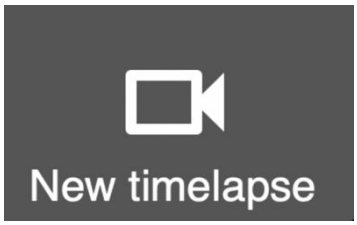
Take a screenshot

The screenshot button at the top of the screen  allows you to take a screenshot of what is being displayed at any time and share it or save it to your photos.

Save the survey

When you have finished tap the blue left arrow at the top to automatically save the survey and return to the main screen. The survey will be given a unique name based on the time of the survey, it will also archive the survey to the Heat3D cloud.

9. Starting a New Timelapse Survey



The “New timelapse” mode should be used for **measuring U-values**.

A time-lapse survey will capture infrared images at a specified interval (default 1 min), the minimum survey time is 45 minutes but the survey may be extended if the required conditions are not met.

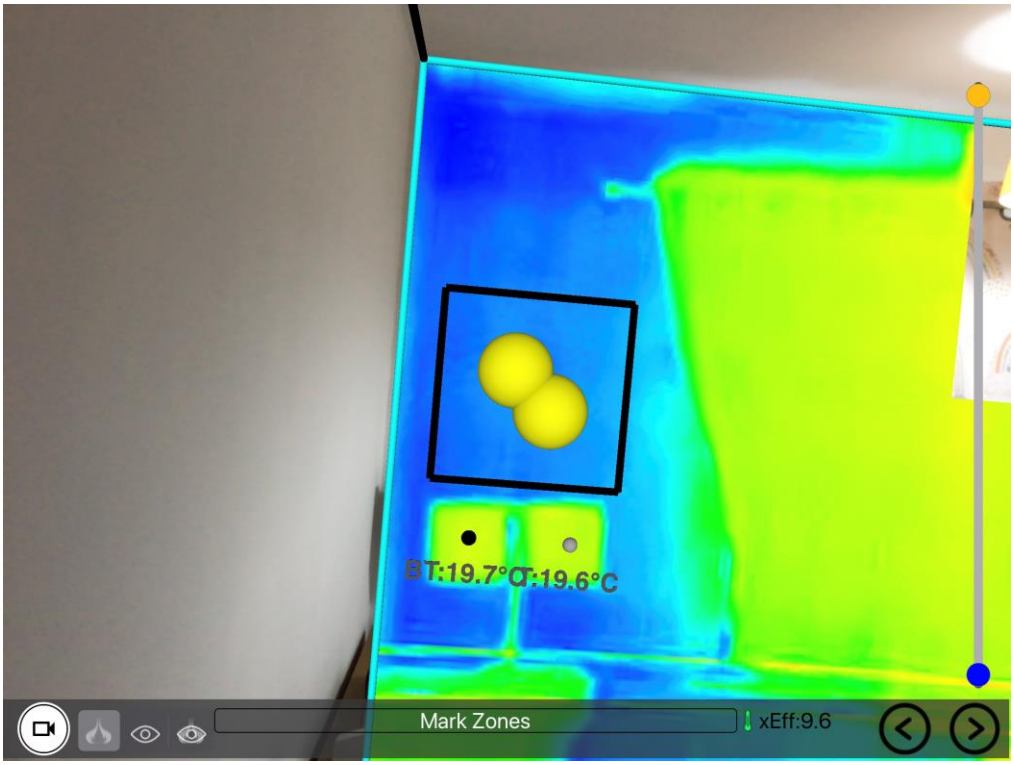
Time-lapse surveys can be used to measure U-values accurately.

Tap the ‘New Timelapse’ button on the main screen. Follow the same procedure as *Section 6: Starting a Survey*. The device must have a data connection during the timelapse survey to communicate with the browser user interface (heat3d.online).

Mount the iPad/iPhone on a tripod

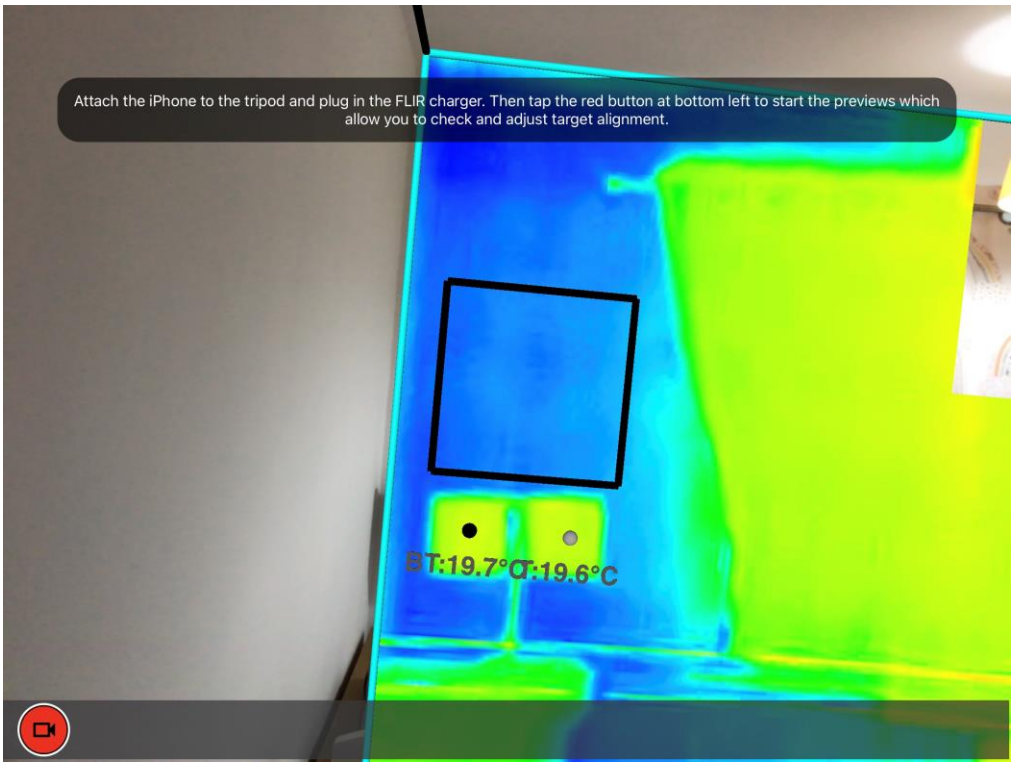
At this point, the iPad/iPhone should be mounted on the tripod. Make sure the target area, air and reflective targets are all within view.

Make sure the USB-C charging cable is connected to the FLIR camera to ensure that is doesn’t run out of power during the time-lapse survey. When you are ready tap the white camera button in the bottom left to start the time lapse, after you press the button the device will prepare to start the timelapse and a buffering symbol will appear on the screen. This could take a few minutes.

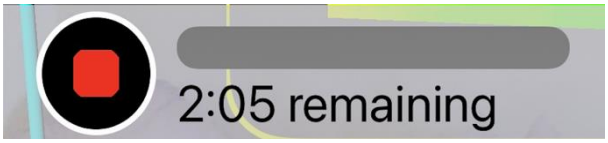


Once the device is ready to start the timelapse the buffering symbol will disappear and the camera button will turn red. Press this button to start the timelapse. Once the time-lapse has started, it will show a

countdown slider with time remaining and runs unattended. At this point, vacate the room and close the door behind you.



The capture data is automatically saved to your device and archived as the timelapse progresses including the final summary and timelapse video on completion. You can stop a timelapse at any time using the stop button or let it run to completion.



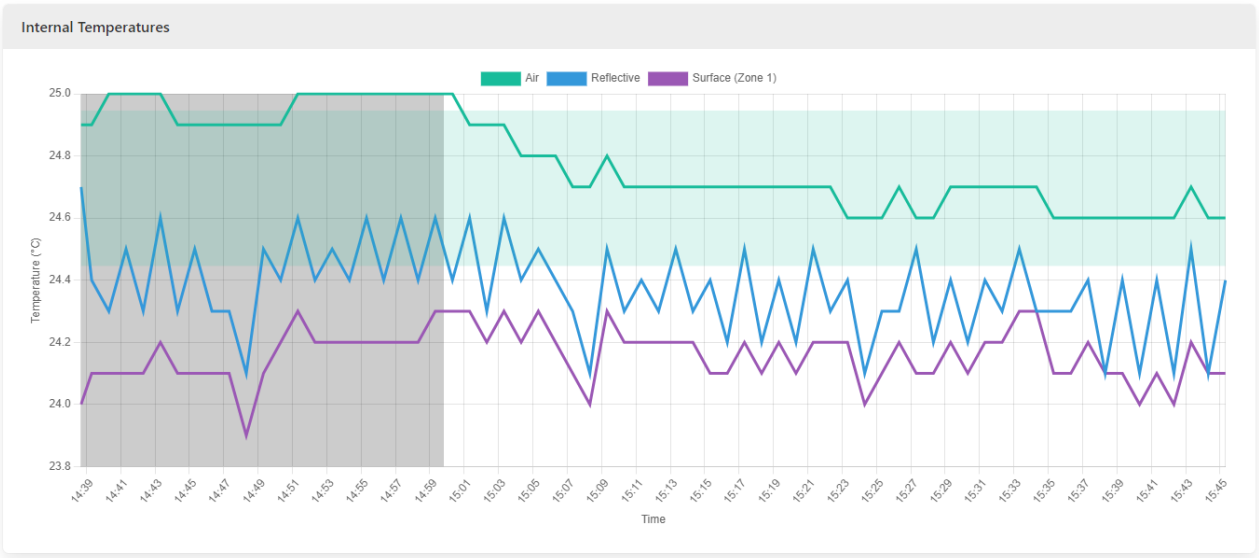
During the timelapse survey

While the survey is taking place, the data will be sent to the Heat3D cloud server and can be viewed at heat3d.online. It's useful to have the survey open on a second device during the survey to check that it is running successfully. In order to accurately measure the U-value it's essential that the conditions in the room are stable, to manage this Heat3D applied criteria to check room stability, these are applied to:

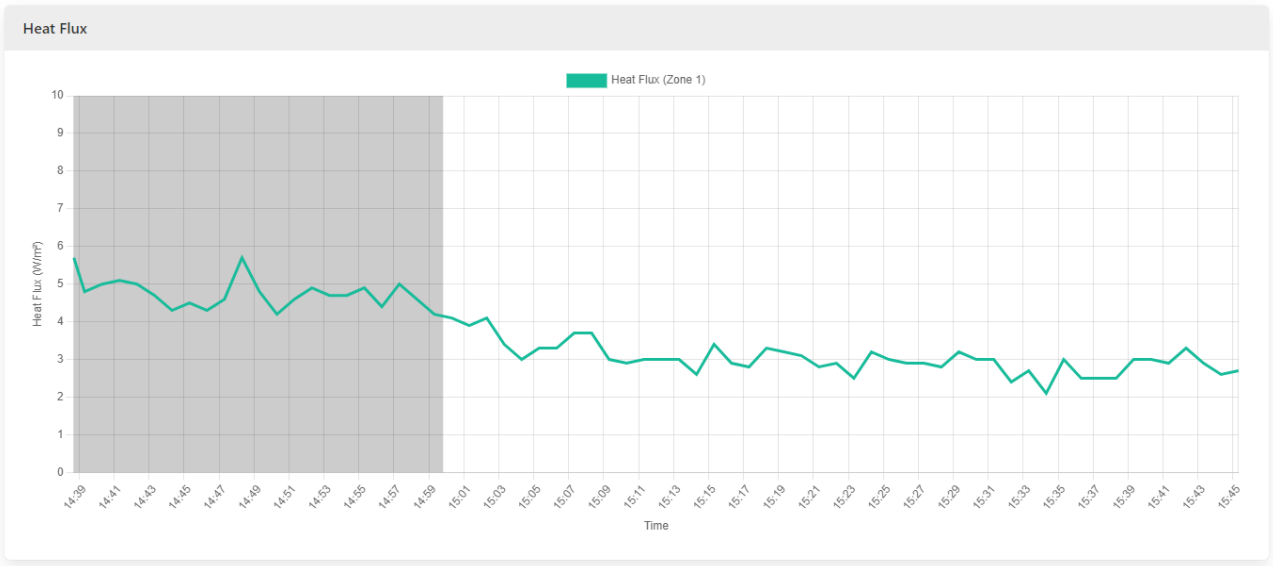
- The air temperature, which must not vary by more than 0.2^{o}C during a valid survey
- The U-value, minutely measurements must not vary by more than 0.2W/m^{2}K during a valid survey
- The heat flux, the overall trend of heat flux measurements must be close to stable during a valid survey

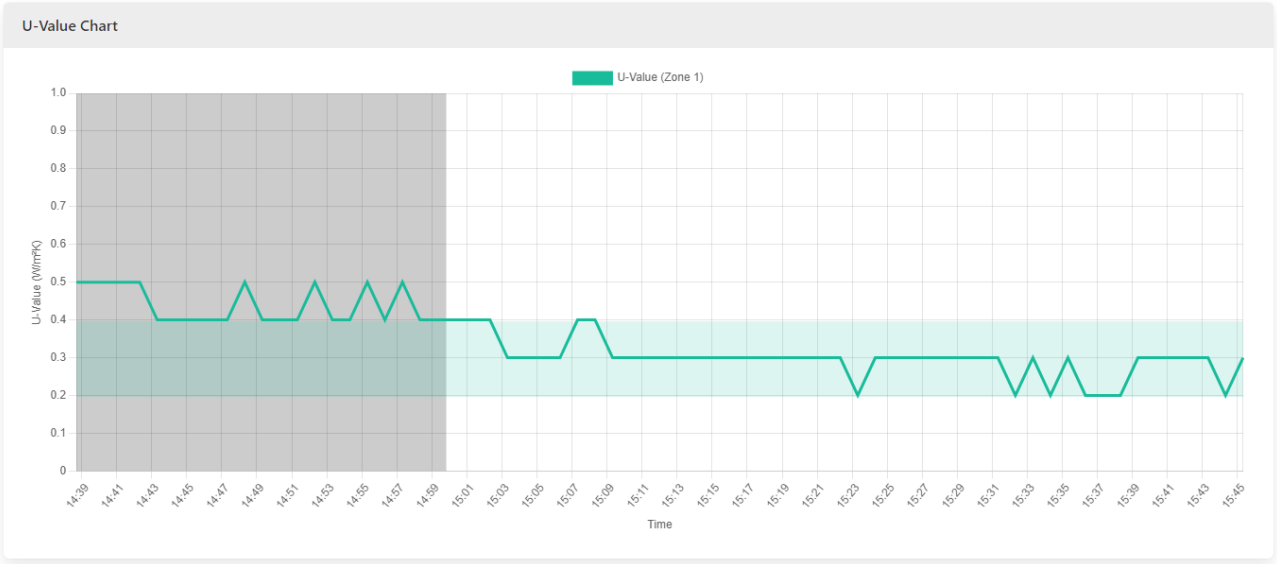
If the criteria are not satisfied then the timelapse will automatically be extended to try and achieve valid measurements. The user will be informed of extensions both on the app and at heat3d.online.

A worked example of a timelapse measurement which achieved a valid result after an extension is shown below. At the start of the measurement period the internal temperature was reducing, which caused an extension in the survey until a stable temperature was achieved. In the screenshot below the shaded area shows the data which is rejected and not used in the survey.



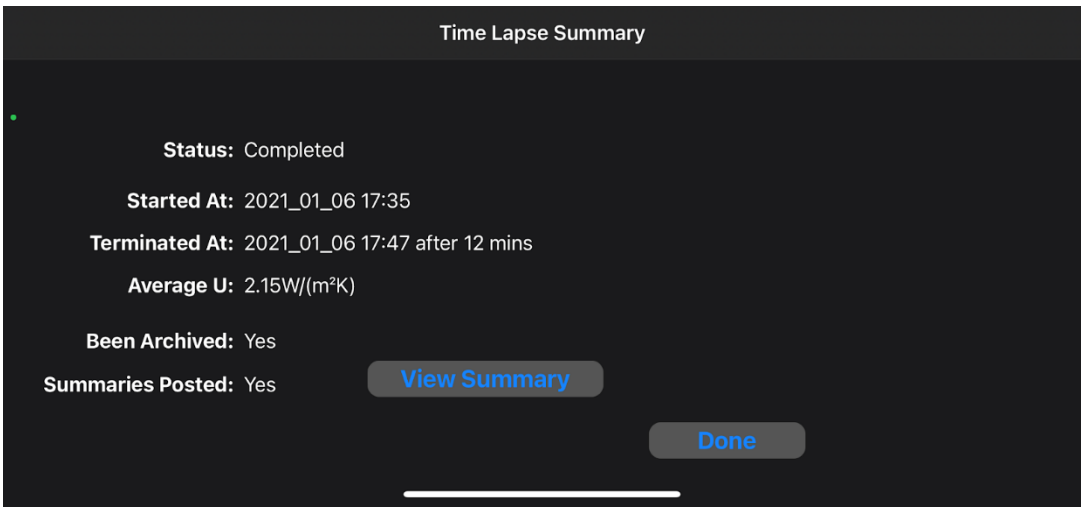
The falling internal temperature at the start of the survey is matched by a falling heat flux measurement during this period, indicating that the wall is not in a stable condition. Once the temperature stabilises, the heat flux and U-value do too, resulting in a valid measurement with a U-value of 0.3W/m^{2}K ± 44%.





Viewing results

At the end of the time-lapse survey, a completion summary screen is displayed with a link to the summary stats and graphs. Results can also be viewed at heat3d.online, and measurement reports can be generated to be shared externally.



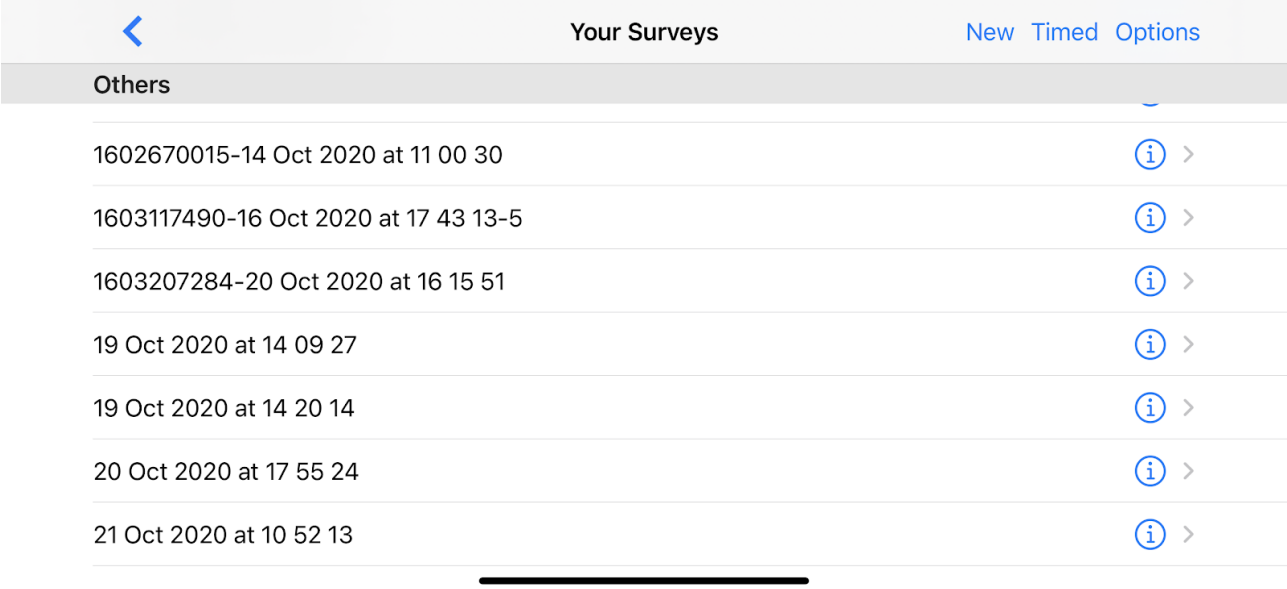
10. Viewing Saved Surveys

To save surveys to the cloud and view them using a web browser, you need a Heat3D account.

Contact BTS if you do not know your organisation name, username or password.

Viewing surveys on your device

Tap ‘View Surveys’ on the main menu to view a list of the surveys saved on your device.



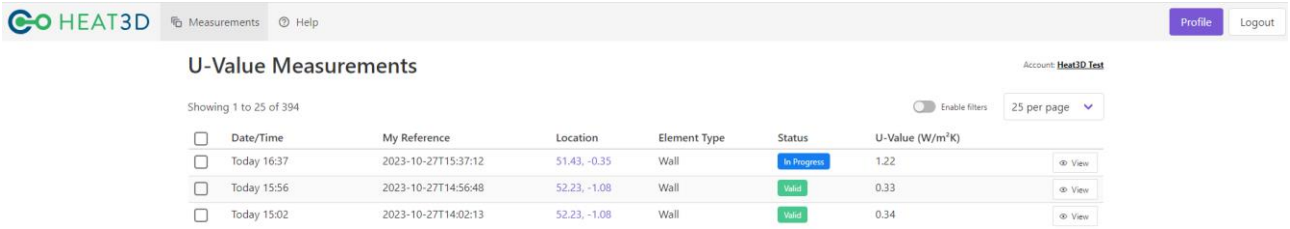
You can load and view a room again by tapping on it. When viewing you can pan and scale the room with pinch gestures. You can also re-select target positions and zones and re-save the survey if required.

Tap the ‘i’ icon next to a survey to view the summary including date, time, location, weather plus images of the walls captured. You can add a survey name, edit the notes and save them by tapping ‘Done’ at the top right.

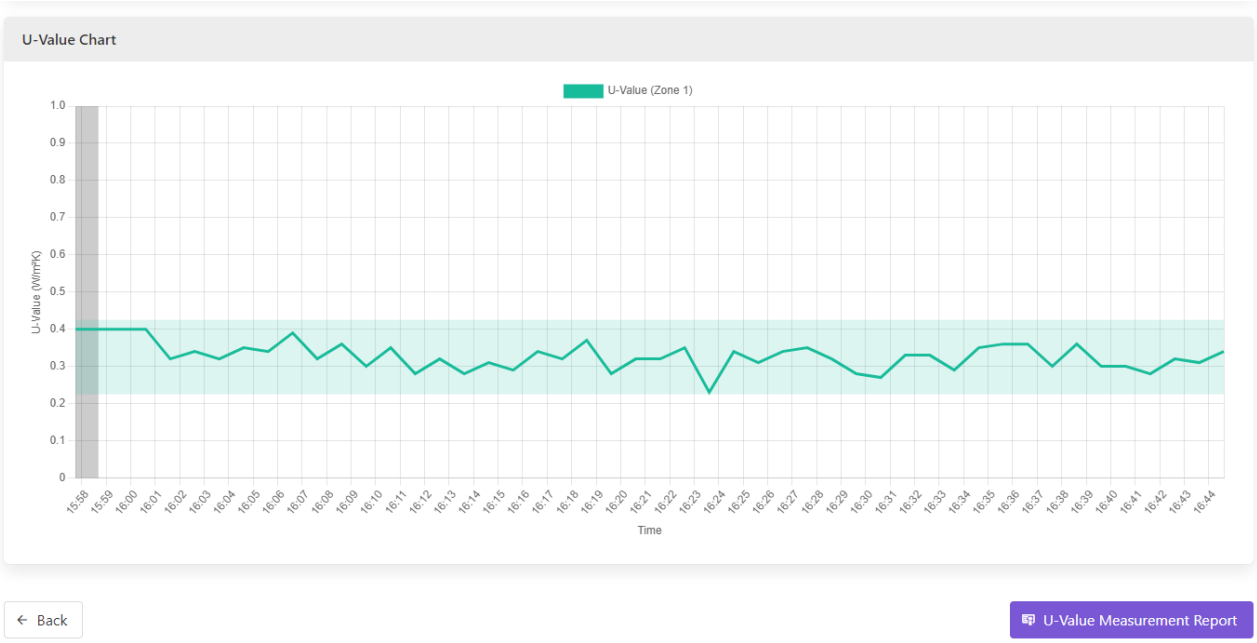
When viewing the survey summary, you can also share the survey and re-archive it. Surveys are grouped together based on the survey name. Delete a survey by swiping left on the entry in the list.

View surveys stored in the cloud

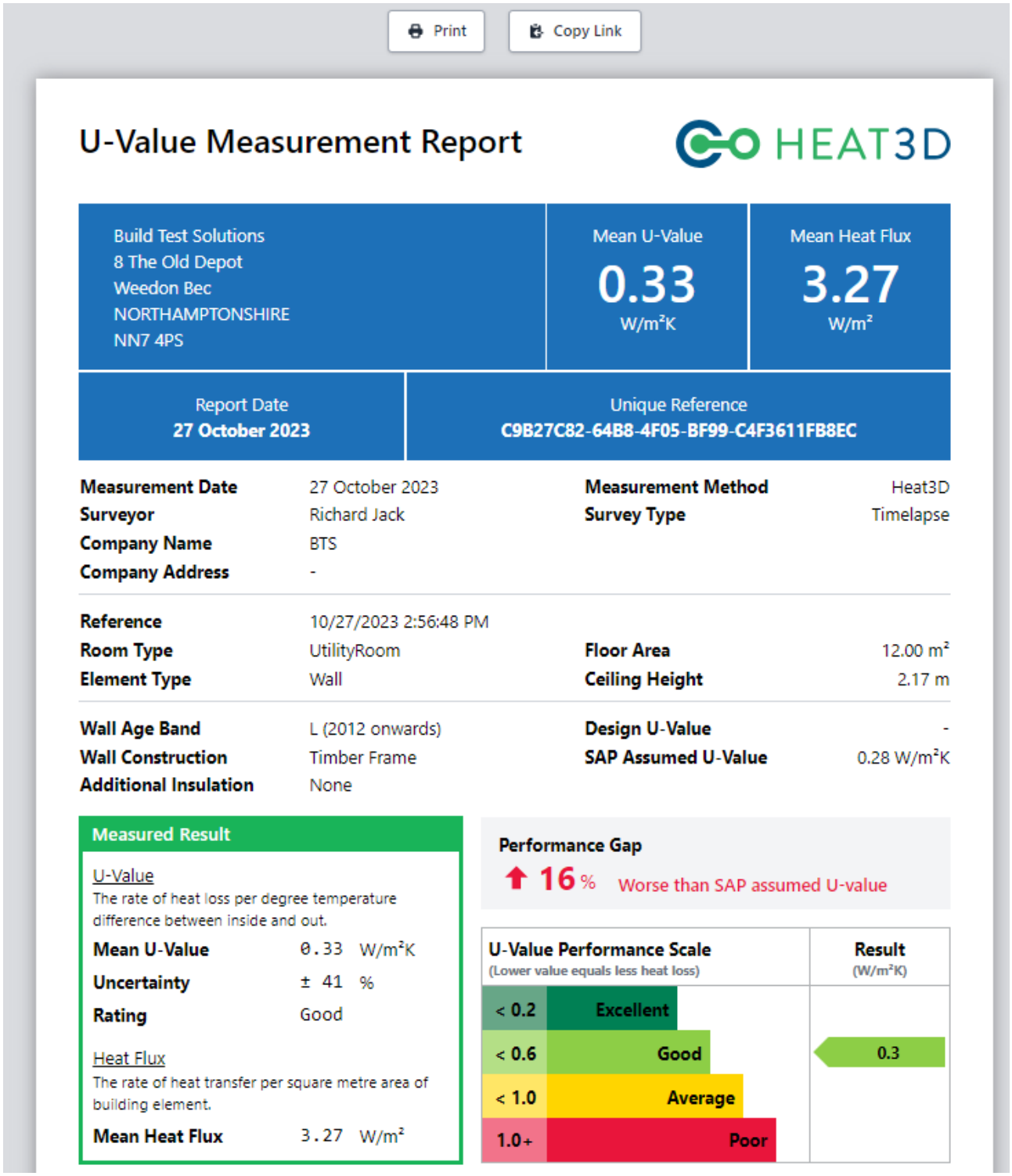
Tap the White Heat3D logo button in the centre on the main screen or go to heat3d.online and then enter your login details. You will be logged into the cloud interface and see the list of all the surveys ordered by most recent first.



After a survey is complete a U-Value Measurement Report can be created and viewed.



This is a PDF report which can be shared by email or by sharing the unique web link, it includes all of the details relevant to the measurement. The user can also add the address of the building and the predicted U-value for the wall, this will produce a comparison between the measured and predicted value for the wall.


Print
Copy Link
U-Value Measurement Report
HEAT3D
Build Test Solutions
8 The Old Depot
Weedon Bec
NORTHAMPTONSHIRE
NN7 4PS
Mean U-Value
0.33
W/m²K
Mean Heat Flux
3.27
W/m²
Report Date
27 October 2023
Unique Reference
C9B27C82-64B8-4F05-BF99-C4F3611FB8EC
Measurement Date 27 October 2023
Surveyor Richard Jack
Company Name BTS
Company Address -
Measurement Method Heat3D
Survey Type Timelapse
Reference 10/27/2023 2:56:48 PM
Room Type UtilityRoom
Element Type Wall
Floor Area 12.00 m²
Ceiling Height 2.17 m
Wall Age Band L (2012 onwards)
Wall Construction Timber Frame
Additional Insulation None
Design U-Value -
SAP Assumed U-Value 0.28 W/m²K
Measured Result
U-Value
The rate of heat loss per degree temperature difference between inside and out.
Mean U-Value 0.33 W/m²K
Uncertainty ± 41 %
Rating Good
Heat Flux
The rate of heat transfer per square metre area of building element.
Mean Heat Flux 3.27 W/m²
Performance Gap
16 % Worse than SAP assumed U-value
U-Value Performance Scale
(Lower value equals less heat loss)
Result
(W/m²K)
< 0.2 Excellent
< 0.6 Good
< 1.0 Average
1.0+ Poor
0.3

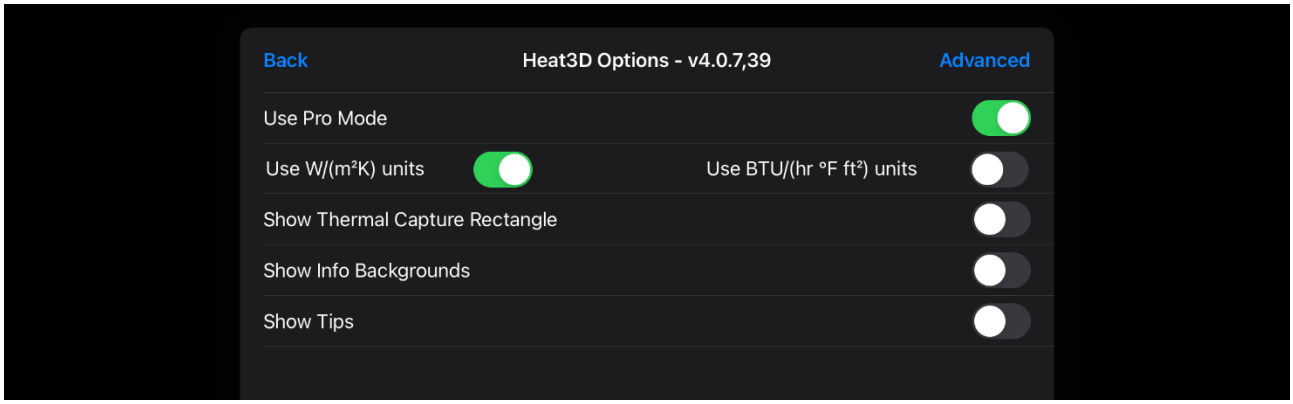
11.Configurable Settings

Settings are saved and remembered each time you open the Heat3D app.

To access, click the ‘Settings’ button on the main menu.

Basic Settings

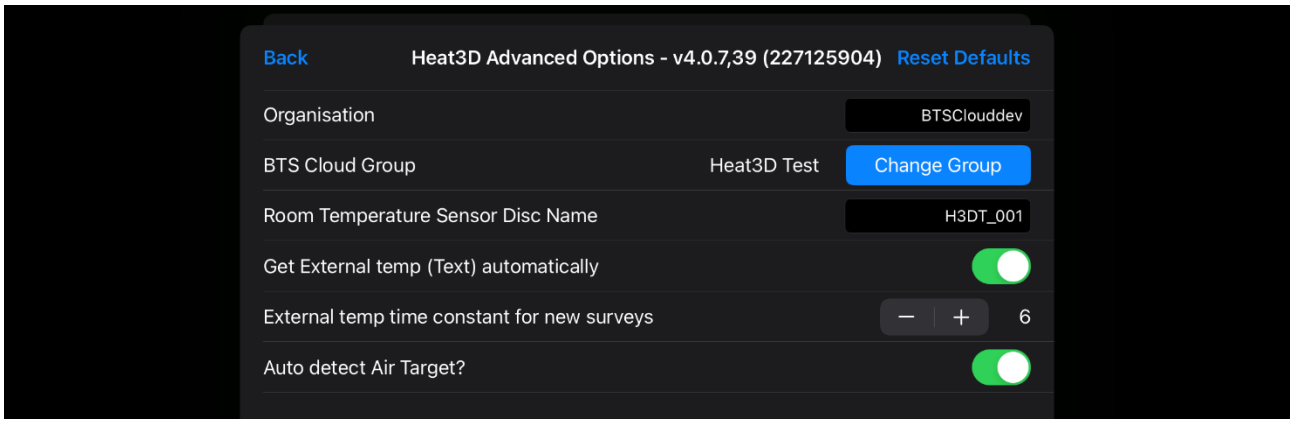
Basic settings allow you to customise look and feel of the user interface.



Advanced Settings (only available pre-survey)

This is where you enter your organisation, username and password. You can also change various options like the time-lapse period and interval.

Other Advanced settings should only be changed by experienced operators.



Contact

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