COSMOS

Cultivate resilient smart Objects for Sustainable city applicatiOnS

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WP7: Use cases Adaptation, Integration and Experimentation

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1. Introduction

This document aims to update the COSMOS deliverable concerning the implementation and experimentation of the London Use Case Scenarios. This is with regards to the Smart Heat Scenarios with our partners, Camden London Borough Council.

In this Work Package deliverable, we will:

- Show the Use Cases that have been trialled in the second iteration of the project;
- Describe the work that is being carried out to implement systems for use within COSMOS;
- Provide operational plans on data flows and communications from the city partners, including dependencies; and
- Articulate some of the challenges that have been encountered and any anticipated challenges that may lie ahead.

In this Work Package deliverable, we cover the following projects:

- Window Contact Sensor and Heating Control Valve Project
- Temperature and Humidity Enriching Data Project
- UrbisAPI Project Developments
- The Playbook Document

The intended outcome of this deliverable is not only to update the project, but also to give future Smart City projects some working models for delivery of projects.

2. Application Use Cases

This deliverable provides an update to the scenarios from Years 1, 2 and 3, with a final review of the Use Cases in order to make a full and operational system. Detail of the scenarios can be found in deliverable 7.1.3.

2.1 Camden Scenario

2.1.1. Capital Planning / Energy Performance

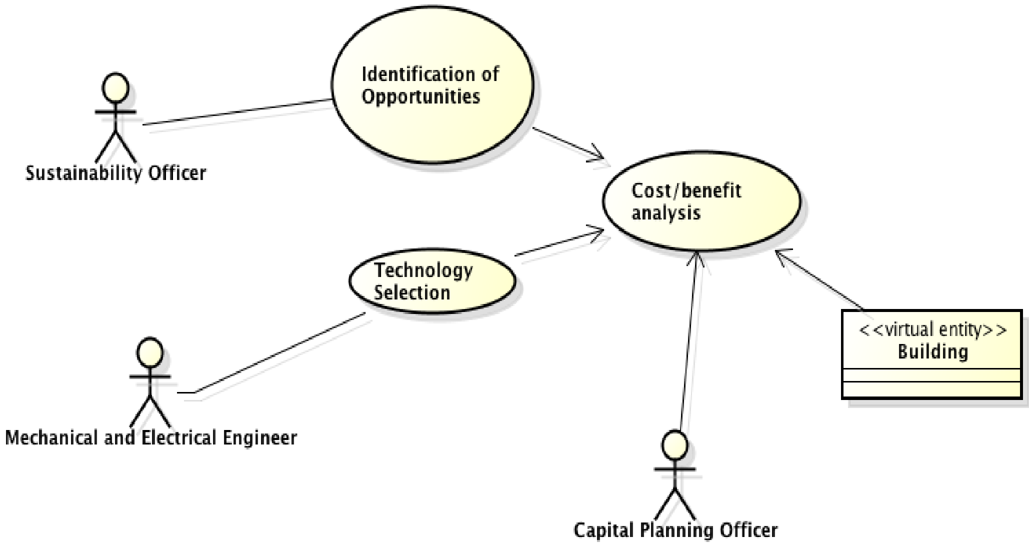


Figure 1Use Case diagram for Capital Planning/Energy Performance

Use Case: Capital Planning/Energy Performance and Commissioning and Quality Assurance
ID: 1
Brief Description: The EnergyHive system in each building enables Capital Planning/Senior Energy Performance Officer to perform a more rigorous cost/benefit analysis of suggested programs or technology installations. The system provides accurate information as to the carbon/monetary saving of an implementation.
Primary Actor(s): Senior Energy Performance Officer; Design and Compliance Manager
Secondary Actor(s): Mechanical and Electrical Engineer; Sustainability Officer
Preconditions: EnergyHive system must be installed throughout each building in the estate, as well as boiler controls and verification systems.
Main Flow: 1. Temperature readings are collected at distribution level within Camden heat networks. 2. The energy balance model will be run against the Trend readings, and the temperature/electricity readings showing performance indicators (degree hour per kWh) against a network model for the delivery.

3. Normalisation for seasons and weather conditions should be applied (subtract degree hours inside versus degree hours from weather). 4. Sensors will be installed wherever suitable on the district heat network to manage distribution losses.
Postconditions: Ranked performance of the buildings' heat networks is reported to enable interventions to improve network inefficiencies.

2.1.2. Minimising CO_2 Emissions

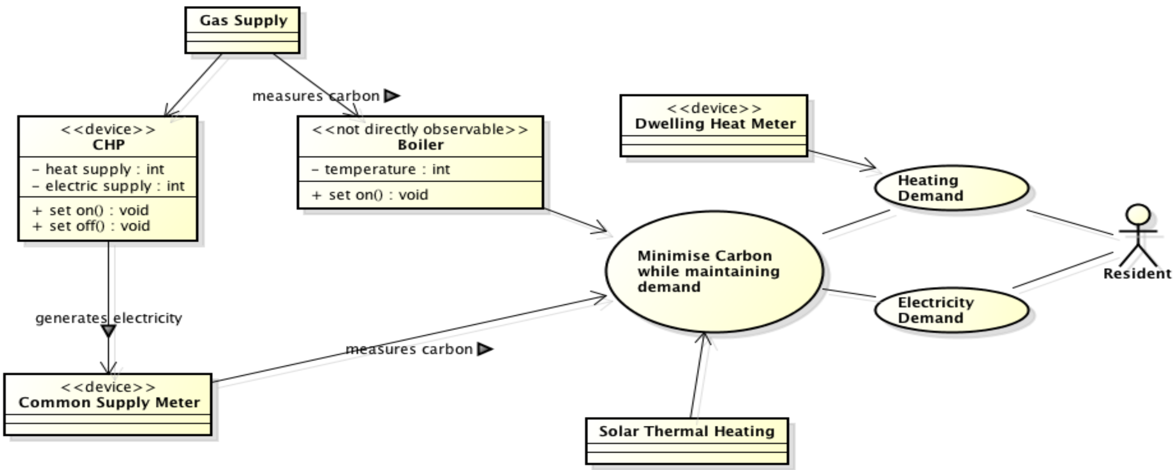


Figure 2 Use Case diagram for minimising C02 emissions.

Use Case: Minimising $C0_2$ Emissions
ID: 2
Brief Description: An effective way to minimise carbon is to give more weighting to processes with lower $C0_2$ levels whilst maintaining the demand. The interconnected IoT-based system using an energy platform will make possible effective management of the energy supply in order to minimise $C0_2$ emissions. With minimal input by the resident or site staff, the system will predict the estate's heat in half-hourly intervals and manage the CHP and boiler accordingly.
Primary Actor(s): Resident
Preconditions: Specialised Instalments: 1. Gas Flow meter to CHP from boiler to regulate the Gas supply. 2. Control system with temperature sensor on boiler. 3. Flow meter/temperature sensor on Solar Thermal. 4. Heat meter in each dwelling. 5. Communication infrastructure between sensors and hub.
Main Flow: 1. System predicts the estate's heat and electricity demand for a half-hour period. 2. System calculates required gas supply and distributes to CHP and boiler accordingly.

3. CO_2 emissions are produced is measured. 4. Individual resident heat consumption is monitored.
Postconditions: 1. The resident is charged for their personal heat consumption. 2. Prediction errors are logged to improve system on later iterations.

2.1.3. Minimising Demand

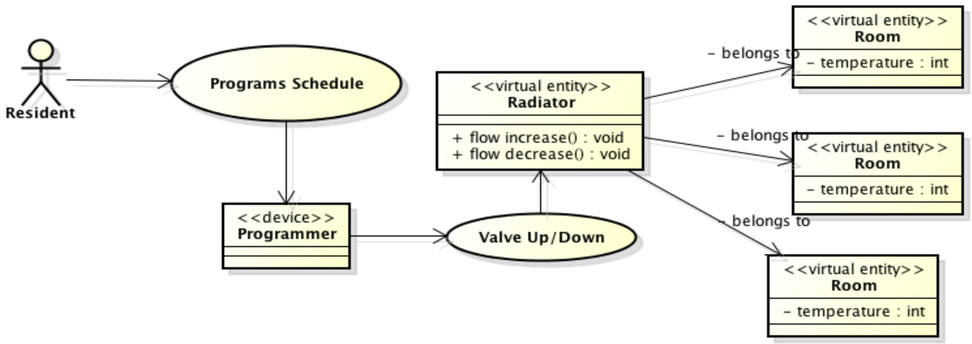


Figure 3 : Use Case diagram for minimising demand

Use Case: Minimising Demand
ID: 3
Brief Description: Another method of reducing CO_2 emissions is to minimise the demand for Heat Energy. This is possible through the current IoT platform, namely EnergyHive (designed by Hildebrand). The EnergyHive system will use smart meters to report real-time energy consumption information, both automatically and remotely. The system, with support from a council Sustainability Officer, assists the user in setting a heating schedule in accordance with their budget. The purpose is to make users aware of the cost of heating, with the Sustainability Officer being able to identify and support users who are particularly high consumers and, therefore, at risk of fuel debt. Similarly, Council Officers will be able to identify particularly low use, which may indicate a health risk or non-occupancy.
Primary Actor(s): Sustainability Officer; Energy Performance Officer; Resident
Preconditions: 1. EnergyHive system implemented in each dwelling. 2. Valve up/down control system to the radiator.
Main Flow: 1. Resident accesses their customer account to view balance. 2. Resident can set a heating schedule. 3. Resident is given tariff and projected balance for a given schedule.

Postconditions: User can optimise their schedule to minimise their consumption.

2.1.4. Heating Control

Use Case: Heating Control
ID: 5
Brief Description: The EnergyHive system is measuring the temperature of the properties where it is installed and has the ability to control the delivery of heat through a valve. A new tablet has been deployed within the property that allows for a set point and schedule to be entered. Feedback from users has been that they would like the system to automatically help them set a programme and manage efficiencies on an ongoing basis, for instance: detection of whether or not they are at home; using the weather forecast to help with program and supply-side management when the solar thermal is available for use. The tablet is a COSMOS-compatible device and it can act locally to run case-based reasoning in an efficient manner.
Primary Actor(s): Resident
Secondary Actor(s): Mechanical and Electrical Engineer; Sustainability Officer
Preconditions: EnergyHive system must be installed within a resident's premises.
Main Flow: 1. Resident will select an autopilot function on their tablet. 2. Autopilot will determine a recommended set point for the temperature in the house. 3. Set point can be overridden by the resident. 4. The system will learn the patterns of occupation and adjust the run programme to turn off the system based on un-occupied property; the resident can override. 5. Savings should be quantified over using a normal time-based programmer.
Postconditions: An improvement to the efficiency of the heating system should be reported.

2.1.5. Building Performance Management

Use Case: Building Performance Management
ID: 6
Brief Description: The boiler systems within buildings have master programmers and temperature settings that are controlled by a Trend boiler control system. There are also verification instruments installed within buildings to measure the effects of the boiler control; they can provide feedback to inform the run-time commands to the boiler control as well. A more granular view of the energy demand, including trade-offs with electricity usage, is desired so that individual residential premises are getting higher comfort while balancing the energy input.

Primary Actor(s): Mechanical and Electrical Engineer; Energy Performance Officer
Secondary Actor(s): Resident; Sustainability Officer
Preconditions: EnergyHive system must be installed throughout each building in the estate, as well as boiler controls and verification systems.
Main Flow: 1. Temperature readings are collected at distribution level within Camden heat networks. 2. The energy balance model will be run against the Trend readings, and the temperature/electricity readings showing performance indicators (degree hour per kWh) against a network model for the delivery. 3. Normalisation for seasons and weather conditions should be applied (subtract degree hours inside versus degree hours from weather). 4. Sensors will be installed wherever suitable on the district heat network to manage distribution losses. These losses may be within the energy centre (boiler room), pipework laterals and risers and/or dwelling cylinders.
Postconditions: Ranked performance of the buildings' heat networks is reported to enable interventions to improve network inefficiencies.

2.1.6. Identification of Opportunities

Using machine learning, identify where energy savings opportunities exist. This will help Sustainability Officers to identify projects with sound business cases, with both $C0_2$ emissions savings and energy reduction benefits, which can then be submitted for formal approval.

Use Case: Identification of Opportunities
ID: 7
Brief Description: The EnergyHive system running in planning mode can use machine learning to suggest opportunities for efficiency. This is largely an unsupervised learning exercise where cause and effect models can be run with comparisons to other like buildings or similar conditions that have been observed.
Primary Actor(s): Sustainability Officer; Energy Performance Officer
Secondary Actor(s): Budget holders; Rent and Billing Services; Air Quality Officer
Preconditions: EnergyHive system must be installed throughout each building in the estate.
Main Flow: 1. Sustainability Officer creates model constraints for parameters to optimise (i.e. cost or carbon savings desired with physical systems). 2. Model runs within system bringing up bands of savings that can be made from changes in input parameters.

3. System provides control ranges that would have to be implemented in order to make potential savings.
Postconditions: A quantified opportunity for efficiency within the energy system is presented for evaluation.

2.1.7. Damp/Condensation Monitoring

Use Case: Damp/Condensation Monitoring
ID: 8
Brief Description: The aim is to help residents to identify and reduce/eliminate damp, where it exists: humidity sensors monitor condensation levels and identify where damp is best detected; temperature sensors measure how the temperature of the properties affects damp; and window open/close sensors demonstrate the extent to which the residents are ventilating their properties.
Primary Actor(s): Resident
Secondary Actor(s): Sustainability Officer
Preconditions: EnergyHive system must be installed throughout each dwelling, including humidity, temperature and window sensors in rooms that are concerned.
Main Flow: 1. Log readings from humidity, temperature and window sensors against rooms where they are installed. 2. Obtain feedback from resident if damp is present, on the basis that they are told to report damp when detected. 3. Create a learning model to understand the causes of damp (supervised learning with the report of damp as the training of the machine learning algorithm). 4. Continuously calculate a prediction for damp from the machine learning model, and alert the Sustainability Officer if damp looks likely. 5. Alert resident of the likelihood of damp through some feedback mechanism. 6. Help the resident to use the “damp kit” (cleaning and drying equipment supplied by Camden Council) to eliminate any damp detected. 7. Continue to learn the conditions that prevent damp, and use feedback and control to re-enforce good conditions in humidity, temperature and ventilation.
Postconditions: Damp model using sensor input and feedback from resident; damp alerts based on prediction of damp; maintenance of dry conditions.

3. Back-Office and UrbisAPIs

[INSERT NEW CONTENT]

3.1 Progress and Achievements

3.2 Future Plans

4. Scenario Progression

4.1 Survey Research

4.1.1. User Interface Questionnaire

Throughout the COSMOS project, there has been a question about residents' willingness and ability to interact with technology, in particular where new technical paradigms such as Internet of Things (IoT) challenge trust yet aid users with very easy, if not passive, user interfaces.

In deliverable 7.4.3, we presented the results of primary research on residents' attitudes and ability to interact with smart heating systems to inform how technology that has been developed within COSMOS should be designed and applied to satisfy the needs and preferences of the end user. These results showed a strong correlation between users' comfort level using technology and their ideal heating control preference; the less comfortable they felt, the more they preferred to exert manual control, even if an automated system promised to be highly intelligent and deliver better results. We concluded that there is a stronger trust in technology when there is a higher familiarity with the information and communication technology.

In this deliverable, we wanted to test the relationship between users' self-determined and actual levels of comfort when using their existing heating programmer, compared to a prototype smartphone application offering the same functionality. We were also interested to see whether users' age correlated with their willingness and ability to use 'new' technology in a practical sense, as it did in residents' responses to the Home Heating questionnaire.

One of the COSMOS project's key aims has been to determine how council residents can better manage their heat consumption, in order to improve the quality and comfort of their homes and make warmth more affordable. Respondents to this questionnaire were recruited from the group already participating in the Heating Use Case Pilot, a pool of Camden council residents with the highest heat usage in the Ampthill Square estate, in order to determine whether their inefficient use of the heating system stemmed from an inability to comprehend and/or operate their existing programmer, and how readily this could be improved by the control offered by a smartphone application.

4.1.2. Residents' Existing Heating Programmer

The residents of the Ampthill Square estate use a programmable thermostat the same as, or similar to, the Drayton Digistat+2 / +2RF (photographed in Figure 4 below).

Figure 4 Photograph of a Drayton Digistat+2 / +2RF Programmable Room Thermostat.

This programmer offers its users basic heating schedule functionality, including up to 6 time/temperature events during a 24-hour day, as well as an "Auto-Mode" function for instantaneous temperature change for a short period lasting until the next pre-programmed event. It also comes with a 24-hour pre-set programme for convenience (see Appendix A for a complete instruction manual).

The programmer is located in the lobby or hallway of each residence (010 and 009 in Figure 5 below). These rooms receive no direct sunlight and are frequently poorly lit. Residents often resort to using a torch when setting their programmer as it does not have a back-lit screen.

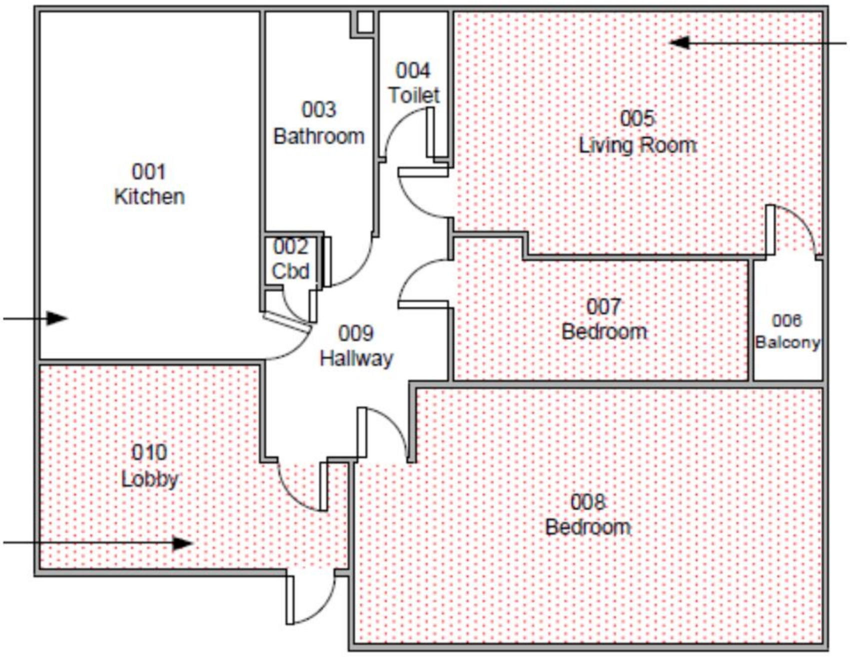


Figure 5: Floorplan example of an Ampthill Square estate residence.

4.1.3. Prototype Smartphone Application

Hildebrand developed a prototype smartphone application with a stripped-down, intuitive interface that would handle the same range of functionality and control that residents currently experience with their existing heating programmer. We wanted to gauge the residents' response to 'new' technology, and determine the extent to which their interface with their current programmer resulted in their inefficient use of the heating system.

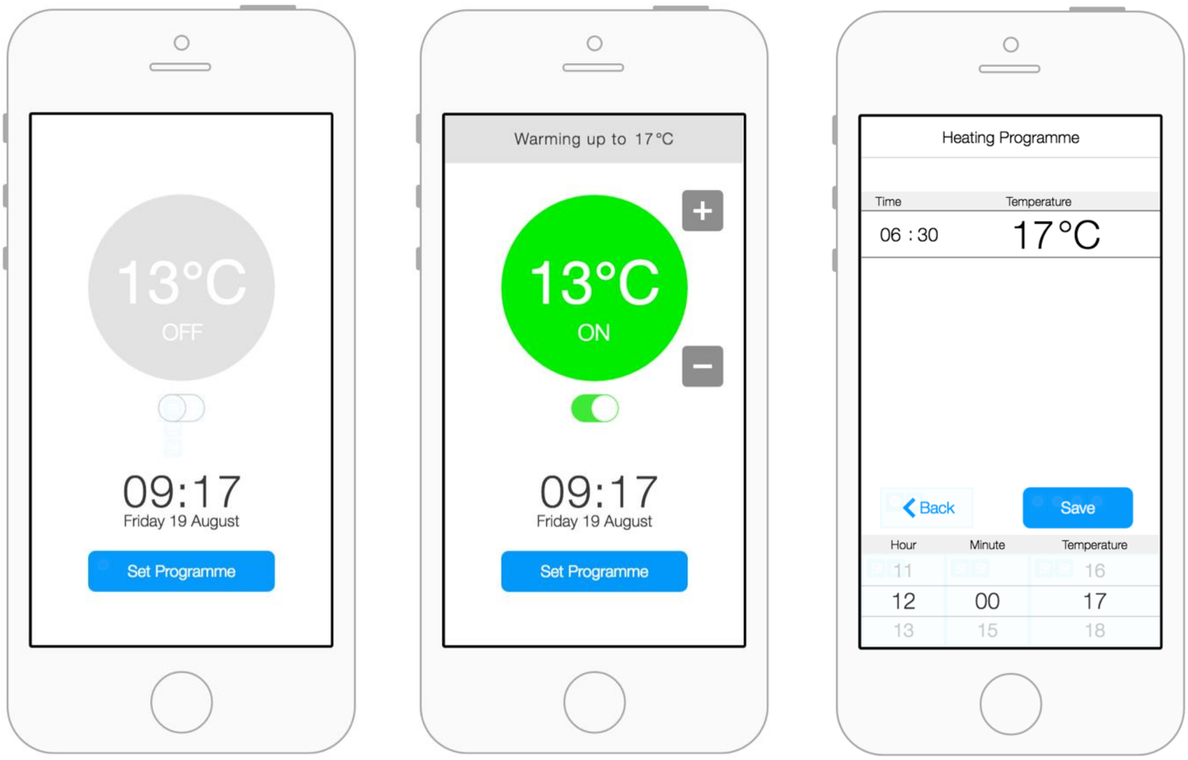


Figure 6 screenshot showing screens 1, 2 and 3 of Hildebrand's prototype smartphone application.

Figure 6 above shows the three screens offered by the prototype. The application launches in screen 1 or 2, depending on whether the heating programmer has been switched on (screen 2) or off (screen 1) by the resident. Both screens display a real-time room temperature and an ON/OFF function. The + and – buttons on screen 2 can be used to manually raise or lower the current room temperature, overriding the set heating schedule, similar to the "Auto-Mode" function offered by the Drayton Digistat+2 / +2RF Programmable Room Thermostat. Once a new temperature has been set, a notification appears at the top of screen 2 confirming the new input. The 'Set Programme' button on screens 1 and 2 directs the user to the Heating Programme page (screen 3). This page allows users to set a schedule for time and temperature throughout a 24-hour period.

4.1.4. Survey Documents

Hildebrand and Camden developed a set of explicatory documents and questionnaires, including:

- a **Participant Information Sheet**, summarising the purpose of the COSMOS project, the type of information to be addressed in the questionnaires, and how the information will be used in the project;

- an **Informed Consent Form**, stating how the data is to be stored and analysed in compliance with current data protection legislation, and who will be permitted to access the information;
- a **Participant Profile Questionnaire** to determine the age group, cultural and educational backgrounds of each participant; and
- a **User Interface Questionnaire**, designed to gauge residents' self-determined and actual levels of comfort and competence when using their existing heating programmer and a prototype smartphone application. Each resident was asked to perform the following three tasks using their existing programmer and then the smartphone application:
    1. Can you turn your heating on or off?
    2. Can you set the current temperature to 23°C (for example)?
    3. Can you set the temperature to 25°C starting at 7pm (for example)?

See Appendix B for complete versions of these tools.

This deliverable will evaluate residents' responses to the Participant Profile and User Interface questionnaires.

4.1.5. Survey Results

Responses were collected from a total of 5 Camden residents already participating in the Heating Use Case Pilot. We identified a significant disparity between users' self-determined and actual levels of comfort using their existing heating programmer, as well as the smartphone application. A full summary of the questionnaire results can be found in Appendix C.

Question 1 of the User Interface questionnaire asked participants how comfortable they feel using their current heating programmer. All of the residents that either responded 'not at all comfortable' or 'don't know' rarely interact with the programmer: they either rely on visiting family members to help them, or use the control valve on their radiators and open windows to regulate the temperature in their flats. One resident leaves the radiators on their highest setting year-round, and uses open windows to adjust the temperature according to the season, for fear of creating an unsafe environment for her elderly mother; another resident also stated that it was 'safer' to use radiators and windows to control the heating, and avoids using her programmer to set a heating schedule in case she 'messes up' the controls. When asked to complete the tasks, only two of these residents were able to adjust the current temperature, and none of the three knew how to set a heating schedule, although one resident felt 'very comfortable' with this limited functionality.

Two residents stated in Question 1 that they felt 'very comfortable' using their existing programmer, yet both answered 'not at all comfortable' when asked how they felt completing the tasks. Neither resident was able to set a heating schedule, and one could not operate the programmer at all. The inconsistency of these attitudes reveals, at least in the case of some users, a tendency to trust in technology which is familiar, even if it not easy to use or does not deliver any benefit. Indeed, both residents then admitted that they never use the heating programmer because they do not know how.

In Question 4, participants were asked how comfortable they feel using new technology. 4 of the 5 reported that they were either 'not at all comfortable' or weren't sure how they felt.

Although the participants belong to a wide age range (between 45 and 74), all 5 believe that 'new technology' belongs to a younger generation, and often rely on younger family members to manage it for them. Several of the residents professed a willingness to learn how to use new technology, provided that it is beneficial and easy to understand. These findings support conclusions drawn in deliverable 7.4.3, that there is a strong correlation between trust in technology and its familiarity to a user. Conversely, users feel intimidated by unfamiliar technology if they feel it will be complicated to use, and might even avoid using it altogether, even if it promises to deliver them better results.

When residents were asked to use the smartphone application to complete the tasks, the success rate was significantly higher: only two of the residents were unable to complete all three of the tasks, and 4 of the 5 residents felt either 'comfortable' or 'very comfortable' using the application, despite feeling 'not very comfortable' about using new technology. Most significantly, all of the residents found the application easier to use than their programmer and were interested in using a smartphone application to control their heating in the future. The majority of the respondents also felt that a smartphone application that could send them notifications and suggestions about their heating would be useful, suggesting that they would be open to a higher level of interaction with the application were it to offer additional functionality.

There was a similar attitudinal shift in residents' responses to questions addressing their preferred level of interaction with their heating system. In Question 2, asking respondents to describe their ideal heating control, over half preferred a manual system because they felt it would be more simple to use, and the control it affords them would make it more reliable. Accordingly, residents expressed distrust towards 'new' technology, in this case the idea of an automated system, because it seemed unfamiliar and complicated. However, in response to Question 9, 4 of the 5 the respondents stated that they would feel either 'comfortable' or 'very comfortable' using a heating system that could automatically control their heating by watching their usage over time. This would suggest that, by familiarising the residents, even briefly, with technology that they had previously been resistant or unwilling to use, their comfort level had increased and, accordingly, had encouraged a more open attitude to heating control preferences.

4.1.6. Future Plans

Hildebrand, Camden and NTUA intend to use the knowledge that results from this survey research, as well as the results of the resident engagement events and online activities we have hosted throughout Year 3, to inform the design of an actuated smartphone application. We will test functionality with residents participating in the Heating and Damp/Condensation Use Case Pilots, and use further survey research to inform development of the user interface in order to ensure that we are satisfying the needs and preferences of the end user.

4.2 Heating Use Case Pilot

Fifteen high energy users were initially selected to participate in the Heating Use Case Pilot study at the Ampthill Square estate. Residents were initially sent information by letter, before being contacted by a Camden Officer to arrange an installation appointment. However, several residents opted not to participate in the Pilot on the day of the installation due either to the nuisance factor or a cultural/language barrier (many residents were not comfortable inviting guests into their home without a male family member being present).

Sensors were installed in a total of ten properties, as detailed in Table 1 (below).

Table 1 : Installations of temperature, window and humidity sensors in the Ampthill Square estate.

Date of Installation	Property Reference	Type of Sensor Installed
02/03/16	Prop-1, Prop-2	Temperature Window
18/04/16	Prop-3 to Prop-6	Temperature Window Humidity
19/04/16	Prop-7 to Prop-9	Temperature Window Humidity
19/04/16	Prop-2	Humidity
20/04/16	Prop-1	Humidity
23/05/16	Prop-10	Temperature Window Humidity

The COSMOS partners intend to use the data flowing from these sensors to actuate the smartphone application. Although residents participating in the Pilot have not needed to interact with the sensors, they will be a key response group in the development of this application.

4.3 Damp Use Case Pilot

Camden identified three severe cases of condensation from the "Well and Warm" fuel poverty service that could be used to pilot the COSMOS system. Table 2 below summarises the main issues in each property, and any corresponding effects on residents' health:

Table 2: Property types

Property A	Property B	Property C
Mould throughout the property.	Bad case of mould in bedrooms and hallway – soggy to touch. Heating system not working properly.	Dampness in bedrooms, on outside walls and in the bathroom.
	Family with children. One person with severe health problems and respiratory difficulties.	Young child ill due to damp conditions.

Temperature, window and humidity sensors have been installed in the rooms most affected by damp in each of the three properties. All of the households have confirmed that the problem is persisting, and have welcomed the idea of a remote monitoring system. The COSMOS partners intend to use the data flowing from these sensors to design a notification system integrated within the smartphone application that will monitor temperature and humidity conditions and notify residents and Camden council when they are at risk.

5. Appendix A

Drayton

Digistat +2 / + 2RF

Programmable Room Thermostat
24 Hour

Models: 22084, 22088 / RF700, 22090

QUICK START GUIDE

Drayton Digistat + 2 and + 2RF

The Digistat +2/+2RF thermostat is a programmable thermostat with **24 Hour** timing and **6 time/temperature** events during the day.

Clock Setting

Your **Digistat +2/+2RF** is fitted with a **"real-time clock"**, which is "pre-set" at the factory; you will not have to alter the time settings. A special feature of this real-time clock is it will automatically change over during the GMT/BST summer/winter change over removing the need to manually alter the clock.

General Operation

Programmable thermostats do not have **"On"** and **"Off"** times like traditional timers. They offer temperature control both day and night and you simply select which temperatures you require at which times of the day.

With the unit in **"Auto-Mode"** (the small arrow to bottom of screen will point to Auto) the temperature can be changed for a short time by using the + or - buttons. Changing the temperature in this way will keep the Digistat +2/+2RF set to your new temperature until the next pre-programmed event (at which time it will revert to programmed temperature). The temperature you are setting will flash on the screen. Once temperature is set, the unit will revert to showing the room temperature. The indicator will show on the screen if the heating is calling for heat.

Programming the Digistat +2/+2RF

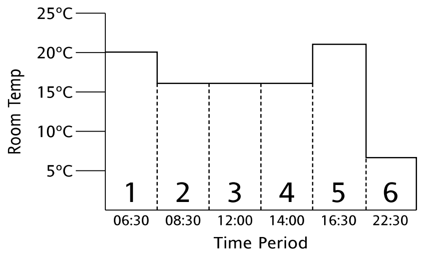
Your Digistat +2/+2RF comes with the following settings pre-programmed for your convenience:

Pre-set Program 1 (9 til 5): EVERY DAY

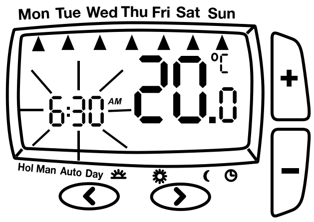
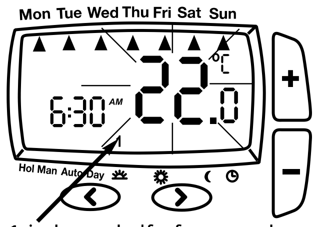
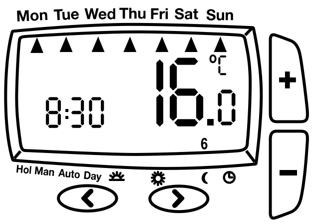
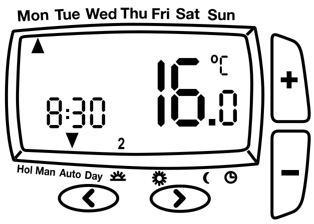
Event	1	2	3	4	5	6
Time	*6:30*	*8:30*	*12:00*	*14:00*	*16:30*	*22:30*
Temperature	20.0	16.0	16.0	16.0	21.0	7.0

**The above settings can be understood using the chart below:*

As you can see, at 06:30, the heating will come on to raise the temperature to 20°C. At 8.30, the temperature set point is dropped from 20°C down to 16°C, at which time it stays at 16°C *throughout the day*, until 16:30 when the temperature *increases* to 21°C. The temperature then *drops down* to a night-setback temperature of 7°C until 06:30 when the cycle repeats for a new day.



Setting up Times/Temperatures on the Digistat +2/+2RF

1. With the product operating as normal in the Auto mode, press > twice, until the display is flashing as shown. The time will be flashing, use the + or - buttons to adjust the 1st time as required.	
2. Once the time has been set press the > to confirm and use the + or - buttons to adjust required temperature (temperature shown flashing)	 (* small 1 in lower half of screen shows which time period is being set e.g. 1=1st period, 2 = 2nd period etc)
3. Once the temperature has been set press > to confirm and move to the next time and temperature periods to be adjusted confirming changes by pressing > button. (max. 6 periods).	
4. To exit press > or < until you return to auto mode with the bottom arrow pointing to auto (as shown).	

Congratulations!

The unit is now set correctly to follow your required timings

Invensys Controls Europe
Customer Service Tel: 0845 130 5522
Customer Service Fax: 0845 130 0622
Technical Helpline Tel: 0845 130 7722
Website: www.draytoncontrols.co.uk
Email: customer.care@invensys.com

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6. Appendix B

6.1 Participant Information Sheet

What is this research for?

The purpose of this research is to understand how you currently use your heating, and how technology might be used to improve the way that you manage your heating, so that your heating bill is reduced.

The research is being conducted on behalf of COSMOS, a European funded project in which Camden collaborates with nine other European partners, including universities, IT companies and public sector entities.

What will I do as part of this research?

You will fill out a couple of questionnaires. In the first, you will be asked questions about yourself. In the second, you will be asked for your opinion on technology and heating controls. Both questionnaires will be *anonymous*.

Why have I been chosen?

The groups of people taking part in this research have been randomly selected, and are all volunteers.

How long will this take?

Both questionnaires should take no more than 30 minutes to complete, but you are free to spend as much time as you like answering the questions.

What will be done with the data?

We will analyse the data and draw conclusions from your answers. These will be used to help make improvements to your existing heating controls.

Results may be published in academic journals or presented at conferences. However, you will not be personally identified in any publication or presentation.

What are the benefits of taking part in this research?

You are contributing to the improvement of the way that data, involving probability, is presented. You will also have the opportunity to experience being part of a behavioural study and a research project.

Is the research confidential?

Your responses will be kept strictly confidential, and will only be used for the purpose of this study. The information that you provide will not be made available to anyone who is not directly involved in the study.

Contact Information

If you have any questions regarding the research, please contact Stella Doukianou at doukians@uni.coventry.ac.uk or Susana Espino at susana.espino@camden.gov.uk.

6.2 Informed Consent Form

Ref _______

In order to collect data for this research, we need to have your consent. By writing your initials in the boxes below, you are agreeing with the following statements:

Please initial

1. I have read and understood the Participant Information Sheet for the above study, and have had the opportunity to ask questions. ☐
2. I understand that that my participation is voluntary, and that I am free to withdraw at any time without giving a reason. ☐
3. I understand that all the information that I provide will be treated in confidence. ☐
4. I understand that I have the right to change my mind about participating in this study. ☐
5. I am over 18 years old. ☐
6. I understand that the data is being collected for research purposes. ☐
7. I agree to be filmed during this workshop (optional). ☐
8. I agree to take part in this research project. ☐

Date: …………………………………………………………..

Name of Participant: ………………………………..

Signature of Participant: ……………………………

6.3 Participant Profile Questionnaire

Ref _______

Ethnicity: What is your ethnic group? (Please tick one box)		
White	English/Welsh/Scottish/Northern Irish/British	
	Irish	
	Gypsy or Irish Traveller	
	Any other White background (please specify)	
Asian or Asian British	Indian	
	Pakistani	
	Bangladeshi	
	Chinese	
	Any other Asian background (please specify)	
Black or Black British	Caribbean	
	African	
	Any other Black/African/Caribbean background (please specify)	
Mixed/multiple ethnic groups	White and Black Caribbean	
	White and Black African	
	White and Asian	
	Any other mixed/multiple ethnic background (please specify)	

Other ethnic group	Arab	
	Any other ethnic group (please specify)	

Age: What is your age? (Please tick one box)									
0-15		16-24		25-34		35-44		45-54	
55-64		65-74		75-84		85+			

Gender: What is your gender? (Please circle the answer)			
Male	Yes/No	Is your gender identity different to the sex you were assumed to be at birth?	Yes/No
Female	Yes/No		

Highest level of education gained: (Please tick one box)				
School		University		Other (please specify)
College		None		

Family status: (Please tick one box)			
Live alone		Live with children	
Live with partner		Live with partner and children	
Live with extended family (please specify)			

END OF THE QUESTIONNAIRE

6.4 User Interface Questionnaire

Ref ________

1. **How comfortable do you feel using your current heating programmer? (Please tick one answer)**

	Very comfortable		Comfortable		Not at all comfortable		Don't know

Why?

2. **What is your ideal heating control? For example, fully automated, manual only, etc.**

<u>We will now ask you to complete a series of short tasks using your current heating programmer.</u>

3. **How comfortable did you feel using your current heating programmer? (Please tick once answer)**

	Very comfortable		Comfortable		Not at all comfortable		Don't know

Why?

4. **How comfortable did you feel using new technology? (Please tick once answer)**

	Very comfortable		Comfortable		Not at all comfortable		Don't know

Why?

5. **Do you have a smartphone or tablet? (Please circle one answer)**

Yes / No / Don't know

We will now ask you to complete a series of short tasks using a smartphone app.

6. **How comfortable did you feel using the smartphone app? (Please tick one answer)**

	Very comfortable		Comfortable		Not at all comfortable		Don't know

Why?

7. **Would you be interested in using a smartphone app to control your heating in the future? (Please circle one answer)**

Yes / No / Don't know

8. **Would you find a smartphone app that could send you notifications and suggestions about your heating useful? (Please circle one answer)**

Yes / No / Don't know

9. **How comfortable would you feel using a heating system that could automatically control your heating by watching your usage over time? (Please tick one answer)**

	Very comfortable		Comfortable		Not at all comfortable		Don't know

END OF THE QUESTIONNAIRE

7. Appendix C

	Participant Profile Questionnaire					User Interface Questionnaire														
						Current Programmer						Smartphone Application								
	Ethnicity	Age	Gender	Education	Family Status	Question 1	Question 2	Task 1	Task 2	Task 3	Question 3	Question 4	Question 5	Task 1	Task 2	Task 3	Question 6	Question 7	Question 8	Question 9
1	White (English/Welsh/Scottish/ Northern Irish/British)	45-54	Female	School	Live alone	Very comfortable	Manual	X	X	X	Not at all comfortable	Not at all comfortable	Yes	✔	✔	✔	Comfortable	Yes	Yes	Very comfortable
2	Black or Black British (Any other Black/African/ Caribbean background)	35-44	Female	None	Live with children	Don't know	Manual	✔	✔	X	Very comfortable	Very comfortable	Yes	✔	✔	✔	Very comfortable	Yes	Yes	Very comfortable
3	White (English/Welsh/Scottish/ Northern Irish/British)	75-84	Female	College	Live alone	Not at all comfortable	Automated with manual override	X	✔	X	Don't know	Not very comfortable	Yes	X	✔	✔	Comfortable	Yes	Yes	Comfortable
4	Black or Black British African	55-64	Female	College	Live alone	Not at all comfortable	No preference	X	X	X	Not at all comfortable	Don't know	Yes	✔	✔	✔	Comfortable	Yes	Yes	Don't know
5	White (English/Welsh/Scottish/ Northern Irish/British)	65-74	Female	College	Live alone	Very comfortable	Manual	X	✔	X	Not at all comfortable	Not at all comfortable	No	X	✔	X	Not at all comfortable	Yes	No	Comfortable