

Chariot sensing and energy advice platform



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1 Chariot and the need to monitor temperature, humidity and energy consumption

Chariot is an IT platform for collecting, interpreting and displaying information about the home's performance in delivering a comfortable and healthy environment. Chariot has been developed by Southampton and Nottingham Universities in partnership with the Centre for Sustainable Energy (CSE) a national charity delivering energy advice with funding from the Engineering and Physical Sciences Research Council (EPSRC).

1.1 What Chariot does

Chariot allowing visualisation of the relationships between our behaviour, external temperatures, our energy consumption and the effects this has on internal temperatures and humidity levels. This makes it a potent tool in the delivery of energy advice, allowing diagnostics of the home's energy performance, identification of anomalies and opportunities for wiser energy use. By presenting analysis supported by interactive graphs and visualisation of the data, advice becomes much more engaging and therefore likely to be acted upon.



CSE and partners are continuing to develop the Chariot platform, adding new functionality such as the ability to create What If? scenarios and in improving the integration of energy consumption data from specialist energy sensing equipment. Further improvements are expected to become available during the summer of 2016. This user guide gives guidance on:

- The appropriate situations for using the Chariot kit
- Setting up and troubleshooting the installation of the kit
- The recommended process for using the kit to give energy advice
- How to interpret the data

1.2 Healthy temperatures

Living in a cold home has a variety of direct and indirect impacts on health and wellbeing, particularly for vulnerable people.

1.2.1 Health impacts of cold homes

Long term effects lead to increased mortality for example the death rate rises 2.8% for every degree Celsius drop in the outdoor temperature for people in the coldest 10% of homes. This compares with a 0.9% rise in deaths for every degree Celsius drop in the warmest 10% of homes¹. As well as increasing mortality a cold home is a significant factor in a range of other disease and illness. The main direct health conditions associated with cold housing are circulatory diseases, respiratory problems and mental ill-health. Other conditions influenced or exacerbated by cold housing include the common flu and cold, as well as arthritis and rheumatisms including mental health illness in a variety of other household types².

A number of negative indirect impacts of living in a cold home have also been identified. These include impacts on children's educational attainment, emotional wellbeing and resilience and also negative impacts on dexterity with increases in the risk of accidents and injuries in the home.

- Temperatures that are lower than 16 degrees reduce resistance to respiratory disease³.
- Temperatures below 12 degrees place strain on the cardiovascular system. The coldness causes a narrowing of the blood vessels, and an increase in the thickness of the blood which can put people at greater risk of heart attack⁴.
- Temperatures below 6 degrees place people at risk of hypothermia. Increased risk of hypothermia is particularly associated with older people because temperature control is weaker and because they have less subcutaneous fat, making them vulnerable
- One statistic suggests that sleeping in a bedroom with a temperature of 15°C increases the likelihood of depression and anxiety by 50 per cent, compared to those with a bedroom at a temperature of 21°C⁵.

1.2.2 Recommended indoor temperatures

Public Health England's advice is that the minimum temperature for homes in winter is 18°C (65°F)⁶. Following World Health Organisation recommendations, the UK government defines an adequate standard of warmth in England, as 21°C in the living room and 18°C in other occupied rooms.

¹ Cold Comfort: www.jrf.org.uk/report/cold-comfort-social-and-environmental-determinants-excess-winter-deaths-england-1986-1996

² The Marmot Review for Friends of the Earth reviews evidence of the relationships between cold homes and direct and indirect health impacts. See www.foe.co.uk/sites/default/files/downloads/cold_homes_health.pdf

³ Lacroix, E., and Chaton, C. (2015). Fuel poverty as a major determinant of perceived health: the case of France. Public Health 129, 517–524.

⁴ O'Sullivan, K.C., Howden-Chapman, P.L., and Fougere, G. (2011). Making the connection: The relationship between fuel poverty, electricity disconnection, and prepayment metering. Energy Policy 39, 733–741

⁵ See Dept. for Health factsheet (2007):

www.housinglin.org.uk/library/Resources/Housing/Housing_advice/Health_and_Winter_Warmth_-_Reducing_Health_Inequalities_January_2007.pdf

⁶ See page 42 of the government's cold weather plan at <https://www.gov.uk/government/publications/cold-weather-plan-cwp-for-england>

However these temperatures may still not feel comfortable for some groups. Sedentary older people generally need slightly higher temperatures to feel comfortable.

1.2.3 Who is vulnerable to cold homes

Winter related mortality and morbidity is more common in, but not confined to, older people⁷. For example, children living in cold homes are more than twice as likely to suffer from a variety of respiratory problems than children living in warm homes. The National Institute of Clinical Excellence (NICE)⁸ lists the following types of household as vulnerable to cold homes:

- a) people with cardiovascular conditions
- b) people with respiratory conditions (in particular, chronic obstructive pulmonary disease and childhood asthma)
- c) people with mental health conditions
- d) people with disabilities
- e) older people (65 and older)
- f) households with young children (from new-born to school age)
- g) pregnant women
- h) people on a low income.

In many cases simple preventive action could avoid many of the deaths and illnesses associated with the cold. Many of these measures need to be planned and undertaken before cold weather starts.

1.3 Healthy humidity levels

If house temperatures fall below 16°C, the risk of respiratory illness increases. This is because cold houses are also usually damp, which can lead to respiratory symptoms. House occupants produce a significant amount of moisture in their day-to-day activities, for example, cooking, showering and drying laundry. Even breathing has an effect – each person produces one litre of moisture per day this way. Moisture condenses on cold surfaces, such as uninsulated walls. As well as dampness being a health risk in itself, it can lead to mould growth, which may also contribute to respiratory problems.

Mould growth is worse when there is also poor ventilation, such as when a house has well-sealed windows that are kept shut, or doesn't have an extractor fan in the bathroom. Most mould is not harmful for healthy people. However, some species release substances which are potentially toxic and may cause adverse reactions in some people, such as those with pre-existing respiratory conditions. Mould also produces spores when it reproduces. When these are inhaled or come into contact with skin they may cause allergies and skin irritation, and aggravate asthma.

A review for the World Health Organisation concludes that there is sufficient evidence of an association between indoor dampness-related factors and a wide range of respiratory health effects

⁷ The Office for National Statistics' Statistical bulletin: excess winter mortality in England and Wales, 2014/15 reported:

56% of cold-related deaths were in people aged 85 and older, 27% were in people aged between 75 and 84

⁸ See the NICE guidance on tackling illness associated with living in cold homes here:

www.nice.org.uk/guidance/QS117/chapter/introduction#why-this-quality-standard-is-needed

including asthma development, asthma exacerbation, current asthma, respiratory infections, upper respiratory tract symptoms, cough, wheeze and dyspnoea⁹.

There appears to be an optimal range for indoor relative humidity between about 40 and 60%¹⁰. Below about 40% relative a range of bacteria and viruses thrive leading to a range of respiratory infections and other illness. Equally above about 60% the conditions are right for bacteria, viruses, fungi and mites to thrive again leading to a range of health impacts including respiratory problems.

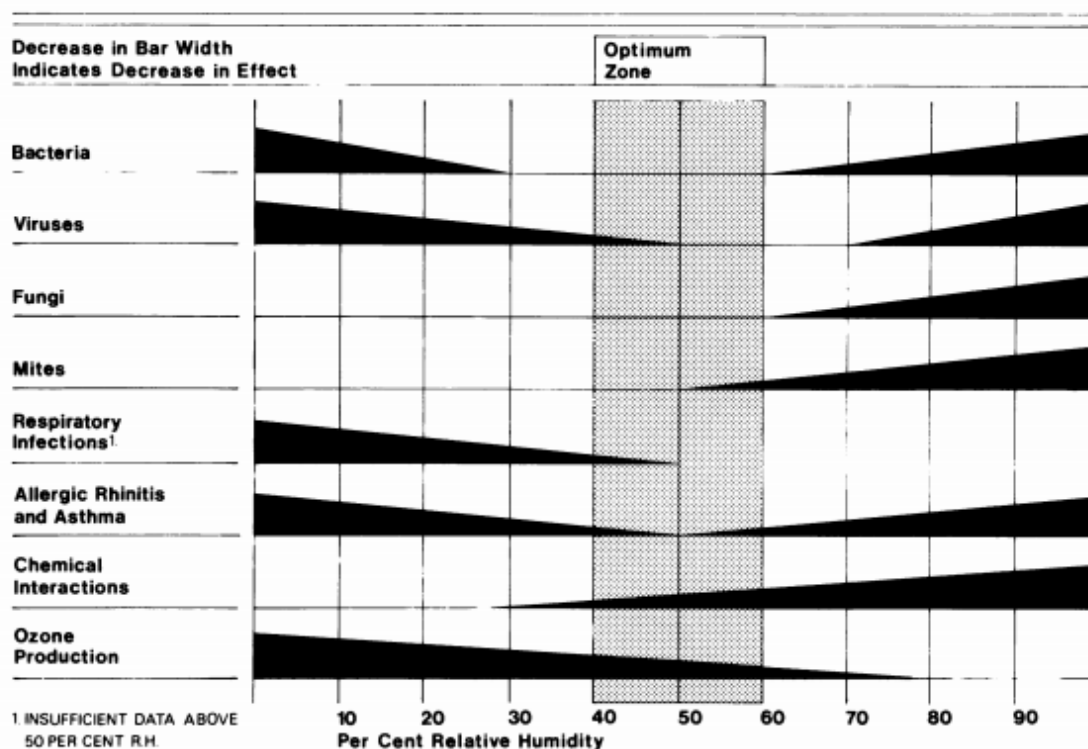


Figure 1. Optimum relative humidity range for minimizing adverse health effects.

Figure 1: Optimum humidity zone avoiding biological pathogens. From Arundel et al 1986

1.4 The relationship between temperature and relative humidity

Relative humidity means the humidity of air relative to 100% humidity which is point at which the air is saturated and water begins to come out of the vapour state and condense on surfaces – this point is also known as the dew point. So as the temperature of the air increases and its capacity to hold moisture also increases as a result, its the relative humidity *decreases* – increasing air temperature means the air is further from reaching its dew point. Hence high relative humidity can lead to condensation of moisture onto the coolest surfaces in a home (such as windows or cold spots on walls). The maximum amount of water held by the air at increasing temperatures is shown in Figure 4.

⁹ The WHO guidelines on biological impacts on indoor air quality are found here:

www.euro.who.int/_data/assets/pdf_file/0017/43325/E92645.pdf?ua=1

¹⁰ Indirect Health Effects of Relative Humidity in Indoor Environments. Arundel et al. Environmental Health Perspectives. Vol 65. Pp 351-361, 1986

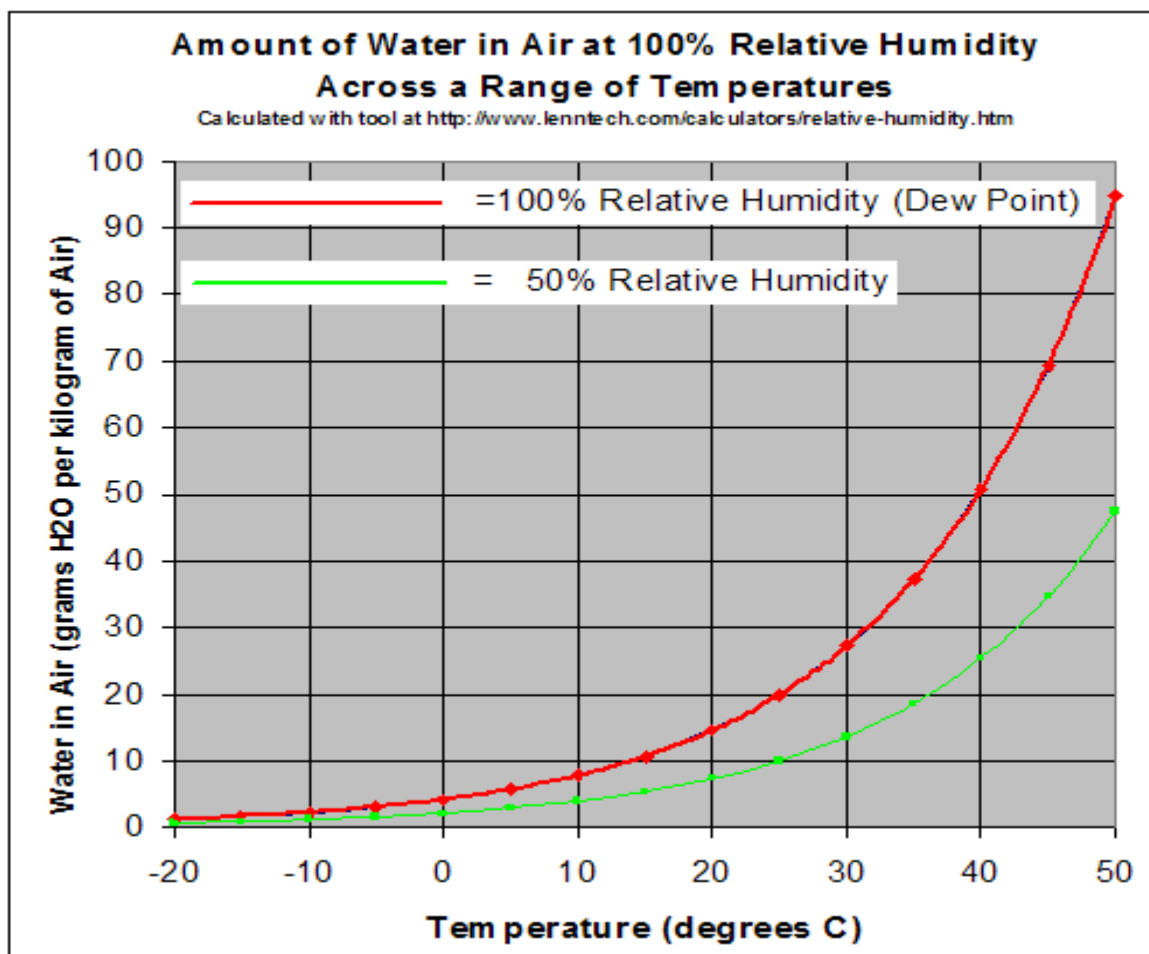


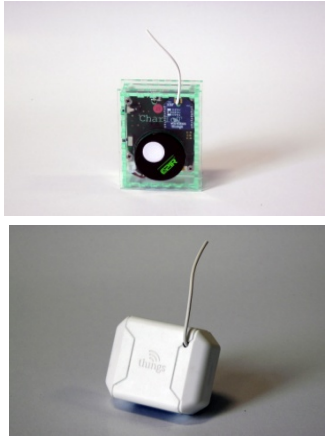
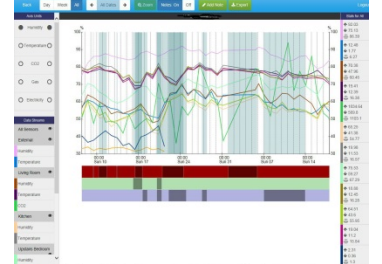
Figure 2: Relationship between temperature and humidity

Figure 2 shows that at a humidity level of 10 grammes of water in a kilogram of air, moisture would start condensing out of the air at around 15 degrees C – the 100% relative humidity mark and the dew point at this temperature. But if the temperature were increased to 25 degrees C in the space the relative humidity would drop to around 50% - the recommended humidity level for minimising pathogens and avoiding risks of damp and mould growth.

Chariot data can demonstrate to householders the relationships between temperature and relative humidity by showing how the two vary together in the home. This should mean advice on controlling humidity levels, for example by ensuring the right temperature regime is maintained and discontinuing practices that increase humidity levels beyond acceptable thresholds, is more engaging and likely to be acted upon.

2 What the Chariot kit is

The Chariot kit comprises:

A comms hub This hub is in the form of a modified raspberry pi computer with an integrated radio link. The hub collects the sensor and energy data and is connected to the internet usually via an Ethernet cable plugged into the household's broadband router.	
Wireless sensors Wireless temperature, humidity and carbon dioxide sensors. These use radio waves rather than WI-Fi as this results in much better battery life and the ability to send signals through solid walls. The sensors in a transparent green case monitor all three kinds of data. The plain white sensors only monitor temperature and humidity	
Wireless electricity and gas consumption monitoring devices. Pictured is a electricity monitoring device capable of monitoring 4 different circuits. This device is part of the Open Energy Monitor kit available at: openenergymonitor.org/emon/modules/emonTxV3	
Web based user interface	

Once the sensors are positioned in the home, the data is recorded at intervals set by the user and sent via the home's internet connection or through the mobile phone network to a Cloud hosting service where it is stored on a database. The Chariot interface tool, a web based application viewable on tablet or computer screen, then allows the user to interrogate and view the data with a range of functions and presentation options. An overview of the Chariot components is shown in Figure 3.

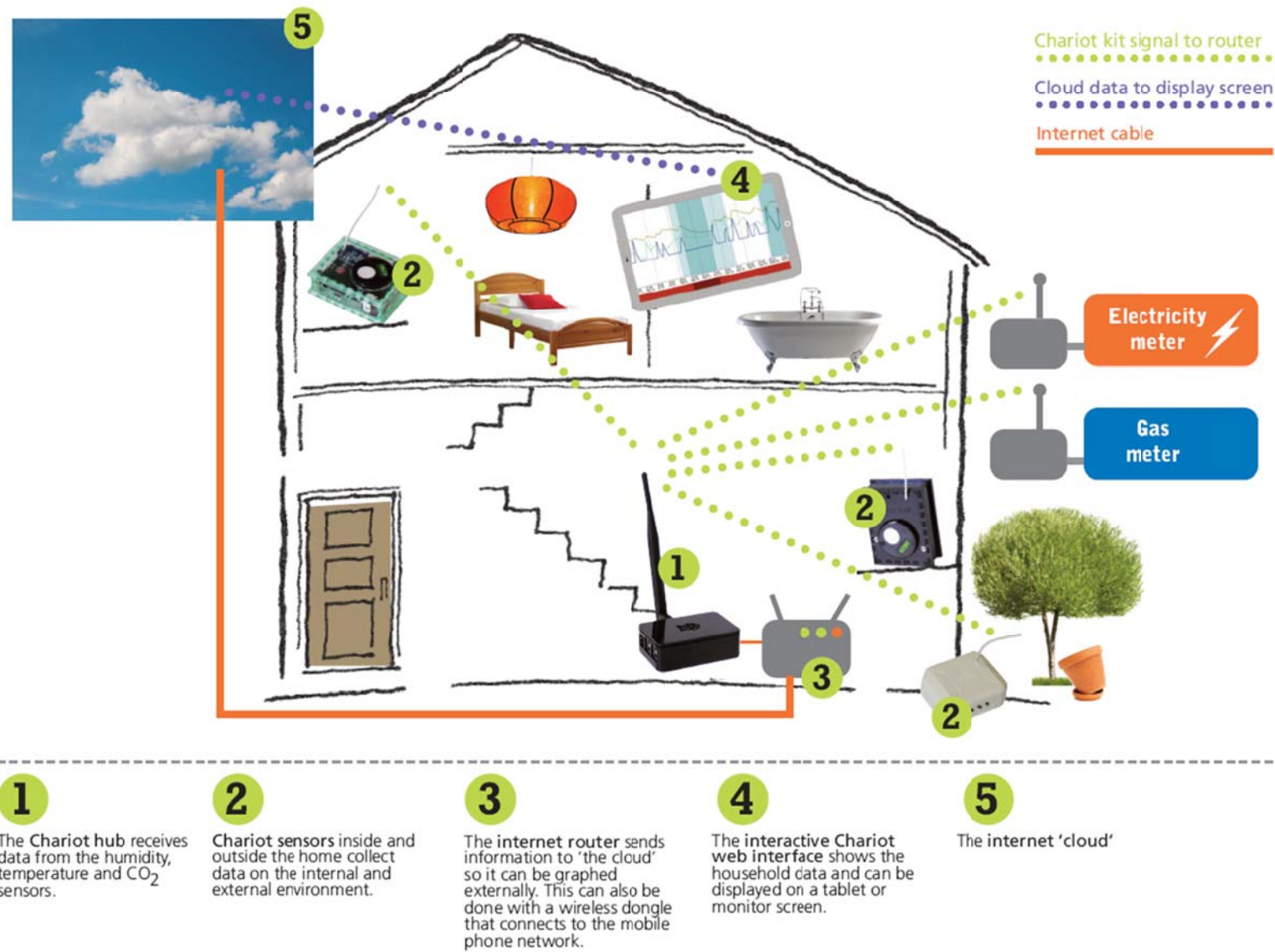


Figure 3: Chariot overview

3 When and where would you use it?

By measuring temperature, humidity and associated energy consumption the Chariot kit can give useful information about how the home is performing in delivering a comfortable and healthy environment. It can be also be used to diagnose particular issues with the home. For example if there is a persistent problem with mould growth in a room then deployment of a humidity and temperature sensor would reveal whether this was as a result of the space being underheated or has high levels of relative humidity for other reasons. If relative humidity levels in the space were not particularly high then the cause of the mould growth could be for other reasons such as water penetration into the wall. Below we list some contexts in which the Chariot can be particularly usefully deployed.

3.1 Situations where it would be useful to use the kit

- Properties/rooms which have high levels of condensation, damp or mould
- Properties/rooms which are cold.
- Properties/rooms which are draughty.
- Situations where the heating/energy bills are high
- Situations where the occupants have health condition which the advisor/support worker believes is being made worse by the condition of the house – dampness or coldness (note a cold house is also more likely to be damp).
- Situations where it would be useful to compare rooms in a property – if a room/wall has insulation but another room does not to be able to compare the difference.
- Situations where there is an energy efficiency/condensation issue that is being made worse by a repair¹¹ being needed, i.e. penetrating damp, additional ventilation needed.
- Clients who do not manage their condensation production effectively – i.e. do not ventilate sufficiently.
- Clients who underheat the property.
- Clients who are not making full use of their heating controls.

3.2 What do you need to successfully deploy and use a Chariot kit?

To successfully deploy a Chariot kit you will need:

- a) A willing and motivated household
- b) A broadband connection or good 3g/4g signal
- c) Sensor kit
- d) A laptop or tablet to access the Chariot web portal
- e) The ability to explore the relationships between temperature, humidity and energy consumption as the basis for energy advice.

A willing motivated household

It might seem like stating the obvious, but to successfully deploy a Chariot kit you need a household with an issue related to their home environment like damp and mould, which is willing to be proactive and potentially change household behaviours to address that. Potential participants need

¹¹ Note the landlord will not be under any obligation to carry out a repair based on the data that is recorded, but that CharIoT data could provide useful supporting evidence for a request for repair.

to feel that it is within their power to remedy the situation at least partly, and/or with the assistance of a relevant organisation or landlord.

Households need to be easy to contact and to be prepared to be present for appointments. Deploying the sensors, gathering data and offering energy efficiency advice will require at least a couple of visits and is usually carried out over quite a short time period. If the client is not easy to contact it could result in the sensors being at their house for a long period of time. As there are a limited number of sensors it might be better to offer this person alternative forms of advice. Failure to be present for deployment, advice meeting or final collection visits also uses valuable resources and advisor time and will quickly result in additional project costs.

It is also important to get buy-in from the whole household. We found in deploying one kit with mum's agreement that another family member repeatedly tinkered with the hub preventing data collection. This led to recurring visits to deploy and redeploy the kit which proved costly and fruitless. To get a household on board be clear and upfront about the process and timescales involved, emphasising the personalised nature of the advice that will be offered to them.

If you are seeking a quick snap shot of a home situation below gives the deployment process and is a good basic guideline to give a household an idea of what to expect. It also includes related activities and documents for advisers/support workers for the different stages of deployment.

Time	Visit	Activities and resources
Pre-visit	Initial engagement	Initial contact (by phone) to gather basic information about the issue and household circumstances. You could include some basic occupancy questions from the Deployment visit questionnaire in Appendix 9 e.g. any vulnerability in the home (young children; over 70 years, or cold-related health issues). In relation to fuel poverty it would also be useful to know of any difficulties households have in managing fuel bills, and rough annual household income (e.g. < £16,000 pa). Note that energy advice using the Chariot kit given out of the heating season will largely be confined to power and hot water usage. Where there are particular issues with heating then deployment is better made during the heating season.
Interim activities by adviser		Send household more information on what is involved with confirmation of the deployment visit. Access the property Energy Performance Certificate if possible at www.epcregister.com or from other records for insulation and energy efficiency information. Assign the sensor kit to the home on the web portal and test it is working.
Week 1	Deployment visit (about 60 minutes)	Clarify the process involved and what will happen so participant can ask questions. Discuss data security and confidentiality. Householder signs consent for data recording and use for intended purpose only. Gather detailed information on household activities (e.g. heating patterns), appliances and their use. There are example forms to help with this in 7.37.3.2. Check insulation/energy efficiency information on the property and any difficulties or updates. Take photos (if relevant) and details of the housing issue. Show participant the sensors and hub, and an example of how the data will appear on a tablet, and what you'll do with the data. Set up the kit and check it is working. Use the Deployment visit questionnaire in Appendix 9
Interim activities by adviser		Check data is being collected on the web portal. Possible trouble shooting with participant by phone if sensors drop out Data analysis and preparation for advice visit. Guidance on what to look for is shown below.
Week3	Advice visit (60-90 minutes)	Feedback to participant on what the data showed relevant to their issue referring to web portal charts (depending on interest levels of client). Ask householder for more details if there are anomalies. Offer personalised advice, discuss possible actions and support to make changes if needed e.g. setting heating controls. If you want to check back with the household to assess challenges/benefits of actions suggested/implemented leave the kit in place for another 1-2 weeks (e.g. if you want to observe any change in behaviour and/or energy use). If this is not relevant remove the kit at the end of the advice visit. See Appendix 9 Home Visit Form Remove kit or let it remain (see below)
Interim activities by adviser		Data analysis (if required) for closure visit. Explore whether any suggested changes to settings and behaviours are reflected in the data.

Week 4/5 (optional)	Feedback and collection visit (30-45 minutes)	Work through data with client once more to identify whether any suggested changes to settings and behaviours given in the advice visit are reflected in the data. Give final advice perhaps linking Chariot data interpretations with data shown on an In Home Display if they have one installed. Collect the kit See Appendix 9 Questionnaire for Third/closure visit
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Table 1: Summary of sensor kit process and advisor activities

A broadband connection

The kit in use at the moment needs to be connected to the household's broadband. This ensures successful data transmission to the Cloud (i.e. a server configured to receive and store the data). Where the household has no broadband connection an alternative set up is possible which uses a 3g or 4g dongle to send the data to the server via the mobile phone network. However this mechanism is not very reliable due to patchy network area coverage. Reassure the householder that sending the data uses a tiny part of their data allowance (less than 1 MB a week – about 1/100 of the data requirements for watching 30 mins of video¹²) and the hub costs about 20p a week to run¹³.

A Chariot kit

The various elements of the kit (hub, broadband connector lead, hub electric plug, 3-4 interior sensors, 1 exterior sensor) can all be carried in a small bag – there are no transport issues. Additional extras that are useful to bring along are:

- A single socket extension lead
- An Ethernet port expansion device known as a “switch” – sometimes households have no spare sockets on the back of their broadband router for the Chariot hub to plug into The number of sockets can be increased using a “switch”¹⁴.

A laptop or tablet to access the Chariot web portal

Visual data can be captivating and very persuasive when linked to a participant's home activities and behaviour. People's personal preferences vary greatly in terms of how much they engage with charts and graphs – check this out during the deployment visit by briefly showing them an example. You will need to access the web portal on the deployment visit, to establish that the kit is working. On the advice visit the laptop/tablet offers a focus to huddle round with the participant to share the data and your interpretation of it. You can discuss any anomalies in the data or queries you or they might have. For example they are likely to be able to identify what they were doing on a specific day that relates to the data.

We have found that requesting that people keep a diary of their activity during the trial period is rarely successful because people forget to complete it but this may be an option to consider if you feel the household has capacity to do this.

The ability to explore basic data on temperature and humidity

The ability to explore basic data on temperature and humidity and to convey relevant points highlighted by the data to the household, along with advice and possible actions they can take themselves or with support.

¹² Thirty minutes of video represents between 25 and 175 MB of data.

iplayerhelp.external.bbc.co.uk/tv/mobile_3G_costs

¹³ 1.4kWh per week of electricity at 15p/kWh

¹⁴ An example of an Ethernet switch is here: <http://www.maplin.co.uk/p/tp-link-8-port-10100-network-switch-zf83e>

There is guidance included in this manual on how to interpret the data, supported by information on recommended temperature and humidity levels in homes. The key here is to pull out a small number of salient points for the participant (i.e. relevant to their issue) and make it easy for them to understand. Prepare a list of possible actions to share with them, whilst encouraging the household to suggest their own. This has a galvanising effect, promoting proactivity and ongoing dialogue / engagement.

Some social housing may have humidistat extractor fans fitted. It would be worthwhile finding out from the repairs team what the standard relative humidity setting is for them to switch on. Sometimes the usage of extractor fans is also relayed to the housing provider, which can give very useful information before or during deployment.

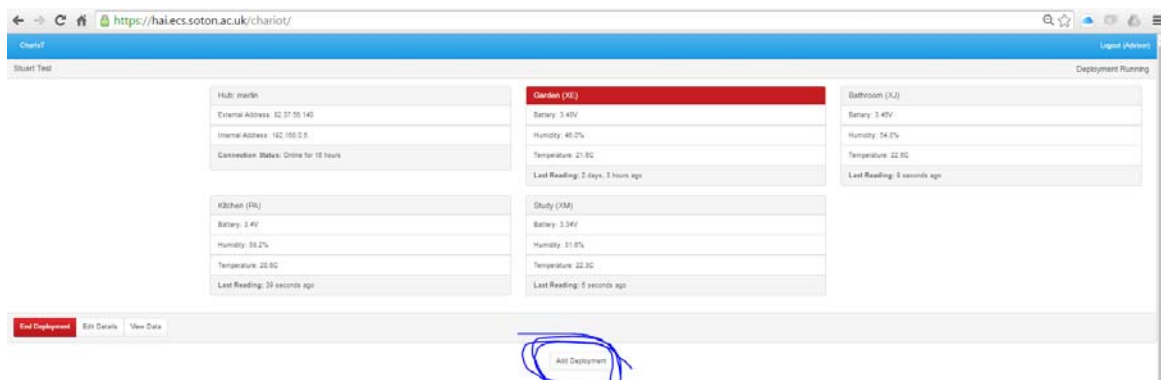
4 Setting up the system

4.1 Setting up the database and portal

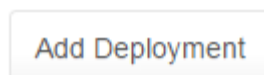
TBC

4.2 Setting up the sensors

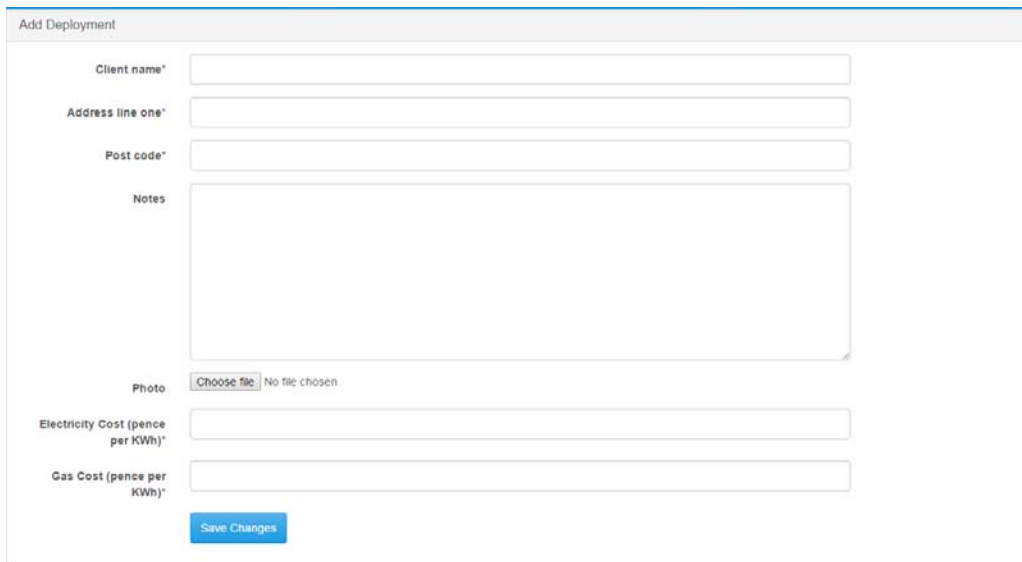
1. Log into the system using existing credentials from <http://hai.ecs.soton.ac.uk/Chariot/>. The dashboard below appears.



2. Add a new deployment using the add deployment button at the bottom of the dashboard



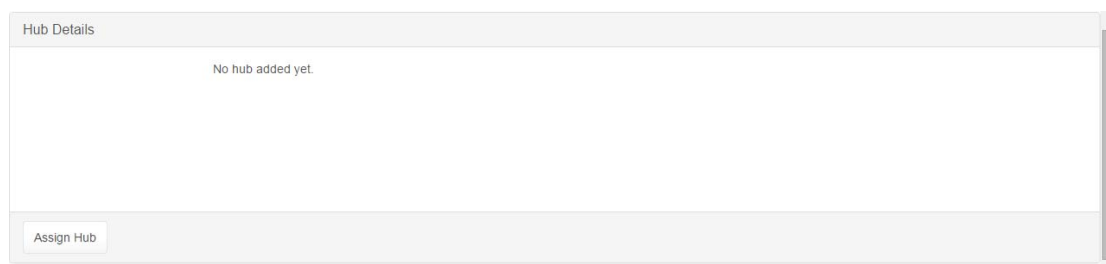
3. Fill in the basic household details on the add deployment page adding a photo if required



The 'Add Deployment' form contains the following fields and controls:

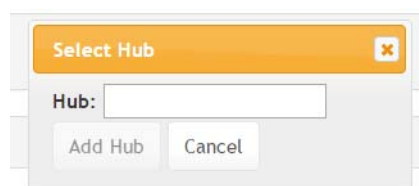
- Client name***: Text input field.
- Address line one***: Text input field.
- Post code***: Text input field.
- Notes**: Large text area for notes.
- Photo**: A 'Choose file' button and the text 'No file chosen'.
- Electricity Cost (pence per KWh)***: Text input field.
- Gas Cost (pence per KWh)***: Text input field.
- Save Changes**: A blue button at the bottom.

4. Click the "save changes" button
5. Click on the "assign hub" button in hub details pane



The 'Hub Details' pane shows the text 'No hub added yet.' and an 'Assign Hub' button at the bottom.

6. Enter the hub name into pop up box - names are in lower case and the add button will become active once a valid unused hub name has been entered. The names of each hub is written on its side.

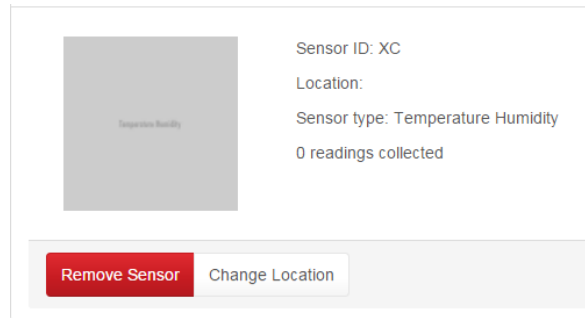


The 'Select Hub' pop-up box includes:

- Select Hub**: Title bar with a close button (X).
- Hub:**: Text input field.
- Add Hub**: Button that becomes active when a valid name is entered.
- Cancel**: Button to dismiss the pop-up.

7. Use the add sensors button in the sensor details pane to "add" sensors to the hub (i.e. to tell the hub which sensors will be sending data to it). Sensors are identified by a two letter code which are written on the side of the sensor and these should be entered in capitals

Add Sensor



8. Connect the hub (raspberry pi) to the internet. There are two ways of doing this:

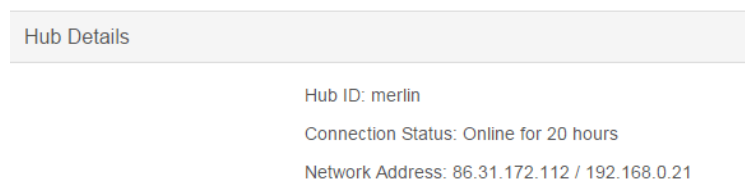
a) Householder Wi-Fi option

- Plug the Raspberry Pi (Hub) into the back of the household router
- If there are not enough ports then use the 'switch' device (see above)

b) 3g dongle option

- Connect a 3g dongle to a mini "TP link" router (usb connection)
- Connect the Raspberry Pi (Hub) to the mini TP link router using an Ethernet cable
- Power up the mini TP link router and wait for one minute to allow it to get an internet connection

9. Power up the hub which should show as online on the user dashboard after a couple of minutes



10. Place the sensors close but not too close to the hub and wait for initial readings to be shown on dashboard

lounge (JE)
Battery: 3.43V
Humidity: 33.9%
Temperature: 21.0C
Last Reading: 52 seconds ago

11. Once the hub is showing as online and the sensors have started to send readings the deployment can be started using the start deployment button on the main dashboard
12. Place the sensors in relevant areas of the household and update the dashboard with these locations
13. Wait in the household until it is possible to see that all sensors are operating properly and transmitting data. If any sensors are not transmitting data try moving them closer to the hub to see if it is due to distance. If they are still not working replace them with another sensor.
14. Complete deployment questionnaire. We'd advise doing this with the client to ensure all the fields are completed rather than leaving it with the household to complete in their own time.

5 Interpreting data

In this section we provide guidance on how to use the Chariot interface to interpret data.

5.1 Overview of the Chariot interface

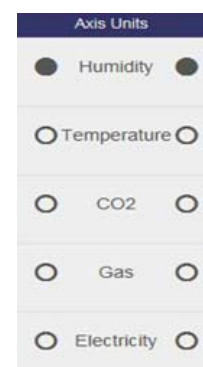
When you look on the interface, you might be presented with something like this for your household. The address will appear in the black header bar.



Figure 4: Interface overview

The central chart has two vertical axes (both set to relative humidity % in this picture), with sensor data recorded for the time of the deployment between them. At the top of the screen, the turquoise bar allows you to select for different time frames in the data – All of it, just one week, or a day. You can also add notes to the data and export it – more of this later.

The top left of the screen 'Axes Units' allows you to choose the units of measurement for the left and right axes – a dark button selects what you want to explore. You could choose to have temperature on one axis and humidity on the other.



The bottom left, Data stream, indicates the sensors you have allocated to different rooms, with each sensor assigned a colour. You can deselect sensors by clicking on them, for example if you just wanted to explore temperature, or only one room in the home. This can help in interpreting data streams – with all data streams visible the screen can become too busy and confusing.



The right side of the screen, Stats for All, gives the highest (↑), lowest (↓) and average (⚖️) readings for the data stream for that sensor. For example the pink colour for 'external humidity' had an average of 86.39% over the deployment period, and the minimum external temperature (turquoise) was a chilly 1.77 °C. If electricity and gas data is available, the final figure is the amount spent on fuel over the time scale in view.



5.2 Adding notes

You can select a period of time on the chart and add a note using the button in the turquoise bar, to highlight key points or questions raised by the data. The time period on the chart then has a pale blue background (for example Sunday 7th-14th in the chart below). The note will appear right at the bottom of the screen.

It is only possible to add one note to one time period selection, so there are three layers for note-making you can use. This is useful if the same time period highlights interesting aspects from different sensor data or rooms.

The three bars at the bottom of the chart - red, green and blue – indicate these layers for note-making. For example in the chart below a note has been added for a short time period around Sunday 17th to the red layer, and a slightly larger time period has been selected and annotated in the green layer. There is more on annotating later.

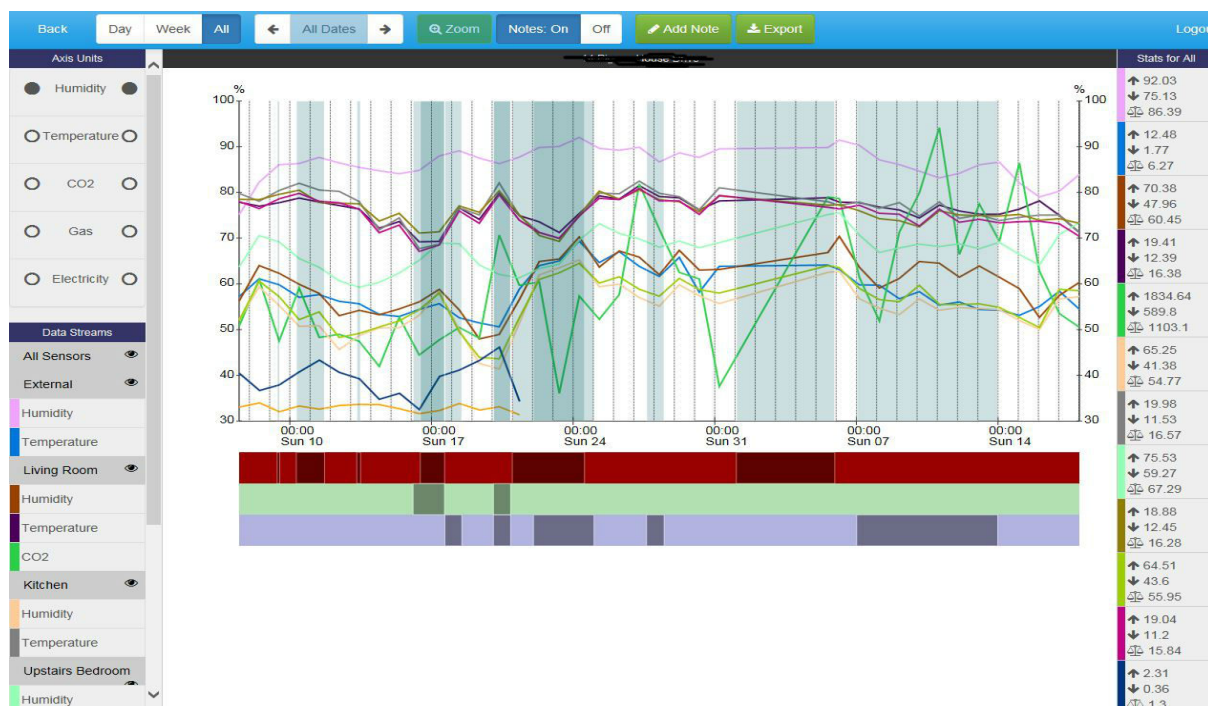


Figure 5: Adding notes

5.3 Data interpretation

Before you start analysing the data refresh your knowledge of the home situation and the issue in question from the Deployment visit questionnaire, especially for occupancy information, patterns of heating and appliance use, and property details from the EPC.

1. Are there any key questions that immediately stand out that you want to explore?
2. What is the best way to offer advice based on the data with this household? Do you want to show the household relevant data or is it more appropriate to focus on actionable advice with minimal reference to charts?

5.3.1 Broad brush approach – overview of temperature and humidity

Temperature

Select just the temperature sensors including the external one, select 'Temperature' on the Axis Units, and look at the stats on the right hand side of the screen.

- Are the minimum/maximum and average temperatures in each room within recommended health levels of 18-21 °C? Are there any particularly high/low temperature recordings in any of the rooms?
- Does the temperature vary in different rooms? Which rooms are the warmest/coldest? Is any variation in temperature between rooms large or small?

Then explore the data across a broad time frame, all of it or a week.

- What are the heating patterns? Is there a similar pattern every day or anything out of the ordinary? Does this correspond to the household's reported heating practices? Temperature rise can be due to external temperature rising, solar gain through windows and/or householder heating.

- Are there any cooling patterns? Cooling patterns can indicate the energy efficiency of a property e.g. slow cooling (heat retention) suggests good insulation.
- Does heating occur at occupancy times? Refer to the household stated occupancy and heating patterns. Anomalies (like heating at night) can highlight incorrectly set heating timers/programmers.

For example Figure 6 shows the temperature in 4 rooms:

- kitchen (grey),
- living room (purple),
- upstairs bedroom (olive) and
- hall (pink).

All temperatures are below 15 °C at the start – was the household away or had they run out of credit on their key meter? The home appears to be under heated, as the temperature regularly drops to less than 18 °C. The downstairs rooms have a similar pattern for temperature increase; the upstairs bedroom is lower and the temperature more variable. There are increases in temperature in the kitchen which are higher than in other rooms and temperature spikes which do not occur in other rooms probably due to cooking. Temporally there is a temperature pattern, with a rise early morning and sometimes a second peak in the evening. This corresponds with occupancy times. The slow cooling from 12noon on Friday 29th to a day later from 18 °C to 15 °C would suggest that the home is well insulated.

Next investigate the temperature in individual rooms by deselecting the other rooms' and external sensors.

- Are there big fluctuations/variations in temperatures in any of the rooms?
- Do temperature patterns correspond with heating practices for the rooms?

Jot down any days or time periods you may want to explore in more detail later on.

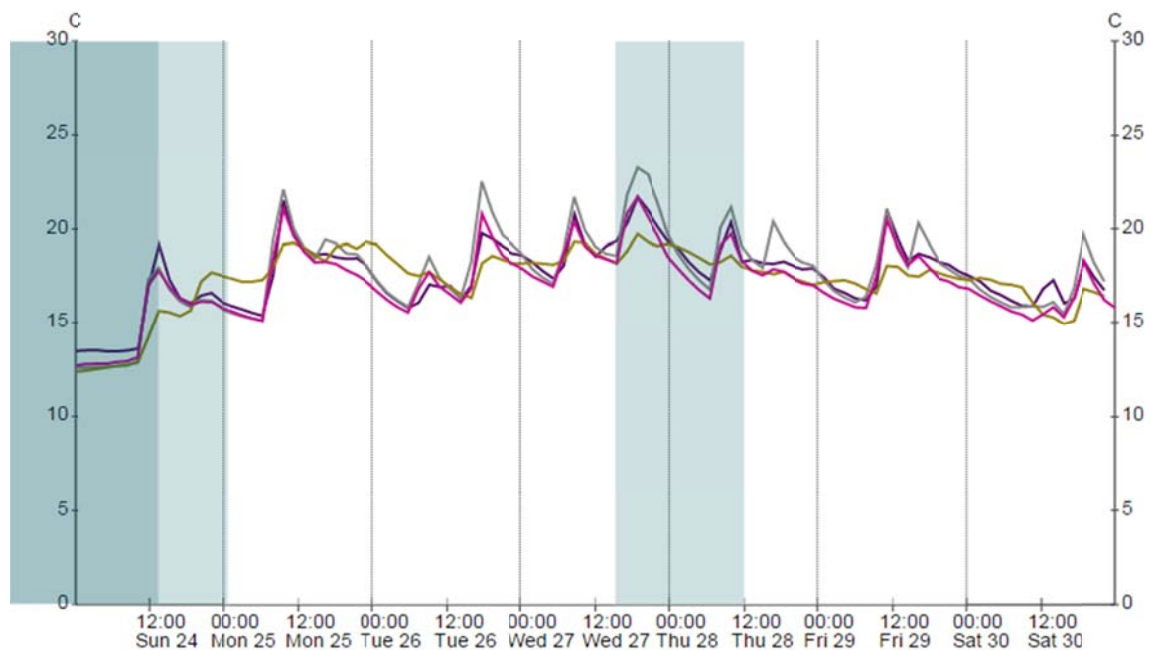


Figure 6: Temperature data for a home for one week

Kitchen (grey), living room (purple), upstairs bedroom (olive) and hall (pink)

Humidity

Select just the humidity sensors including the external one, select 'Humidity' on the Axis Units, and look at the stats on the right hand side of the screen.

- Is the minimum/maximum humidity in each room within recommended levels? (40-60%, not consistently 70+% or below 30)
- Is there variation in humidity in different rooms? Is the variation large or small? Does this relate to any household issues?

Then as for Temperature, explore the humidity data across a broad time frame.

- Are there patterns in the occurrence and levels of humidity? Does it tend to be similar each day or are there spikes of high humidity or periods of low humidity?
- How does humidity change at occupancy times?

Then check individual rooms to identify levels, patterns and fluctuations in humidity.

- Do rooms have very high or low humidity?
- Do any rooms have humidity consistently above 70%?
- Does humidity drop slowly or quickly?
- If there any unusual patterns, do they correspond with the household's bathroom/kitchen usage or laundry habits?
- Do increases in humidity relate to occupancy?

c) Temperature / humidity relationship

This is first and most useful data combination to investigate when thinking about household health. There is an inverse relationship between temperature and relative humidity. As the temperature of air drops, relative humidity increases as the air can carry less water.

Select the temperature and humidity sensors in one room only, and adjust the Axis Units so both temperature and humidity are active. Is there a relationship between temperature and humidity?

Figure 7 below shows temperature (grey), humidity (pale pink) and electricity use (yellow) in a kitchen. It is a good example of an inverse relationship between temperature and humidity – the pink humidity is almost like a reflection of the grey temperature line above it for most of the time. Some peaks in electricity use correspond to temperature increases. On the right the electricity final figure of £47.87 is the sum spent on electricity for the period in view for the house as a whole.

There is a note at the bottom of the screen highlighting these points. Also there's another note in the red layer for Saturday 16th at 12:00 to Sunday around 3pm (you'd need to click on the darkened red layer area to read it). For that period there is no electricity use, the temperature drops slowly and humidity rises slowly. That note queried whether the household were away for that time.

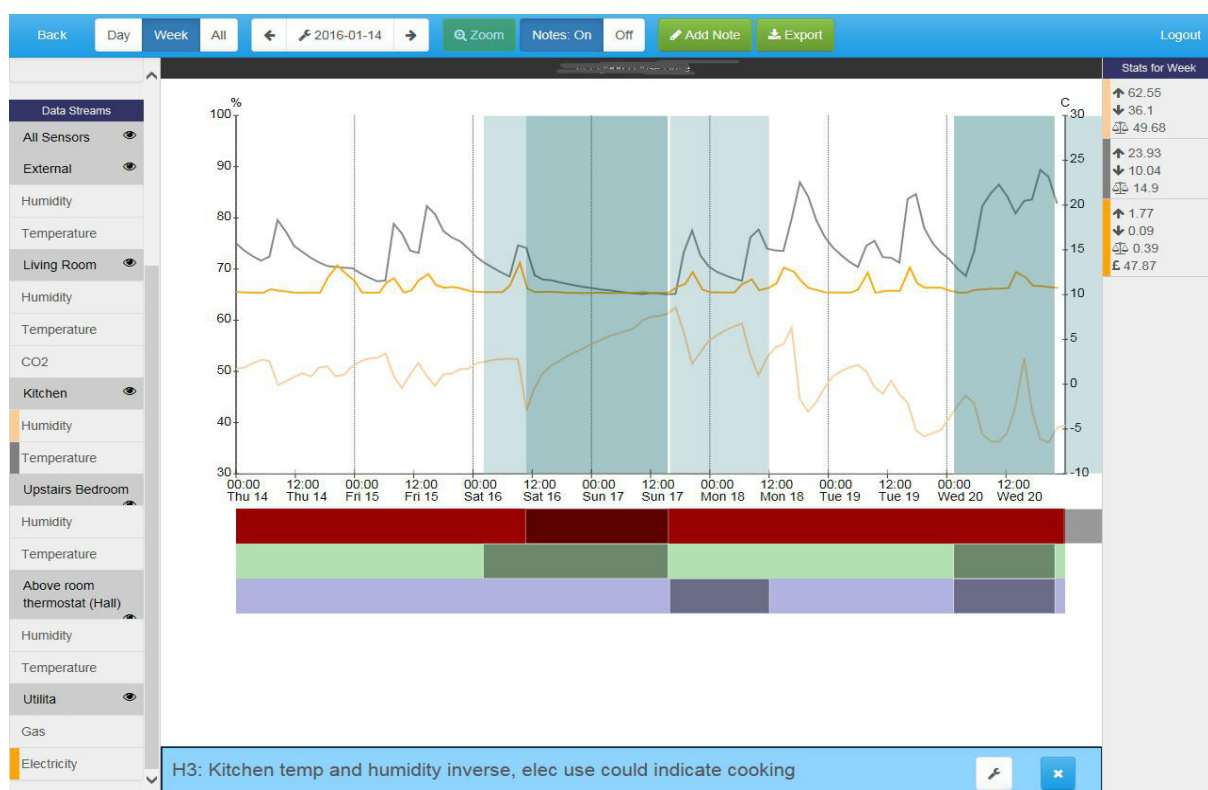


Figure 7: kitchen temperature, humidity and electricity use

The relationship between temperature and humidity in the data may not appear to be exactly inverse because other factors are involved like occupancy, damp issues, or other household practices that affect humidity levels for example taking damp clothes from the washing machine and

drying them on the radiators. We tried using CO₂ sensors as an indication of occupancy which could then be connected with humidity data but found it to have limited usefulness¹⁵.

d) Incorporating energy data

As in the example above, the next stage to data interpretation would be to integrate electricity and gas data. If the household has gas is it only for heating or is it for showers and cooking as well?

With fuel use check for:

- Minimum and maximum usage. Is it low or are there spikes? What appliance might be involved for spikes? Can you select for that time period to inform the household how much that spike in energy use cost?
- Patterns of usage. Are there days which are below or above average fuel use?
- Usage for a given period. Is the household a high, medium or low user relative to Ofgem guidelines¹⁶? For comparison Appendix 7.5 shows low, medium and high levels of domestic gas and electricity consumption. People generally consider themselves to be 'average' users and comparison to national figures and/or neighbouring properties can be very insightful for households and spur them to action.
- Is there a correlation of heating fuel use with temperature and humidity
- Is there a correlation between electricity consumption and appliance use. High electricity use could indicate an inefficient appliance.

Figure 8 shows gas use and its correlation with temperature in a home for one day. Spikes in gas use generally precede a rise in temperature. However for the living room (purple) at 15:00 the temperature rises before the gas goes on. Did the client use an electric heater first before putting on the central heating? That's a costly habit. In the right column the final gas figure shows that the home spent £6.13 on gas that day.

¹⁵ Indoor CO₂ levels cannot be attributed solely to occupancy – they are affected by other factors such as use of unvented gas or solid fuel appliances. In addition the rate of CO₂ accumulation in a space will be affected by air change rates (linked to the age of the building and the standards prevailing at the time of construction) and ventilation practices.

¹⁶ Typical Domestic Consumption Values at <https://www.ofgem.gov.uk/gas/retail-market/monitoring-data-and-statistics/typical-domestic-consumption-values>

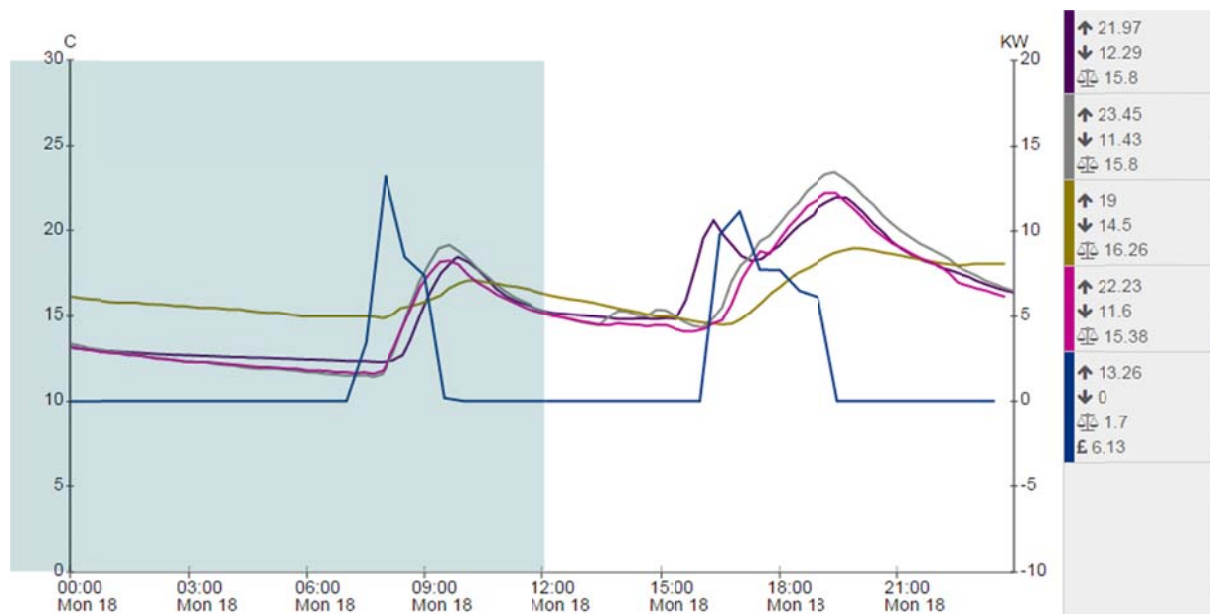


Figure 8 Temperature (key below) and gas use (dark blue) on 18.01.16
Kitchen (grey), living room (purple), upstairs bedroom (olive) and hall (pink)

Figure 9 shows the temperature (olive), humidity (pale green) and gas use (dark blue) for an upstairs bedroom for the same period as the kitchen in Figure 8. There's no inverse relationship here between temperature and humidity, in fact the humidity is consistently fairly high (average 64%) and peaks at nearly 75%. On Sunday 17th around 3pm the gas is used, temperature rises slightly and humidity increases and remains high for more than 12 hours. This might be due to bathing in the adjacent bathroom or possibly laundry drying in that room. Connecting the chart with householders activities at that time bring the sensor data to life. This can stimulate further discussion and action.

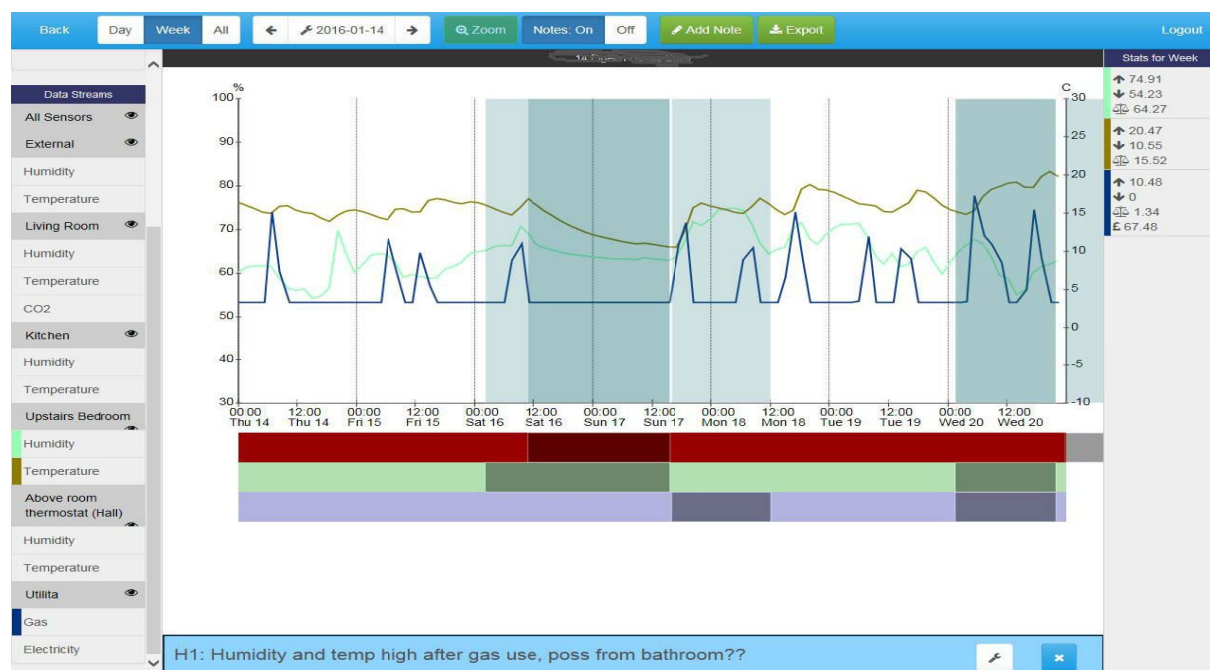


Figure 9: Upstairs bedroom sensor data for one week
Temperature (olive), humidity (pale green) and gas use (dark blue)

e) Disaggregating energy data

The granularity of the electricity data available – the detail available depending on whether you’ve got half hourly or 10 second readings for electricity – can also be great to play with depending on your needs. If you have data from an energy monitor or sensor readings could be every 10 seconds; from a smart meter they will show usage over a 30 minute time span.

High resolution electricity data can be useful to identify poor efficiency appliances (e.g. a fridge with a faulty seal) and the extent of appliance use (and therefore how much they are contributing towards bills). You can attempt to ‘disaggregate’ or separate out the electricity use for different appliances, depending on their pattern of use. Appliances have different ‘signatures’ or energy use patterns.

Figure 11 and **Error! Reference source not found.** show electricity use (kilowatts) from one household on different (but comparable) Sundays. The home had an electric oven but no electric shower. The first chart is 30 minute interval data; the second shows 10 second interval data. Note that the kilowatt scales are different for the two charts: the first is 0-5 KW, whereas the second is 0-10 KW.

1. Both charts show a basic level electricity use of about 0.2kW per hour. Figure 11 shows a ‘battlement pattern’ - alternating periods of slightly higher then lower electricity usage – which is the signature for a fridge or freezer (indicating cooling cycles).
2. Where there is a peak in electricity use it is only possible to guesstimate what that relates to from householder appliance ownership and use, and the power ratings of appliances. For example a 2kWh peak in electricity use for a short time (8am in Figure 11) could be due to a kettle, toaster, or coffee maker as they have similar power ratings.
3. Where there’s a chunk of electricity use (12 noon in Figure 11) from various appliances being used at the same time, discussion with the client can help to identify what was occurring. This example could be the electric cooker, kettle, and probably a washing machine (the zigzag pattern at the end signifies spin cycles).

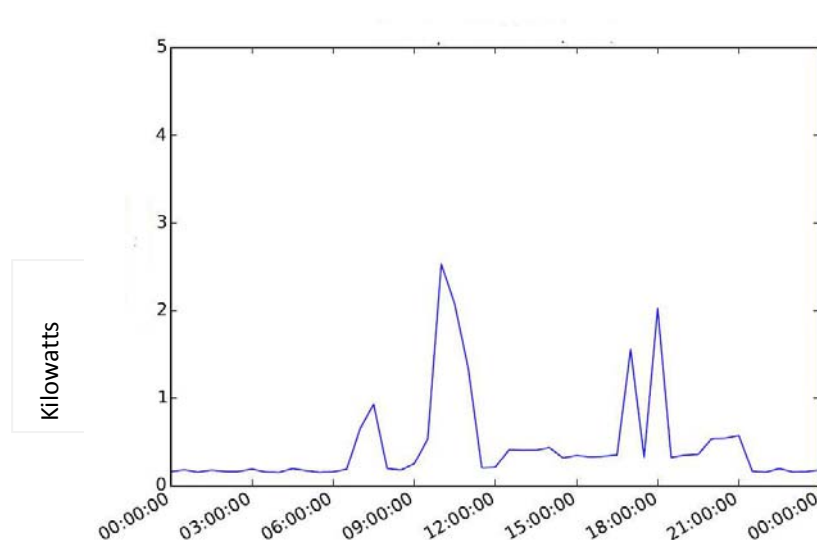


Figure 10 One day of 30 minute interval electricity data (from smart meter)

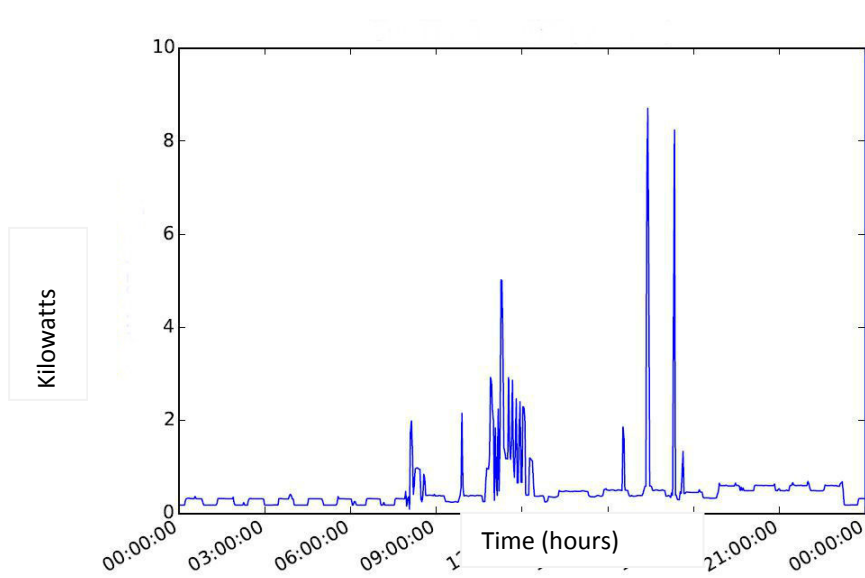


Figure 11 One day of 10 second interval electricity data (from energy sensor)

There is a useful brief introduction to appliance signatures and disaggregation at http://www.jack-kelly.com/smart_meter_disaggregation.

f) Drilling down into the data and annotating

As you combine data streams you will want to zoom in and out of different time frames to get a richer sense of what is happening in the household, and pinpoint key aspects of the data that bring up questions for you or that relate to a household issue.

You can zoom into specific times of the data using the All, Week, Day time selection buttons (which will bring up a calendar) or by using the zoom button on the turquoise bar. To zoom into an area on a chart click on the start time and drag the cursor right to the end time to select it. The exact times will be shown at either end of the selected time period, as in the Figure below. Then press the Zoom + button. The screen will change to just show your selected area.

To add a note:

- Click on either the red, green or blue band at the bottom of the chart. This is the note-making layer you will add a note to.
- Select the time period you are interested in as for zooming in. (The figure below shows the red bar for note-making active, and the start and end times for the chosen time period).

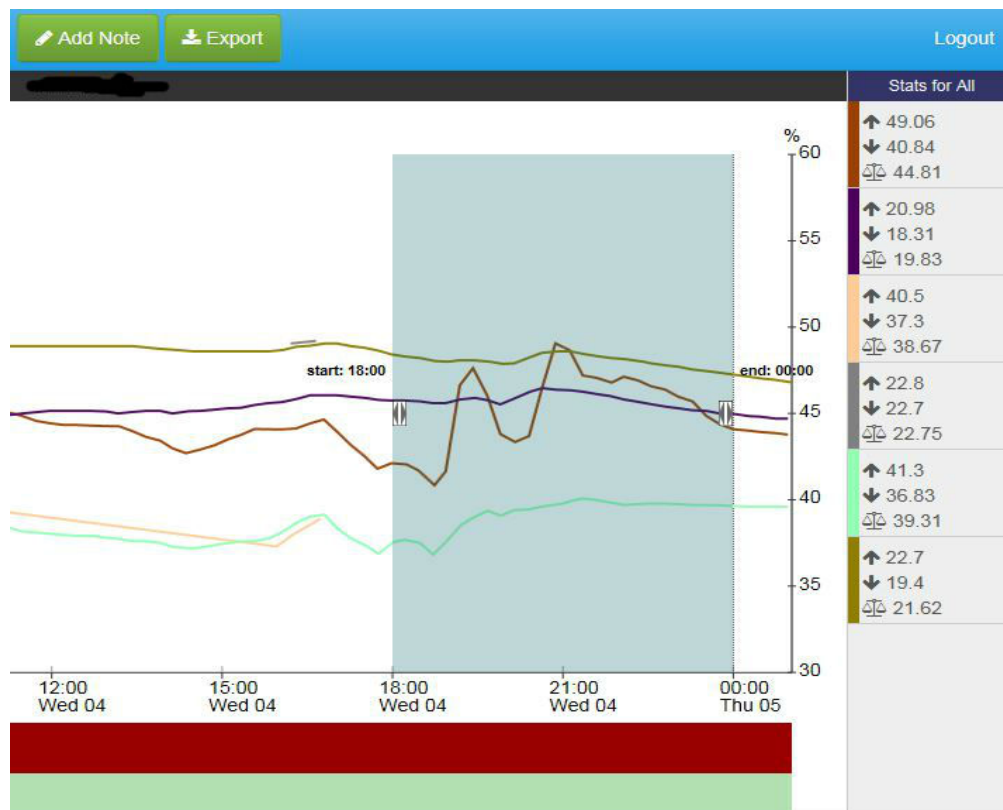


Figure 12: Zooming in on a zone

- Click the Add note button. The 'Create a new annotation' box will appear. Add in a brief note, then save it. You can view the note again by clicking on the selected time period on the chosen bar.

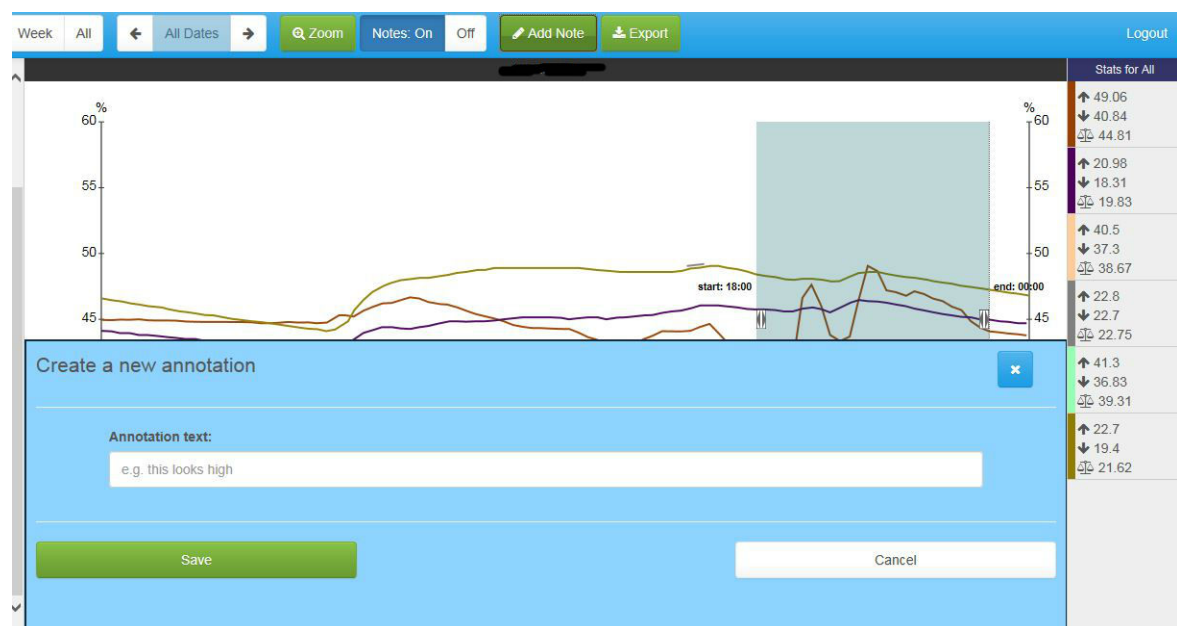


Figure 13: Creating a note

- You can edit an existing annotation by clicking on the spanner button on a note. You can also delete it.

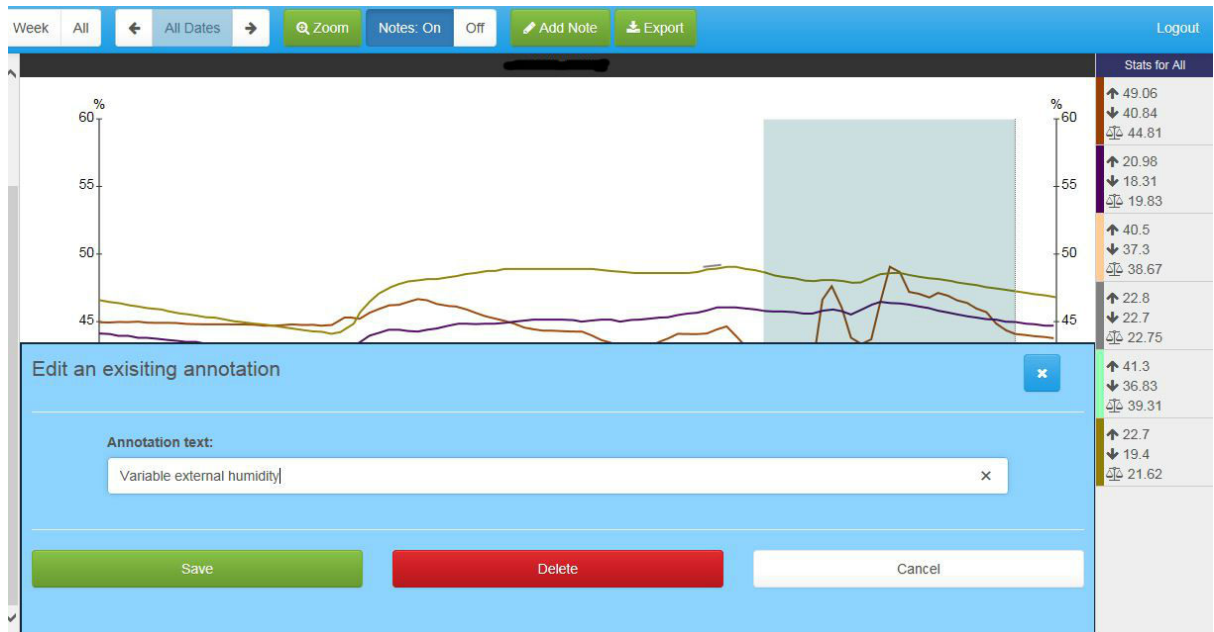


Figure 14: Edit an existing annotation

- To add a second note within or including a selected time period, select a different colour bar, then your new time period, and add the note in the same way. Below the green bar is now active for note-making for a shorter time period than the existing red note.

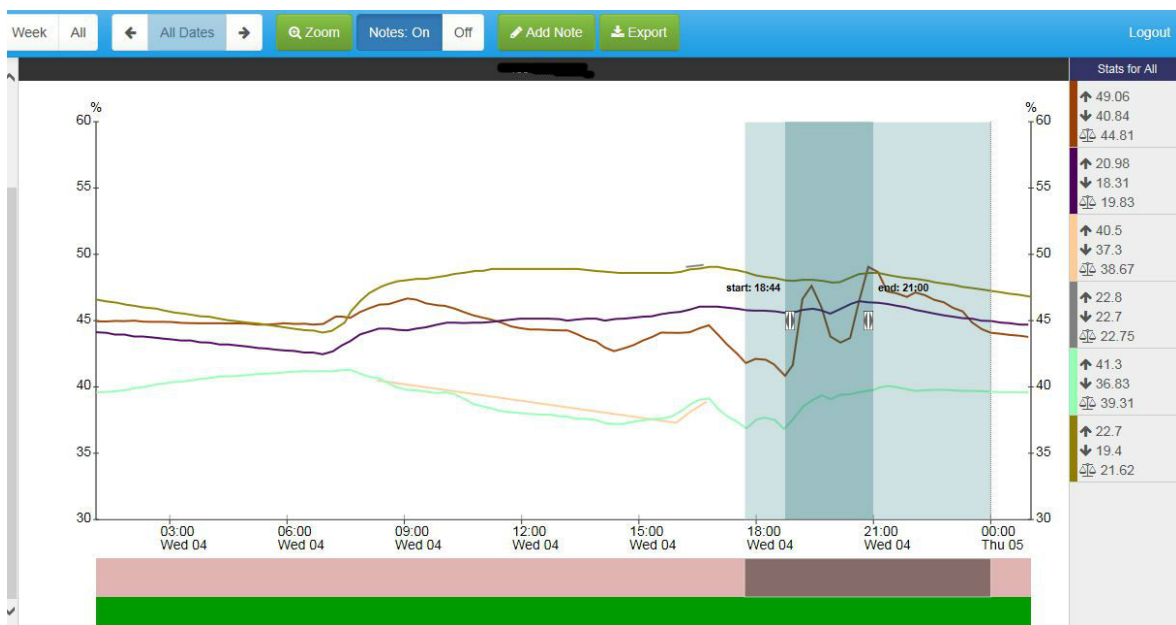


Figure 15: Adding additional notes

Labelling your notes for easy communication with clients during the advice visit

To make it easy during the advice visit to show clients the data, and pull out key points you might want to develop a system for labelling your notes. Find out what works for you, but a suggestion is

to start each note with a number, then add which data streams and rooms that note refers to e.g. H for humidity, T for temperature, and the room names. You will then know quickly which data streams to select on screen during the visit. The note below is labelled, “1. [H&T ext. and lounge]” = humidity and temperature data for the exterior and lounge.



Figure 16: Referencing notes

Then write the number of the note, note band colour and time period onto the relevant section of the Home Visit form to prompt you to go to that note. (In this case it is 1. Green band, Wed 4th 19:00) Then in the visit itself you know exactly which note to go to and when.

Otherwise you could end up with a screen in a home visit with lots of notes which are not visible till you click on them. You may not remember which notes are the most important to convey to the client.

Drilling into the data and annotation can be time consuming, so keep the household issue in mind. Also use annotations to highlight **anomalies in the data** that you want to ask the client about. These might include:

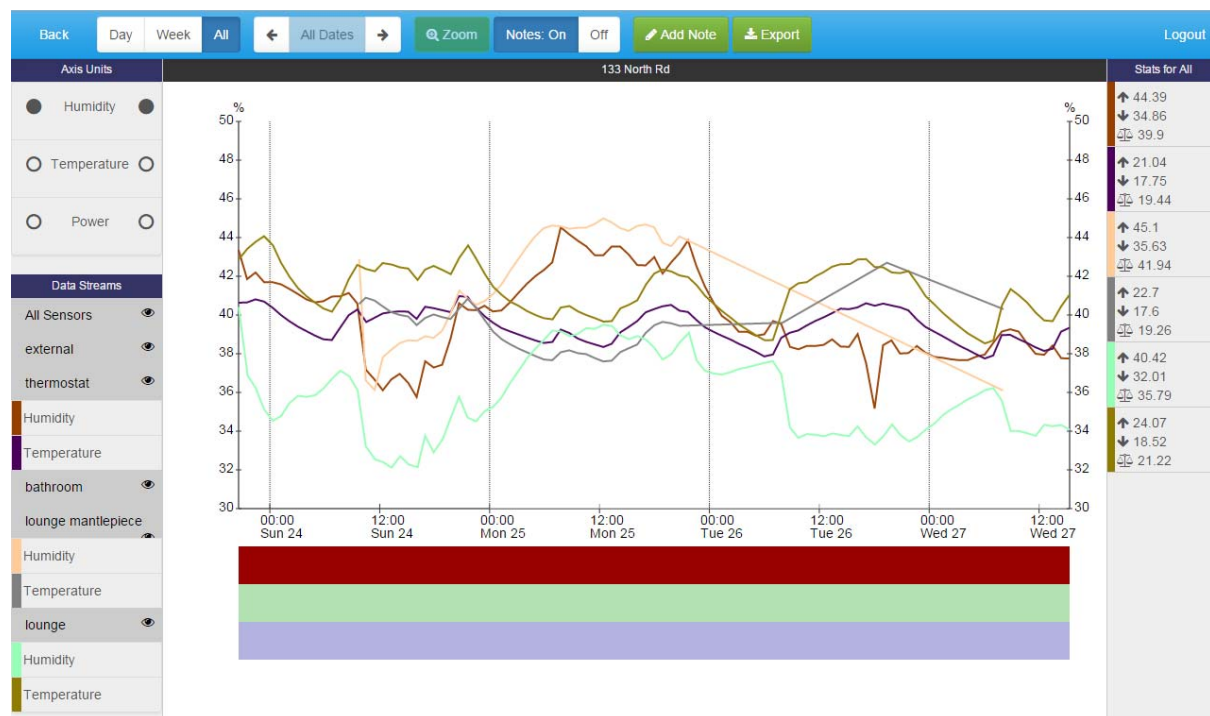
- Fuel use (especially heating) at unusual times or when the home isn't occupied (check the heating control settings)
- High or low sensor data streams (under/overheating, appliance use, danger of mould)
- Large variations between rooms e.g. on one visit we found a bedroom to be colder than the rest of the house. The client hadn't mentioned that the radiator didn't work in that room.

6 Sharing findings from the data with clients

Here we provide some guidance on how to effectively share insights from the data with clients in the context of a home energy advice visit. The guidance here assumes that the data is displayed through the web application. However there may be occasions when being able to print off the chart in advance would help [e.g. where there is nowhere to share looking at the laptop, or cultural barriers to close proximity - male/female].

6.1 Preparing for the advice visit

In order to effectively engage with the service user group, it is important to have identified key areas to focus on before your advice visit. These areas should include any samples of data that show why a pre-existing problem could be occurring (e.g. high humidity causing condensation), or alternatively areas of data where you have spotted a previously unidentified concern (e.g. temperature regularly rising above 21 degrees, leading to increased energy use).



6.2 Annotating data with the client

As described above it is possible and recommended to annotate the data via the dashboard. This can be done whilst interpreting the data and identifying what to focus on. These annotations draw the client's attention to certain sections and help avoid the sheer volume of data becoming confusing. It is suggested that you use these annotations to highlight specific relevant points, for example highs or lows in temperature.

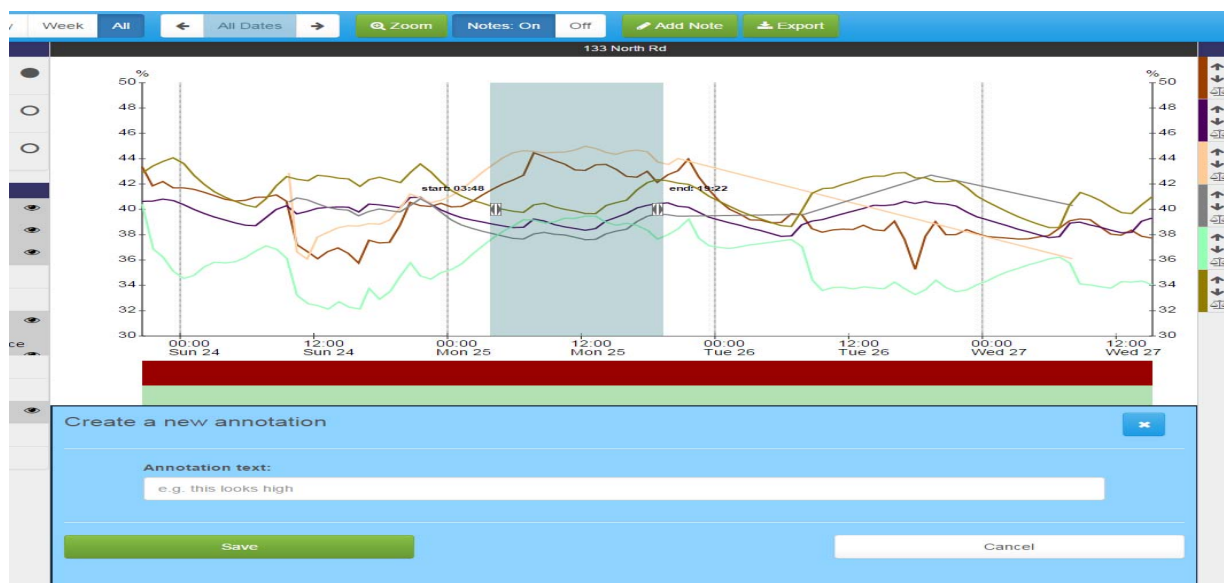


Figure 17: Annotating data with the client

6.3 Working through the data with the client

Each advisor will undoubtedly develop their own method of working through the data with the client, but the following are some successful proven techniques: -

- If you identified any pre-existing problems within the household on your initial deployment visit, begin by focussing on any data that relates to this. For example, it could be by pointing out that the bathroom, where mould is a persistent problem, actually has humidity levels above a certain percentage for a large amount of time.
- Work through the household room by room whilst looking at different combinations of temperature, humidity, gas and/or electric use looking for patterns. In this scenario your annotations will prove invaluable as they will save you time.
- Cross reference the sensor data with the household information gathered during the first visit. For example, look at the information that was provided about how the household uses their heating and compare this with data gathered on temperature or energy use.
- Focus on one element of the data (e.g. humidity) and look at how this varies from room to room, again looking for anomalies or patterns. Then do the same for the other variables and then perhaps try combinations for each room.
- Talk through the client's day to day lifestyle for the period studied and then show them how this affected the data. If members of a large household all use an electric shower in the morning, show them how this affects electricity consumption and the humidity in the bathroom.

6.4 Optimising engagement

What you should hopefully find whilst working through the data is that the householder begins to engage with it. A good indication of this is that they will start asking questions. These will either be about what the data means or whether they can alter the dashboard view to see a certain selection of data. Quite quickly they will learn to understand how the dashboard works and it is your job to explain to them what the data actually means. However, be careful not to display too much data at once, as this risks confusing the service user.

The obvious reason for going through the data is to draw the service user's attention to potential concerns. Once you have done this you can begin to offer all relevant energy advice to help to resolve the issues.

There may be occasions when a client is not willing to engage with the data you are presenting and this could be for various reasons. If you notice that this is occurring, simply stop showing them the charts whilst explaining what they mean, and work through the data yourself at a quicker pace and only highlight the main areas of concern. This allows you to move swiftly onto providing valuable energy advice without alienating or frustrating the service user.

6.5 Linkages with the IHD

Some households may have an in-home display linked to their meter or an energy monitor. If this is the case, then use this opportunity to teach them how to use the display but also show them how the sensor data you have gathered relates to the information that their display provides.

7 Appendices

7.1 FAQs

- **How will I know when a sensor is not providing readings?**

The sensor will be displayed in red on the dashboard. There will also be either no readings at all or the last reading will have been some time ago.

external (XD)
No readings yet.
Last Reading: Unknown

- **How will I know when the HUB is not connecting?**

As with the sensor the HUB will show as red on the dashboard and the connection status will show as 'Awaiting Connection'

Hub: james
External Address: 90.204.35.212
Internal Address: 192.168.0.21
Connection Status: Awaiting Connection

- **What if it is not possible to get energy consumption figures?**

Ensure that meter readings are taken at the beginning of the deployment and again when you return to provide advice. See if it is possible to get the householder to take readings during the deployment period. This will at least allow you to see the households usage over that period of time and potentially also a pattern of usage. Additionally see if it possible to get this information from the household fuel supplier. This process should be begun on the first visit, as you will need to obtain permission from the householder to speak to their supplier.

- **What if the data does not show any concerns with the property?**

During the advice visit focus on how the householders are doing the right thing and run through suggestions on how they could potentially do even more to reduce their bills, keep warm and prevent condensation.

- **What if the data does not show any concerns within the property even though you know there are some?**

Firstly make sure that the data that you have is for the correct household. If it is then explain to the householder that although the sensor equipment does usually provide relevant and useful data, on occasion it does not correlate with what is previously known about the household. Explain that this could be for various reasons e.g. where the sensor has been

positioned or sensor recording issues. Then continue to give advice relevant to the areas of concern.

- **What if the data for the household appears wrong?**

It is possible that the data you have been provided with is not the data that relates to the household or sensor it is claiming to be from. If you believe this is the case you should seek tech support.

- **What if you have difficulty getting the sensor kit back from the service user?**

This is a difficult issue to overcome so it is better to be more preventative. Make sure that when deciding on where to deploy kit you have a good idea about the reliability of the household.

- **What if the 3g dongle keeps losing signal?**

Unfortunately there is little that can be done about this. Try moving the dongle around to pick up stronger signal but if this is not possible then you may have to abandon the deployment or consider the sd card storage option.

7.2 Troubleshooting decision tree

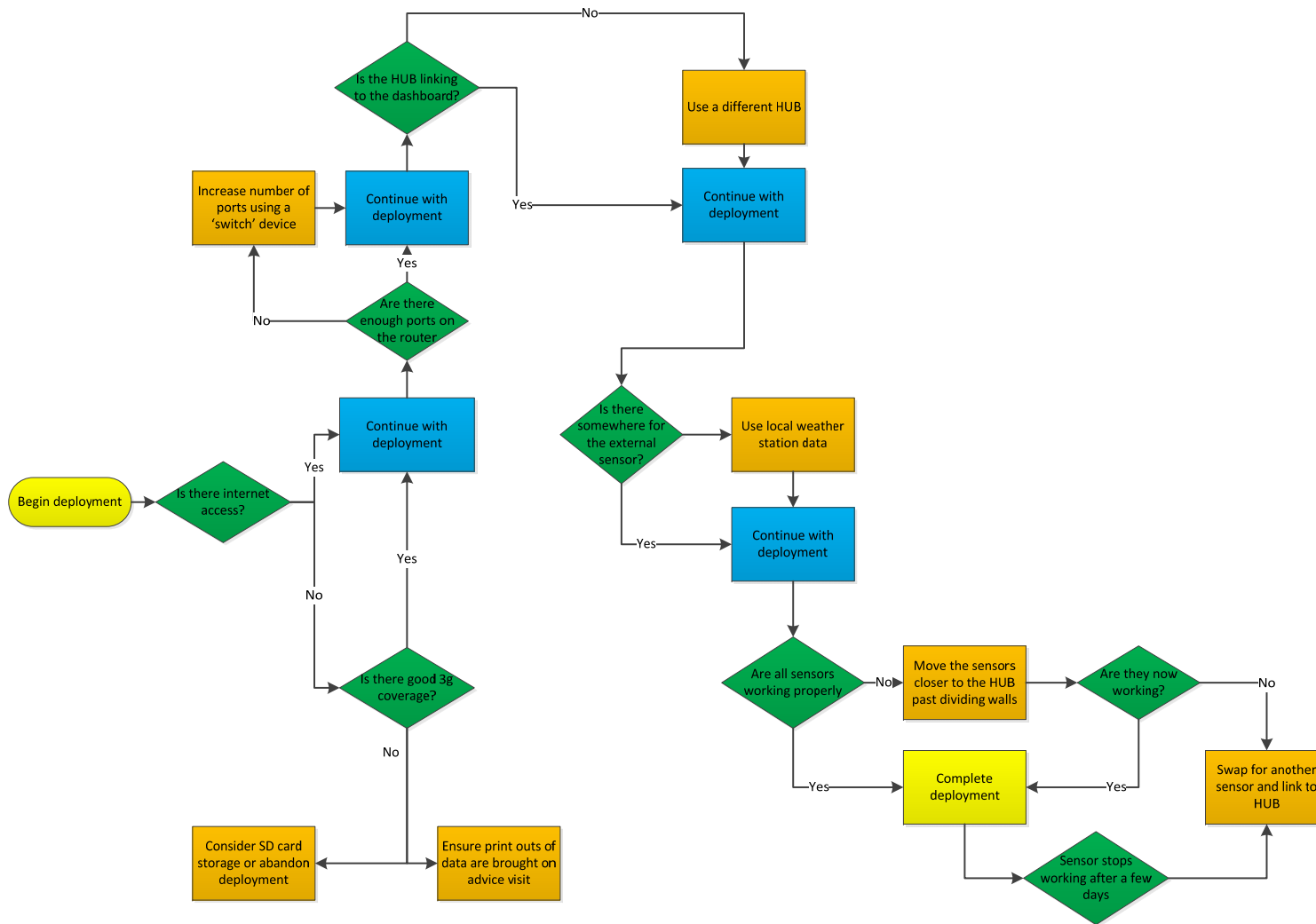


Figure 18 Troubleshooting decision tree

7.3 Forms

7.3.1 For securing permission to use the data

Consent Form

By signing below, I give permission for [insert name of organization here] to record data for the purpose of providing energy efficiency advice.

Please read carefully and sign below.

I permit [insert name of organization here] to use data recorded, either complete or in part, alone or in conjunction with any wording and/or drawings solely and exclusively for the purposes of providing energy efficiency advice.

[Insert name of organization here] will only use the data in accordance with all applicable laws and regulations. It will not be used for any sales or marketing activities and will not be seen by members of the general public on public broadcast.

This consent is given on the condition that [Insert name of organization here] will not divulge name, address or any other data identifying me to any third parties (unless compelled to do so by law). I understand that my participation will remain confidential, and my anonymity will be preserved in keeping with the Data Protection Act 1998.

I understand that copyright of the data is owned by [Insert name of organization here] for the purposes detailed above.

I understand that I can withdraw at any time, and my personal data will be erased from the records. I confirm that I am over 16 years of age.

I give permission for data that could identify me (e.g. photos, videos) to be recorded.

Please initial:

I give permission for data that could identify me (e.g. photos, videos) to be published.

Please initial:

NAME:

DATE/SIGNATURE:/.....

Internal use only

NAME:
(of person providing this form)

I have explained the contents of this document to the above participant in his/her own language and he/she understands the content and has given his/her agreement. I have handed out the accompanying information sheet.

SIGNED:

7.3.2 Checklist for deployment - auditing equipment in the home and recording settings

Deployment visit Questionnaire:

Name:	
Address:	
Phone number:	
Email	
Sensor kit	
Date	

Reason for referral:	
Property Information	
Property age, type and wall type <i>(from EPC beforehand if possible)</i>	
Energy efficiency measures (insulation, double glazing, draught-proofing, renewable technology) <i>(from EPC beforehand if possible)</i>	
Are there any issues with condensation, damp and mould?	
If so, where is it located and how severe is it?	
Are there any draughts in the property?	
Occupancy Information	
Number of people present in the home (including children) Ages of occupants?	
Is anyone in the property in receipt of any benefits? Which ones?	

Does anyone in the property have any of the following health conditions? asthma; COPD, stress/anxiety; disability/mobility issues; any previous strokes, any previous falls or trips.	
Does anyone in the property rely on any electrical medical equipment?	
General description of occupancy times Monday – Friday	
General description of occupancy times at the Weekend	
Hot Water and Heating System	
Describe the heating system (including age, type, fuel and working condition) <i>Make a note of the manufacturer and model so we can check the energy rating</i>	
Describe hot water system	
Describe Hot Water Settings - each day of the week	
How do they use their heating system? Is it manually controlled or timed? Room thermostat settings? TRV's settings?	
If they use their programmer: What time is the heating programmed to come on for each day of the week? <i>Ask to see their heating controls to see if it corresponds with these settings</i>	
Do they ever use the override or boost buttons?	
Do they use any other (secondary) heating? (either when the central heating is on or off) When do they use it? How often do they use it?	
If they don't use their programmer: What are their heating patterns – each day of the week	
Do they ever forget to turn their heating off?	
Do they use any other (secondary) heating? (either when the central heating is on or off)	

When do they use it?	
How often do they use it?	
Energy Bills	
Do they feel their energy bills are high?	
Current spend for gas/electric	
Do they owe any money for gas/electric?	
Cooking Habits	
Time(s) of day they usually cook?	
How often they use the hob	
How often use the oven (<i>>1 daily, daily, several times week, once per week, <once per week</i>)	
How often do they use the kettle during the day?	
Is there an extractor fan in the kitchen? Do they use it?	
Is there a door to the kitchen Do they usually close it?	
Bathing Habits	
Shower type (gas or electricity)	
Is there an extractor fan in the bathroom? Do they use it?	
Time of day they usually shower? Every day?	
Laundry Habits	
Days and times they usually do laundry?	
Where do they dry their clothes?	
Appliance Audit	
Tick the appliances they use frequently and make relevant notes including if they have more than one.	

Kitchen Oven (gas) ☐ Oven (electric) ☐ Hob (gas) ☐ Hob (electric) ☐ Microwave ☐ Fridge ☐ Freezer ☐ Fridgefreezer ☐ Toaster ☐ Kettle ☐ Blender ☐ Dishwasher ☐ Other kitchen appliances ☐ Laundry/cleaning Washing Machine ☐ Tumble Dryer ☐ Vacuum Cleaner ☐ Iron ☐ Other Laundry/cleaning appliances ☐	Entertainment/Leisure TV ☐ (size) Games Consoles ☐ Desktop Computer ☐ Laptop/ipads/tablets ☐ Printer ☐ Hi-fi/sound system ☐ Radio ☐ Telephone ☐ Other Entertainment/Leisure appliance ☐ Health/Beauty Hairdryer ☐ Hair Straighteners ☐ Other Health/Beauty appliances ☐ Gardening/DIY Lawn Mower ☐ DIY equipment ☐ Water Features/outdoor pump ☐ Other Gardening/DIY appliances ☐ Other Household Appliances Fishtanks/Reptile tanks ☐ Dehumidifier ☐ Other household appliances ☐						
Type of lightbulbs?							
Sensors							
Where are the sensors located? <table style="width: 100%;"> <tr> <td style="width: 50%;">Sensor 1</td> <td style="width: 50%;">Sensor 2</td> </tr> <tr> <td>Sensor 3</td> <td>Sensor 4</td> </tr> <tr> <td>Sensor 5</td> <td>External sensor</td> </tr> </table> <i>If there is a room thermostat one of the sensors <u>must</u> go on there.</i> If possible take a photo of each sensor and a photo of the house from outside		Sensor 1	Sensor 2	Sensor 3	Sensor 4	Sensor 5	External sensor
Sensor 1	Sensor 2						
Sensor 3	Sensor 4						
Sensor 5	External sensor						

Are there any energy issues the household is particularly interested in?

7.3.3 Checklist for the advice visit

Checklist for Advice visit

Before visiting the client:

Using the suggestions below, look at the sensor data and make notes of things to highlight/discuss on the home visit form.

You can also add notes to the data using the annotation tool so that it flags up when you show the client the data.

Temperature Data:

- Any high/low temperature recordings in any of the rooms?
- Which rooms are the warmest/coldest?
- Is there a big variation between rooms?
- Are there big fluctuations/variations in temperatures in any of the rooms?
- Does it cool down slowly or quickly?
- Do the temperature patterns correspond with the heating and occupancy patterns and the amount they pay for their heating bills?
- Is there a similar pattern every day or anything out of the ordinary?
- Are there any links/patterns between the temperature and humidity data?
- Can the data be linked back to the initial reason for the referral?

Humidity Levels:

- Any high/low humidity recordings in any of the rooms?
- Is this a normal range (should be between 40 – 60%)?
- Which rooms have the highest levels of humidity?
- Is it above 70% for much of the time?
- Do the humidity levels decrease quickly?
- Are there any spikes?
- Are there any unusual patterns, do they correspond with the client's bathing/cooking/laundry patterns?
- Are there any links/patterns between the humidity and temperature data?
- Can the data be linked back to the initial reason for the referral?

Electricity usage data:

- Total electricity consumption for the period.
- Average consumption per day.
- Any days when the usage is above/below average?
- Are they a low, medium or high user of electricity?
- Are any of their electricity appliances likely to be causing high usage?
- If possible show them the cost of their energy usage for a particular period of time (i.e. when there is a large spike in usage).
- Can the data be linked back to the initial reason for the referral?

Gas Data:

- Minimum and maximum recordings:
- Usage, variations
- Patterns, times of day
- Only heating or is it showers, baths cooking
- Usage per day compared with average usage per day
- If possible show them the cost of their energy usage for a particular period of time (i.e. when there is a large spike in usage)

7.3.4 Checklist for the wrap up / kit collection visit

Questionnaire for third/closure visit

What do you remember from the information given on the last visit? What was the most useful?

Please be honest and if you cannot remember the advice you were given or if you didn't find it helpful let us know why.

Did you do something different following the advice you were given? If so, what did you do?

Did you use your heating system differently? Ventilate more? Turn things off when they were not in use? If you made no changes can you say why?

Do you require any further information/advice?

For internal usage

Was there a change in their data?

Any other feedback from the advisor?

Collection Checklist

Collect all sensors – refer back to the deployment questionnaire for the location of all the sensors.

Unplug the hub and disconnect it from the client's router.

Agree and confirm any follow up actions with the client.

7.4 Case studies

Case study 1

Property details

Semi-detached three bedroom house built 1945-1960 with double glazing and loft insulation. Wall insulation was assumed within the timber frame on the EPC.

Heating System

Gas boiler with thermostatic radiator valves (set on full) and a room thermostat (set to 30 °C) heating was controlled manually.

Occupants

There are two adults and five children under 16 living in the property. The household income was less than £16,000 a year. The family experiences lots of coughs and colds.

Reason for referral

The house was cold in the winter, and they have high energy bills that they struggle to pay. He spent on average £20 a week on gas and £10-£15 a week on electricity, and so was a high user for both fuels.

There was mould in an upstairs bedroom on the cold side of the home, on the corner of an external wall. There were also issues with condensation in bedrooms.

Usefulness of the data

The temperature graphs were extremely useful to show the high temperature to which the house was being heated. From a minimum temperature of 19 °C the property was heated to 24-28 °C, with 1-3 heating periods a day.

The data also highlighted that there wasn't a set heating pattern

The 24 hour format was good. It was useful to have something visual to focus the discussion around and relate to people's lives.



Advice given and behavioural changes recommended:

- Use of heating controls to reduce gas use (e.g. turning down room thermostat from 30 °C, turning down upstairs TRVs or off when rooms not in use, turned down the boiler central heating temperature controls from Max to 4).
- Condensation and mould management -wiping down the mould with bleach solution, to adequately ventilate the bedroom, to have the heating on low when the window was closed in cool weather, and to dry laundry outside (the washing line was broken and the client hadn't got round to fixing it).
- Draught proofing repairs request should be made to the housing association for the front door, and suggested to put a thick curtain across the front door in winter.
- Closing internal doors to retain heat in rooms of the house that most need it (there was no door partitioning the kitchen and hall).

Case study 2

Property details

The property is a 1930's end terrace Bristol City Council house. It has cavity wall insulation and a loft insulated up to current standards. The house is fully double glazed. It has an extension to the rear which also has cavity wall insulation and which has a flat roof.



Heating System

The property has a one year old condensing combination boiler with a programmer, room thermostat and thermostatic radiator valves. The system is used manually.

Occupants

There are three adult occupants, two older adults and their younger adult son who is disabled and has brain damage, heart problems and mental health problems. The husband and son both have asthma and the son also has more serious breathing problems.

Reason for referral

The tenants have ongoing issues with condensation and mould growth in the two rooms at the rear of the property that are in the extension with the flat roof. The room on the upper floor is the disabled son's bedroom and the room on the ground floor is the kitchen. The son's room is not used (apart from for storage) as it is unsuitable for someone with his medical conditions. The bedroom continuously has problems with condensation and mould growth on the walls and ceiling. The council did renew the flat roof a number of years ago. The kitchen is difficult to keep warm during the winter and there have been numerous problems over the time they have lived there (20 years) with mould growth on the walls and ceiling.

Usefulness of the data

This temperature data showed the kitchen remained below 17 degrees for the whole period. The humidity data showed that the levels in the kitchen were consistently high.

The data produced was consistent with the concerns of the tenant: that the kitchen was cold and that it had problems with condensation and gave the client the confidence that what she had been saying was correct.

Advice given and behavioural changes recommended:

The client was given the standard advice to assist with condensation and mould problems i.e. ventilation, heating, insulation and excess moisture production. She explained that the extractor fan did not work properly so the advisor agreed to talk to the council about getting it fixed and also to see whether it was possible to increase the size of the radiator in the kitchen as it was obviously not able to heat the room up to above 17 degrees, as this was likely to be the largest contributing factor to why condensation and mould growth was occurring in the kitchen area.

By having this data recorded it gave more weight to the tenant's complaint about the property and resulted in the issue being dealt with more quickly.

Case Study 3

Property details

The property is a semi-detached, system built property with a flat roof. The property has double glazing but no wall insulation and limited roof insulation.

Heating System

The property has storage heaters and instant electric heaters (one electric fire in living room) although they do not use the storage heaters very often.



Occupants

There are two adults and two young children living there. One adult has Asthma and Fibromyalgia and one of the children also has Asthma. There is usually one adult and one child at home with the other adult working full time and the other child attending school.

Reason for referral

The client has high energy consumption and is spending between £7-8 a day during the winter months on energy. This works out to be around £1,700 a year.

The client also struggles to keep the house warm during the winter months.

Usefulness of the data

The consumption data was very relevant for the purposes of advising this client as the pre-existing problem was high consumption and the data showed peaks and troughs which although consistent with an Economy seven tariff, also showed that there were peaks during the day when the electricity was being charged at the higher rate, thus contributing to the high energy bills. The size of the peaks indicated that something with high power consumption was being switched on which turned out to be the electric fire.

It was useful to have the data so that this could be represented to the clients visually and she could see the impact that switching the instant fire on was having on consumption.

Advice given and behavioural changes recommended

The clients were advised on making the most of the Economy seven tariffs and using the storage heaters correctly. They were advised to start using the storage heaters so that the heat in the property is more evenly distributed and to reduce the amount that the instant electric fire is used. They were also told to try and make use of cheaper electric overnight where possible, i.e. using the washing machine during the off-peak hours.

Case study 4

Property details

This is a privately rented 3 bedroom semi-detached house which was built between the 1930 and 1950's. The property has double glazing and loft and cavity wall insulation have been installed in the last 2 years.

Heating System

There is a gas condensing combi boiler which is less than 2 years old.

The central heating is switched on manually from the boiler – there aren't any heating controls and there isn't a room thermostat. There are TRV's but the client doesn't use them.

Occupants

There is the client and her four children (ages 4, 7, 9 and 12 years old) living in the property

They are usually out between 8.30am and 3.30pm during the week but are generally at home at the weekend.



Reason for referral

In winter the client spends around £20/week on both gas and electricity, she feels that this is 'somewhat manageable' but also feels that the house is colder than she'd like and reported that one of the downstairs rooms is really cold.

She has some issues with condensation, damp and mould in the property, this is concentrated in the left-hand bedroom.

Usefulness of the data:

The temperature data showed that the temperature rarely went above 20°C and in two of the rooms the temperature went down to 12°C on a couple of occasions.

High humidity levels were recorded in the left hand bedroom, which was frequently over 80% – this is the room with damp issues.

The data was able to highlight the extent of the humidity and damp problem damp problems in the bedroom and corroborated what she had said about cold temperatures in the downstairs room.

Advice given and behavioural changes recommended:

The client was given advice on things that she could do to make the rooms warmer which included: installing draught-proofing measures; foil panels, thicker curtains/curtain liners, draught excluders, and new internal doors in the downstairs room to keep the heat in.

She was also given advice on ways to reduce condensation through ventilating the room every morning and, as the bathroom is next to this room, ensuring the moisture escapes from this room by closing the door and opening windows and using the extractor fan.

There are some repair works needed such as clearing the blocked gutter which the client was advised to report to the landlord and this should significantly improve the damp problems.

As the client is a low user of gas and a medium user of electricity she was advised on ways to reduce electricity consumption with the idea that she could save money on her electricity and use these savings to spend on her gas by having it on for longer.

Case study 5

Property details

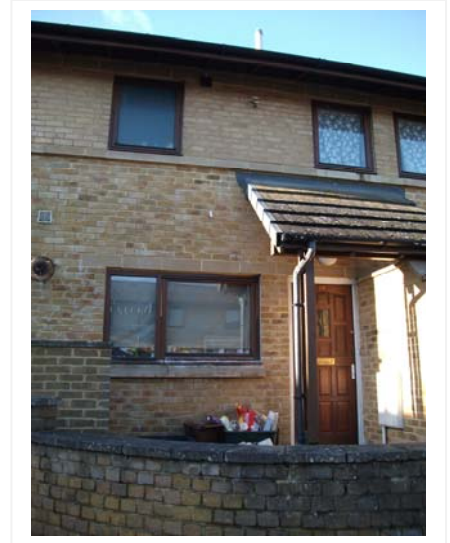
This is a two bed end-terrace Housing Association property. It has cavity wall insulation, some loft insulation (150mm) and wooden framed double glazing.

Heating System

The house has gas central heating with a room thermostat in the hall and a programmable timer on the boiler. The boiler is a combi boiler that was installed in 2013. The heating is controlled using the room thermostat. The client also has an electric fan heater in the lounge to provide additional heat.

Occupants

The client lives with her partner who works and so is out of the house for most of the day. Client has two young children and a baby. One child is at school, the toddler and baby are at home during the day. The eldest child has an inhaler which she has to use overnight and the baby has a heart condition. Client also has a dog, house rabbit, lizard and goldfish.



Reason for referral

The client spends around £10-15 on electric and £10-£15 on gas. This is less during the summer months. Client does not heat the home very often, 1-2 hours in the morning and evening. The property has a significant damp, condensation and mould problem in the main bedroom. In this room there was mould covering the window frame and along the window sill. There was also mould on the ceiling connecting to the external wall. Condensation could be seen on the window despite the window being left open for the majority of the day.

Usefulness of the data for the advisor:

The temperature data helped to identify that the client was not sufficiently heating their home, with the average temperature over the course of the research being 16°C. It also highlighted that the temperature was very rarely above 20°C which could be detrimental to the health of the children. High humidity levels 60-76% were recorded in the upstairs bedroom. When the higher levels were reached, the temperature was often at its lowest (<15 °C). This helped shape the advice to be given in regards to tackling the condensation and mould problem.

Advice given and behavioural changes recommended:

The majority of the advice given focussed around tackling the issue of condensation and mould in the upstairs bedroom. This included increasing the temperature at which the thermostat is set, as well as increasing the length of time the heating is on for. Advised to reduce moisture production by ensuring the bathroom door is closed when in use and that the bedroom door is closed when the tumble drier on the landing is on. Client currently has blinds on all windows so advised to fit thick lined curtains. Radiator in main bedroom is small for the size of the room. Client prompted to speak to the housing association about fitting a reflective radiator panel and getting them to check the level of loft insulation.

7.5 Typical low, medium and high domestic energy consumption

		Low user	Medium User	High User
Electricity (kWh)	Annual	2000	3100	4600
	Quarterly	500	775	1150
	Monthly	167	258	383
	Daily	6	9	13
Electricity (costs in £)	Annual	281	436	646
	Quarterly	70	109	162
	Monthly	23	36	54
	Daily	0.77	1.19	1.77
Gas (kWh)	Annual	8000	12500	18000
	Quarterly	2000	3125	4500
	Monthly	667	1042	1500
	Daily	22	34	49
Gas (costs in £)	Annual	344	538	774
	Quarterly	86	134	193
	Monthly	29	45	65
	Daily	0.94	1.47	2.12
Economy 7 (kWh)	Annual	2500	4300	7200
	Quarterly	625	1075	1800
	Monthly	208	358	600
	Daily	7	12	20
Economy 7 (costs in £) Based on a 65%/35% split between off-peak and on-peak	Annual	251 (115 + 136)	433 (198+235)	724 (331 + 393)
	Quarterly	63 (29 +34)	108 (49 + 59)	181 (83 + 98)
	Monthly	21 (10 + 11)	36 (16 + 20)	61 (28 + 33)
	Daily	0.70 (0.32 + 0.38)	1.20 (0.55 + 0.65)	2 (0.91 + 1.09)

Consumption figures are taken from Ofgem's [revised Typical Domestic Consumption Values for gas and electricity](#) (May 2015).

Prices:

- Electricity prices were calculated based on **0.1405p/kWh**
- Gas prices were calculated based on **0.043p/kWh**.
- Economy 7: off-peak was calculated based on **7.07p/kWh**, on-peak was calculated based on **15.59p/kWh**.

Please note: the prices **do not** include standing charges and these will be approximately £77/year for electricity and £88/year for gas. The figures were average costs taken from EST (2014).